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Chapter V

IP Switching and MPLS

S. Manikantan
Future Software Limited, India

The growth of the Internet and its widespread usage has lead to greater demands being made on the industry to provide faster and better solutions. This chapter focuses on the current developments in the areas of IP Switching and MPLS. It also explains the circumstances that led to the development of the MPLS concept and the solutions that MPLS offers.

IP NETWORKS: BASICS AND HISTORY

IP Addresses

The four-byte unique address assigned to each host in the Internet, known as the IP address, contains the identifier of the network to which the host is attached and the identifier of the host. Earlier, the networks were few in number and could be classified as Class A, Class B and Class C networks. These address types identify a single node and are known as unicast address, while a multicast address type identifies a group of nodes. IP multicast addresses are classified as Class D addresses. Class E address type, though created, is reserved as of now. The IP addresses based on classes of networks soon led to what is known as a Running Out of ADdress Space (ROADS) problem. Though the initial solutions to this problem such as Transparent Routers, Proxy ARPs, and Subnetting were proposed, the solution of Supernetting or Classless Inter Domain Routing solves this issue to a large extent. In both subnetting and supernetting schemes, an IP address is associated with a mask (also known as IP Address Mask). The IP address bit-wise ANDed with the mask provides the network to which the host belongs and the remaining part provides the host identification. IPv6 (Deering & Hinden, 1998) is an another solution for the IP address space problem, as the four-byte IP address is replaced here by a sixteen-byte IP address.

This chapter appears in the book, Enterprise Networking: Multilayer Switching and Applications by Vasilis Theoharakis and Dimitrios Serpanos.

IP Routing Protocols

With the growth of the Internet since 1969, the number of networks interconnected to form the public IP backbone increased. Initially, two networks were connected via a "Gateway," later known as Routers. The gateways were responsible for the transfer of data between the networks. The networks were generally grouped into logical administrative domains or Autonomous Systems (AS) and the network resources within an AS came under a single management. Routing protocols were evolved to help the efficient transfer of IP datagram between hosts on the Internet. The routing protocols can be divided into i) Exterior Gateway Protocols and ii) Interior Gateway Protocols.

The Exterior Gateway Protocols help in the exchange of reachability information across AS domains, whereas Interior Gateway Protocols help in determining the reachability information within an AS. Exterior Gateway Protocol (EGP) (Mills, 1984) was defined and used to exchange net-reachability information between Internet gateways belonging to the same or different autonomous systems. The Border Gateway Protocol (BGP) (Rekhter & Li, 1995) evolved from the EGP is currently widely used.

The Interior Gateway Protocols can be further classified into two types as i) Protocols using Distance Vector-based algorithms and ii) Protocols using Link State based algorithms. Routing Information Protocol (RIP) (Malkin, 1998) belongs to the former category, while Opening Shortest Path First (OSPF) (Moy, 1998) belongs to the latter category. RIP, due to its inherent limitations, is used in some small networks at the fringes of the Internet, while the OSPF, which is capable of handling the reachability of large networks, is deployed in the IP backbones.

As mentioned above, the routing protocols have been defined to handle both unicast addressing as well as multicast addressing. While RIP, OSPF, etc., have been defined for exchanging reachability for unicast addressing, the Internet Group Management Protocol (IGMP) (Fenner, 1997), Distance Vector Multicast Routing Protocol (DVMRP) (Pusateri, 2000), Protocol Independent Multicast-Sparse Mode (PIM-SM) (Estrin et al., 1998), Multicast extensions to OSPF (MOSPF) (Moy, 1994) and CBTv2 (Ballardie, 1997) provide efficient solutions to determine multicast reachability. The algorithm used by DVMRP is known as Reverse Path Multicasting (RPM), while CBTv2 uses a Core Base Tree (CBT) algorithm. PIM-SM uses a combination of RPM and CBT, and MOPSF uses a link-based algorithm.

IP VPNs

The limitations of the basic IP backbone, such as privacy, guaranteed type of service, etc., affect the direct use of the Internet for corporate activities. The different offices of an organization located at different geographical locations require a dedicated private network for their services. As the creation of dedicated networks between the offices using dedicated network resources (both hardware and software) is not cost effective, the solution of Virtual Private Networks (VPNs) over the public IP backbone gains importance.