White Paper

Cisco 7600 Series Internet Router Multiprotocol Label Switching

Introduction

This paper introduces Cisco 7600 Series Internet Router Multiprotocol Label Switching (MPLS) features and advantages. It first provides a summary of Cisco 7600 MPLS benefits, followed by an overview of MPLS technology and applications of MPLS technology in providing Layer 2 and Layer 3 services to Internet service provider (ISP), metro service provider (MSP), and enterprise customers.

Cisco 7600 MPLS Benefits

Following is a summary of key benefits of the Cisco 7600 MPLS applications for service providers, including ISPs and MSPs, and end customers.

- Highly scalable standards-based implementation
- Efficient Layer 2 transport across Layer 3 MPLS core
- End-to-End IP quality-of-service (QoS) support
- Support for Layer 2 and Layer 3 MPLS virtual private networks (VPNs)
- MPLS-based traffic engineering support for ISPs and MSPs
- Basic MPLS switching support for ISP core

Cisco 7600 MPLS Technology Overview

MPLS fuses the intelligence of routing with the performance of switching and provides significant benefits to networks with a pure IP architecture, as well as those with IP and ATM, or a mix of other Layer 2 technologies. MPLS technology is key to scalable VPNs, end-to-end QoS, enabling efficient utilization of existing networks to meet future growth and rapid fault correction of link and node failure. The technology also helps deliver highly scalable, differentiated, end-to-end IP services with simpler configuration, management, and provisioning for both Internet providers and enterprises.

Published by the Internet Engineering Task Force (IETF), the MPLS standard evolved from the Cisco Tag Switching implementation. Cisco leadership and experience in the tag switching and MPLS arena translates into a feature-rich implementation and a robust, proven platform for service-provider and business networks.

Based on label swapping, a single forwarding mechanism provides opportunities for new control paradigms and applications. MPLS Label Forwarding is performed with a label lookup for an incoming label, which is then swapped with the outgoing label and finally sent to the next hop. Labels are imposed on the packets only once at the edge of the MPLS network and removed at the other end. These labels are assigned to packets based on groupings or forwarding equivalence classes (FECs). Packets belonging to the same FEC get similar treatment. The label is added between the Layer 2 and the Layer 3

header (in a packet environment) or in the virtual path identifier/virtual channel identifier (VPI/VCI) field (in ATM networks). The core network merely reads labels, applies appropriate services, and forwards packets based on the labels. This MPLS lookup and forwarding scheme offers the ability to explicitly control routing based on destination and source addresses, allowing easier introduction of new IP services because it gives a greater control on the edges of the network as well as customer network administrators, and not so much in the core of the network.

The Cisco 7600 Series Internet Router delivers high-performance WAN and MAN networking with high-touch IP services at the network edge. Now, service providers and enterprises can "service enable" their networks at optical speeds, providing competitive advantage and service differentiation to the SP and high-speed connectivity and link usage efficiency to the enterprise. The Cisco 7600 helps service providers and enterprises break through the services, and bandwidth barriers to increase new revenue and profits.

The Cisco 7600 provides customers the flexibility of three different form factors through a 3-slot, 6-slot, and 9-slot chassis. As one of the most scalable systems in the industry, each chassis offers the ability to bring DS0 to OC-48 WAN connectivity, and 10 Mbps Ethernet to 10 Gigabit Ethernet LAN connectivity to Metro Aggregation, WAN Edge Aggregation, and enterprise networking applications.

The Cisco 7600 is focused as an edge device, a label edge router (LER) for pure MPLS-based networks, and a provider-edge (PE) device for the MPLS VPN networks. With its numerous interface types and speeds available, the Cisco 7600 is able to perform aggregation of various types of traffic for transport across an MPLS-based Layer 3 core. It also has the capability to perform as a provider (P) device for some MPLS networks based on the switching capacity it provides. Whereas a PE device is aware of Layer 2 as well as Layer 3 VPNs, a P device is purely a label-switching device that can swap an incoming label with an outgoing label at a very high speed.

The Cisco 7600 MPLS implementation on the Cisco 7600 is compliant with RFC 3031, Multiprotocol Label Switching Architecture, RFC 3036, LDP Specification, and various other IETF drafts as well as RFCs.

Cisco 7600 MPLS Applications

The Cisco 7600 provides network administrators and designers a choice of number of applications based on a Layer 3 MPLS core. Furthermore, these applications can be enabled in various combinations, as needed by service providers and enterprise customers alike to achieve the ultimate scalability, flexibility, and speed provided by the Cisco 7600 platform.

- MPLS-based Layer 2 VPN
- MPLS-based Layer 3 VPN
- Quality of service (QoS)
- Traffic Engineering (TE)—available mid-2003.

MPLS-Based Layer 2 VPN Service

Ethernet is migrating from local-area networks (LANs) to metropolitan-area networks (MANs) and attracting MSPs because of its simplicity, flexibility, low cost, and quick time to service. However, Ethernet lacks several key service-level agreement (SLA) capabilities such as QoS, TE, reliability, and scalability. This scenario prevents pure Ethernet-based MSPs from providing premium traditional value-added services such as Layer 2 VPN to its end users and achieving competitive advantages. MPLS adds connection-oriented, path-switching capabilities and provides premium service-level capabilities such as scalability, reliability, QoS, and TE.

The combined Ethernet and MPLS capabilities of the Cisco 7600 improve economics of Ethernet-based service deployment and provide an optimal Layer 2 VPN solution in the metropolitan area.

MPLS-based Layer 2 VPNs provide a flexible, high-speed service that removes the complexity associated with the wide-area network (WAN) from the end users. With Layer 2 VPN, a service provider interconnects an enterprise LAN, regardless of its physical location, in such a way that the WAN services supporting the network are not apparent to the customer.

One of the primary ways the Cisco 7600 provides Layer 2 VPN is by using Ethernet over MPLS (EoMPLS) as the primary transport technology. EoMPLS takes advantage of an existing MPLS backbone network to deliver Layer 2 VPN connectivity to two or more customer sites. For instance, in the EoMPLS-based Layer 2 VPN implementation, each customer's traffic from a given site is mapped onto an MPLS label switched path (LSP) that extends across the MAN or WAN.

These LSPs are point-to-point in nature, and must be established between sites that have Layer 2 traffic transport needs. Each LSP can enjoy reserved bandwidth across the MPLS cloud, as well as other QoS guarantees. This MPLS implementation allows the service provider to provide service-level guarantees critical to offering premium SLAs.

This implementation also provides the ability to scale the customer virtual LANs (VLANs) because an incoming customer's VLAN traffic on the ingress Cisco 7600 PE device can be configured to map onto either the same or a different VLAN at the egress Cisco 7600 PE device.

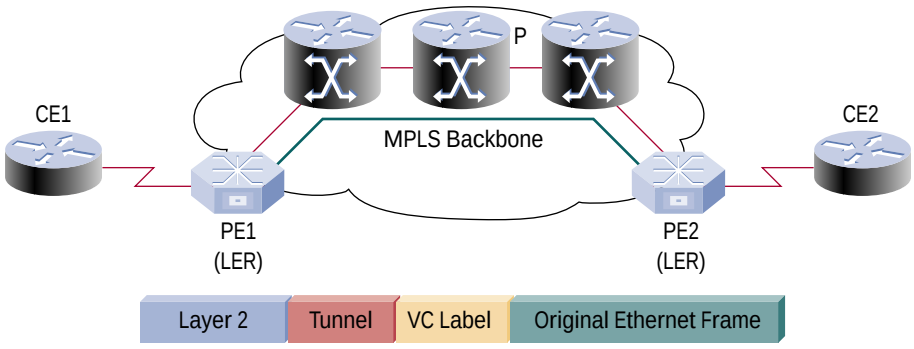
The Cisco EoMPLS implementation is compliant with and supports the following two IETF drafts:

- Transport of Layer 2 Frames over MPLS (draft-martini-l2circuit-trans-mpls-07.txt)
- Encapsulation Methods for Transport of Layer 2 Frames over MPLS (draft-martini-l2circuit-encap-mpls-03.txt)

Ethernet ports or IEEE VLANs are dedicated to customers on PE routers acting as LERs. Customer traffic is mapped to a specific MPLS Layer 2 VPN by configuring Layer 2 FECs based upon the input port or VLAN. Further, Cisco 7600 EoMPLS utilizes Label Distribution Protocol (LDP) sessions between two Cisco 7600 PEs, as well as two-level labeling, and a virtual circuit (VC), as described in the IETF drafts mentioned above. In addition, Cisco 7600 EoMPLS relies on industry-standard implementation of LDP as specified by RFC 3036.

Figure 1 shows a typical EoMPLS topology with a Cisco 7600 (shown as PE1 and PE2) as LERs. It also shows a typical frame as it traverses from customer edge 1 (CE1) through the MPLS backbone to CE2.

Figure 1
EoMPLS Logical Topology and Packet Frame



MPLS-Based Layer 3 Virtual Private Network

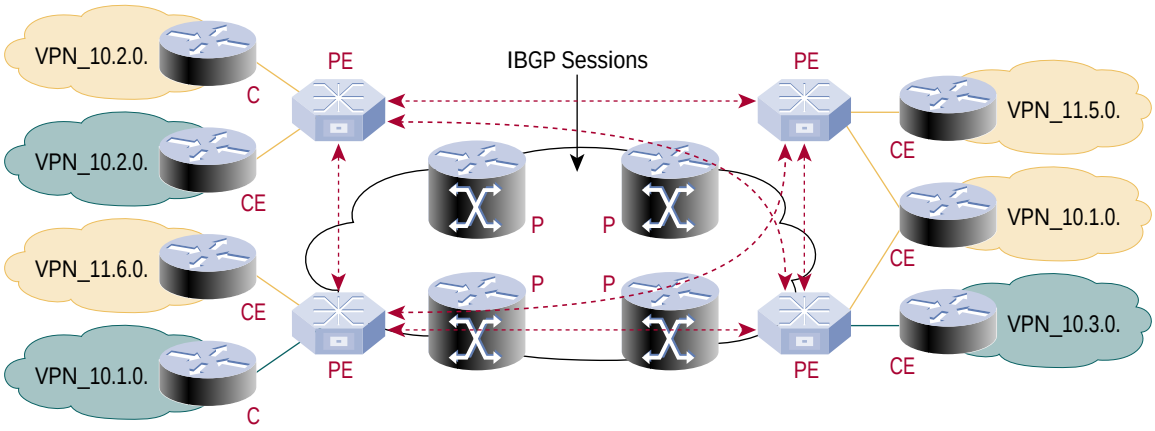
MPLS-based VPNs are becoming increasingly popular because of their ability to scale to support a very large number of customer sites as well as end users compared to traditional VPN technologies such as Frame Relay/ATM. This is largely due to a need in traditional VPNs to maintain a large number of VCs to accomplish a full-mesh topology, as well as the inability of core devices to carry a very large number of Border Gateway Protocol (BGP) routes for inter-/intra-customer access as well as Internet access. The Cisco 7600 can support the role of an MPLS PE device as well as the role of a P device in the MPLS VPN networks.

The Cisco 7600 can support RFC 2547 and 2547bis-based MPLS VPNs and a variety of interface types in both the CE and P directions.

Cisco 7600 MPLS VPNs can also support up to 1023 virtual routing and forwarding instances (VRFs) acting as a PE device for MPLS VPN networks as well as numerous routing protocols between PE and CE routers. This support translates to a great benefit for customers and service providers alike because it enables them to include a large number of customer devices on the same PE device, as well as manage a variety of customer routing environments without any configuration change on the customer's part.

Figure 2 shows a typical MPLS VPN network using a Cisco 7600 as a PE device. It shows two customer VPNs, green and yellow, with several different sites of each as well as overlapping address space being used by the two customers.

Figure 2
Cisco 7600 MPLS VPN Connection Model



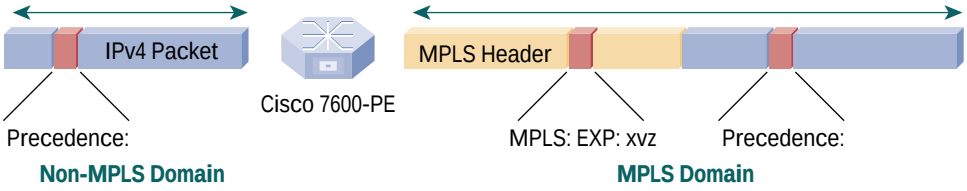
Cisco 7600 MPLS QoS

To differentiate their offerings and attract more customers, service providers must provide tiered services. Cisco 7600 MPLS enables ISPs and MSPs to differentiate service tiers with the ability to support end-to-end IP QoS.

Cisco 7600 MPLS maps IP Precedence/type-of-service (ToS) bits to the MPLS experimental bits (EXP) at the entry point, the ingress of the network. The EXP is a 3-bit field as part of the MPLS header, which was created by the IETF on an experimental basis, but later became part of the standard MPLS header. The EXP bits in the MPLS header carry the packet priority. Each label switch router along the path will honor the packet priority by queuing the packet into the proper queue and by servicing the packet accordingly. Therefore, service providers can deliver the IP services that businesses demand, across either switched or routed networks.

Figure 3 shows an example of how the end-to-end IP QoS is retained and supported by the Cisco 7600-based MPLS network. At the ingress PE, IPv4 IP Precedence/ToS bits are copied into the EXP bits in the MPLS header. At the egress PE, the same is remapped into IPv4 header ToS bits.

Figure 3
Cisco 7600 IP QoS-to-MPLS QoS Mapping



Cisco 7600 Traffic Engineering

The Cisco 7600 MPLS Traffic Engineering (TE) features, available in mid-2003, will enable Service Providers to replicate and expand upon the TE capabilities of Layer 2 ATM and Frame Relay networks.

Traffic engineering is essential for SPs' backbones. Such backbones must support a high utilization of transmission capacity, and the networks must be very resilient, so that they can withstand link or node failures. MPLS TE provides an integrated approach to traffic engineering. With MPLS, TE capabilities are integrated into Layer 3, optimizing the routing of IP traffic, given the constraints imposed by backbone capacity and topology. MPLS TE routes traffic flows across a network based on the resources the traffic flow requires and the resources available in the network. This setup provides a flexible way to use the underutilized links with minimal node configuration and maintenance steps involved.

TE on the Cisco 7600 will provide support for RFC 2702, Requirements for Traffic Engineering over MPLS. The Cisco 7600 implementation of TE will make use of Resource Reservation Protocol (RSVP) for signaling as well as TE extensions to RSVP to support communication of constraints needed to support the TE model.

Corporate Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 526-4100

European Headquarters
Cisco Systems International BV
Haarlerbergpark
Haarlerbergweg 13-19
1101 CH Amsterdam
The Netherlands
www-europe.cisco.com
Tel: 31 0 20 357 1000
Fax: 31 0 20 357 1100

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-7660
Fax: 408 527-0883

Asia Pacific Headquarters
Cisco Systems, Inc.
Capital Tower
168 Robinson Road
#22-01 to #29-01
Singapore 068912
www.cisco.com
Tel: +65 317 7777
Fax: +65 317 7799

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