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Research Article

Improving the usage of Network Resources using MPLS Traffic Engineering (TE)

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Abstract

Traffic Engineering is defined as way of routing data through network in lieu of management view, availability of resources and the current and expected traffic. It also helps the network provider to make the best use of available resources. Different uses of internet requires different levels of services to be supplied, for instance voice traffic requires low delay and very small delay variation. Video traffic adds the requirement for high bandwidth, etc. Hop-by-hop approach is used to forward a packet in a network using IP protocol. Routing protocols are used to create routing tables, to find a path which has the minimum cost, according to its metrics to each destination in the network. This technique results in the over-utilization of some links while other links remain unused and are under-utilized, which leads to the congestion in the Network (I. Zafar et al, 2011; F. Ahmed et al, 2011). MPLS does not route data on the basis of destination address rather it routes data according to the labels. Using MPLS network, resources can be optimized by sending data through less congested path rather than the shortest path used in routing protocols. These new paths are created manually or through some signaling protocols. MPLS supports many features like traffic engineering, QoS and VPNs etc. (Hussein A. Mohammed et al, 2013; Adnan Hussein et al, 2013)Through MPLS in traffic engineering we can improve the usage of network resources making it more efficient. In this paper a comparison analysis is done based on traffic engineering parameters like effective utilization of bandwidth, delay, throughput, etc. for different type of traffic in their movements across the network for both MPLS-TE and traditional IP network. OPNET Modeler is used to simulate the results of comparisons.

Keywords: *Multiprotocol layer switching OPNET modeler, Traffic Engineering, Virtual Private Network.*

1. Introduction

Due to huge demand of multimedia services traffic engineering has become an essential feature, traffic engineering in telecommunication is based on certain performance parameters. It provides opportunity to select best path for data routing while efficiently using network resources. Hence to accomplish this task IETF (Internet Engineering Task force) has developed MPLS. MPLS improve traffic engineering over IP-based networks while using the layers of the Open System Interconnection Model (OSI), especially between the Link Layer (Layer 2) and the Network Layer (layer 3).

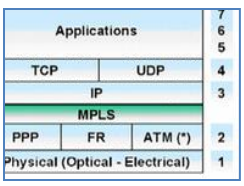

Figure 1: Position of MPLS in OSI Model

2. Drawbacks of Traditional IP routing

- All devices in the network use routing protocol to distribute routing information.
- All the packets in the network are forwarded using destination address only regardless of the routing protocols the router uses.
- Each router in the network performs routing lookups. Every router makes independent decision while forwarding packet.
- Unlike IP, MPLS reduces the number of routing lookups, changes the criteria of forwarding and eliminates the need to run the routing protocol on each router.

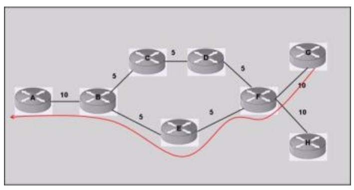

Figure 2: IP routing (based on shortest path)

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3. MPLS

MPLS was developed to address the flaws of IP, it provides additional services to the applications using IP.As demand for multimedia services is on a high, traffic engineering has become an essential concern for the network service providers as it forms the basis of certain performance parameters. MPLS provides the solution to the traffic engineering problems like speed, QoS, delay, network congestion etc. MPLS forwards data through labels attached to each packet, these labels are distributed among all the nodes comprising the network. Resource Reservation Protocol (RSVP) and Constraint-based Routed Label Distribution Protocol (CR-LDP) are the two label distribution which provides support for Traffic Engineering. MPLS is best describe as a "layer 2.5 networking protocol", as it sits between layer 2 and layer 3 providing essential features for the transport of data across the network (Cisco Press *et al*, 2006). In contrast with IP which performs an IP lookup, MPLS does label switching.

3.1 Now what exactly is label switching?

The first router performs the routing lookup, same as in IP routing based protocol, but instead of next hop it finds the destination router and also a predetermined path from its current position to the final router. The router applies a label (or shim) on the data packets based on this information. Now following routers as shown uses this label to route further the traffic in the network without performing any additional IP lookups. At the final router the packet is delivered through normal IP routing and label is removed (I. Zafar *et al,* 2011; Wei Sun *et al*, 2000).

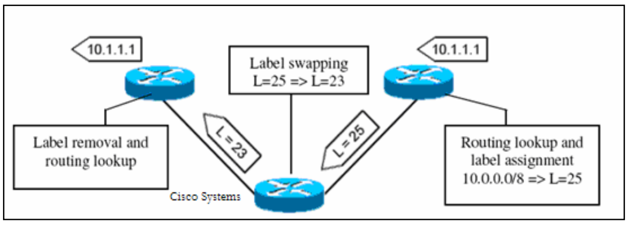


Figure 3: MPLS forwarding

3.2 MPLS Network Infrastructure

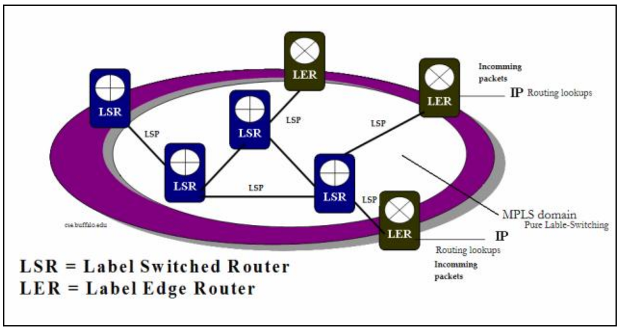


Figure 4: MPLS Network infrastructures

MPLS data routing or forwarding of packets requires an LSP or label switched path which is a unidirectional tunnel existing between a pair of routers in a MPLS network model. The LER or label edge router is a router which selects the initial path and inserts a packet in an MPLS LSP. Switching in MPLS network in the middle of LSP is performed by Label switching router or LSR. The final router in an LSP also known as egress router removes the label (E. Rosen *et al*, 2001). A label distribution protocol is used to distribute address/label mappings between adjacent neighbors. MPLS label format uses a 32-bit label field, which is comprises the under mentioned fields.

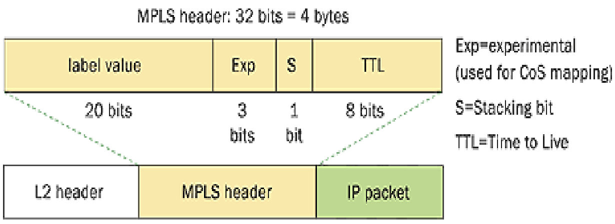


Figure 5: MPLS Label

Table 1 MPLS label format description

Field	Description
20 bit label	The actual label
3 bit experimental field	Used to define a class of service
Bottom of stack bit	MPLS allows multiple labels to be inserted, this bit determines if this label is the last label in the packet. If this bit is set(1),it indicates that this is the last label.
8 bits Time to live, TTL	A timer field that has the same function as the TTL in IP which is to track the lifetime of the datagram.

In MPLS, every packet carries a label with them. This label is a field of shim header. The shim header is inserted between IP header and link layer header of the packet. These headers carried by a packet forms an MPLS stack. The given figure shows an MPLS stack containing many headers and its position in the packet.

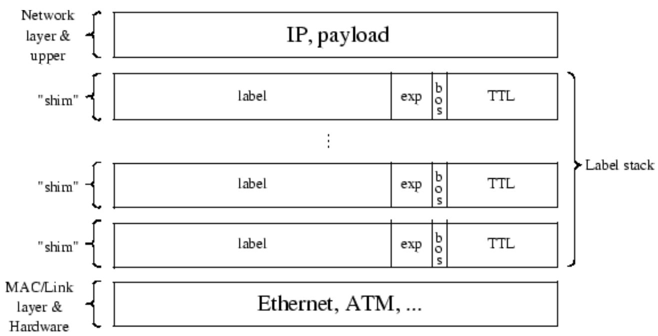


Figure 6: Position of MPLS stack in Network Protocol stack

3.3 MPLS Forwarding

Suppose an IP packet is sent by host A to host B in Figure 7 the packets are forwarded using MPLS routing network. When first MPLS router present in MPLS domain also called as Ingress label edge router or LER receives a packet, its source and destination are analyzed and the packet is classified in forward equivalence class. All the packets belonging to same FEC use same virtual path or circuit also called as label switched path or LSP. Now consider in figure 7 that virtual path or circuit has already been established for the FEC of the packet sent from point A to point B, the ingress LER inserts a header L1 on the packet and forwards it further. The following routers of the MPLS domain update their MPLS header by swapping label among them as L1 with L2 and L2 with L3 (Cisco Press *et al,* 2006). The last router also known as egress router or LER removes MPLS header L3 so that the packet can be handled by subsequent host or IP routers that may be unaware of MPLS domain.

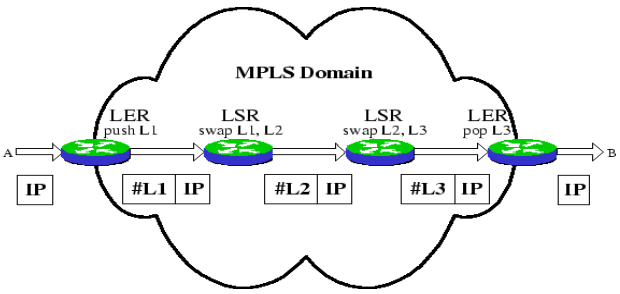


Figure 7: MPLS Forwarding

4. MPLS Traffic Engineering

Traffic engineering is a challenging task in traditional IP network, this type of networks use shortest path algorithms to send data from source to destination. For example, OSPF (open shortest path first) in IP. These protocols do serve the function of forwarding data packets but can easily leads to problems like (I. Zafar *et al,* 2011; D.O. Awduche *et al*, 2012)

- Longest path is under-utilized while shortest is over-utilized leading to congestion in the network
- Load sharing cannot be obtained in IP network.
- And routing lookups are performed at every router.

MPLS traffic engineering means that routers use the MPLS label switching technique in order to improve the usage of network resources. Labels are assigned to the routers using label distribution protocol; ingress router assigns labels to packets. These packets are then forwarded using label switching. When full label information is exchanged, any router can reach any other router in MPLS domain. Unlike IP which routes on the basis of destination address, MPLS let the LSP source to calculate the path, build MPLS Forwarding state and maps packets on to that particular LSP. The concept of traffic trunk is used to implement traffic engineering in a MPLS network domain. The traffic trunk is defined as a collection of traffic flows located inside an LSP(E. Osborne *et al*, 2002; I. Zafar *et al,* 2011).

5. Simulation Methodology

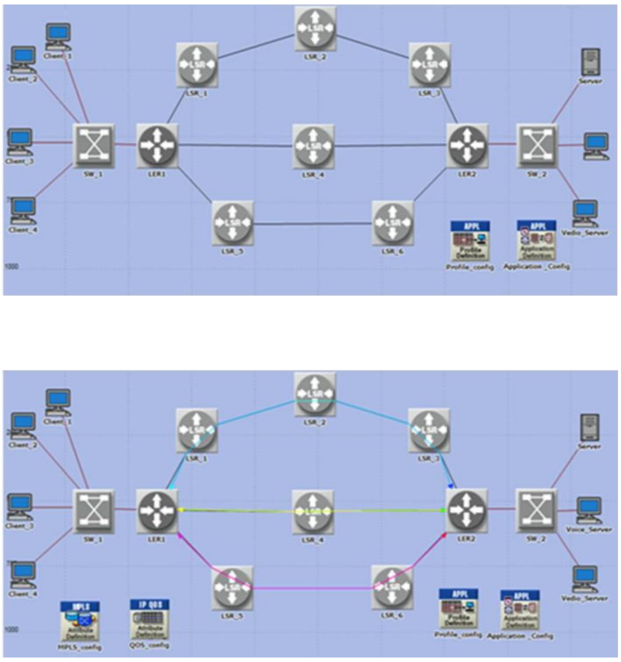
The Simulation of IP and MPLS network has been done using OPNET modeler.

Two scenarios have been considered for Simulations having same network topology.

Scenario 1 is for IP network without TE.

Scenario 2 is for MPLS network with TE.

The results have been compared between two network models.



Scenario 1 and Scenario 2

Table 2 Network Topology

Composition of Network topology	Use
Six LSR routers(LSR1, LSR2, LSR3, LSR4, LSR5, and LSR6	Works as switching routers.
Two LER routers(LER1, LER2)	Works as edge routers
Two switches	Connected to routers
100BaseT cable	Used to connect switches and routers.
10BaseT	Used to connect workstations with switches.
Three servers and Four clients	For Transmission of packets.

All the links works in full duplex mode. Three servers and four clients are also used. Each client uses different type of traffic VoIP, Video conferencing, and FTP.

6. Result Analysis

Performance metric of MPLS-TE and IP model networks are compared. Parameters that are compared includes throughput (packet send and receive), end to end delay, FTP response time. It is clearly observed that MPLS-TE performed better than IP network model. In the case of heavy load i.e. high traffic the performance of MPLS-TE is again better.

In 1st scenario, i.e in IP network model packets are routed using OSPF, therefore all packets are routed through shortest path and no other path was considered. While in 2nd scenario i.e. in MPLS-TE network model LSPs are created, the edge router LER1 is considered as the source router and the edge router LER2 is considered as destination router of the LSPs. To make LSP reachable from other sections of MPLS domain a loop back interface is configured. The load is evenly distributed among LSPs which makes MPLS an efficient technology.

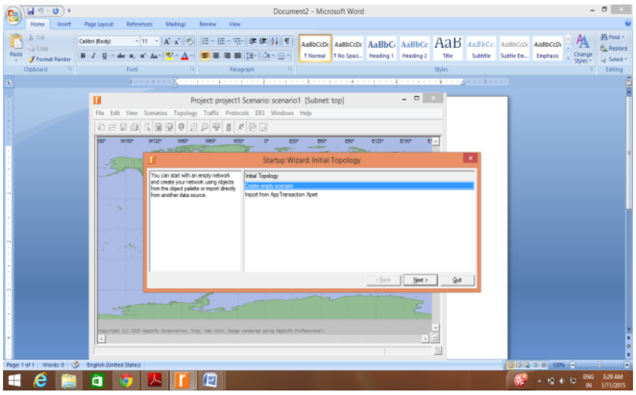


Figure 8: Initiation of project using OPNET modeler

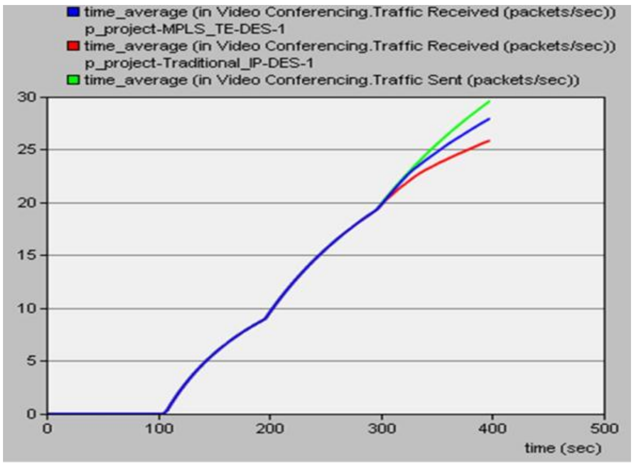


Figure 9: Video packets send and received

Simulation results shown in figure 9 and figure 10 shows that the throughput of MPLS model is more than that of IP model and also during worst possible load IP network packets are start to drop earlier than MPLS network model. The traffic engineering implemented in MPLS temporarily reduces the congestion. Packets are delivered with lower delays and high transmission speed in MPLS.

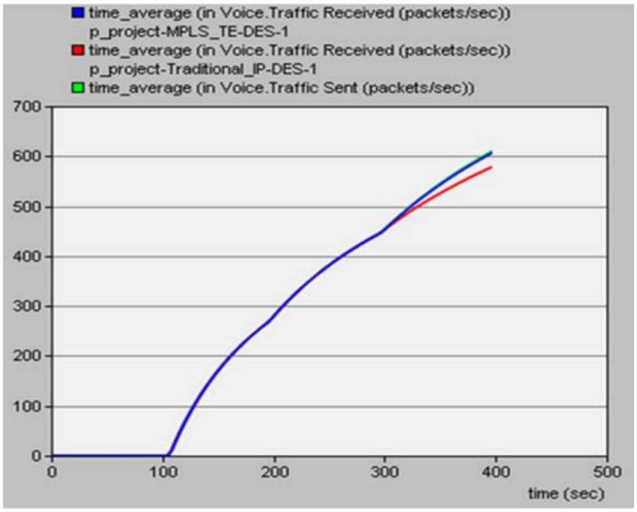


Figure 10: Voice Packet send and received

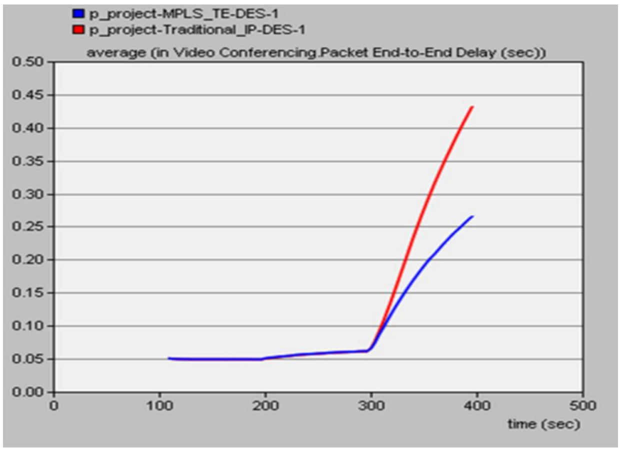


Figure 11: Video Packet End to End Delay

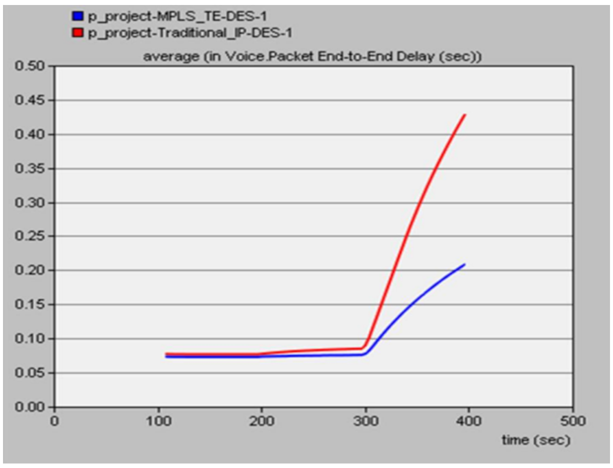


Figure 12: Voice Packet end to end delay

Figure 11 and figure 12 shows the end to end delay of video and voice traffic, it is clearly shown that MPLS has lower delay than the IP model in case of heavy load. Figure 12 shows the delay variation of voice and video traffic, the delay variation exceeds the threshold in IP earlier than MPLS TE and also it is lower in MPLS.

Conclusion

The paper work has shown the effective implementation of resources in MPLS network. The simulation results shows that the performance of traffic engineering parameters like packet delay, throughput etc. in MPLS network is very stable and much better as compared to traditional IP network. The network resources are optimized at their optimum performance with the help of Traffic engineering. Also the end to end quality of service is also being ensured.
In this paper, performance metric of MPLS-TE and IP model networks are compared. Parameters that are compared includes throughput (packet send and receive), end to end delay, FTP response time. It is clearly observed that MPLS-TE performed better than IP network model. In the case of heavy load i.e. high traffic the performance of MPLS-TE are again better.

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