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Optimizing QoS for Voice and Video using DiffServ-MPLS

By

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Abstract:

All the new emerging QoS architectures are motivated by the desire to improve the overall performance of an IP network. Differentiated Services (Diffserv) define a model for implementing scalable differentiation of QoS in the Internet. Multiprotocol Label Switching (MPLS) is a fast label-based switching technique that offers new QoS capabilities for large scale IP networks. When an MPLS network supports DiffServ, traffic flows can receive class-based network treatment that provides bases for QoS guarantees.The objective of this work is to study the influence of the QoS mechanism via DiffServ-MPLS on network parameters such as jitter, delay and throughput . The comprehensive study showed general improvement in the throughput, jitter and delay particularly of voice and video transmission when using DiffServ-aware MPLS network as compared to pure IP only or MPLS only.

Keywords:

VOIP, MPLS, Diffserv QoS, OPNET

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1. Introduction:

Various multimedia applications such as video streaming, VOIP and video conference are gaining demand bringing with it a massive congestion to the IP networks. With the emergences of multimedia applications in IP networks, bandwidth consumption has become a critical issue among the Internet community and Internet providers. Also a lot of the recent multimedia applications and services not only have bandwidth requirements, but also require other QoS assurances, like end-to-end delay, jitter or packet loss likelihood. These QoS requirements put new challenges on Internet service providers [1].

The standard organization such as Internet Engineering Task Force (IETF) has proposed several standards in order to achieve the quality of service in the IP networks. These include the MPLS Network and also Differentiated Services where several Request for Comments (RFCs)had been published for these two services and their interoperability [2].

In the coming sections, the MPLS Network and Differentiated Services architectures and its operational behavior are explained, and this will be followed by a discussion on the interoperability of these two architectures in order to meet the quality of service (QoS) requirements.

2.Multiprotocol Label Switching (MPLS):

In this section we describe the problems occurred when voice is transmitted on a MPLS protocol was proposed by IETF in 1997 to improve the scalability of network-layer routing, provide routing flexibility, increase network performance, and simplify the integration of equipment using non-IP forwarding paradigms [3,4].

MPLS is a packet-forwarding technology which uses labels to make data forwarding decisions. Routers that support the MPLS protocol suite are known as Label Switching Routers (LSRs). LSRs make forwarding decisions based on a label added at the shim header between link-layer and network-layer header rather than performing complex resource consuming routing lookups which result in fast routing process [5].

Label Edge Router (LER) is an edge LSR that makes the boundary of the MPLS domain. Ingress LER encapsulate (“push”) label onto an IP packet, which is then forwarded across the network on the corresponding LSP. When the packet reaches the edge of the MPLS network, the label is then removed (“popped”) from the packet, which is then forwarded as an ordinary IP packet [6].

The MPLS label is depicted in Fig 1, where the EXP field is used for signaling QoS priority, TTL the time to live and S field for marking the last label of a stack.

TTL	S	EXP	LABLE
8 bits	1 bit	3 bits	20 bits

Figure (1): *MPLS Header*

MPLS introduce the concept of Forward Equivalent Class (FEC). In FEC, IP packets can be classified according to the packet's priority which will determine how the packets are handled within the network. Thus all packets which belong to the same FEC get treated in the same way and get quickly routed along their path.

3. Differentiated Services (DiffServ):

Differentiated Services[7] 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 [8].

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 [2] .The IETF defined a set of 14 standard PHBs as follows:

- Best effort (BE). Traffic receives no special treatment.
- Expedited Forwarding (EF) PHB[9] is the key ingredient in DiffServ for providing a low-loss, low-latency, low-jitter, and assured bandwidth service. EF can be implemented using priority queueing with rate limiting on the class. Real time applications with stringent delay requirement such as VoIP, interactively game are especially suitable to be forwarded using EF. Although EF can provide the premium

service, only the critical applications should be provided by it since under congestion it is not possible to treat all traffic as high priority traffic .

- Assured forwarding (AF) [10] 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. Therefore, packets within the same class AFx may experience similar QoS in delay and jitter but different QoS in loss rate. Usually, packets are marked according to their service agreements with the service provider. Packets exceed the service profile will be marked a high drop precedence and dropped first under congestion. Those non real-time applications such as streaming video can use AF service [11].

To summarize, DiffServ provides differential forwarding treatment to traffic, thus enforcing QoS for different traffic flows. It is a scalable solution that does not require per-flow signaling and state maintenance in the core. However, it cannot guarantee QoS if the path followed by the traffic does not have adequate resources to meet the QoS requirements.

4. Integration of MPLS and DiffServ:

RFC 3270 describes the mechanisms for MPLS support of DiffServ. 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. LSPs for which the PHB is inferred from the EXP bits are called E-LSPs it is very useful in networks supporting less than 8 Diffserv classifications.

In networks that support more than eight PHBs, the EXP bits alone cannot carry all the necessary information to distinguish between PHBs. Thus, the PHB is determined from both the label and the EXP bits. LSPs which use the label to convey information about the desired PHB are called L-LSPs (where L stands for “label-inferred”). L-LSPs can carry packets from a single PHB, or from several PHBs that have the same scheduling regimen but differ in their drop priorities (such as AFxy where x is constant and y is not constant) [8,12].

MPLS and Diffserv are complementary techniques that can be implemented in an IP QoS network to implement an end-to-end QoS solution. When used together, Diffserv provides the Standardized QoS mechanisms and MPLS provides routing techniques increasing the network resource optimization and providing traffic engineering. An MPLS domain uses MPLS signaling protocols to establish a label switched path to forward data through a common path. The ingress LSR labels the packets, and the LSRs along the LSP forward the packets to the next hop. In Diffserv, the ingress router classifies the packets and then marks them with the corresponding DSCP .The intermediate routers use PHB to determine the scheduling treatment and drop probability for each packet [13].

MPLS makes the DS more reliable and faster due to its path-oriented feature. With the MLS/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 [14, 15].

5. Simulation model:

All the simulations in the paper are performed on the Network Simulator, OPNET. Fig 2, shows the network topology used in this experimental study. The experimental study was divided into two parts, first part only shows how MPLS improves the overall performance of the network and the second part inserts the DiffServ and the integration of DiffServ and MPLS together.

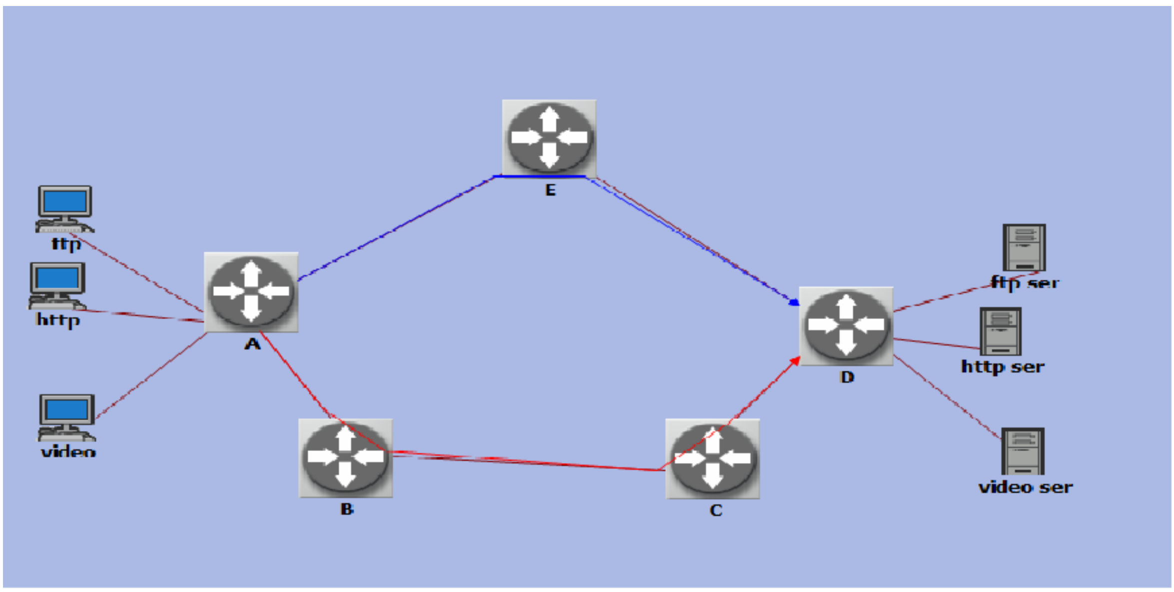

Figure (2): *Network model*

5.1 Voice simulation:

In this project the performance of voice traffic on the IP and MPLS networks are studded, DS3 (44.736 Mbps) links are used to connect all the routers and 100 Mbps links are used for connecting workstations to the two LERs. The routing protocol was OSPF; therefore, the best effort path would be from Router A-E-D and hence would constitute the bottleneck. There are two scenarios being tested which are:

1) IP _Best effort topology
2) MPLS topology.

In these scenarios the voice traffic increased by adding voice application every two seconds to observe and compare the efficiency of the two topologies architecture in addressing voice throughput, end-to-end delay and jitter as the load increases.

FTP traffic was set to low load and best effort type of service, where files are 1000 bytes and time between client request is exponentially distributed with mean 3600 seconds. Low resolution video starting at 10 fps (frames per sec) arrival rate and 128x120 pixels are used. For voice traffic, the voice encoder scheme is G.711 and the silence and talk spurt lengths are exponentially distributed. All these settings were made using OPNET Application Attributes Profile.

Background traffic has been specified at the links. The primary purpose of the background traffic is to model the effect of general traffic in the network on selected traffic of interest. Background traffic was configured as 50% of the links capacity in order to create enough traffic to make the link congested.

In MPLS configuration two LSP established in the network, LSP1 hold voice traffic from the shortest path and LSP2 force the other traffic to follow the long path in order to decrease the congestion in the network.

5.2 Vedio simulation:

In this project, three classes of service are provided: Expedited Forwarded (EF), Assured Forwarded namely AF11 and AF21.The EF traffic has an optimum bandwidth guarantee with low latency, low jitter and no packet loss. Video traffic was defined as the EF service in the simulation. E1 (2.048 Mbps) links are used to connect all the routers and 10 Mbps links are used for connecting workstations to the two LERs. The same topology used only voice station replaced by http station.

FTP traffic was set to high load and best effort type of service, where files are 50000 bytes and time between client requests is exponentially distributed with mean 360 seconds. For Http traffic, heavy browsing was selected where, page inter-arrival times are exponentially distributed with mean 60 seconds, and each page has 1000 bytes of text and 5 "medium images". There are four different scenarios being tested which are:

1) IP _Best effort topology
2) MPLS topology
3) DiffServ topology
4) Integration of MPLS and DiffServ (DiffServ-MPLS).

In DiffServ-MPLS protocol, Weighted Fair Queuing (WFQ) applied in the network which give EF class more priority than AF11 and AF21 . The advantage of employing DiffServ-MPLS in the IP network is the capability of the service provider to make full use of Forward Equivalent Class (FEC) by DiffServ traffic classification via PHB.

6. Results and discussion:

In the simulations pure IP network only provides best effort services for FTP, video and voice traffic flows. All the traffic used the shortest path (A-E-D) and exceeded its bandwidth capacity, while the longer path was under-utilized. The throughput increased at the links as the voice increased its traffic rate with time. Packets get dropped and delayed as buffers overflow because the resources in the network cannot meet all traffic demand.

6.1.Voice Results:

6.1.1.Voice throughput

As shown in Fig 3, MPLS solve the problem partly by distributing the load on the network links using FEC. Moreover, MPLS benefits from its fast switching in the routers but did not apply any QoS mechanism.

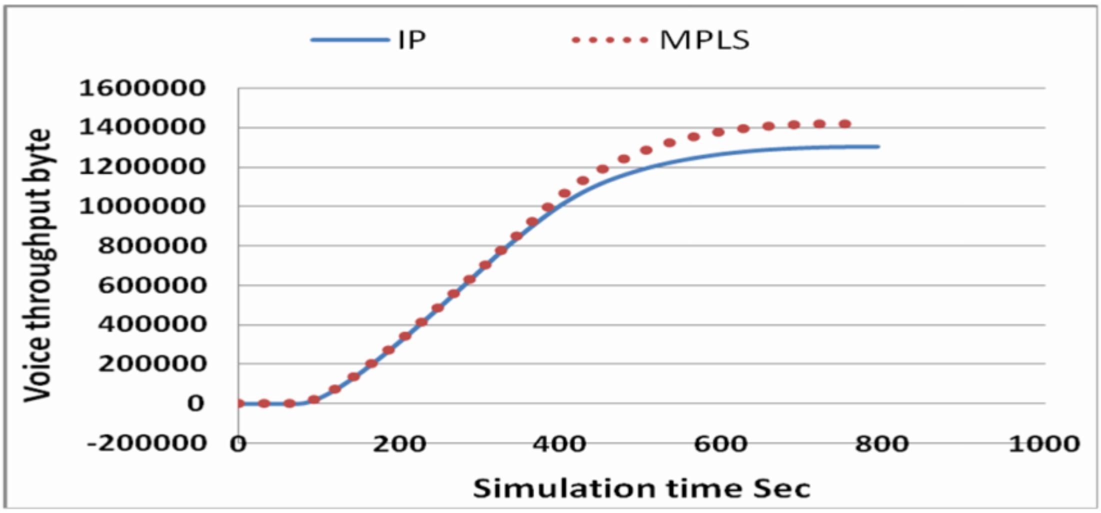

Figure (3):*Voice throughput*

6.1.2. Voice End-to-End Delay

As shown in Fig 4, MPLS had shown end-to-end delay lower than traditional IP network. In MPLS, the labeling of packets has provided faster processing rate at the routers as compared to the conventional IP, where address matching procedure is carried out.

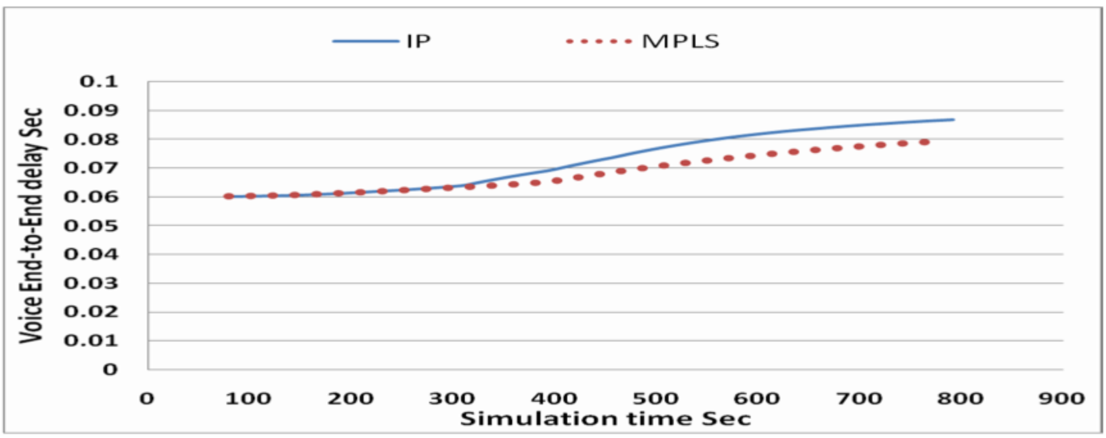

Figure (4):*Voice End-to-End Delay*

6.1.3. Voice jitter

Fig .5 shows the Voice packet jitter of MPLS and IP network model. It is noticed that Voice Jitter starts to increase in IP network before MPLS network starts to increase and reach higher value more than MPLS network.

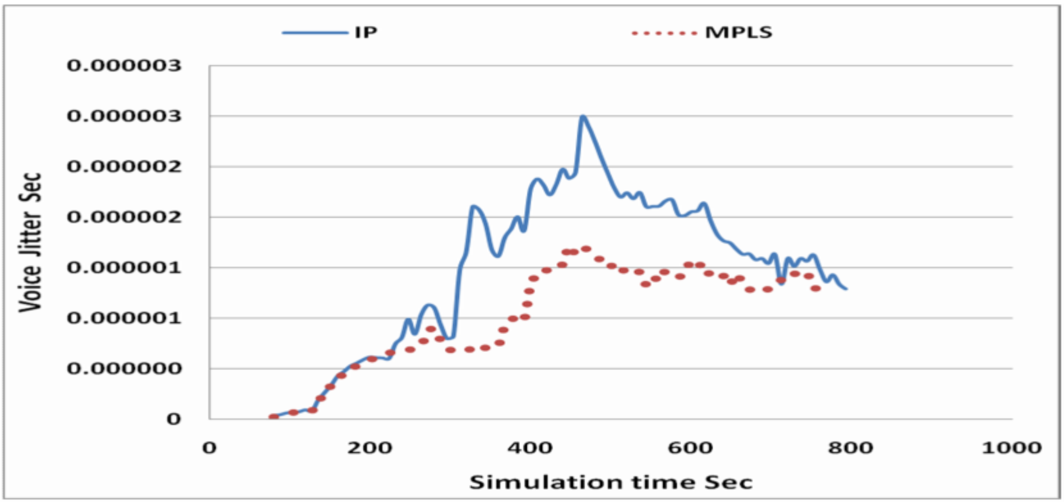

Figure (5): *Voice Jitter*

6.2. Video Results:

6.2.1. Video Throughput

Fig 6, displays the video throughput of the four scenarios. DiffServ-MPLS clearly improved the video throughput by more than 63 percent compared to the conventional routing by merging the MPLS features and DiffServ QoS mechanism.

6.2.2. Video End-to-End Delay

As shown in Fig 7, DiffServ-MPLS had shown the lowest end-to-end delay among these four schemes because it serves the network in terms of its PHB where prioritization was offered to the video application. And the MPLS used to distribute the traffic on the network resources.

Therefore, DiffServ-MPLS demonstrated the advantage to utilize these two attributes in offering the lowest end-to-end delay for video traffic even though at high traffic flow.

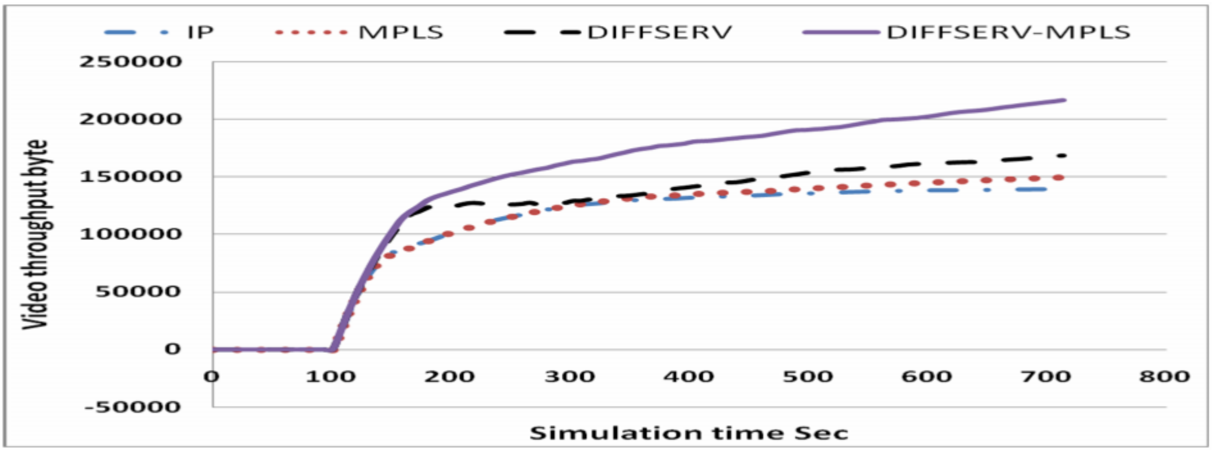

Figure (6):*Video throughput*

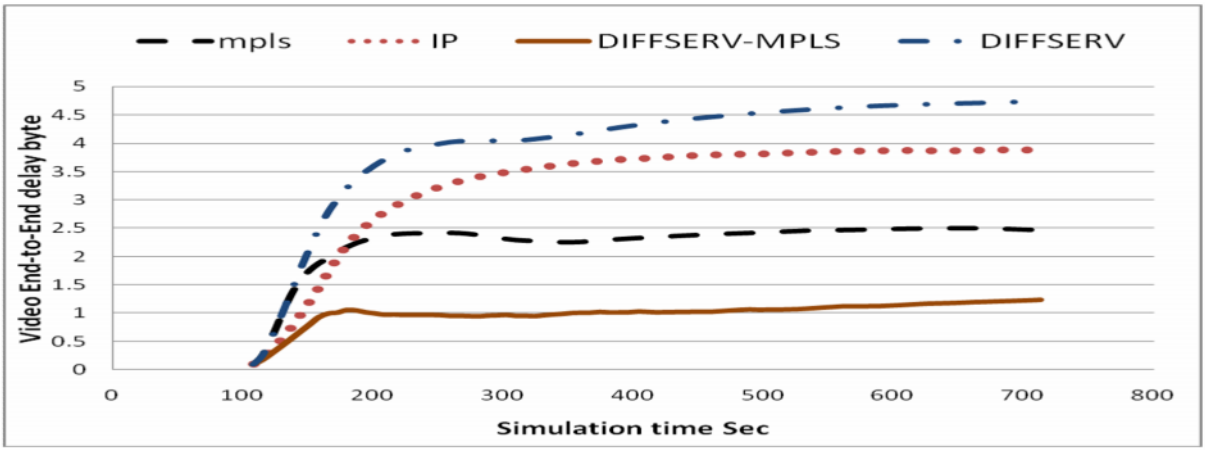

Figure (7):*Video End-to-End delay*

6.2.3. HTTP and FTP Traffic Flow

Fig 8, and Fig 9, demonstrate how the Assured Forwarded traffic is being affected in the network when the three QoS schemes were used. It is reminded that in DiffServ network, FTP was given higher priority than Http traffic. Since

FTP was classified better QoS than Http, it is observed that DiffServ-MPLS has served FTP far better than other schemes. This is because in DiffServ-MPLS, FTP and Http shared the same network path while video was routed to another and FTP was given better services than Http.

It is important to note that FTP and Http traffic are TCP while video is UDP. When TCP detects network congestion , the TCP source undergoes congestion control phase and slows down the transmission rate. However, when DiffServ-MPLS are used they reduce the congestion in the network so that the transmission rate don't decrease significantly as shown in Figs. 8 and 9. Moreover, it can be seen from Fig. 6, that video through put continue to increase since UDP has no congestion control.

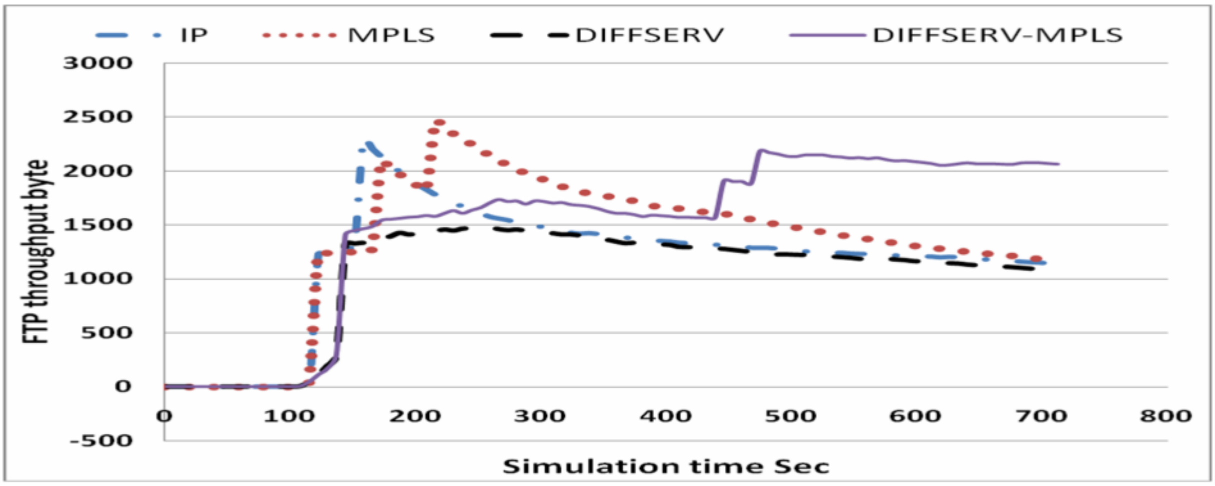

Figure (8): *FTP throughput*

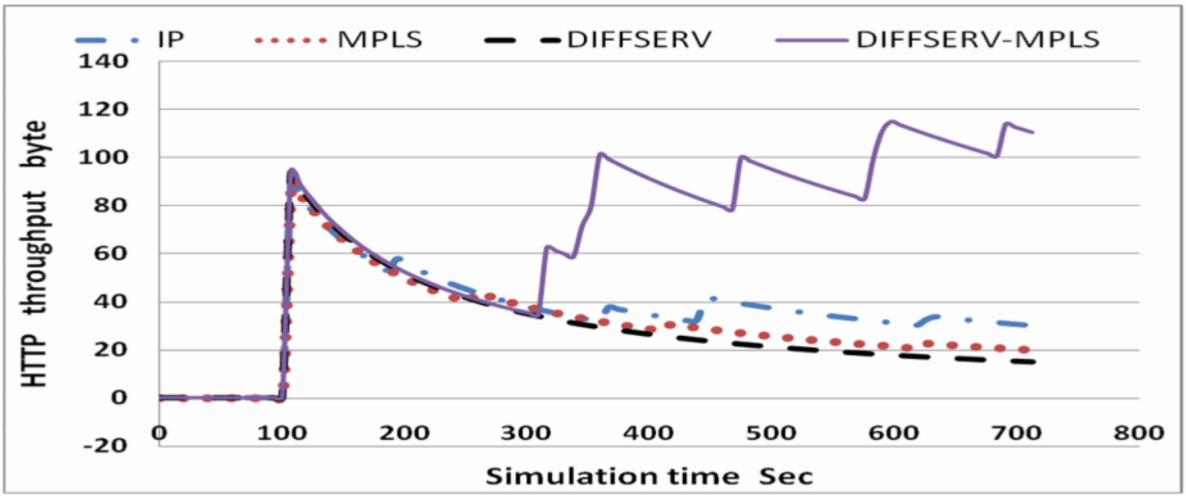

Figure (9): *HTTP throughput*

7. Conclusions:

In conclusion, MPLS support of DiffServ satisfies both necessary conditions for QoS: guaranteed bandwidth and differentiated queue servicing treatment [16].. MPLS satisfies the first condition, i.e., it forces applications flows into the paths with guaranteed bandwidth; and along these paths, DiffServ satisfies the second condition by providing differentiated queue servicing In future work there is still a need to study on the QoS mechanism such as traffic policing, queuing, scheduling and congestion avoidance to achieve guaranteed QoS across the IP/MPLS networks.

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