

## Implementing Cisco MPLS

**Duration: 180 Days**    **Course Code: MPLS**    **Version: 3.1**

### Overview:

Multiprotocol Label Switching (MPLS) is a high-performance method for forwarding packets through a network enabling routers at the edge of a network to apply simple labels to packets. This practice allows the edge devices to switch packets according to labels, with minimal lookup overhead. MPLS integrates the performance and traffic-management capabilities of data link Layer 2 with the scalability and flexibility of network Layer 3 routing.

This course covers both introductory and advanced MPLS and MPLS VPNs concepts. Configuration, implementation and troubleshooting skills are all included with a significant focus on the use of labs to consolidate the learners knowledge. At the end of this course you should be able to design, implement and maintain core IP routing network infrastructures.

Each student will have their own virtual pod of equipment with access to the labs 24x7 for 90 days

**This course is worth 40 Credits in the Continuing Education Program**

e-Learning

Interactive self-paced content that provides flexibility in terms of pace, place and time to suit individuals and organisations. These resources also consist of online books, educational podcasts and vodcasts, and video-based learning.

### Target Audience:

Service Provider and Enterprise network engineers that design, deploy and maintain core IP routing network infrastructures.

### Objectives:

- **After you complete this course you should be able to:**
- Describe the features of MPLS
- Describe how MPLS labels are assigned and distributed
- Identify the Cisco IOS tasks and command syntax necessary to implement MPLS on frame-mode Cisco IOS platforms
- Describe the MPLS peer-to-peer architecture and explain the routing and packet forwarding model in this architecture
- Identify the Cisco IOS command syntax required to successfully configure, monitor, and troubleshoot VPN operations
- Identify how the MPLS VPN model can be used to implement managed services and internet access
- Describe the various internet access implementations that are available and the benefits and drawbacks of each model
- Provide an overview of MPLS Traffic Engineering

### Prerequisites:

**Attendees should meet the following prerequisites:**

- Intermediate to advanced knowledge of Cisco IOS Software configuration
- Configuring and troubleshooting EIGRP, OSPF, IS-IS and BGP
- CCNA - Implementing and Administering Cisco Solutions
- ENCOR - Implementing and Operating Cisco Enterprise Network Core Technologies
- SPFNDDU - Understanding Cisco Service Provider Network Foundations

### Testing and Certification

**Recommended preparation for exam(s):**

- There are no exams currently associated to this course

## Content:

### Introducing Basic MPLS Concepts

- Foundations of Traditional IP Routing
- Basic MPLS Features
- Benefits of MPLS
- MPLS Terminology: Label Switch Router
- MPLS Terminology: Label Switched Path
- MPLS Terminology: Upstream and Downstream
- MPLS Architecture Components
- Architecture of Ingress Edge LSRs
- Architecture of Intermediate LSRs
- Architecture of Egress Edge LSRs

### Introducing MPLS Labels and Label Stack

- MPLS Labels
- FEC and MPLS Forwarding
- MPLS Label Imposition
- MPLS Label Stack

### Identifying MPLS Applications

- MPLS Services
- MPLS Unicast IP Routing
- MPLS Multicast IP Routing
- MPLS VPNs
- MPLS Traffic Engineering
- MPLS Quality of Service
- Any Transport over MPLS
- Interactions Between MPLS Services

### Discovering LDP Neighbours

- Label Distributing Protocols
- LDP Neighbour Session Establishment
- LDP Link Hello Message
- LDP Negotiating Label Space
- Discovering LDP Neighbours
- Negotiating LDP Sessions

### Introducing Typical Label Distribution in Frame-Mode MPLS

- Propagating Labels Across a Network
- Building Blocks for IP Forwarding
- Using the FIB Table to Forward Packets
- Using LDP to Forward Packets
- Label-Switched Path
- Propagating Labels by Using PHP
- Impact of IP Aggregation on LSPs
- Label Allocation in a Frame-Mode MPLS Network
- Label Distribution and Advertisement
- Receiving Label Advertisement
- Liberal Label Retention
- Further Label Allocation
- Frame-Mode Loop Detection Using the MPLS TTL Field
- Normal TTL Operation
- Disabling TTL Propagation

### Introducing Convergence in Frame-Mode

### Introducing MPLS VPN Architecture

- MPLS VPN Architecture
- PE Router Architecture
- VRF Overview
- Methods of Propagating Routing Information across the P-Network
- Route Distinguishers
- RD Format
- RD Operation in MPLS VPN
- RD Process Flow
- Route Targets
- RT Operation
- RT and RD Process Flow

### Introducing the MPLS VPN Routing Model

- MPLS VPN Routing
- CE Router MPLS VPN Routing
- IP Router MPLS VPN Routing
- PE Router MPLS VPN Routing
- Support for Internet Routing
- Routing Tables on PE Routers
- Identifying End-to-End Routing Update Flow

### Forwarding MPLS VPN Packets

- End-to-End VPN Mechanisms
- VPN Penultimate Hop Popping
- Propagating VPN Labels Between PE Routers
- Effects of MPLS VPNs on Label Propagation
- Effects of MPLS VPNs on Packet Forwarding

### Implementing an MP-BGP Session Between PE Routers

- VRF Table
- Need for Routing Protocol Contexts
- VPN-Aware Routing Protocols
- Using VRF Tables
- Propagating BGP Routes - Outbound Example
- Propagating Non-BGP Routes - Outbound Example
- Propagating BGP Routes - Inbound Example
- Propagating Non-BGP Routes - Inbound Example
- Configuring BGP Address Families
- Enabling BGP Neighbours
- Configuring MP-BGP
- Configuring MP-IBGP
- VRF Configuration Tasks
- Creating VRF Tables and Assigning RDs
- Specifying Export and Import RTs
- Using MPLS VPN IDs

### MPLS VPN Implementation

### Troubleshooting MPLS VPNs

- Identifying Preliminary Steps in MPLS VPN Troubleshooting
- Verifying the Routing Information Flow
- Validating CE-to-PE Routing Information Flow
- Validating PE-to-PE Routing Information Flow
- Validating PE-to-CE Routing Information Flow
- Identifying the Issues when Verifying the Data Flow
- Validating Cisco Express Forwarding Status
- Validating the End-to-End LSP
- Validating the LFIB Status
- MPLS VPN Troubleshooting Command Summary

### Complex MPLS VPNs

- Participants in Overlapping VPNs
- Typical Overlapping VPNs
- Overlapping VPN Routing
- Overlapping VPN Data Flow
- Configuring Overlapping VPNs
- Central Services VPN
- Central Services VPN Routing
- Central Services VPN Data Flow Model
- Central Services VPN and Overlapping VPN Requirements
- Configuring RDs and RTs in a Central Services VPN and Overlapping VPN
- Advanced BRF Features
- Configuring Selective VRF Import
- Configuring Selective VRF Export
- Managed CE Routers
- VRF Creation and RD Overview
- Configuring Managed CE Routers

### Internet Access and MPLS VPNs

- Customer Internet Connectivity Scenarios Overview
- Classical Internet Access
- Multisite Internet Access
- Wholesale Internet Access
- Internet Design Models for Service Providers
- Internet Access Through Global Routing
- Internet Access Through a Separate VPN Service
- Internet Access Through Route Leaking
- Classical Internet Access for a VPN Customer
- Implementing Classical Internet Access for a VPN Customer
- Using Separate Subinterfaces
- Implementing Internet Access from Every Customer Site
- Internet Access as a Separate VPN
- Implementing Wholesale Internet Access

## MPLS

- MPLS Steady-State Operation
- Link Failure State
- Routing Protocol Convergence After a Link Failure
- MPLS Convergence After a Link Failure
- Link Recovery Actions

### Implementing Frame-Mode MPLS Implementation on Cisco IOS Platforms

- Cisco IOS Platform-Switching Mechanisms
- Using Standard IP Switching
- Cisco Express Forwarding Switching Architecture
- Configuring IP Cisco Express Forwarding
- Monitoring IP Cisco Express Forwarding
- MPLS Configuration Tasks
- Configuring the MPLS ID on a Router
- Configuring MPLS on a Frame-Mode Instance
- Configuring IP TTL Propagation
- Configuring Conditional Label Distribution

### Monitoring and Troubleshooting Frame-Mode MPLS on Cisco IOS Platforms

- Monitoring MPLS
- Monitoring LDP
- Monitoring Label Switching
- Debugging MPLS and LDP
- Common Frame-Mode MPLS Issues
- Solving LDP Session Start-up Issues
- Solving Label Allocation Issues
- Solving Label Distribution Issues
- Solving Packet-Labeling Issues
- Solving Intermittent MPLS Failures
- Solving Packet Propagation Issues

### Introducing VPNs

- Basic VPN Overview
- VPN Implementation Models
- Overlay VPN Technologies
- Peer-to-Peer VPN Technologies
- Benefits of VPNs
- Drawbacks of VPNs

- Using MPLS VPN Mechanisms of Cisco IOS platforms
- Configuring an MP-BGP Session Between PE Routers
- Configuring VRF Tables
- Configuring Small-Scale Routing Protocols Between PE and CE routers
- Monitoring MPLS VPN Operations
- Configuring OSPF as the Routing Protocol Between PE and CE Routers
- Configuring BGP as the Routing Protocol between PE and CE Routers
- Troubleshooting MPLS VPNs

### Configuring Small-Scale Routing Protocols Between PE and CE Routers

- Configuring PE-CE Routing Protocols
- Selecting the VRF Routing Context for BGP
- Configuring Per-VRF Static Routes
- Configuring RIP PE-CE Routing
- Configuring EIGRP PE-CE Routing
- Configuring SOO for EIGRP PE-CE Loop Prevention

### Monitoring MPLS VPN Operations

- Monitoring VRFs
- Monitoring VRF Routing
- Monitoring MP-BGP Sessions
- Monitoring an MP-BGP VPNv4 Table
- Monitoring Per-VRF Cisco Express Forwarding and LFIB Structures
- Monitoring Labels Associated with VPNv4 Routes
- Identifying MPLS VPN Diagnostic Commands

### Configuring OSPF as the Routing Protocol Between PE and CE Routers

- OSPF Hierarchical Model
- OSPF in an MPLS VPN Routing Model
- OSPF Superbackbone-OSPF-BGP Hierarchy Issue
- OSPF in MPLS VPNs-Goals
- OSPF Superbackbone- Route Propagation Example
- OSPF Superbackbone- Rules
- OSPF Superbackbone- Implementation
- OSPF Superbackbone- External Routes
- OSPF Superbackbone- Mixing Routing Protocols
- Configuring PE-CE OSPF Routing
- Routing Loops Between MP-BGP and OSPF
- OSPF Down-Bit-Loop Prevention
- Optimizing of Packet Forwarding Across the MPLS VPN Backbone
- Routing Loops across OSPF Domains
- OSPF Tag Field-Operation
- OSPF Tag Field-Usage Guidelines
- OSPF Tag Field-Routing Loop Prevention
- Sham Link

- Separate Internet Access Benefits and Limitations
- Running an Internet Backbone in a VPN: Benefits and Limitations

### Introducing MPLS TE Components

- TE Concepts
- TE Motivations
- Business Drivers for TE
- Congestion Avoidance and TE
- TE with a Layer 2 Overlay Model
- Example of TE with a Layer 2 Overlay Model
- Drawbacks of the Layer 2 Overlay Solution
- Layer 3 Routing Model Without TE
- TE with a Layer 3 Routing Model
- MPLS TE Model
- MPLS TE Traffic Tunnels
- Traffic Tunnel Attributes
- Link Resource Attributes
- Constraint-Based Path Computation
- Example of Constraint-Based Path Computation (Bandwidth)
- MPLS TE Processes
- Role of RSVP in Path Setup Procedures
- Path Setup and Admission Control with RSVP
- Forwarding Traffic to a Tunnel
- Autoroute
- Autoroute Example

### Understanding MPLS TE Operations

- Attributes Used by Constraint-Based Path Computation
- MPLS TE Link Resource Attributes
- MPLS TE Link Resource Attributes: Maximum Bandwidth and Maximum Reservable Bandwidth
- MPLS TE Link Resource Attributes: Link Resource Class
- MPLS TE Link Resource Attributes: Constraint-Based Specific Link Metric (Administrative Weight)
- MPLS TE Tunnel Attributes
- MPLS TE Tunnel Attributes: Traffic Parameter and Generic Path Selection and Management
- MPLS TE Tunnel Attributes: Tunnel Resource Class Affinity
- MPLS TE Tunnel Attributes: Adaptability, Priority and Pre-emption
- MPLS TE Tunnel Attributes: Resilience
- Implementing TE Policies with Affinity Bits
- Using Affinity Bits in TE Policies
- Propagating MPLS TE Link Attributes with Link-State Routing Protocol
- Constraint-Based Path Computation
- Constraint-Based Path Computation: Path Selection
- Example of Constraint-Based Path Computation (resource Affinity)
- Path Setup
- RSVP Usage in Path Setup

## Configuring BGP as the Routing Protocol Between PE and CE Routers

- Configuring a Per-VRF BGP Routing Context
- Reasons for Limiting the Number of Routes in a VRF
- Limiting the Number of Prefixes Received from a BGP Neighbour
- Limiting the Total Number of VRF Routes
- Identifying AS-Override Issues
- AS-Override Implementation
- AS-Path Prepending
- Identifying the Allow-AS Issue
- Allow-AS in Implementation
- Implementing SOO for Loop Prevention

- Hop-by-Hop Path Setup with RSVP
- Tunnel and Link Admission Control
- Path Rerouting
- Path Reoptimization
- Path Rerouting: Link Failure
- Assigning Traffic to Traffic Tunnels
- Using Static Routing to Assign Traffic to a Traffic Tunnel
- Autoroute
- Autoroute: Path Selection Rules
- Autoroute: Default Metric
- Autoroute: Relative and Absolute Metric
- Forwarding Adjacency
- Forwarding Adjacency Traffic Flows

## Configuring MPLS TE on Cisco IOS Platforms

- MPLS TE Configuration Flow Chart
- Enabling Device-Level MPLS TE Support
- Enabling MPLS TE Support in IS-IS
- Enabling MPLS TE Support in OSPF
- Enabling Basic MPLS TE On an Interface
- Creating and Configuring a Traffic Tunnel
- Mapping Traffic into Tunnels with Autoroute

## Monitoring Basic MPLS TE on Cisco IOS Platforms

- Monitoring MPLS TE Tunnels
- show ip rsvpinterface Command
- show mpls traffic-eng tunnels brief commands
- Monitoring MPLS TE
- show mpls traffic-eng autoroute Command
- show ip cef Command

## Labs

- Discovery 1: Implement SP and Customer IP Addressing and IGP Routing
- Discovery 2: Verify Cisco Express Forwarding
- Discovery 3: Enable MPLS
- Discovery 4: Change IP TTL Propagation
- Discovery 5: Implement the Core MPLS Environment in the Service Provider Network
- Discovery 6: Configure MP-IBGP
- Discovery 7: Configure the VRF Instances
- Discovery 8: Configure RIP as a PE-CE Routing Protocol
- Discovery 9: Configure EIGRP as a PE-CE Routing Protocol
- Discovery 10: Implement EIGRP-Based MPLS VPNs
- Discovery 11: Configure OSPF as a PE-CE Routing Protocol
- Discovery 12: Implement OSPF-Based MPLS VPNs
- Discovery 13: Configure BGP as a PE-CE Routing Protocol
- Discovery 14: Implement BGP-Based MPLS VPNs
- Discovery 15: Configure a Central Services

VPN

- Discovery 16: Configure MPLS Traffic Engineering
- Discovery 17: Implement MPLS Traffic Engineering

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### Further Information:

For More information, or to book your course, please call us on Head Office Tel.: +974 40316639

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