



## Survey on Traffic Engineering Using MPLS Technology

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*Abstract-Traffic Engineering is a topic which ensures the best possible use of the resources. Now to support traffic engineering in our today's network, Multi Protocol Label Switching (MPLS) is being used which is very helpful for reliable packet delivery in an ongoing Internet service. During the delivery of packets from one location to another, it ensures high transmission speed, efficient use of bandwidth and lower delays. MPLS is a process which depends on Label Switching for taking forwarding decisions. Label is created for every route in the routing table. This paper presents a general idea of the MPLS technology and how it is faster and better than traditional IP routing.*

*Keywords-MPLS; Traffic engineering; CBR; RSVP; CBTS; Fast Reroute.*

### I. INTRODUCTION

Keeping in mind the huge demand of multimedia services, traffic engineering is an essential concern at the design level and also at handling of operations through the Internet. It gives a chance to select the best path for forwarding data packets while using the network resources efficiently. So, in order to deal with the flaws in the traditional IP networks, IETF (Internet Engineering Task Force) has developed the MPLS (Multiprotocol Label Switching). Traditional IP forwarding depends on the destination address present in the IP header of each packet, but in Multi-Protocol Label Switching (MPLS), routers use the technique of labels for forwarding the packets based on the label which is present in the MPLS header [1].

The modern networks are compact networks; they carry voice, video and normal data by using the same network resources. Since some user data traffics such as voice, video or bank transactions are more important and are less tolerant to delay; they are treated based on their delivery requirements such as bandwidth and maximum affordable delay. As per the large number of internet users and various data traffic types, Internet Service Providers (ISP) face a challenge in the form of Traffic Engineering [5].

MPLS Traffic Engineering is an application of MPLS which gives network to use all the available links in the network comfortably [6]. MPLS provides a proper approach to divert network traffic from a crowded part of the network to a non-crowded part [7]. In traditional IP networks, Links which are less used was a major issue in which one best route was over used for heavy network traffic and the other routes were less used which results in wastage of bandwidth [8].

MPLS TE lets us to manage the traffic the way we want not the way the routing protocol wants. It was not possible with traditional IP networks. Since Traditional IP network forwards all the traffic on the shortest path calculated by the SPF algorithm [9]; it doesn't consider non-shortest paths for sending traffic apart from the availability of bandwidth links. MPLS TE lets us create LSP (Label Switching Path) tunnels at the non-shortest paths that satisfy the bandwidth requirements in such a way that we can map traffic to these LSP tunnels to gain the bandwidth [2]. Multi-Protocol: Masks a data packet and put an MPLS header in front of the packet. Label Switching: MPLS header includes a label and switches Labels between MPLS capable routers. Multiprotocol Label Switching (MPLS) directs data from one node to the next based on labels rather than long IP addresses, which avoids complex lookups in a routing table [3].

### II. ELEMENTS OF MPLS

#### 1) Constraint Based Routing (CBR):

In constraint based routing a shortest path is taken if it satisfies a particular set of constraints. The constraints are minimum bandwidth, link attributes and administrative weight, setup and hold priority values [6]. MPLS TE uses constraint shortest path first algorithm (CSPF) to build LSP tunnels. CSPF is an extension of SPF(Shortest Path First) [10] and it depends not only on the cost values but also on the constraints to select the best path as per the resource needs [2].

#### 2) RSVP Signaling:

RSVP [11] is a resource reservation protocol; it uses bandwidth along the LSP to form tunnels. For resource reservations, RSVP messages are sent by head end router. A head end router is the starting point of the tunnel whereas tail end is the ending point of it[12]. The actual available bandwidth is configured to the physical interfaces, which is given by RSVP. The exact bandwidth for the formation of tunnels is configured on the tunnel interfaces. So before forming a tunnel, a desired bandwidth of the tunnel and the available bandwidth provided by RSVP are compared. If there is enough bandwidth available to contain the tunnel, the tunnel will form along the LSP [2].

3) **Class Based Tunnel Selection:**

Class Based Tunnel Selection (CBTS) is a way of forwarding traffic based on Class of Service (CoS) values [13]. We can create many tunnels on the same head end and tail end devices and give different data traffic based on CoS values. Each tunnel is configured based on a specific CoS value on the incoming traffic. Traffic is sent on a particular tunnel if the CoS of the traffic matches the value configured on tunnel. There are only three 3 bits specified in the EXP field of MPLS label which are used for CoS purposes [14]. Therefore there can be a maximum of 8 different tunnels between same head end and tail end devices [2].

4) **Fast Reroute:**

Fast Reroute (FRR)[15] is a very important element of MPLS TE. If a link or a node fails in LSP of MPLS network, FRR automatically switches traffic to the secondary path. For FRR, there are two paths; Primary path and Secondary or Backup path. Primary path is the main tunnel used to carry traffic. Secondary path is used to carry traffic if a node or a link fails in primary tunnel. The purpose of FRR is to reduce the packet loss and switch the traffic as soon as possible. Even if routing algorithm such as an SPF algorithm can also recalculate new paths after the occurrence of a node or a link failure but this process is slow. It takes time for routing protocols to transmit, link or node failure information across the network. Important traffic such as voice and video can't wait for such long time. FRR provides protection against two types of failures [2].

- 1) Link Failure
- 2) Node Failure

1) **Link Protection:**

MPLS Link Protection provides backup tunnels that bypass only a single link of the LSP's path. They protect LSPs if a link along their path fails by rerouting the traffic to the next hop as shown in Figure 1. These are known as next-hop (NHOP) backup tunnels because they end up at the LSP's next hop after the point of failure [3].

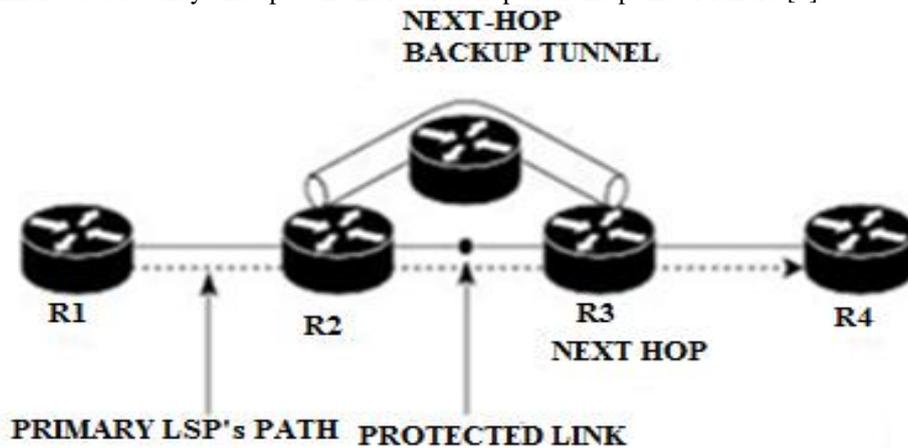


Figure 1: Link Protection

2) **Node Protection:**

Backup tunnels that protect next-hop nodes along LSP paths are called next-next-hop (NNHOP) backup tunnels because they terminate at the node following the next-hop node of the LSP paths as shown in Figure 2. If a node along their path fails, they protect LSPs by enabling traffic to the next-next hop around the failed node [3].

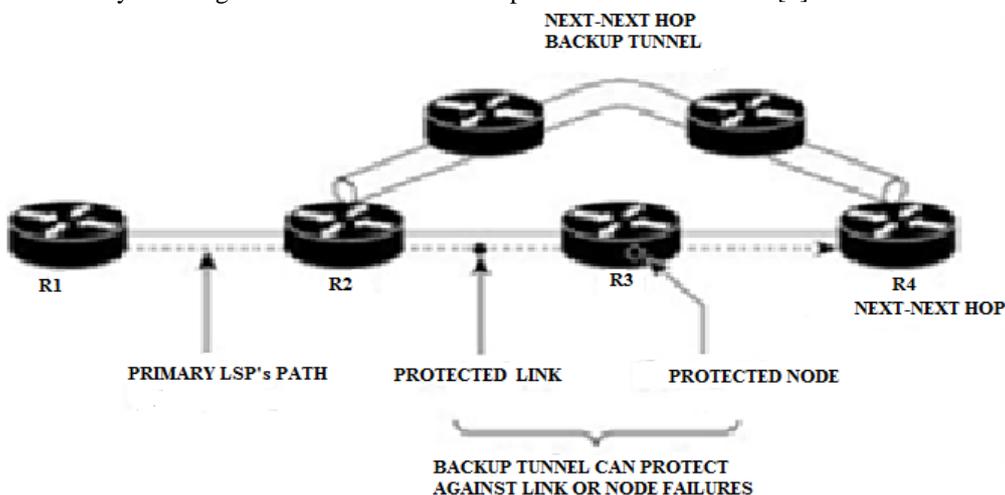


Figure 2: Node Protection

### III. MPLS TERMINOLOGY

#### 1) Label switch router (LSR):

It refers to any router that has knowledge of MPLS labels. The entry and exit routers of an MPLS network are called edge LSR (or label edge routers – LER), which, respectively, inject an MPLS label onto an incoming packet and remove it off the outgoing packet.

#### 2) Label switched path (LSP):

It is path defined by the labels given between end points. An LSP can be applied automatically using routing information or are manually applied.

#### 3) 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.

#### 4) Label distribution protocol (LDP):

It communicates labels and their contents among LSRs. It assigns labels in edge and core devices to form LSPs in combination with various routing protocols [4].

### IV. MPLS INFRASTRUCTURE

In MPLS technology, a specific path is set up for a given order of data packets. The packet label has a knowledge of these packets , so it saves the time that a router takes to search the address where the packet should next be forwarded [4].

MPLS allows routers at the edge of the provider network to include labels into the incoming packets from the customer side and then forward traffic to the core routers based on labels rather than performing complex routing lookups [1]. MPLS works between the Data-Link and Network layers (layer 2 & layer 3) which results in layer 2.5.

The MPLS area can be divided into MPLS core and MPLS edge as shown in Figure 3. The core consists of nodes nearby to MPLS capable nodes, while the edge consists of nodes nearby both MPLS capable and incapable nodes. The nodes in the MPLS area are often called LSRs (Label Switch Routers). The nodes in the core network are transit LSRs and the nodes in the MPLS edge are called LERs (Label Edge Routers).The first node at LER is called an ingress router where the label is given to the IP packet. The last node at LER is called Egress router where the label is removed from IP packet and sent to the customer end [3].

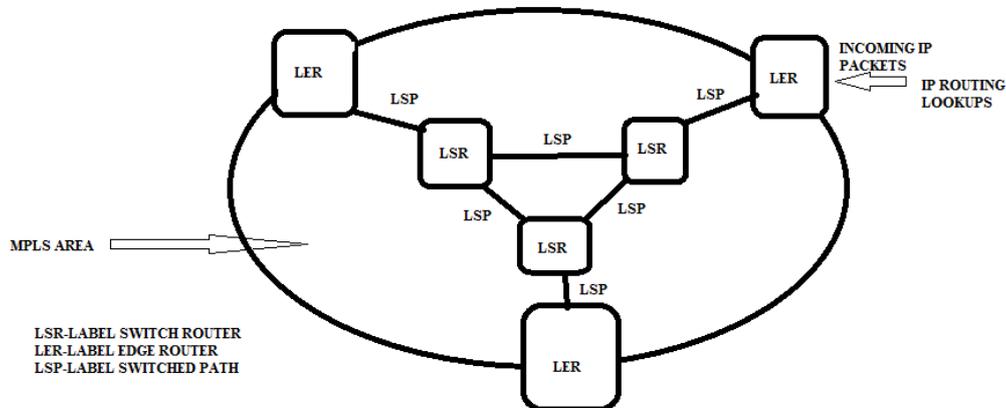


Figure 3: MPLS Infrastructure

MPLS traffic engineering automatically forms and maintains LSPs across the network by using RSVP. LSP resource requires network resources like bandwidth to find the path taken by the LSP. Traffic engineering tunnels are pre calculated at the head end of LSP based on required and available resources. Usually, in MPLS traffic engineering packet travels on a single LSP that connects the ingress point to the egress point [3]. It uses a fixed-length label in order to decide the packet handling. MPLS label format uses a 32-bit label field, which consist of the following table.

Table 1: MPLS Label Content

Field	Description
20-bit label	The actual label.
3-bit experimental field	Used to define Class of Service(CoS).
Bottom-of-the-stack bit	This bit determines if this label is the last label in the packet. If this bit is set(1),it shows that this is the last label.
8-bit time-to-live(TTL) field	It's a timer field used to track the lifetime of the datagram.

The main idea behind MPLS is based on the packets according to the labels which are checked by each LSR on the LSP. The usual IP routing look-ups problems are resolved through this technique. Basically, the operation is based on routing at the edges and simple label switching in the core [1].

#### V. CHALLENGES FOR TE MPLS IN IP NETWORK:

- 1) There is the chance that the shortest paths from various sources may overlap at some positions in the Internet. So, overcrowding would be the final outcome for those links.
- 2) Also the longest path between the two nodes is less used even if the capacity of traffic increases the capacity of shortest path between the nodes.
- 3) Load balancing of the links is the other concerns which create difficulty to implement the TE in IP networks.
- 4) Load sharing is another important factor which could not be obtained in IP networks among multiple paths of different costs.
- 5) Also the routing lookups are being carried out on every hop [1].

#### VI. SIGNALING PROTOCOLS IN MPLS

The LSPs is formed in MPLS network. Then, the labels are given on each hop along the LSPs before the packets are forwarded. In an MPLS network, LSPs are established in two ways, that is control driven LSP and the other is explicitly routed LSP. Control driven is set by using the LDP protocol and is also called hop-by-hop LSP. The routed LSPs are also called as constraint based routing LSPs (CR-LSPs). CR-LSPs are set by giving the route for LSP in the setup message. This setup message travels all the hops along the given route. Following two protocols are used to set CR-LSPs in MPLS which are as follows:

- 1) Constraint based routed LDP (CR-LDP)
- 2) Resource Reservation Protocol (RSVP) [1]

#### VII. COMPARISON WITH TRADITIONAL NETWORK & MPLS BASED NETWORK

There is a precise comparison between the traditional network and MPLS based network in the following table.

Table 2: Comparison between the traditional network and MPLS based network

Parameters	Traditional network	MPLS based network
Routing decisions	Taken by Every router.	Taken by the ingress router.
Layer 2 & layer 3 processing	Both. Hence time consuming.	Layer 2 only. Hence faster.
IP routing	Performed at each hop.	Done for finding the destination router.
IP header analysis	Entirely at each hop.	Label analysis is done on the ingress router.
For handling multicast traffic	Requires special multicast routing & forwarding algorithms.	Forward Equivalence Class (FEC) is used.
Packet length supported	Fixed.	Variable.
Packet-forwarding decisions	Based on the whole data packet.	Based on the label content of the packet itself.
Link utilization	Only the best possible link.	Best path as well as un used paths.

#### VIII. CONCLUSION

MPLS simplifies the network infrastructure by allowing the improvement of multiple technologies and applications such as voice, video and data. MPLS provides enhanced security & high availability through the above-mentioned theories & analysis we can see that the MPLS is faster than traditional routing technique. If we can improve hardware facilities and software platform by real-time routers then we can notice the significant difference. Also in a certain event of a network link failure when recovery mechanisms are in use at the IP layer, reinstallation takes several seconds which are unacceptable for real-time application. So Fast Reroute concept in MPLS meets the requirements of real-time application with fast recovery.

#### REFERENCES

- [1] Faiz Ahmed, Dr.Irfan Zafar . *Analysis of traffic engineering parameters while using multi-protocol label switching (MPLS) and traditional IP networks* - Asian Transactions on Engineering (ATE ISSN: 2221-4267) Volume 01 Issue 03.
- [2] Mohsin Khan . *MPLS Traffic Engineering in ISP Network* - International Journal of Computer Applications (0975 – 8887) Volume 59– No.4, December 2012.
- [3] Shuguftha Naveed, S. Vinay Kumar *MPLS Traffic Engineering – Fast Reroute*, International Journal of Science and Research (IJSR) Volume 3 Issue 5, May 2014.

- [4] Madhulika Bhandure, Gaurang Deshmukh, Prof. Varshapriya J N. *International Journal of Engineering Research and Applications (IJERA)*, Vol. s3, Issue 4, Jul-Aug 2013.
- [5] V. Alwayn . *Advanced MPLS Design & Implementation*, Cisco Press Indianapolis 2002.
- [6] Eric Osborne, Ajay Simha . *Traffic Engineering with MPLS*, Cisco Press Indianapolis 2002.
- [7] Cisco Systems . *MPLS Traffic Engineering Technology*, 2002.
- [8] Ravi Ganesh V, M. V. Ramana Murthy . *MPLS Traffic Engineering (An Implementation Framework)*, 2012.
- [9] Cisco IOS. *Multiprotocol Label Switching (MPLS) Traffic Engineering*,2012.
- [10] Juniper Networks . *Constrained-Path LSP Computation*,2012.
- [11] Juniper Networks, Inc. *Understanding the RSVP Signaling Protocol*,2010.
- [12] Lancy Lobo, Umesh Lakshman *RSVP with TE Extensions: Signaling*,2012.
- [13] Cisco Systems, *Class Based Tunnel Selection*,2012.
- [14] J. Reagan, *CCIP MPLS Study Guide - SYBEX Inc.*2002.
- [15] Cisco Systems, *MPLS Traffic Engineering (TE)—Fast Reroute (FRR) Link and Node Protection*,2012.