

# A Survey On Multi Protocol Label Switching

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**ABSTRACT:** The Multiprotocol Label Switching (MPLS) technology is the most deployed technology by service providers over backbone networks at present. Majority of the carriers are deploying MPLS in their backbone networks to facilitate a number of services and applications such as virtual private networks, quality of service (QoS) and traffic engineering. The primary benefit of MPLS is to eliminate the dependence on a particular OSI model data-link layer technology such as asynchronous transfer mode (ATM), Frame Relay or Ethernet and eliminates the need for multiple layer-2 networks to satisfy different types of traffic. This paper presents a detailed overview on MPLS with its architecture, operation and working, benefits and the services that it offers.

**Keywords:** MPLS, QoS, BGP, Label, ATM, LSP, LDP

## 1 INTRODUCTION

Multiprotocol Label Switching (MPLS) was introduced by IETF [1]. MPLS belongs to the family of packet switching networks and was designed to overcome the limitations of IP based forwarding. In a traditional IP network each router performs an IP lookup, determines the next hop based on its routing table and forwards the packet to the next hop thereby creating a lot of overhead at each routers interface. However, MPLS on the other hand makes packet forwarding decisions which are based entirely on the contents of label without the need to examine the packet itself. MPLS works in between OSI data link layer and network layer and it is often referred to as Layer 2.5 protocol. MPLS is an innovative approach that uses label for forwarding the packets. The basic advantage of MPLS technology which we just noticed is that IP header analysis which on the other hand is necessary in traditional IP packet forwarding mechanism does not need here. The IP header is analyzed and a small label is appended to the packet at the entry point of the MPLS network. A label is a short fixed length identifier that is used to forward the packets [2]. Labels indicate both routes and service attributes. MPLS technology has emerged mainly to provide high speed packet delivery. MPLS is known as "multi-protocol" because it works with Internet Protocol (IP), Asynchronous Transport Mode (ATM) and Frame Relay network protocols [2]. MPLS is a method that directs data from one system node to the next based on short path labels rather than long network addresses in high-performance telecommunications association. It offers high scalability, end-to-end IP services having simple configuration and management for customers and service providers. It forwards packets in any system protocol, which are the building blocks of data transmitted over the Internet. It gives the ability to offer highly scalable, advanced IP services end-to-end with simpler configuration and management for both service providers and customers. A number of different technologies were previously deployed with essentially identical goals, such as Frame Relay and ATM. Frame Relay and ATM use it to move frames or cells throughout a network. The header of the ATM cell and the Frame Relay frame refer to the virtual circuit that the cell or frame resides on. The similarity between Frame Relay and ATM is that at each hop throughout the network, the "label" value in the header is changed. This is different from the forwarding of IP packets. MPLS technologies have evolved with the strengths and weaknesses of ATM in mind. Many network engineers agree that ATM should be replaced with a protocol that requires less overhead, while providing

connection-oriented services for variable-length frames. MPLS is currently replacing some of these technologies in the marketplace. It is highly possible that MPLS will completely replace these technologies in the future, thus aligning these technologies with current and future technology needs.

## 2 MPLS TERMINOLOGY

The terminology is given below which is based on fundamental to the concepts, architecture and operation involved in the MPLS networks.

### 2.1 Switching

Switching is the process by which, two circuits are interconnected for exchanging information. Information is in the form of either analog or digital. In electro mechanical era, information was in the form of analog. Presently, information is in the form of digital. In order to interconnect the circuits, supporting the digitized information, suitable digital switches are designed. Digital Switches are classified as Circuit Switch and Packet Switch. MPLS model is configured in Packet switch area.

### 2.2 Label Switching

Connectionless IP routing is converted Connection oriented by overlaying Network layer function with Data Link layer function. Label Switching overcome the limitations that presents in the circuit Switching. IP address is converted into Labels according to the class and type of services like categories and priorities. An intermediate router uses only the labels for further routing of destined IP packets with appropriate label. This technique is used in MPLS. An MPLS frame uses various Data link frames like ATM, Frame Relay, and Ethernet. Since MPLS uses Label Switching and supports multiple protocols, it is called as Multi Protocol Label switching.

### 2.3 Label

A label in MPLS is used as the routing code like STD code in circuit switch. It identifies the path a packet should traverse in the MPLS domain. Label is encapsulated in a Data link layer. Thus new layer is formed in between Network layer and Data link layer in the OSI model. The name of the new layer is MPLS SHIM layer. The shim is composed of 32 bits out of which 20 bits are allocated to the label also called label stack, 3-bits are experimental bits often used for specifying class of service. One bit is reserved for bottom of stack bit and is set if no label follows. 8-bits are used for time-to-live (TTL) used in the same way like IP [3].

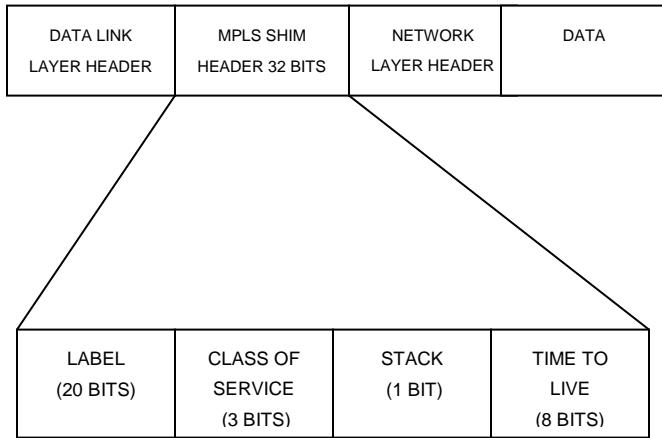


Fig.1. Generic MPLS Label format

### 2.4 Label Bindings

Once a packet has been classified as a new or existing FEC, a label is assigned to the packet. The label values are derived from the underlying data link layer. Labels are bound to an FEC as a result of some event or policy that indicates a need for such binding. These events can be either data-driven bindings or control-driven bindings. Policy of label binding is based on Destination Unicast Routing, Traffic engineering, Multicast, Virtual Private Network (VPN) and QoS.

### 2.5 Label Creation

Label is created during the following events:

- The construction of MPLS architecture
- The creation of new LER and LSR
- Introduction of new user with distinguished service like VPN.
- Several methods are used in label creation such as,
- **Topology-based method:** It uses normal processing of routing protocols (such as OSPF and BGP).
- **Reuest-based method:** It uses processing of request based control traffic (such as RSVP).
- **Traffic based method:** It uses reception of packet to trigger the assignment and distribution of label using label request and label assignment mechanism for routing the unlabeled IP packet.

### 3 MPLS ARCHITECTURE

MPLS is a tunneling technology used in many service provider networks. MPLS works by prefixing packets with an MPLS header having one or more label known as label stack [3]. With the contribution of MPLS-capable routers or switches in central gateway protocols such as Open Shortest Path First (OSPF) or Intermediate System to Intermediate System (IS-IS), the network automatically builds routing tables.

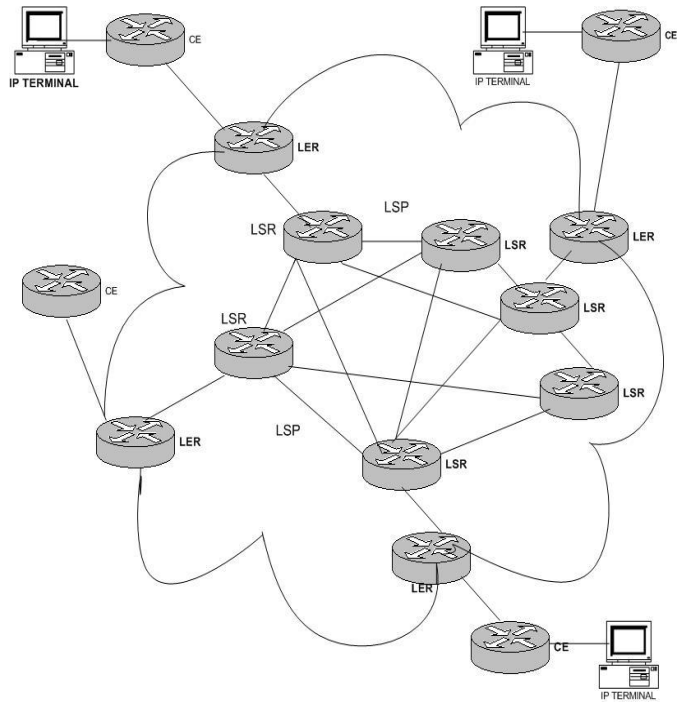


Fig. 2. Architecture of MPLS

As shown in the fig.2, the MPLS network consists of the following components:

- **Customer Edge**

It structures the customer message into IP Packets and sends to the entry node of MPLS domain. While receiving the IP Packets from the egress node of the MPLS domain, CE sends packets to Network layer of its own, after removing the IP address.

- **Label Edge Router**

Label Edge Routers are working as the gateways of MPLS Domain. Ingress LER, it receives the IP Packet from CE, assigns the appropriate Label. After wrapping label, it sends labeled packet towards the next hop through the Label Switched Path, which is assigned for the specific Forward Equivalence Class. Assigning the Label is known as Label Binding. LER also acts as the egress Router. It receives the labeled IP Packets from the previous transit router, pops up the label (removes the label) and routes the IP packets towards the destined CE. LER receives the multiplexed input from CE, and extends the switched output towards the transit routers [2].

- **Label Switching Router**

Label Switched Routers are basically working as transit switches in MPLS cloud. It receives Labeled IP packets through the appropriate LSP. It analyses the Label bound over the packet, consults the forwarding information table (LIB) and routes the packet through the appropriately mapped outgoing LSP. When the LSR is routing the packets from incoming LSP to outgoing LSP, it strips out the Incoming Label and assigns a new label to same packet to ensure the security from the intruders. This process is known as Label Swapping or Label Changing. MPLS Network architecture is as shown in the diagram. Lines, shown between CE and LER carry the IP Packets bi-directionally.

- **Label distribution protocol (LDP)**

It is one of the primary signaling protocols for distributing labels in MPLS network. It is a set of procedures and messages by which Label Switched routers (LSR) establish Label Switched Path (LSP) through a network by mapping network layer routing information directly to data link layer switched paths [3]. By means of LDP LSR can collect, distribute and release label binding information to other LSRs in the MPLS network thus enabling hop-by-hop delivery of packets in the network along routed paths.

- **Label Switched Paths**

Within an MPLS domain, a path is set up for a given packet to travel based on an FEC. The LSP is set up prior to data transmission. Lines, shown in the MPLS domain, are the Label Switched Paths that carry labeled IP Packets between the routers. There are two types of Label Switched Path. One is Static LSP and the other is Signaled LSP.

## 4 MPLS OPERATION

The operation of MPLS is based on two planes. MPLS has the following two planes:

**Control Plane:** The Control Plane is responsible for the routing information exchange and label distribution between Adjacent devices. It uses standard routing protocols such as OSPF, IS-IS and BGP to exchange information with other routers to build and IP forwarding table or label forwarding information base. It also needs label distribution protocols such as LDP.

**Data Plane:** The Data Plane is responsible for forwarding packets according to the destination IP address or label using LFIB managed by the control plane. The Data plane is a simple label based forwarding engine i.e independent of the type of routing protocol or label distribution protocol running on the Control plane.

### 4.1 LDP Principle

MPLS network after establishing LSPs. For a given flow the LER acting as an entry point is called "Ingress LER" and the LER acting as exit point is referred as "Egress LER". A label in its simplest form identifies the path a packet should traverse. A label is carried or encapsulated in a layer-2 header along with the packet. The receiving router examines the packet for its label content to determine the next hop. On receiving a packet from non-MPLS domain the LER first analyzes the network layer header and decides "Forward Equivalence Class (FEC)" to which the packet belongs to and assigns one label to it. The FEC is a representation of a group of packets that share the same requirements for their transport.

## 5 BENEFITS OF MPLS

### 5.1 Scalability

The MPLS network is very scalable and it scales thousands of IP based ATM networks when compared to IP based network. It provides point to point connection to the local users as well as the users connecting from outside the local network. It is also capable of managing of tens of thousands of VPN networks.

### 5.2 Easy Management

It provides MPLS administrators a great ease when they manage MPLS network [4]. Its creation and management is very easy and involves no complexity. The other important thing which is very attractive is that MPLS does not require traffic matrix updating, no permanent virtual circuit mesh resizing, and no need to update the topology table.

### 5.3 Standard Based

The Internet Engineering Task Force (IETF) has introduced MPLS as a standard. It is available to all network vendors like, CISCO, JUNIPER to make sure that there should be interoperability in large networks where different vendor's products are in use [6].

## 6 SERVICES PROVIDED BY MPLS

### 6.1 MPLS VPN

It is a tunneling technology, which gives the platform to create and implement MPLS based Virtual Private Networks (VPNs). It is developed to enhance the packet forwarding over the high performance backbone networks. MPLS forwards the IP packets to the distinct routers instead of the end devices on the basis of small labels [9]. The MPLS application helps to create a tunnel or Label Switched Path (LSP). The small labels are sent over the path. The ingress (entry point of MPLS network) router over the MPLS network path appends this small label to the arriving packet. Over LSP, the hops swap the labels with the new ones to forward the packet. This process keeps on going until the packet arrives at the egress (exit point of MPLS network) router. The egress router strips-off the label and sends the packet towards its destination [9]. The basic advantage of MPLS technology which we just noticed is that IP header analysis which on the other hand is necessary in traditional IP packet forwarding mechanism does not need here. The IP header is analyzed and a small label is appended to the packet at the entry point of the MPLS network. The ingress router may also analyze some extra information about the entering packet to assign it the best route which results in achieving the Quality of Service (QoS). When we talk about the traffic engineering as compared to traditional IP networks, it becomes so easier after choosing the explicit routes in MPLS network. So, this makes the MPLS technology more efficient. The demand of securely sharing confidential data over public networks is growing day by day as the organizations are expanding their networks. The data sharing between offices, sub offices, and end users is an important requirement of large organizations and ensuring data confidentiality and integrity is a major concern. Keeping these requirements in view, the technology which is in use is VPN. The VPNs provides the platform to share data securely across the public network. The main users of VPNs are the service provider administrators, local enterprise network administrators and the end users [8]. The MPLS based VPNs offers verity of good services as compared to the traditional VPNs. They offer scalability, better flexibility, eases management. They are low cost, and support different QoS models MPLS VPNs use Border Gateway Protocol [10] to distribute routes and MPLS technology to forward packets across the network. BGP/MPLS is point-to-point VPN, which uses the services of both BGP and MPLS [5]. The introduction of MPLS technology into VPN network is made to achieve different services like, easy integration, simplification of virtual network, enhance network securi-

ty, minimizes the complexity, cost reduction and the most important is QoS. The QoS is the major point of concern when services are required from service providers. Therefore, the MPLS VPN technology helps the service provider to achieve QoS over high performance backbone networks.

## 6.2 Traffic Engineering

Traffic Engineering is the process of routing data traffic in order to balance the traffic load on various links, router and switches in the network. It has the ability to control specific routes across a network to reduce congestion and improves the cost of efficiency of carrying IP Traffic [10]. MPLS is capable of full traffic engineering.

## 6.3 Quality of Service of MPLS

QoS stand for 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 supervise network traffic. It refers to a number of related features of telephony and computer networks that permits the transportation of traffic with the necessities. At the ingress to the MPLS network, Internet Protocol (IP) precedence information can be copied as Class of Service (CoS) bits or can be mapped to set the appropriate MPLS CoS value in the MPLS label. This is the distinction between IP QoS that is based on IP precedence field in the IP header and MPLS QoS that is based on the CoS bits in the MPLS label [11]. MPLS CoS information is used to provide differentiated services. Hence MPLS CoS enables end-to-end IP QoS across the network.

## 7 CONCLUSION

This paper highlights the need for implementing MPLS technology to overcome some of the limitations involved in pure IP based forwarding. This paper also explains the concept of MPLS protocol in depth by providing the fundamentals of MPLS protocol and operation and working of MPLS network module. So, for this MPLS is an emerging technology and by no means a perfect solution to current IP network problems. It provides much better Traffic Engineering capability than the other networks. MPLS operates in coordination with IP Routing and its main objective is to provide the speed of switching to Layer 3. Introduction of labels provides an effective alternative and evades the need of large routing table lookups and results in fast routing. However, the telling factor of MPLS is its ability to manage and classify the traffic in order to provide better utilization of resources. Hence, this technology is used to effectively resolve integration and traffic engineering issues in carrier networks.

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