

Comparative Analysis of Mpls and Non -Mpls Network

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ABSTRACT

A new standard for a new world of networking, MPLS is a forwarding mechanism based on Tag Switching. MPLS is an innovative approach in which forwarding decision is taken based on labels. Label is created for every route in routing table. Large operators have embraced multiprotocol label switching, deploying it in their backbone networks to enable a number of services and applications such as virtual private networks to just name one. This paper presents an overview of the MPLS technology and related IETF standards, and how it is faster and better than traditional IP routing.

Keywords - LDP, LSP, LSR, MPLS, QoS

I. INTRODUCTION

Early computer networks were circuit switched networks where continuous bit streams carried over the physical links. This was well suitable for voice and data unicast communications. This leads to some severe consequences in case of failure. All the communications over the failed link are interrupted in such situation. These days packet switched networks are used in which data is divided into small chunks called as a packet and these packets are routed over the communication links. Different packets can take different paths. In case of link failure, the packets can be rerouted through alternate available path to avoid failed link and hence communication is not interrupted. This feature makes packet switched networks more reliable but on other hand as packets are routed individually, it is difficult to manage flow of data. Traditional IP networks offer little predictability of service, which is undesirable for applications such as telephony, and for rising and future real-time applications. IP networks are frequently layered over ATM networks, which is very expensive in terms of overhead (adding 25 percent or more of overhead to every IP packet)[5], but had one great advantage, IP networks have no means of tagging or monitoring the packets that cross them. The history tells us the upper limit of transmittable bandwidth doubles and sometimes quadruples every nine to twelve months. We need matching data transferring topologies as well as improved system reliability.

Multiprotocol Label Switching is a tool applied in distinguished performance telecommunications networks that carries materials

from on complex over to the next. Originally MPLS created by a crew of engineers that were consumed with improving the quickness of routers nevertheless from the time it has emerged as a classic in today's telecommunications. There have been a multitude number of attempts at developing many technologies with the identical goals, to date none have reached the position of success that we now see with MPLS. To this extent what benefits arise out of using MPLS you may wonder? Well firstly, they allow internet service providers the savvy to maintain rapidly growing internet. In addition allows for fundamental adjustability. Appreciating MPLS means looking to some of the parts that exist concerning to the MPLS such as the label which is a locally significant identifier that is allotted to a packet. Every label contains four fields, a label value, traffic class field which determines the quality of service, bottom of stack label which is not always set but when it is it signifies that the label is currently the last in the stack and finally there is the "time to live" (also referred to as TTL) field which is the limit of time that data can experience before it will be discarded. To realize the magnitude of MPLS one just has to measure it against some earlier technologies that are similar like the frame relay which focused on making previously existing physical resources more adequate. In recent days the use of frame lay has been given a poor name in several markets because of overdone bandwidth used by some companies hence making the use of MPLS much more alluring.

One more similarity would be that between ATM (also referred to as Asynchronous Transfer Mode) MPLS when comparing the two have many differences both offer connection oriented service to allow for transporting data across networks. An MPLS connection shows the most significant difference in its approach as they are able to work with various lengths of packets where as an ATM is only capable of dealing with a fixed length. The most favorable difference you will find between the two is MPLS configuration which was developed specifically for internet protocol. MPLS are just being used only with internet protocol networks and are standard. It can connect to two facilities or can control thousands of locations simultaneously. MPLS does not compete with IP forwarding but it complements IP forwarding. MPLS technology works to solve those flaws of IP, encapsulating IP packets within labels.

MPLS is not designed to replace IP; it is designed to add a set of rules to IP so that traffic can be classified, marked, and policed. MPLS (Multiprotocol label switching) as a traffic-engineering tool has emerged as an elegant solution to meet the bandwidth management and service requirements for next generation Internet Protocol (IP) based backbone networks [12]. An MPLS network can offer the quality of service guarantees that data transport service like frame relay (FR) or ATM give, without requiring the use of any dedicated lines. The availability of traffic engineering has helped MPLS reach critical mass in term of service provider mind share and resulting MPLS deployments. Most carriers run MPLS underneath a wide range of services, including FR, wide-area Ethernet, native IP, and ATM. Advantages accrue primarily to the carriers. User benefits include lower cost in most cases, greater control over networks, and more detailed Quality of Services.

This paper is organized as follows: Section 2 gives details about MPLS. Section 3 gives the comparative analysis of MPLS and non-MPLS network. Sections 4 introduce proposed topology for comparative analysis. Section 5 shows the experimental results. Section 6 summarizes our work and concludes this paper.

II. MULTIPROTOCOL LABEL SWITCHING

Multiprotocol Label Switching (MPLS) is a data-carrying mechanism, in computer networking and telecommunications, which is highly scalable and protocol agnostic. Often referred to as "Layer 2.5 protocol" MPLS technology operates between the Data Link layer (Layer 2) and the Network Layer (Layer 3) of the OSI Model. MPLS is part of the family of packet-switched networks. It was designed primarily to provide a unified data-carrying service for Circuit-based as well as Circuit-switching clients. Both the clients offer a datagram service model. Multiprotocol Label Switching enables to carry diverse types of traffic such as Asynchronous Transfer Mode (ATM), Internet Protocol (IP) packets, Synchronous Optical Networking (SONET), and Ethernet frames. Labels are assigned to the data packets in an MPLS network. Based on the label contents, packet-forwarding decisions are made, without necessitating examination of the data packets. Through this feature, end-to-end circuits may be created using any protocol over any type of transport medium. MPLS technology is beneficial as it helps to eliminate the dependence on ATM, Frame relay, SONET, Ethernet, etc., which are Layer 2 technologies. It also does not require multiple data link layer networks to gratify different traffic types.

In MPLS technology, a specific path is set up for a given sequence of data packets. These packets are identified by the packet label, thereby saving the time that a router takes to search the address where the packet should next be forwarded. MPLS is referred to as "multiprotocol" since it closely works with IP, ATM, and frame relay network protocols.

The major benefits of MPLS networks include:

Traffic Engineering - The capacity to determine the path that the traffic will take through the network

MPLS VPN - Service providers can create IP tunnels all over their networks using MPLS, which does not necessitate encryption or end-user applications

Layer 2 services (ATM, Ethernet, frame relay) can be carried over the MPLS core Simplified network management through elimination of multiple layers

MPLS has become popular due to its capability to form multi-service networks with high speed. It can support pre-provisioned routes that are virtual circuits known as Label-Switched Paths (LSPs), across the network. Provision for backing up multiple service categories containing different forwarding and drop priorities, is also available with this technology. Multiprotocol label switching addresses common networking problems such as scalability, speed, Quality of Service (QoS), and traffic engineering, and provides them a viable and effective solution. Owing to its versatility, MPLS has emerged as a solution capable of meeting bandwidth and other service requirements for IP-based networks. Scalability and Routing - based issues can be resolved by MPLS technology, which also has the capacity to exist over existing ATM and Frame relay networks. Considering the positive points and shortcomings of ATM, MPLS technologies were designed to provide more leverage to network engineers and to be deployed flexibly.

The marketplace is constantly being replaced with new technologies and technology devices. MPLS came to the forefront when there was a requirement for a protocol that needs less overhead and at the same time provides connection oriented-services for frames of variable length. Technology such as ATM and frame relay has been replaced in many areas by MPLS technology, which combines many options to satisfy the technology requirements of clientele. Specifically, MPLS has dispensed cell-switching and signaling protocol used by ATM. Concurrently, Multiprotocol label switching technology continues to maintain the traffic engineering and bandwidth control, which was popularized by ATM and frame relay in large-scale networks. Migration to MPLS technology is beneficial especially since the benefits of traffic management are important. Performance level increases and so does reliability.

Currently, MPLS is used in large "IP only" networks. It is mainly used for forwarding Ethernet traffic and IP datagrams. MPLS VPN (Virtual Private Network) and traffic engineering are the major application areas of MPLS technology. MPLS IP VPN, a layer 3 VPN technology, is used to check, classify, and monitor IP packets. It is based on the service provider, to secure overlay VPN solutions. MPLS IP VPN is distinguished for its flexibility in networking modes, and features such as network scalability, QoS, and traffic engineering. Today's business operations employ diverse applications across the Wide Area Networks (WANs) and it is essential to manage and prioritize traffic over the networks securely. This necessitates the use of technology such as MPLS IP VPN, which is a proven method for traffic engineering and network security.

Here is some MPLS terminology:

Label switch router (LSR): It refers to any router that has awareness of MPLS labels. The entry and exit routers of an MPLS network are called edge LSR (or label edge routers – LER), which, respectively, inject (push) an MPLS label onto an incoming packet (label assignment) and remove (pop) it off the outgoing packet (label removal). An edge LSR is often a high-speed router device in the core of an MPLS network that participates in the establishment of Label Switched Paths (LSP) using the appropriate label signaling protocol and high-speed switching of the data traffic based on the established paths.

Label switched path (LSP): It is path defined by labels assigned between end points. An LSP can be dynamic or static. Dynamic LSPs are provisioned

automatically using routing information. Static LSPs are explicitly provisioned.

Label virtual circuit (LVC): It is a hop-by-hop connection established at the ATM transport layer to implement an LSP.

LFIB: Used by the core MPLS routers (which are not ingress and egress MPLS routers). They compare the label in the incoming packet with the label they have in their LFIB. If a match is found, the routers forward that packet based on that match. If not, the packet will be dropped.

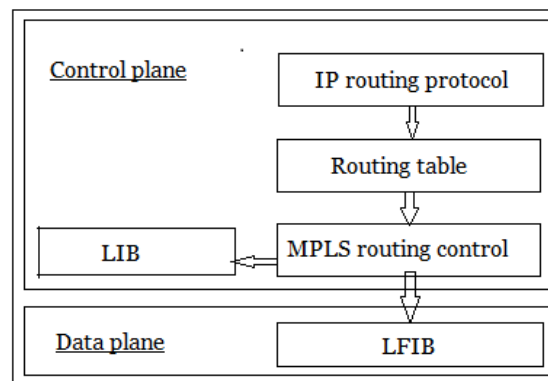


Fig 1. Planes of router

Label distribution protocol (LDP): It communicates labels and their meaning among LSRs. It assigns labels in edge and core devices to establish LSPs in conjunction with routing protocols such as Open Shortest Path First (OSPF), Intermediate System to Intermediate System (IS-IS), Routing Information Protocol (RIP), Enhanced Interior Gateway Routing Protocol (EIGRP), or Border Gateway Protocol (BGP).

III. COMPARATIVE ANALYSIS OF MPLS AND NON -MPLS NETWORK

3.1 TRADITIONAL IP ROUTING

In traditional IP routing, each router in the network has to make independent routing decisions for each incoming packet. When a packet arrives at a router, the packet is stored in data plane of router. Each port of router is in its data plane. Now first layer 2 processing will be done on packet to check whether the packet is destined for that particular MAC of router. If yes then now layer 3 processing of packet is performed. Layer3 process will check routing table, which is in control plane, the router to find the next hop for that packet based on the packets destination address in the packets IP header (longest match prefix lookup). Each router runs IP routing protocols like Border Gateway Protocol (BGP), Open Shortest Path First (OSPF) or Intermediate System-to-Intermediate System (IS-IS) to build the routing table. Now if next hop is available then again layer 2 processing will be done to change the destination MAC of the packet and then the packet is forwarded to required port. Now routing table, layer 2 and processes are present in control plane of router. Each time for each packet which in data plane, each router performs the same steps of finding the next hop for the packet. The main issue with conventional routing protocols is that for entire decision making process, there will be transfer of processing from control plan to data plan many times. So this is time consuming process. Also IP routing is performed at each hop of the packets path in the network. Entire IP header analysis is done at each hop which is time

consuming. Additionally there is problem if traffic is of different type. Now for multicast traffic , router maintains routing multicast table. IP routing requires special multicast routing and forwarding algorithms. These are the three main reasons because of which the traditional IP routing is slower. MPLS overcomes all these three drawbacks of IP routing.

3.2 MPLS TECHNOLOGY

Multiprotocol label switching (MPLS) is an addition to the existing Internet Protocol (IP) architecture. By adding new capabilities to the IP architecture, MPLS enables support of new features and applications. In MPLS short fixed-length labels are assigned to packets at the edge of the MPLS domain and these pre assigned labels are used rather than the original packet headers to forward packets on pre-routed paths through the MPLS network [12]. In MPLS, the route the packet is forwarded through the MPLS domain is assigned only once i.e., when the packet enters the domain. Before a router forwards a packet it changes the label in the packet to a label that is used for forwarding by the next router in the path.

MPLS unicast IP forwarding logic forwards packets based on the labels, however when choosing the exit interfaces, MPLS considers only the routes in the unicast IP routing table. This results in the packet flows over the same path as it would have even if MPLS was not used. Using MPLS labels does not add any benefit by itself, but it essentially enables the MPLS traffic engineering in an MPLS network, and therefore a critical feature of the MPLS. MPLS still requires the use of control plane protocols such as OSPF and LDP to learn the labels and relate those labels to particular destination prefixes for building correct forwarding tables. MPLS also requires a fundamental change to the data plane's core forwarding logic, it defines a completely different packet-forwarding logic. In an MPLS network, the hosts should not send and receive labeled packets. All labeled packets are only for the routing and only routers should be sending and receiving the labeled packets in an MPLS network. Here when packet arrives at a router, it is stored in data plane. Now to take forwarding decision , router refers the LFIB table which in data plane itself. Now decision will be done on basis of LFIB and taken in data plane only. Labeled packet is switched to required port and as it does not involve processing of control plane , the process is faster. The principal difference between a lookup in the routing table and the MPLS LFIB is that the routing table lookup is concerned with longest prefix match, i.e. having potentially many (imprecise) matches and selecting the one that most closely resembles the destination IP address. On the other hand, the MPLS LFIB

always performs lookups on fixed-length values and with equality operation, not with prefix-based logic. Hence, at least in theory, a routing table lookup is algorithmically more complex than a lookup in the LFIB, as finding a longest prefix match is more computationally intensive than simply finding a single matching value. Therefore the LFIB lookups should be faster.

MPLS forwards packets based on the MPLS labels, instead of using the packet's destination IP address. Advantage of using labels and not the destination IP address is that packet forwarding decision can be made on the other factors such as traffic engineering and QoS requirements. In MPLS the first device does a routing lookup, just like in traditional IP routing. But instead of finding a next-hop, it finds the final destination router. And it finds a pre-determined path from current router to that final router. The router applies a "label" (or "shim") based on this information. Future routers use the label to route the traffic without needing to perform any additional IP lookups. At the final destination router, the label is removed and the packet is delivered via normal IP routing. Therefore in an MPLS network, data packets are assigned labels. Packet-forwarding decisions are made solely on the contents of this label, without the need to examine the packet itself. FEC is forward equivalence class which means providing the type of behavior to reach the destination. Whatever is the type of traffic (unicast or multicast), the mechanism used and forwarding algorithm used to take decision is same. Hence MPLS is faster.

IV. PROPOSED METHODOLOGY

The simulation environment employed in this paper is based on GNS 3.0 simulator. The simulations were setup using a normal IP network without Traffic engineering (composed of OSPF and BGP) and a MPLS network (composed of OSPF and BGP) are implemented. The results from these simulations are used for comparison between the two networks. Both simulations are based on the common topology as shown in Fig 2 .

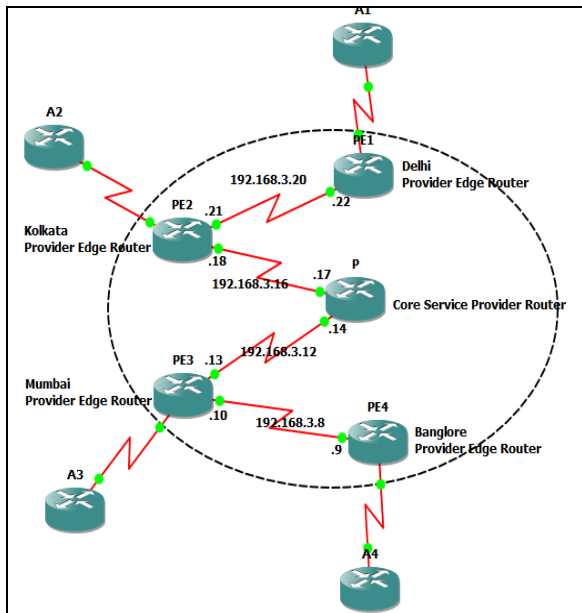


Fig 2. Experimental topology

The network consists of 9 nodes. Out of which, 5 nodes are service provider nodes. So to compare performance of service provider networks, we will initially use only these 5 nodes. All links were setup as duplex. The MPLS Traffic Engineering simulation topology is similar to the IP topology with only difference being that all nodes are MPLS capable, which allow label switching.

The work is simulated using a network with following characteristics.

- Service provider network with 4 provider edge router (PE1-PE4) and one core router (P)
 - Delhi site
 - Mumbai site
 - Bangalore site
 - Kolkata site
- All type of traffic
- Without QoS
- Traffic routed by LSP
- OSPF as IGP

The output trace file from the simulation is used to measure the performances of the network such as: Average packets per sec, average packet size, bytes transferred, average bytes per sec, average megabits per sec etc.

V. SIMULATION RESULTS

Now we can compare the differences between both scenarios. Both scenarios use OSPF as IGP. Also the core router is not connected to any customer router, so there should not be any customer route present here. Due this fact, the routing table of P router will be precise and concise. And this P router will do forwarding on wired speed. BGP is used to form indirect neighbourhood between edge routers.

Table 1. Comparing IP and MPLS network

	IP(non mpls network)	MPLS
Number of packets received	335	332
Average packets per sec	0.769	4.728
Average packet size	83.313	98.705
Bytes transferred	27910	32770
Average bytes per sec	64.061	466.703
Average megabits per sec	0.001	0.004

In Table 1. we can see that, though size of packet in MPLS is bigger than in IP because of additional label, average packets per sec in MPLS is three-four times more than that in traditional IP routing. Also average megabits per sec is more in MPLS domain. Hence we can say MPLS is faster than traditional IP routing. Using GNS3 for bandwidth testing might not be the best idea, as bandwidth in GNS3 is very limited because IOS is emulated, which is very slow. We can usually expect a few KB/s only depending how fast is our computer. In fact here all the results were obtain through a simulator software and will differ from results on actual hardware. But we can compare both networks using this simulator.

VI. CONCLUSION

MPLS is a technology that is extremely beneficial to enterprises. MPLS simplifies the network infrastructure by allowing the consolidation of multiple technologies and applications such as voice, video and data. MPLS provides enhanced security, scalability and high availability. Via the above-mentioned theories analysis and experiment simulation we can see, the MPLS is faster than traditional routing technique. If we can improve hardware facilities and software platform by real routers then we can notice the significant differences.

REFERENCES

- [1] A. Ghanwani. "Traffic Engineering Standards in IP Networks Using MPLS" IEEE Communications Magazine, vol. 37, no. 12, pp. 49- 53. Dec. 1999.
- [2] B. Jamoussi et al, "Constraint-Based LSP Setup using LDP" IETF RFC 3212, Jan. 2002.
- [3] D. Awduche et al, "RSVP-TE: Extensions to RSVP for LSP Tunnels" IETF RFC 3209, Dec. 2001

- [4] E. Rosen, A. Viswanathan and R. Callon, "Multiprotocol Label Switching Architecture," RFC 3031, Jan. 2001.
- [5] IEEE Communication magazine, September – 2006.
- [6] J. L. Marzo, E. Calle, C. Scoglio, and T. Anjali, "QoS online outing and MPLS multilevel protection: a survey," IEEE Communication Magazine, vol. 41, pp. 126-132, Oct. 2003.
- [7] J. M. Chung, E. Marroun, H. Sandhu, and S. C. Kim "VoIP over MPLS Networking Requirements," Proceedings of IEEE International Conference on Networking, France, July. 2001.
- [8] J. M. Chung, "Analysis of MPLS Traffic Engineering," Proceedings of the IEEE Midwest Symposium on Circuits and Systems, USA, Aug. 2000.
- [9] J. Wroclawski, "The Use of RSVP with IETF Integrated Services" IETF RFC 2210, Sep. 1997.
- [10] L. Zhang et al, "Resource Reservation Protocol (RSVP)" IETF RFC 2205, Sep. 1997.
- [11] Muzammil Ahmad Khan. "Quantitative Analysis of MPLS in VPN's", Sir Syed University of Engineering and Technology, from www.ieeexplorer.org.
- [12] UYLESS BLACK – MPLS and Label Switching Network.