A Review of Multi-Protocol Label Switching: Protocol for Traffic Engineering on Internet

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Abstract: **Existing Routing protocols like OSPF, IGRP and RIP enable routers to dynamically choose the path to the destination on a packet by packet basis. But these techniques respond slowly to congestion issues and do not provide quality of service to certain bandwidth specific applications. All the data may flow from the same end points thus leading to congestion and choking on the network. In MPLS, data flows as per the QoS and traffic demands. Thus packets are forwarded on a flow by flow basis and substantially increasing network capacity. We emphasise the universal nature of MPLS technology as it entices all the users who are seeking the ways to optimize resources and expand QoS support. In this paper, we reviewed MPLS technology in details which is an advanced packet forwarding techniques.**

Keywords: **Traffic Engineering, Interior Gateway Routing Protocol (IGRP), Multi-Protocol Label Switching (MPLS), Label Discovery Protocol (LDP), Label Edge Router (LER), label Switch Router (LSR), Label Switch Path(LSP), Forward Equivalence Class (FEC), label Information Base(LIB).**

I. INTRODUCTION

Traffic Engineering

The process of controlled data flow on Internet with the objective to optimize resources and network performance is known as traffic engineering. The existing routing protocols such as RIP, OSPF, IGRP, EIGRP etc. always exploits the concept of shortest path for data forwarding. Although the selected shortest path preserve the network resources but may also suffers from different problems. Firstly, the certain links of the shortest path gets over swamped as different sources sends the data and causing congestion on those links. Secondly, other longer paths may remain underutilized as all the data flows through the selected shortest path only. [1-3]Thus traffic engineering is needed. Fig1 illustrates that path3 is the shortest path through which all the data will be forwarded leading to congestion on that path. Path1 and Path 2 are also available but not preferred by IGP so remains underutilized.

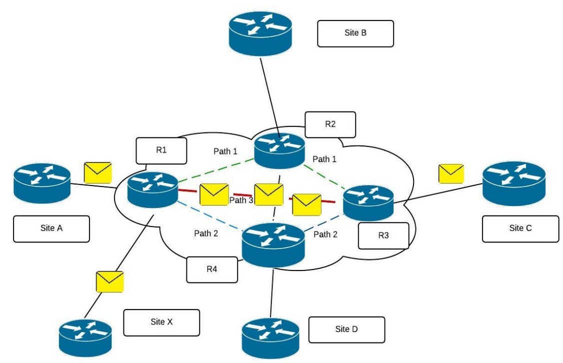

Fig 1: Shortest Path selection using IGP

For effective traffic engineering, an international organization, Internet Engineering Task Force (IETF) introduced the concept of Multi-Protocol Label Switching for effective utilization of the network resources and overcome the problems of network congestion [3].

Section II introduces the concept of MPLS and drawbacks of traditional IP Routing. Section III briefing about the architecture and working of MPLS. Section IV discuss the case study of how routing takes place in MPLS. Section V derives the conclusions and future work from the study of MPLS.

II. MPLS: MULTI-PROTOCOL LABEL SWITCHING

Traditional IP Forwarding routing protocols are used to forward packets in the network in Layer 3 of OSI Model where routing lookups are performed on every hop. Each router in the topology makes an independent decision where to forward the packets based on destination IP address.

MPLS is a scalable, connection-oriented, independent packet forwarding technique. The packets are forwarded on the basis of assigned labels [2-3]. Labels may correspond to Layer 3 destination IP address or other parameters such as Quality of Service, Source address etc. This protocols works between data link layer (Layer 2) and Network Layer (Layer 3) of OSI Model. So it is also called layer 2.5 Protocol (Fig 2).

Layer 2 Data Link Layer	Ethernet
Layer 2.5	MPLS
Layer 3 Network Layer	RIP, OSPF etc

Fig 2: MPLS at Layer 2.5

MPLS helps to minimize the number of destination address based routing lookups in large forwarding table and further eliminates the need to execute a specific routing protocol on all routers. MPLS is designed to support other protocols stack such as ATM, SONET, and Frame Relay etc. Today in industry, MPLS is powerful technology. MPLS does not only enhance the speed of forwarding but it was created to overcome the disadvantage of IP Forwarding. Load can be done shared among multiples paths of different costs as shown in Fig 3. Different packets take distinct paths as Path 1, Path2 and Path 3 to reach the destination.

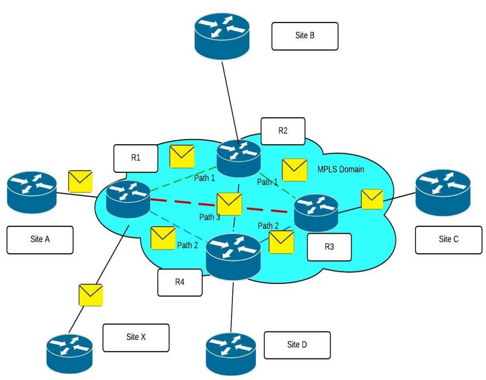

Fig 3: Shortest Path selection using MPLS technology

The main benefit of MPLS is scalability and flexibility. Routers can select any path and perform any kind of routing [5].

III. MPLS ARCHITECTURE

MPLS architecture consists of two major components: Control plane and Data Plane (Fig 4). The control plane performs complex functions such as exchanging layer 3 routing information (RIP, OSPF, EIGRP, and IGRP) and labels (LDP (Label Distribution Protocol). The data plane only forwards the packet on the basis of destination address or labels [6].

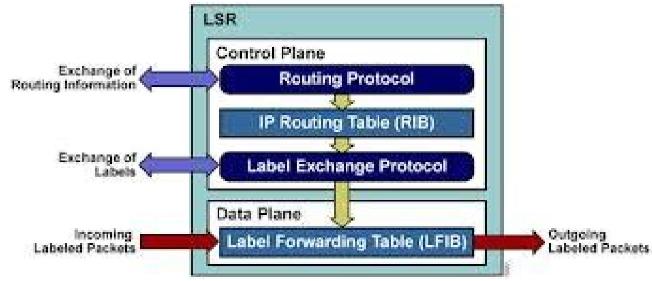

Fig 4: Architecture of LSR[http://faizalrahimi.wordpress.com/]

MPLS can only work in MPLS domain only. The routers under MPLS domain are called LSR (Label switch routers) that are capable of switching and routing packets on the basis of a label which has been appended to each packet. The path from source to destination LSR builds the Label switch path (LSP). The router may be ingress or egress. The starting point of LSP is known as ingress router. The exit from MPLS domain, the router is known as egress router. Other routers are only used for transit the traffic so they are known as core routers. Ingress and egress routers are also known as LER (Label Edge Router) and core routers are also known as LSR (label Switch Router), depicted in Fig 5. Any router can be ingress, egress or core routers depending upon the flow of traffic in LSP. In the given topology, if the data is sent from Site A to Site C, R1 is ingress router and R3 is egress router. If the data is sent from Site D to A then R4 is ingress and R1 is egress router.

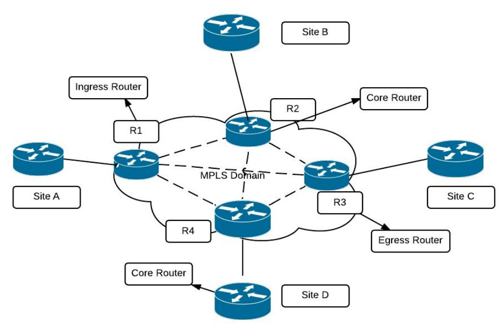

Fig 5: Classification of Routers in MPLS Domain

MPLS header is also known as shim header (Fig 6). All switching is done between the labels. Labels are assigned dynamically. 0-15 labels are reserved that could not be used for label allocation. MPLS always unicast means a single label for single network ID.

Data Link Header	MPLS Label Stack	IP Header	Data	Data Link Trailer

Fig 6: Data Link Frame Format with MPLS

The core of MPLS technology is that all the network traffic is categorised into Forward Equivalence classes (FEC). FEC for a packet can be decided by one or more number of parameters like Network IP addresses, Port numbers, IP Protocol ID, QoS, and IPV6 flow labels etc. These parameters are specified by network manger. At each LSR, labelled packet is forwarded on the basis of its labels. Each LSR replaces the incoming label value with the outgoing label value. This phenomenon is known as label swapping [7].

Label stacking is one of the important features of MPLS. A labelled packet may carry many labels, organised as LIFO stack. Labels may be pushed or popped at any LSR during packet forwarding. Labels are of local significance with in a network. The MPLS label format is a shown in Fig 7. The size of label to be attached is of 32 bits which contains the following fields [7-8].

Label Value 0-19 Bits	Experiment Bits 20-22 Bits	S-bit 23 Bit	TTL 24-31 Bits

Fig 7: MPLS 32 bits Label Format

0-19 LSB represents the actual label value.

20-22 bit reserved for experimental use (also known as class of service field). This signifies the IP precedence same as that of IP header.

23 bit (S-bit): The value of 1 represents the first entry in the label stack.

24-31 bit (TTL) Time to live field is same as IP header. This field is decremented at each hop and the packet is dropped if its value reaches zero.

The operation of MPLS in MPLS domain technology has the key element that, before routing and delivering of packets in MPLS domain, LSP must be defined. For this two protocols are used, IGP (i.e.OSPF) for routing information and Label Distribution Protocol (LDP) for assignments of labels [9-10].

IV. CASE STUDY

Consider a network topology given in Fig 8 where data is forwarded to destination IP address 192.168.7.1. Packets arrive from non-MPLS network from the LAN having destination native IP address that is ordinary IPV4 address. At LER (ingress router) FEC look-up table matches destination IP address. In this case 192.168.7.1 is bound to label 90. This results in MPLS label value of 90 being pushed on to the stack. The packet with MPLS label 90 is now forwarded onto the next hop. At the next hop, the LSR reads the incoming label from its forwarding table known as Label Information Base (LIB). Now label 90 is swapped with value 70 and the packet is forwarded to Fa 0/2. The process of label swapping is repeated with next hop with the label being swapped from 70 to 411 and forwarded out on S00/1.Finally packet reaches the destination LER (egress router) and looks on the forwarding table to see what IP address in label is associated with. Since this is the end of MPLS route, the look up table indicates that the label should be popped. This means the packet is forwarded to its destination with native IP. Finally the path chosen by the packets on the network is Label Switch Path (Shown with dotted arrow in Fig 8).

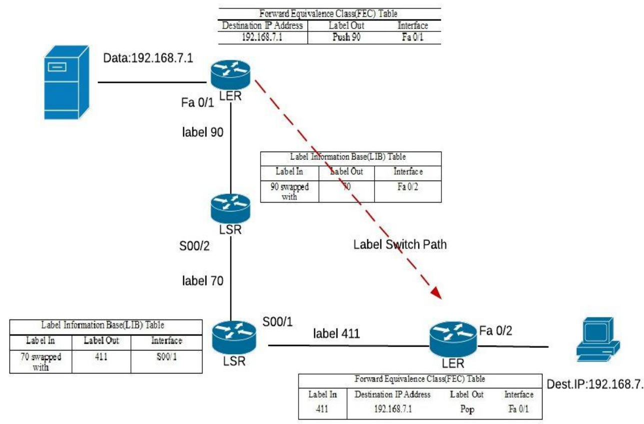

Fig 8: Case Study

The LIB and FEC tables are built dynamically using LDP. LDP works in conjunction with IGP i.e. OSPF, RIP etc. Label Distribution has two modes of operation. First is, ordered control with downstream on demand. Second is, independent control with downstream unsolicited.

In first method, a label request message is sent to the destination label router to ask for label mapping for a given address, eg. 192.168.7.1 The LER selects the label from its pool of labels (label 411). The label mapping message tells the upstream LSR to use this label as the outgoing label. The LSR then selects the label (Label 70) from its pool as the incoming label and sends a label mapping message to the next upstream router to tell label 70 as its outgoing label. This process is repeated until the label mapping reaches the originating label at the router. In the final FEC binding table is made. However this method is not generally used in MPLS based VPNs.

The second method of Label Distribution favoured by VPN provider still uses LDP but in independent control with downstream unsolicited mode. Here LDP has to work with IGP. When the route to 192.168.7.1 is learned by local LER, IGP updates the neighbouring routers. At the same time LDP allocates and maps the labels to use. This process is continued back to the fall LER and the label binding is made. In this method, there is no request of LSP is made.

V. CONCLUSION AND FUTURE WORK

MPLS is a connection oriented technique to support traffic management and quality of service. The technique reduces the amount of per packet processing required at each router. Thus provides improved capability in four domains of performance, QoS Support, Multi protocol support, Virtual Private Networks and traffic engineering. In future we intend to com pare this technique with other existing techniques such as constraint based routing and enhanced link state IGP techniques.

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