

MPLST

Implementing Cisco MPLS Traffic Engineering and Other Features

Course Administration Guide

**For Student Guide
Version 2.0**

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Course Administration Guide

Overview

Service providers are faced with many challenges as they attempt to deal with customer demand, including a continuing need for value-added services. Conventional IP packet forwarding has several limitations. Traditional Layer 2 services and traffic engineering (TE) lack the flexibility to meet the demands of the modern network. More and more service providers realize that something else is needed. Not only must they be concerned with protecting their existing infrastructure, but they must find ways to generate new services that are not currently supportable with existing technologies.

Multiprotocol Label Switching (MPLS) is a high-performance method for forwarding packets through a network. It provides a foundation for a series of applications that integrate the performance and traffic management capabilities of the data link layer (Layer 2) with the scalability and flexibility of network layer (Layer 3) routing. This integration allows service providers the ability to support “value-added” features that are critical for their networks.

Implementing Cisco MPLS Traffic Engineering and Other Features (MPLST) v2.0 is an instructor-led training (ILT) course that extends the knowledge and skills that the learner has obtained from the MPLS Cisco CCIP™ certification track. The course duration is 5 days in length, using a standard ILT format. The course reflects the latest developments in network design and technologies, and uses real-world scenarios to help reinforce key objectives.

The MPLST course is recommended training for individuals who are seeking advanced MPLS-based knowledge and skills. The course will enable learners to gather information ranging from the technology basics to more updated features and functions such as MPLS Traffic Engineering (MPLS-TE), Fast Reroute (FRR), and Any Transport over MPLS (AToM). The focus of the course is on the technology issues of MPLS from a service provider perspective and how to configure some of the MPLS features and functions in an existing routed environment.

Course Version

This course is the first version of the MPLST course. It carries a label of “version 2.0” to keep it in synchrony with the current version of the *Implementing Cisco MPLS (MPLS) v2.0* course.

Objectives

Upon completing this course, the learner will be able to meet these overall objectives:

- Identify the MPLS peer-to-peer architecture and explain label allocation, routing update distribution, and packet forwarding as they relate to this architecture
- Use the Cisco IOS commands that are required to successfully configure, monitor, and troubleshoot service provider support using the MPLS Carrier Supporting Carrier service
- Identify the MPLS Traffic Engineering architecture and explain how MPLS implements traffic engineering, establishes the constraint-based path, and assigns traffic to traffic trunks
- Use the Cisco IOS commands that are required to successfully configure, monitor, and troubleshoot MPLS Traffic Engineering
- Use the Cisco IOS commands that are required to successfully implement a defined SLA using MPLS QoS services
- Use the Cisco IOS commands that are required to successfully configure, monitor, and troubleshoot Layer 2 services using the Any Transport over MPLS service
- Use the Cisco IOS commands that are required to successfully configure, monitor, and troubleshoot IPv6 support in an MPLS environment

Target Audience

The target audience for the MPLST course consists of network administrators and technicians responsible for implementing and troubleshooting basic IP multicast-enabled networks within a single domain, as well as Cisco CCNP[®], CCIP, CCDP[®], and CCIE[®] routing and switching candidates.

The course is also targeted at pre- and post-sales technical engineers who are responsible for designing, implementing, and troubleshooting MPLS networks or solutions that are based on MPLS technology.

Learner Skills and Knowledge

The prerequisite for learners who wish to participate in the MPLST course is the CCIP certification or an equivalent level of working knowledge and experience.

Practical experience with deploying and operating networks that are based on Cisco network devices and Cisco IOS software is strongly recommended.

Course Instruction Details

This section provides the information that you need to prepare the course materials and set up the classroom environment.

Instructor Certification Requirements

To teach this course, instructors must have attended the following training or completed the following requirements:

- Attended an MPLST Train-the-Trainer session

or

- Attended an MPLST ILT class

Note Submit questions concerning instructor certification to icad@external.cisco.com.

Classroom Reference Materials

These items should be available for the learner during presentation of the course:

- Access to the Cisco website

Class Environment

This information describes class size and classroom setup:

- The class is designed for 4 to 16 students.
- The class requires a standard lecture classroom with whiteboard and PowerPoint projection system.
- The classroom should contain 8 Windows-based PCs with Internet capability for access to remote lab equipment

Course Flow

This is the *suggested* course schedule. You may make adjustments based on the skills, knowledge, and preferences of the learners in attendance. The presentation of all topics *for noncertification offerings* is optional, but you are encouraged to use them because they are designed to reinforce the lesson concepts and ensure that learners apply some of the concepts.

Day 1: MPLS VPN Review and Carrier Supporting Carrier

	8:30–9:30	Course Introduction
MPLS VPN Review	9:30–12:00	Basic MPLS Concepts Label Distribution in Frame-Mode MPLS Configuring MPLS MPLS VPN Routing Model and Packet Forwarding Configuring Simple MPLS VPNs
	12:00–1:00	Lunch
Carrier Supporting Carrier	1:00–3:00	Carrier's Carrier Overview Implementing the CSC Models
Lab Exercise	3:00–5:00	Lab Exercise 2-1: Implementing CSC in a Native IP Environment
	5:00	Day ends

Day 2: Carrier Supporting Carrier and MPLS Traffic Engineering Technology

Lab Exercise	8:30–10:00	Lab Exercise 2-2: Implementing CSC Using LDP Label Distribution
Lab Exercise	10:00–11:00	Lab Exercise 2-3: Implementing CSC Using MP-BGP Label Distribution
Lab Exercise	11:00–12:00	Lab Exercise 2-4: Implementing CSC Using MPLS VPNs
	12:00–1:00	Lunch
MPLS Traffic Engineering Technology	1:00–5:00	Traffic Engineering Concepts MPLS Traffic Engineering Components Constraint-Based Path Computation Path Setup and Maintenance Assigning Traffic to Traffic Tunnels
	5:00	Day ends

Day 3: Configuring MPLS Traffic Engineering

	8:30–9:00	Review
Configuring MPLS Traffic Engineering	9:00–12:00	Configuring MPLS Traffic Engineering on Cisco IOS Platforms Advanced MPLS-TE Path Selection Advanced MPLS-TE Link Protection Advanced MPLS-TE Bandwidth Control MPLS-TE Interarea Support Monitoring and Troubleshooting MPLS-TE
	12:00–1:00	Lunch
Lab Exercise	1:00–4:00	Lab Exercise 4-1: Implementing MPLS Traffic Engineering
Lab Exercise	4:00–5:00	Lab Exercise 4-2: Implementing Link Protection for MPLS Traffic Engineering
	5:00	Day ends

Day 4: MPLS Quality of Service and Any Transport over MPLS

	8:30–9:00	Review
MPLS Quality of Service	9:00–10:30	QoS Models MPLS Support for DiffServ Configuring MPLS QoS QoS in MPLS Applications
Lab Exercise	10:30–12:00	Lab Exercise 5-1: Implementing MPLS QoS
	12:00–1:00	Lunch
Lab Exercise	1:00–2:00	Lab Exercise 5-2 Implementing MPLS QoS and DS-TE
Any Transport over MPLS	2:00–3:00	Introduction to Any Transport over MPLS Configuring AToM on Cisco IOS Platforms Monitoring AToM on Cisco IOS Platforms
Lab Exercise	3:00–4:00	Lab Exercise 6-1: Implementing a Port-to-Port FRoMPLS Configuration (Case Study)
Lab Exercise	4:00–5:00	Lab Exercise 6-2: Implementing a DLCI-to-DLCI FRoMPLS Configuration (Case Study)
	5:00	Day ends

Day 5: MPLS IPv6 Support

	8:30–9:00	Review
MPLS IPv6 Support	9:00–10:30	Review of IPv6 Implementing IPv6 over MPLS Monitoring IPv6 over MPLS
Lab Exercise	10:30–12:00	Lab Exercise 7-1: Implementing Cisco 6PE Support (Case Study)
	12:00–1:00	Lunch
	1:00–1:45	Wrap-up

High-Level Course Overview

This section provides a general idea of how the course is organized. The course contains these components:

- Course Introduction
- MPLS VPN Review
- Carrier Supporting Carrier
- MPLS Traffic Engineering Technology
- Configuring MPLS Traffic Engineering
- MPLS Quality of Service
- Any Transport over MPLS
- MPLS IPv6 Support
- Lab Guide
- Course Glossary

Detailed Course Overview

This in-depth outline of the course structure describes the objectives and content of each module.

Course Introduction

The Course Introduction provides learners with the course objectives, prerequisite learner skills and knowledge, and general administrative information. The Course Introduction presents the course roadmap and the icons used in the course illustrations and figures. This section also designates time for the learners to introduce themselves and describe their backgrounds, giving the instructor valuable information about the learners' knowledge and experience levels.

- Overview
- Course Objectives
- Cisco Certifications
- Learner Skills and Knowledge
- Learner Responsibilities
- General Administration
- Course Flow Diagram
- Icons and Symbols
- Learner Introductions

Module 1: MPLS VPN Review

This module reviews the features of MPLS and MPLS Virtual Private Networks (VPNs) that were covered in the *Implementing Cisco MPLS (MPLS)* course.

Lesson 1-1: Basic MPLS Concepts

This lesson reviews the basic concepts and architecture of MPLS. The lesson provides information about some of the MPLS components and labels. It lays the foundation for subsequent lessons that cover the key areas, such as MPLS Traffic Engineering (MPLS-TE) and Virtual Private Networks (VPNs). The lesson includes these topics:

- Basic MPLS Concepts
- MPLS Architecture
- MPLS Labels
- Label Switch Routers
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the elements of the MPLS conceptual model
- Identify the elements of the MPLS architecture
- Identify the function of the MPLS label
- Identify the different types of label switch routers

Lesson 1-2: Label Distribution in Frame-Mode MPLS

This lesson reviews MPLS label allocation in a frame-mode environment, and how distribution of labels works in this environment. Also reviewed are penultimate hop popping (PHP) and how the MPLS data structures are built. The lesson includes these topics:

- Label Allocation in a Frame-Mode MPLS Environment
- Label Distribution and Advertisement
- Populating the LFIB
- Packet Propagation Across an MPLS Network
- Penultimate Hop Popping
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify how label allocation is performed in a frame-mode MPLS network
- Identify how labels are distributed in a frame-node network
- Identify how the LFIB table is populated
- Identify packet propagation across an MPLS network
- Identify the function of penultimate hop popping

Lesson 1-3: Configuring MPLS

This lesson reviews the steps that are required to successfully implement MPLS. The lesson includes these topics:

- Configure IP CEF
- Configuring MPLS on a Frame-Mode Interface
- Configuring the MTU Size in Label Switching
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Enable IP CEF
- Enable MPLS on a frame-mode interface
- Configure the MTU size in label switching

Lesson 1-4: MPLS VPN Routing Model and Packet Forwarding

This lesson reviews the MPLS VPN architecture and operation. It details various customer edge-provider edge (CE-PE) routing options and Border Gateway Protocol (BGP) extensions (route targets and extended community attributes) that allow Interior Border Gateway Protocol (IBGP) to transport customer routes over a provider network. The MPLS VPN forwarding model is also covered together with its integration with core routing protocols. The lesson includes these topics:

- Propagation of Routing Information Across the P-Network
- Route Distinguishers
- Route Targets
- End-to-End Routing Information Flow
- MPLS VPNs and Packet Forwarding
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify how routing information is propagated across the P-network
- Identify the need for route distinguishers and how they are implemented
- Identify the need for route targets and how they are implemented
- Identify the end-to-end flow of routing updates in an MPLS VPN
- Describe MPLS VPN packet forwarding

Lesson 1-5: Configuring Simple MPLS VPNs

This lesson reviews the steps that are required to successfully implement a simple MPLS VPN. The lesson includes these topics:

- Configuring VRF Tables
- Configuring an MP-BGP Session Between PE Routers
- Configuring Routing Protocols Between PE and CE Routers
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Configure a VRF table
- Configure an MP-BGP session between PE routers
- Configure the routing protocols between PE and CE routers

Module Assessment

Module 2: Carrier Supporting Carrier

It is becoming common for larger service providers to act as the backbone for smaller service providers. This environment has classically been addressed with overlay VPNs. However, this solution has some serious scalability issues. Earlier attempts to address this environment with MPLS created several issues related to crossing service boundaries. The Carrier Supporting Carrier (CSC) feature was introduced to address these issues.

Lesson 2-1: Carrier's Carrier Overview

This lesson discusses the need for CSC and how MPLS provides this support. The lesson includes these topics:

- Carrier Supporting Carrier
- Benefits of CSC
- How CSC Works
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Describe the need for CSC
- Describe the benefits of CSC
- At an overview level, describe how CSC operates

Lesson 2-2: Implementing the CSC Models

This lesson identifies the different models that are used to implement CSC support and details the configuration steps that are necessary to implement each model. The lesson includes these topics:

- CSC Models
- Customer Carrier: Native IP
- Customer Carrier: MPLS and LDP
- Customer Carrier: MPLS and EBGp
- Customer Carrier: MPLS VPNs
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the CSC models
- Configure CSC to support customer carriers that are running native IP
- Configure CSC to support customer carriers that are running MPLS and LDP label distribution
- Configure CSC to support customer carriers that are running MPLS and MP-BGP label distribution
- Configure CSC to support customer carriers that are running MPLS VPNs

Module 3: MPLS Traffic Engineering Technology

This module on MPLS-TE discusses the requirement for TE in modern networks that must attain optimal resource utilization. The traffic-engineered tunnels provide a means of mapping traffic streams onto available networking resources in a way that prevents the overuse of subsets of networking resources while other subsets are underused. All the concepts and mechanics that support TE are presented, including tunnel path discovery with link-state protocols and tunnel path signaling with Resource Reservation Protocol (RSVP). Some of the advanced features of TE, such as autobandwidth and guaranteed bandwidth, are introduced as well.

Lesson 3-1: Traffic Engineering Concepts

This lesson describes the concepts that allow service providers to map traffic through specific routes to optimize network resources, especially the bandwidth. TE enables backbone networks to be engineered to deliver the total subscribed capacity to service provider customers more efficiently. The lesson includes these topics:

- What Is Traffic Engineering?
- Business Drivers for Traffic Engineering
- Congestion Avoidance and Traffic Engineering
- Traffic Engineering with a Layer 2 Overlay Model
- Traffic Engineering with a Layer 3 Model
- Traffic Engineering with the MPLS-TE Model
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the concepts behind TE
- Identify the major business drivers for implementing TE
- Identify congestion avoidance and how TE can reduce some congestion avoidance issues
- Identify how TE is implemented using a Layer 2 overlay model
- Identify how TE is implemented using a Layer 3 model
- Identify how TE is implemented using the MPLS-TE model

Lesson 3-2: MPLS Traffic Engineering Components

This lesson explains the components of MPLS-TE, such as traffic tunnels (along with associated characteristics and attributes), tunnel path discovery based on link-state protocols, and tunnel setup signaling with RSVP. The lesson includes these topics:

- Traffic Tunnels: Concepts
- Traffic Tunnels: Characteristics
- Traffic Tunnels: Attributes
- Network Links and Link Attributes
- Constraint-Based Path Computation
- Role of RSVP in Path Setup Procedures
- Forwarding Table Modifications
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify, at a conceptual level, how a traffic trunk functions
- Identify traffic trunk characteristics
- Identify traffic trunk attributes
- Identify the relation between network links and link attributes
- Identify the function of constraint-based path computation
- Identify the role of RSVP in path setup procedures
- Identify how using TE modifies the forwarding table mechanisms

Lesson 3-3: Constraint-Based Path Computation

This lesson describes the details of link attribute propagation with an Interior Gateway Protocol (IGP) protocol and constraint-based path computation. The lesson includes these topics:

- Constraint-Based Path Computation Attributes
- MPLS-TE Link Resource Attributes
- MPLS-TE Tunnel Attributes
- Implementing TE Policies with Affinity Bits
- Propagating MPLS-TE Link Attributes with Link-State Routing
- Constraint-Based Path Computation
- DiffServ-Aware TE Subpool
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the constraint-based path computation resource attributes
- Explain how MPLS-TE link attributes affect constraint-based path computation
- Explain how MPLS-TE tunnel attributes affect constraint-based path computation
- Identify how TE policies are implemented using affinity bits
- Identify how MPLS-TE link attributes are propagated with link-state routing protocols
- Describe the characteristics of constraint-based path computation as it relates to LSPs
- Describe the operation of the DiffServ-aware TE subpool as it relates to MPLS-TE

Lesson 3-4: Path Setup and Maintenance

This lesson describes the details of MPLS-TE tunnels, including path setup procedures and path maintenance. The lesson includes these topics:

- Path Setup
- RSVP Usage in Path Setup
- Hop-by-Hop Path Setup with RSVP
- Tunnel and Link Admission Control
- Path Rerouting
- Path Reoptimization
- Path Rerouting: Link Failure
- Path Adjustment with Autobandwidth
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify MPLS-TE path setup procedures
- Identify how RSVP is used in path setup
- Identify the process that RSVP uses to assist in MPLS-TE path setup
- Identify the functions of tunnel and link admission control
- Identify why LSP path rerouting is necessary
- Identify path reoptimization
- Identify how a path is rerouted as a result of link failure
- Identify how traffic tunnels are reoptimized and how the bandwidth requirement is adjusted

Lesson 3-5: Assigning Traffic to Traffic Tunnels

This lesson describes several well-known drawbacks of traditional IP routing: full-mesh requirements in the IP-over-ATM overlay model and lack of TE. The lesson includes these topics:

- Traffic Flow Modifications
- Static Routing Pointing to a Tunnel
- Solving the BGP Next-Hop Problem
- IP Forwarding Database Modification with Autoroute
- Autoroute Path Selection Rules
- Autoroute Examples
- Forwarding Adjacency
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the traffic flow modifications that are available with static routes and policy-based routing
- Identify how tunnel access is implemented using static routing pointing to a tunnel
- Identify how MPLS-TE solves the BGP next-hop problem
- Configure autoroute to modify the IP forwarding database
- Identify the autoroute path selection rules
- Identify what happens in certain autoroute situations
- Identify the function of forwarding adjacency as it relates to MPLS-TE

Module Assessment

Module 4: Configuring MPLS Traffic Engineering

This module discusses the requirement for implementing MPLS-TE in modern networks. It includes configuration of routers to enable basic traffic tunnels, assignment of traffic to a tunnel, control of path selection, and performance of tunnel protection and tunnel maintenance.

Lesson 4-1: Configuring MPLS Traffic Engineering on Cisco IOS Platforms

This lesson describes MPLS-TE commands for the implementation of MPLS traffic tunnels. The configuration commands that are needed to support MPLS-TE are explained, and sample setups presented. The lesson includes these topics:

- MPLS TE Configuration Road Map
- Enabling Device-Level MPLS-TE Support
- Enabling MPLS-TE on an Interface
- Enabling MPLS-TE Support in IS-IS
- Enabling MPLS-TE Support in OSPF
- Creating and Configuring a Traffic Tunnel
- Deploying Traffic Tunnels with Autoroute and Forwarding Adjacency
- Implementing MPLS-TE
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the tasks that are required to implement MPLS-TE
- Enable device-level MPLS-TE support
- Enable MPLS-TE on an interface
- Enable MPLS-TE support in an IS-IS environment
- Enable MPLS-TE support in an OSPF environment
- Create and configure a traffic tunnel
- Enable traffic tunnels with autoroute or forwarding adjacency

Lesson 4-2: Advanced MPLS-TE Path Selection

This lesson describes advanced MPLS-TE commands that are used in path selection. The configuration commands are accompanied by usage guidelines and sample setups. The lesson includes these topics:

- MPLS-TE Case Study
- Creating Dynamic Path Options for a Traffic Tunnel
- Creating Explicit Path Options for a Traffic Tunnel
- Assigning Traffic to Traffic Tunnels with Static Routes
- Configuring Periodic and Event-Triggered Optimization
- Configuring Path Selection Restrictions
- Modifying Administrative Weight
- Autoroute Forwarding Engine
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to use a case study to:

- Describe a typical MPLS-TE implementation
- Identify the command syntax to create dynamic path options for a traffic tunnel
- Identify the command syntax to create explicit path options for a traffic tunnel
- Identify the command syntax to assign traffic to traffic tunnels with static routes
- Identify the command syntax to configure periodic and event-triggered optimization
- Identify the command syntax to configure path selection restrictions
- Identify the command syntax to modify the administrative weight of a traffic tunnel
- Identify the command syntax to enable the autoroute forwarding engine

Lesson 4-3: Advanced MPLS-TE Link Protection

This lesson describes the advanced MPLS-TE commands for link protection. The configuration commands are accompanied by usage guidelines and sample setups. The lesson includes these topics:

- Improving Convergence Time
- Configuring Parallel Tunnels
- Drawbacks of Parallel Tunnels
- Fast Reroute
- Link Protection with FRR
- Node Protection with FRR
- Fast Reroute Configuration
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify issues that are related to improving convergence time in an MPLS-TE network
- Configure a typical parallel tunnel solution
- Identify the drawbacks of using parallel tunnels
- Identify the characteristics of the Fast Reroute feature
- Identify the characteristics of link protection with the Fast Reroute capability
- Identify the characteristics of node protection with the Fast Reroute capability
- Configure fast rerouting

Lesson 4-4: Advanced MPLS-TE Bandwidth Control

This lesson describes advanced MPLS-TE commands for bandwidth control. The configuration commands are accompanied by usage guidelines and sample setups. The lesson includes these topics:

- Bandwidth Reservation with Autobandwidth
- Autobandwidth Configuration Commands
- DiffServ-Aware Service
- DiffServ-Aware Service Configuration Commands
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the characteristics of bandwidth reservation with autobandwidth
- Configure the autobandwidth feature
- Identify the characteristics of the DiffServ-aware service
- Configure the DiffServ-aware service

Lesson 4-5: MPLS-TE Interarea Support

This lesson describes the advanced MPLS-TE topics and commands for interarea support. The configuration commands are accompanied by usage guidelines and sample setups. The lesson includes these topics:

- MPLS-TE Without Interarea Support
- Interarea MPLS-TE
- Interarea MPLS-TE Detailed Operation
- Interarea MPLS-TE Restoration
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Describe the characteristics of MPLS-TE without interarea support
- Describe how MPLS-TE provides interarea support
- Describe interarea MPLS-TE restoration

Lesson 4-6: Monitoring and Troubleshooting MPLS-TE

This lesson describes the monitoring and troubleshooting commands of Cisco IOS software that support MPLS-TE. The troubleshooting guidelines are explained by means of sample command outputs. The lesson includes these topics:

- Monitoring MPLS-TE Tunnels
- Monitoring MPLS-TE
- Monitoring MPLS-TE Resource Usage on Intermediate Devices
- Troubleshooting Device and Link Setup
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the command syntax that is used to monitor MPLS-TE tunnels
- Identify the command syntax that is used to monitor MPLS-TE
- Identify the command syntax that is used to monitor MPLS-TE resource usage on intermediate devices
- Identify the command syntax that is used to troubleshoot device and link setup

Module 5: MPLS Quality of Service

This module covers the concepts and features of MPLS quality of service (QoS) and presents techniques that network administrators can apply to help the service provider meet the service level agreements (SLAs) of customers. The module also covers how QoS is configured in various situations.

Lesson 5-1: QoS Models

This lesson describes the concepts, features, and techniques of QoS that are used within the service provider network. QoS tunneling modes are also discussed, as well as how Differentiated Services Code Point (DSCP) services are handled by MPLS. The lesson includes these topics:

- QoS Models
- The QoS Pendulum
- Integrated QoS Model
- Differentiated QoS Model
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the MPLS QoS models
- Identify the characteristics of the QoS pendulum
- Identify the characteristics of the integrated QoS model
- Identify the characteristics of the differentiated QoS model

Lesson 5-2: MPLS Support for DiffServ

This lesson describes the Differentiated Services (DiffServ) model, including how MPLS supports DiffServ. The lesson includes these topics:

- DiffServ Architecture
- DiffServ Model Features
- DiffServ PHBs and Recommended Codepoints
- DiffServ Scalability by Means of Aggregation
- MPLS Scalability by Means of Aggregation
- Marking MPLS Frames
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the characteristics of the DiffServ architecture
- Identify the features of the DiffServ model
- Identify the DiffServ PHBs and recommended codepoints
- Identify the characteristic of DiffServ scalability by means of aggregation
- Identify the characteristic of MPLS scalability by means of aggregation
- Identify how MPLS marks frames

Lesson 5-3: Configuring MPLS QoS

This lesson describes the configuration tool, Modular QoS CLI (MQC), which is used when applying the QoS parameters on a router. The lesson also discusses how to configure MPLS QoS, including configuration syntax and descriptions. The lesson includes these topics:

- How to Use the QoS Toolkit
- Configuring QoS in Cisco IOS Modular QoS CLI
- Configuring QoS in Cisco IOS MQC Abstractions
- Configuring QoS in Cisco IOS MQC Syntax
- MPLS QoS Configuration Case Study
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the features that are available in the QoS toolkit
- Identify the features of MQC
- Identify IOS QoS MQC abstractions
- Configure QoS in IOS MQC syntax

Lesson 5-4: QoS in MPLS Applications

This lesson focuses on how QoS is integrated in MPLS implementations. The lesson includes these topics:

- MPLS-TE with a Best-Effort Network
- MPLS-TE with a DiffServ Network
- MPLS DS-TE with a DiffServ Network
- QoS-Enabled MPLS VPNs
- QoS Implementation
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify how MPLS-TE is implemented in a best-effort network
- Identify how MPLS-TE is implemented in a DiffServ network
- Identify how MPLS DS-TE is implemented in a DiffServ network
- Identify how QoS is enabled in an MPLS VPN environment
- Identify some QoS implementation tasks

Module: Any Transport over MPLS

MPLS offers a set of advanced features to provide enhanced services. This module looks at one of the most recent supported features: Any Transport over MPLS (AToM). AToM provides transport of Layer 2 frames and cells over an MPLS network.

Lesson 6-1: Introduction to Any Transport over MPLS

There is an ever-increasing demand for the transport of Layer 2 and Layer 3 over a common backbone. This lesson introduces the MPLS application AToM. AToM allows an MPLS network to provide end-to-end transport for Layer 2 frames and cells. It provides support for Ethernet, PPP, High-Level Data Link Control (HDLC), Frame Relay, and ATM. The lesson includes these topics:

- AToM Overview
- Transport Types
- How AToM Works
- AToM Control Word
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Describe the benefits of AToM
- At a high level, describe how AToM transports different Layer 2 frame types and cells across an MPLS network
- Describe how AToM establishes end-to-end connectivity for a Layer 2 frame
- Describe the AToM control word

Lesson 6-2: Configuring AToM on Cisco IOS Platforms

While the configuration of AToM support is not complicated, network administrators must take care to ensure that the proper configuration tasks, parameters, and syntax are used. In addition, AToM provides commands to verify the operation of AToM. The lesson includes these topics:

- MTU Issues
- AToM Packet Forwarding with Summarization in the Core
- AToM Configuration
- EoMPLS Configuration
- PPP over MPLS Configuration
- HDLC over MPLS Configuration
- FRoMPLS Port Configuration
- AAL5 over MPLS Configuration
- ATM over MPLS Configuration
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the effects of AToM on the MTU
- Identify PE loopback summarization problems
- Enable AToM
- Enable a typical EoMPLS configuration
- Enable a typical PPP configuration
- Enable a typical HDLC configuration
- Enable a typical FRoMPLS configuration
- Enable a typical AAL5 over MPLS configuration
- Enable a typical ATM over MPLS configuration

Lesson 6-3: Monitoring AToM on Cisco IOS Platforms

While configuring AToM support is not complicated, network administrators must take care to ensure proper operation. This lesson describes the commands to verify the operation of AToM. The lesson includes these topics:

- Monitoring AToM
- `show mpls 12transport vc`
- `show mpls 12transport vc detail`
- `show mpls 12transport summary`
- `debug mpls 12transport vlan control`
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the commands that are available to monitor AToM operation.
- Identify the function, syntax, and output of the **show mpls 12transport vc** command.
- Identify the function, syntax, and output of the **show mpls 12transport vc summary** command.
- Identify the function, syntax, and output of the **show mpls 12transport vc detail** command.
- Identify the function, syntax, and output of the **debug mpls 12transport vlan control** command.

Module 7: MPLS IPv6 support

IP version 6 (IPv6) is becoming more and more accepted. To meet this market, MPLS has implemented support of IPv6 in several modes. This module discusses the different modes for implementing IPv6 in an MPLS environment and the necessary configuration effort.

Lesson 7-1: Review of IPv6

This lesson provides the learner with a brief review of IPv6 operation. The lesson includes these topics:

- The Benefits of Integrating IPv6
- IPv6 Technology Scope
- IPv6 Address Representation
- Hierarchical Addressing and Aggregation
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the benefits of integrating IPv6 into a network
- Compare IPv4 and IPv6 solutions
- Identify the need for a larger IP address space
- Identify the characteristics of an IPv6 address
- Identify how an IPv6 address is represented
- Identify the hierarchical addressing and aggregation scheme that is used by IPv6

Lesson7-2: Implementing IPv6 over MPLS

MPLS is deployed by many service providers in their IP version 4 (IPv4) networks. Service providers want to introduce IPv6 services to their customers, but changes to their existing IPv4 infrastructure can be expensive and the cost benefit for a small amount of IPv6 traffic does not make economic sense. Several integration scenarios have therefore been developed to leverage an existing IPv4 MPLS infrastructure and to add IPv6 services without requiring any changes to the network backbone. This lesson discusses their implementation. The lesson includes these topics:

- Benefits of Deploying IPv6 over MPLS Backbones
- IPv6 Using Tunnels on the Customer Edge Routers
- Deploying IPv6 Using Tunnels on the Customer Edge Routers
- IPv6 over a Circuit Transport over MPLS
- Deploying IPv6 over a Circuit Transport over MPLS
- IPv6 on the Provider Edge Routers (Cisco 6PE)
- Deploying Cisco 6PE
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the benefits of deploying IPv6 over MPLS backbones
- Identify the characteristics of an IPv6 model that uses tunnels on the customer edge routers
- Deploy IPv6 using tunnels on the customer edge routers
- Identify the characteristics of a model that deploys IPv6 over a circuit transport over MPLS
- Deploy IPv6 over a circuit transport over MPLS
- Identify the characteristics of an IPv6 model (Cisco 6PE) that uses the provider edge routers
- Deploy IPv6 on the provider edge routers

Lesson 7-3: Monitoring IPv6 over MPLS

The IPv6 models for using tunnels on CE routers and using IPv6 over a circuit transport over MPLS are implemented using existing IPv6 and AToM technologies. Therefore, these models use existing **show** and **debug** commands.

The Cisco 6PE model provides additional support over existing MPLS technology. Many of the existing MPLS **show** and **debug** commands are available to monitor Cisco 6PE operations (for information related to these operations, refer to the *Implementing Cisco MPLS (MPLS)* course). An additional set of 6PE-specific commands has also been provided. These commands will be discussed in this lesson.

The lesson includes these topics:

- Monitoring IPV6 Support
- show bgp ipv6 Command
- show bgp ipv6 neighbors Command
- show mpls forwarding-table Command
- show bgp ipv6 labels Command
- show ipv6 cef Command
- show ipv6 route Command
- Lesson Summary
- Lesson Review

After completing this lesson, the learner will be able to:

- Identify the commands that are available for monitoring IPv6 support
- Identify the syntax of the **show bgp ipv6** command and the important fields in its output
- Identify the syntax of the **show bgp ipv6 neighbors** command and the important fields in its output
- Identify the syntax of the **show mpls forwarding-table** command and the important fields in its output
- Identify the syntax of the **show bgp ipv6 labels** command and the important fields in its output
- Identify the syntax of the **show ipv6 cef** command and the important fields in its output
- Identify the syntax of the **show ipv6 route** command and the important fields in its output

Lab Equipment Configuration

The lab equipment for this course is divided into two 8-student labs that share a common Frame Relay and terminal server infrastructure. The two labs are logical mirror views of each other. The labs may be run independently to support two separate 8-student classes or in parallel to support a single 16-student class. The equipment configuration information is necessary for initial setup of the lab configuration.

Equipment List

This table lists the recommended equipment to support the lab exercises.

Lab Equipment List

Number of Units	Part Number	Product Description
2	CISCO3725 * Note	Cisco 3700 router (terminal server routers and Frame relay switch)
5	NM-8A/S	8-port sync interface (WAN interface for Frame Relay switch)
2	NM-32AS	32-port aysnc Interface for terminal server
5	CAB-OCTAL-ASYNC=	Terminal server cables

Note Cisco 3600s may be substituted for Cisco 3700s as the common equipment.

Lab 1 Equipment List

Number of Units	Part Number	Product Description
8	CISCO2610XM	Cisco 2600 router (CE routers)
9	CISCO3725	Cisco 3700 router (PE and P routers)
9	MEM3725-32U64CF	16- to 32-MB DRAM Flash upgrade for 3725
17	WIC-1T	WAN interface for CE, PE, and P routers
17	CAB-V35MT	WAN cable for CE, PE, and P routers to Frame Relay switch
17	CAB-V35FC	WAN cables for Frame Relay switch to router

Lab 2 Equipment List

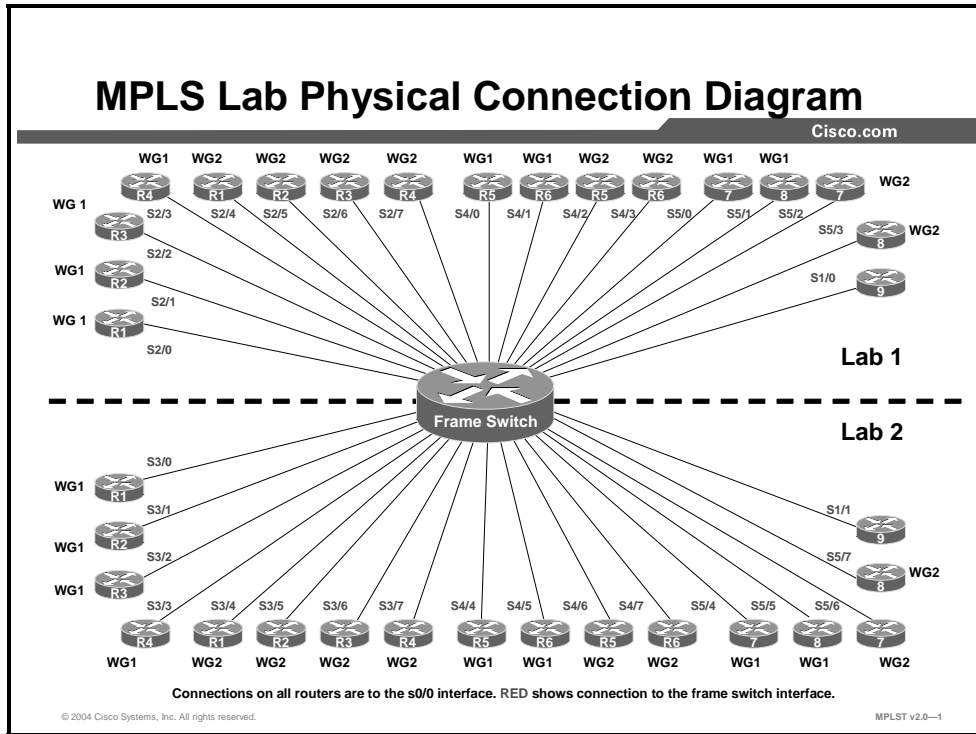
Number of Units	Part Number	Product Description
8	CISCO2610XM	Cisco 2600 router (CE routers)
9	CISCO3725	Cisco 3700 router (PE and P routers)
9	MEM3725-32U64CF	16- to 32-MB DRAM Flash upgrade for 3725
17	WIC-1T	WAN interface for CE, PE, and P routers
17	CAB-V35MT	WAN cable for CE, PE, and P routers to Frame Relay switch
17	CAB-V35FC	WAN cables for Frame Relay switch to routers

Lab Cisco IOS Image

Router	Image
CE	c2600-js-mz.122-10a.bin or later
PE	c3725-js-mz.122-15.t.bin or later
P	c3725-js-mz.122-15.t.bin or later
Frame Relay switch	c3660-js-mz.122-8.T5.bin or c3725-js-mz.122-15.t.bin or later

Lab Environment

This section contains the information about the lab setup, details of the physical and logical connectivity in the lab, and information on the addressing scheme and IGP routing. The class will be divided into workgroups. Each workgroup will have its own CE, PE, and P routers.



The names of all routers in your workgroup follow the naming convention that is presented in the figure.

Equipment Setup (Cabling)

These instructions describe how to cable the lab configuration.

- Step 1** Rack-mount all routers.
- Step 2** Connect each router to a router that is acting as a terminal server as indicated below.

Router Console Connections

Router ID	Type	Terminal Server Card	Terminal Server Port
Lab 1			
P1	3725	S1	0
WG1 R1	2610	S1	1
WG1 R2	2610	S1	2
WG1 R3	2610	S1	3
WG1 R4	2610	S1	4

Router ID	Type	Terminal Server Card	Terminal Server Port
WG2 R1	2610	S1	5
WG2 R1	2610	S1	6
WG2 R3	2610	S1	7
WG2 R4	2610	S1	8
WG1 R5	3725	S1	17
WG1 R6	3725	S1	18
WG2 R5	3725	S1	19
WG2 R6	3725	S1	20
WG1 R7	3725	S1	25
WG1 R8	3725	S1	26
WG2 R7	3725	S1	27
WG2 R8	3725	S1	28
R9	3275	S2	4

Lab 2

WG1 R1	2610	S1	9
WG1 R2	2610	S1	10
WG1 R3	2610	S1	11
WG1 R4	2610	S1	12
WG2 R1	2610	S1	13
WG2 R2	2610	S1	14
WG2 R3	2610	S1	15
WG2 R4	2610	S1	16
WG1 R5	3725	S1	21
WG1 R6	3725	S1	22
WG2 R5	3725	S1	23
WG2 R6	3725	S1	24
WG1 R7	3725	S1	29
WG1 R8	3725	S1	30
WG2 R7	3725	S1	31
WG2 R8	3725	S2	0
P1	3275	S2	3

Common Equipment

FRSW	3632	S2	1
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Step 3 Connect the first serial interface (S0/0) of each router to the router acting as the Frame Relay switch.

Router WAN Interface Connections

Router ID	Type	Frame Relay Card	Frame Relay Port
-----------	------	------------------	------------------

Lab 1

P1	3275	S1	0
WG1 R1	2610	S2	0
WG1 R2	2610	S2	1
WG1 R3	2610	S2	2
WG1 R4	2610	S2	3
WG2 R1	2610	S2	4
WG2 R1	2610	S2	5
WG2 R3	2610	S2	6
WG2 R4	2610	S2	7
WG1 R5	3725	S4	0
WG1 R6	3725	S4	1
WG2 R5	3725	S4	2
WG2 R6	3725	S4	3
WG1 R7	3725	S5	0
WG1 R8	3725	S5	1
WG2 R7	3725	S5	2
WG2 R8	3725	S5	3

Lab 2

P1	3275	S1	1
WG1 R1	2610	S2	0
WG1 R21	2610	S3	1
WG1 R3	2610	S3	2
WG1 R4	2610	S3	3
WG2 R1	2610	S3	4
WG2 R2	2610	S3	5
WG2 R3	2610	S3	6
WG2 R4	2610	S3	7
WG1 R5	3725	S4	4
WG1 R6	3725	S4	5
WG2 R5	3725	S4	6

Router ID	Type	Frame Relay Card	Frame Relay Port
WG2 R6	3725	S4	7
WG1 R7	3725	S5	4
WG1 R8	3725	S5	5
WG2 R7	3725	S5	6
WG2 R8	3725	S5	7

Equipment Setup (Terminal Server Configuration)

The following baseline configuration (click the link) is located in the Lab Configuration Files:

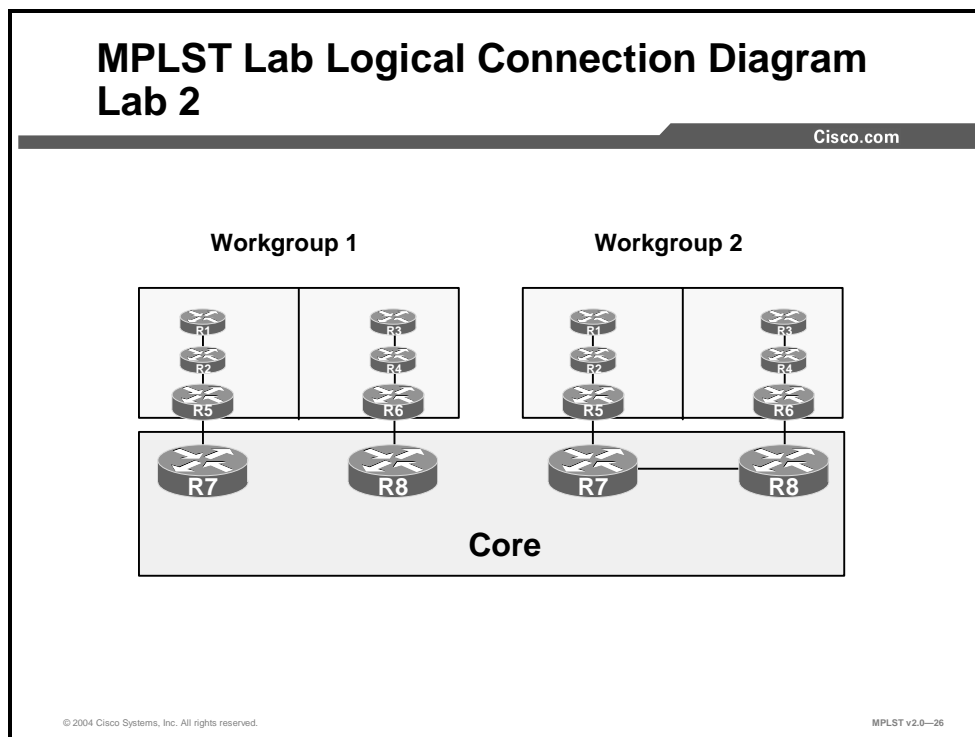
[Terminal Server Baseline Configuration File](#)

Equipment Setup (Baseline Configuration, Lab Exercise 2)

The following baseline configuration (click the link) is located in the Lab Configuration Files:

[Lab Exercise 2 Baseline Configuration](#)

Frame Relay Switch Configuration



Note Ensure that all frame-relay route statements have been cleared for the ports that are supporting the lab that you are using: Lab 1 – ports S0/1, s2/0 - 7, 4/0 - 3, and 5/0 – 3; Lab 2 – ports S1/1, s3/0 - 7, 4/4 -7, and 5/4 – 7.

Frame Relay Switch Baseline Configuration File

Click the links here for the following files:

- Lab 1
- Lab 2

Logical connectivity is provided by preconfigured permanent virtual circuits (PVCs).

The data-link connection identifier (DLCI) values refer to the learner lab guide.

Router Baseline Configuration Files

Click the links here for the following files:

Note These configurations are provided to the learner in the Lab Guide. It is left to the discretion of the instructor as to whether they should be loaded by the learner at the start of the lab or by the instructor before the learner starts the lab.

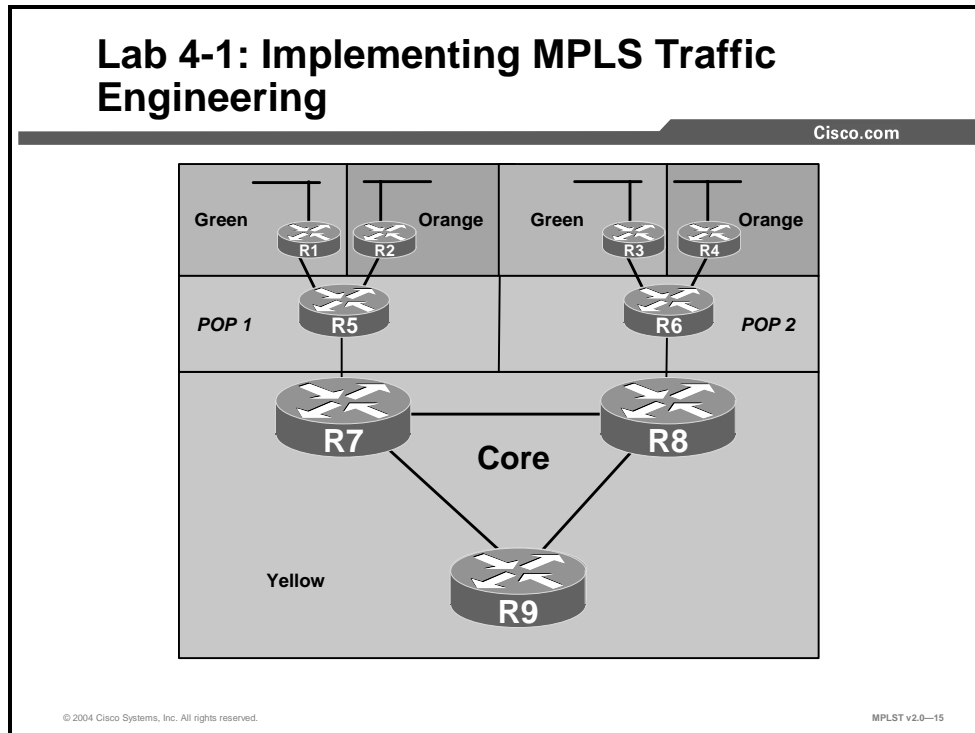
- R1 Baseline
- R2 Baseline
- R3 Baseline
- R4 Baseline
- R5 Baseline
- R6 Baseline
- R7 Baseline
- R8 Baseline

Equipment Setup (Baseline Configuration, Lab Exercise 4)

The following baseline configuration (click the link) is located in the Lab Configuration Files:

Lab Exercise 4 Baseline Configuration

Frame Relay Switch Configuration



Frame Relay Switch Baseline Configuration File

Note You must clear the frame-relay routes from Exercise 2 by loading the “clear” configuration before installing the routes for Exercise 4 using the “set” configuration.

- Lab 1 (click the links):
 - Clear Exercise 2 Frame Relay Routes
 - Set Exercise 4 Frame Relay Routes
- Lab 2 (click the links):
 - Clear Exercise 2 Frame Relay Routes
 - Set Exercise 4 Frame Relay Routes

Logical connectivity is provided by preconfigured PVCs.

The DLCI values refer to the learner lab guide.

Router Baseline Configuration Files

Click the links here for the following files:

Note These configurations are provided to the learner in the Lab Guide. It is left to the discretion of the instructor as to whether they should be loaded by the learner at the start of the lab or by the instructor before the learner starts the lab.

- R1 Baseline
- R2 Baseline
- R3 Baseline
- R4 Baseline
- R5 Baseline
- R6 Baseline
- R7 Baseline
- R8 Baseline
- R9 Baseline

Equipment Setup (Baseline Configuration, Lab Exercise 5)

The following baseline configuration (click the link) is located in the Lab Configuration Files:

[Lab Exercise 5 Baseline Configuration](#)

Frame Relay Switch Configuration

Note This lab uses the same Frame Relay configuration as Exercise 4.

Router Baseline Configuration Files

Click the links here for the following files:

Note These configurations are provided by the instructor for the purpose of recovery. They represent the configurations on the routers at the end of Exercise 4-1 and are therefore the starting configuration for this exercise.

- R1 Baseline
- R2 Baseline
- R3 Baseline
- R4 Baseline
- R5 Baseline
- R6 Baseline
- R7 Baseline
- R8 Baseline
- R9 Baseline

Teardown Procedures

These instructions describe how to clean up after completion of the class:

- Step 1** Erase the startup configurations on all CE, PE, and P routers.
- Step 2** Reload all CE, PE, and P routers.

Lab Configuration Files

Terminal Server Baseline

Note You will need to set your own password and default gateway.

Lab Exercise 2 Baseline

Frame Relay Switch Baseline

Lab 1 Configuration

```
en
conf t

hostname FrameSwitch

enable password slpm

frame-relay switching

ip cef

interface Serial1/0
  description Interface supporting R9 in lab 1
  bandwidth 128
  no ip address
  encapsulation frame-relay
  no fair-queue
  clockrate 128000
  shut

interface Serial2/0
  description Link to R1 router in lab 1 wg1
  bandwidth 128
  no ip address
  encapsulation frame-relay
  clockrate 128000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 101 interface Serial2/1 101
  no shut

interface Serial2/1
  description Link to R2 router in lab 1 wg1
  bandwidth 128
  no ip address
  encapsulation frame-relay
  clockrate 128000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 102 interface Serial4/0 102
  frame-relay route 101 interface Serial2/0 101
  no shut

interface Serial4/0
  description Link to R5 router in lab 1 wg1
  no ip address
  encapsulation frame-relay
```

```

clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial2/1 102
frame-relay route 111 interface Serial5/0 111
no shut

interface Serial5/0
description Link to R7 router in lab 1 wg1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/0 111
frame-relay route 112 interface Serial5/1 112
no shut

interface Serial5/1
description Link to R8 router in lab 1 wg1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/1 111
frame-relay route 112 interface Serial5/0 112
no shut

interface Serial4/1
description Link to R6 router in lab 1 wg1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial2/3 102
frame-relay route 111 interface Serial5/1 111
no shut

interface Serial2/3
description Link to all R4 router in lab 1 wg1
bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/1 102
frame-relay route 101 interface Serial2/2 101
no shut

interface Serial2/2
description Link to all R3 router in lab 1 wg1
bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce

```

```

frame-relay route 101 interface Serial2/3 101
no shut

interface Serial2/4
description Link to all R1 router in lab 1 wg2
bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial2/5 101
no shut

interface Serial2/5
description Link to R2 router in lab 1 wg2
bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/2 102
frame-relay route 101 interface Serial2/4 101
no shut

interface Serial4/2
description Link to R5 router in lab 1 wg2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial2/5 102
frame-relay route 111 interface Serial5/2 111
no shut

interface Serial5/2
description Link to R7 router in lab 1 wg2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/2 111
frame-relay route 112 interface Serial5/3 112
no shut

interface Serial5/3
description Link to R8 router in lab 1 wg2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/3 111
frame-relay route 112 interface Serial5/2 112
no shut

```

```

interface Serial4/3
  description Link to R6 router in lab 1 wg2
  no ip address
  encapsulation frame-relay
  clockrate 128000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 102 interface Serial2/7 102
  frame-relay route 111 interface Serial5/3 111
  no shut

interface Serial2/7
  description Link to R4 router in lab 1 wg2
  bandwidth 128
  no ip address
  encapsulation frame-relay
  clockrate 128000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 102 interface Serial4/3 102
  frame-relay route 101 interface Serial2/6 101
  no shut

interface Serial2/6
  description Link to R3 router in lab 1 wg2
  bandwidth 128
  no ip address
  encapsulation frame-relay
  clockrate 128000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 101 interface Serial2/7 101
  no shut

line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  login

exit

copy run start

```

Lab 2 Configuration

```

en
conf t

no service password-encryption

hostname FrameSwitch

enable password slpm

frame-relay switching

ip cef
interface Serial1/1
  description Interface supporting R9 in lab 2
  bandwidth 128

```

```

no ip address
encapsulation frame-relay
no fair-queue
clockrate 128000
no shut

interface Serial3/0
description Link to R1 router in lab 2 wg1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial3/1 101
no shut

interface Serial3/1
description Link to R2 router in lab 2 wg1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial3/0 101
no shut

interface Serial3/2
description Link to R3 router in lab 2 wg1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial3/3 101
no shut

interface Serial3/3
description Link to R4 router in lab 2 wg1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/5 102
frame-relay route 101 interface Serial3/2 101
no shut

interface Serial3/4
description Link to R1 router in lab 2 wg2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial3/5 101
no shut

interface Serial3/5
description Link to R2 router in lab 2 wg2
no ip address
encapsulation frame-relay

```

```

clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/6 102
frame-relay route 101 interface Serial3/4 101
no shut

interface Serial3/6
description Link to R3 router in lab 2 wg2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial3/7 101
no shut

interface Serial3/7
description Link to R4 router in lab 2 wg2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/7 102
frame-relay route 101 interface Serial3/6 101
no shut

interface Serial4/4
description Link to R5 router in lab 2 wg1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial3/1 102
frame-relay route 111 interface Serial5/4 111
no shut

interface Serial4/5
description Link to R6 router in lab 2 wg1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial3/3 102
frame-relay route 111 interface Serial5/5 111
no shut

interface Serial4/6
description Link to R5 router in lab 2 wg2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial3/5 102
frame-relay route 111 interface Serial5/6 111
no shut

```

```

interface Serial4/7
  description Link to all R6 router in lab 2 wg2
  no ip address
  encapsulation frame-relay
  clockrate 128000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 102 interface Serial3/7 102
  frame-relay route 111 interface Serial5/7 111
  no shut

interface Serial5/4
  description Link to R7 router in lab 2 wg1
  no ip address
  encapsulation frame-relay
  clockrate 128000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 111 interface Serial4/4 111
  frame-relay route 112 interface Serial5/5 112
  no shut

interface Serial5/5
  description Link to R8 router in lab 2 wg1
  no ip address
  encapsulation frame-relay
  clockrate 128000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 111 interface Serial4/5 111
  frame-relay route 112 interface Serial5/4 112
  no shut

interface Serial5/6
  description Link to R6 router in lab 2 wg2
  no ip address
  encapsulation frame-relay
  clockrate 128000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 111 interface Serial4/6 111
  frame-relay route 112 interface Serial5/7 112
  no shut

interface Serial5/7
  description Link to R8 in lab 2 wg2
  no ip address
  encapsulation frame-relay
  clockrate 128000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 111 interface Serial4/7 111
  frame-relay route 112 interface Serial5/6 112
  no shut

line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  login

```

```
exit

copy run start
```

Router Baselines

R1 Baseline

```
hostname R1

ip cef

interface Loopback0
 ip address 10.1.11.49 255.255.255.255

interface loopback11
 ip address 172.11.1.16 255.255.255.0

interface loopback12
 ip address 172.12.1.16 255.255.255.0

interface Serial0/0
 bandwidth 128000
 no ip address
 encapsulation frame-relay
 frame-relay lmi-type cisco
 no shut

interface Serial0/0.101 point-to-point
 description Link to R2
 ip address 10.1.11.129 255.255.255.240
 frame-relay interface-dlci 101

router ospf 1
 log-adjacency-changes
 router-id 10.1.11.49
 network 10.0.0.0 0.255.255.255 area 0

router bgp 65010
 no synchronization
 bgp log-neighbor-changes
 network 172.11.1.0 mask 255.255.255.0
 network 172.12.1.0 mask 255.255.255.0
 neighbor 10.1.12.49 remote-as 65010
 neighbor 10.1.12.49 update-source Loopback0
 no auto-summary

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
 no login
```

R2 Baseline

```
hostname R2

ip cef

interface Loopback0
 ip address 10.1.12.49 255.255.255.255

interface Serial0/0
 bandwidth 128000
 no ip address
 encapsulation frame-relay
 frame-relay lmi-type cisco
 no shut

interface Serial0/0.101 point-to-point
 description Link to R2
 ip address 10.1.11.130 255.255.255.240
 frame-relay interface-dlci 101

interface Serial0/0.102 point-to-point
 description Link to R5
 ip address 150.1.11.17 255.255.255.240
 frame-relay interface-dlci 102

router ospf 1
 log-adjacency-changes
 router-id 10.1.12.49
 network 10.0.0.0 0.255.255.255 area 0

router bgp 65010
 no synchronization
 bgp log-neighbor-changes
 neighbor 10.1.11.49 remote-as 65010
 neighbor 10.1.11.49 update-source Loopback0
 neighbor 10.1.11.49 route-reflector-client
 no auto-summary

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
 no login
```

R3 Baseline

```
hostname R3

ip cef

interface Loopback0
 ip address 10.2.11.49 255.255.255.255

interface loopback11
 ip address 172.11.2.16 255.255.255.0

interface loopback12
 ip address 172.12.2.16 255.255.255.0

interface Serial0/0
```

```

bandwidth 128000
no ip address
encapsulation frame-relay
frame-relay lmi-type cisco
no shut

interface Serial0/0.101 point-to-point
description Link to R4
ip address 10.2.11.129 255.255.255.240
frame-relay interface-dlci 101

router ospf 1
log-adjacency-changes
router-id 10.2.11.49
network 10.0.0.0 0.255.255.255 area 0

router bgp 65010
no synchronization
bgp log-neighbor-changes
network 172.11.2.0 mask 255.255.255.0
network 172.12.2.0 mask 255.255.255.0
neighbor 10.2.12.49 remote-as 65010
neighbor 10.2.12.49 update-source Loopback0
no auto-summary

line con 0
exec-timeout 999 0
logging synchronous
line aux 0
line vty 0 4
no login

```

R4 Baseline

```

hostname R4

ip cef

interface Loopback0
ip address 10.2.12.49 255.255.255.255

interface Serial0/0
bandwidth 128000
no ip address
encapsulation frame-relay
frame-relay lmi-type cisco
no shut

interface Serial0/0.101 point-to-point
description Link to R3
ip address 10.2.11.130 255.255.255.240
frame-relay interface-dlci 101

interface Serial0/0.102 point-to-point
description Link to R6
ip address 150.1.12.17 255.255.255.240
frame-relay interface-dlci 102

router ospf 1
log-adjacency-changes
router-id 10.2.12.49
network 10.0.0.0 0.255.255.255 area 0

```

```

router bgp 65010
  no synchronization
  bgp log-neighbor-changes
  neighbor 10.2.11.49 remote-as 65010
  neighbor 10.2.11.49 update-source Loopback0
  neighbor 10.2.11.49 route-reflector-client
no auto-summary
exit

line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  no login

```

R5 Baseline

```

hostname R5

ip cef

interface Loopback0
  ip address 192.168.1.17 255.255.255.255
  ip router isis

interface Serial0/0
  bandwidth 128000
  no ip address
  encapsulation frame-relay
  no fair-queue
  frame-relay lmi-type cisco
  no shut

interface Serial0/0.102 point-to-point
  desc link to R2
  ip address 150.1.11.18 255.255.255.240
  frame-relay interface-dlci 102

interface Serial0/0.111 point-to-point
  desc link to R7
  ip address 192.168.1.49 255.255.255.240
  ip router isis
  mpls label protocol ldp
  tag-switching ip
  frame-relay interface-dlci 111

router isis
  net 39.0440.0000.0000.0500
  metric-style wide

router bgp 65001
  no synchronization
  bgp log-neighbor-changes
  neighbor 192.168.1.33 remote-as 65001
  neighbor 192.168.1.33 update-source Loopback0
  no auto-summary

  address-family vpnv4
  neighbor 192.168.1.33 activate
  neighbor 192.168.1.33 next-hop-self

```

```

neighbor 192.168.1.33 send-community both
no auto-summary
exit-address-family
exit

line con 0
exec-timeout 999 0
logging synchronous
line aux 0
line vty 0 4
no login

```

R6 Baseline

```

hostname R6

ip cef

interface Loopback0
ip address 192.168.1.33 255.255.255.255
ip router isis

interface Serial0/0
bandwidth 128000
no ip address
encapsulation frame-relay
no fair-queue
frame-relay lmi-type cisco

interface Serial0/0.102 point-to-point
desc link to R4
ip address 150.1.12.18 255.255.255.240
frame-relay interface-dlci 102

interface Serial0/0.111 point-to-point
desc link to R8
ip address 192.168.1.65 255.255.255.240
ip router isis
mpls label protocol ldp
tag-switching ip
frame-relay interface-dlci 111

router isis
net 39.0440.0000.0000.0600
metric-style wide

router bgp 65001
no synchronization
bgp log-neighbor-changes
neighbor 192.168.1.17 remote-as 65001
neighbor 192.168.1.17 update-source Loopback0
no auto-summary

address-family vpnv4
neighbor 192.168.1.17 activate
neighbor 192.168.1.17 next-hop-self
neighbor 192.168.1.17 send-community both
no auto-summary
exit-address-family
exit

line con 0

```

```
exec-timeout 999 0
logging synchronous
line aux 0
line vty 0 4
login
```

R7 Baseline

```
hostname R7

ip cef

interface Loopback0
 ip address 192.168.1.81 255.255.255.255

interface Serial0/0
 no ip address
 bandwidth 128000
 encapsulation frame-relay
 no fair-queue
 frame-relay lmi-type cisco
 no shut

interface Serial0/0.111 point-to-point
 ip address 192.168.1.50 255.255.255.240
 ip router isis
 mpls label protocol ldp
 mpls ip
 frame-relay interface-dlci 111

interface Serial0/0.112 point-to-point
 ip address 192.168.1.113 255.255.255.240
 ip router isis
 mpls label protocol ldp
 mpls ip
 frame-relay interface-dlci 112
exit

router isis
 net 39.0440.0000.0000.0700
 metric-style wide

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
 no login
```

R8 Baseline

```
hostname R8

ip cef

interface Loopback0
 ip address 192.168.1.97 255.255.255.255
 ip router isis

interface Serial0/0
 bandwidth 128000
 no ip address
 encapsulation frame-relay
```

```

no fair-queue
frame-relay lmi-type cisco
!
interface Serial0/0.111 point-to-point
 ip address 192.168.1.66 255.255.255.240
 ip router isis
 mpls label protocol ldp
 tag-switching ip
 frame-relay interface-dlci 111
!
interface Serial0/0.112 point-to-point
 ip address 192.168.1.114 255.255.255.240
 ip router isis
 mpls label protocol ldp
 tag-switching ip
 frame-relay interface-dlci 112
router isis
 net 39.0440.0000.0000.0800
 metric-style wide
exit

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
 no login

```

Lab Exercise 4 Baseline Configurations

Frame Relay Switch Baseline Configuration File

Lab 1

Clear Exercise 2 Frame Relay Routes.

```

en
conf t

interface Serial2/0
 description Link to R1 router in lab 1 wg1
 no frame-relay route 101 interface Serial2/1 101
 shut

interface Serial2/1
 description Link to R2 router in lab 1 wg1
 no frame-relay route 102 interface Serial4/0 102
 no frame-relay route 101 interface Serial2/0 101
 shut

interface Serial4/0
 description Link to R5 router in lab 1 wg1
 no frame-relay route 102 interface Serial2/1 102
 no frame-relay route 111 interface Serial5/0 111
 shut

interface Serial5/0
 description Link to R7 router in lab 1 wg1
 no frame-relay route 111 interface Serial4/0 111
 no frame-relay route 112 interface Serial5/1 112
 shut

```

```

interface Serial5/1
  description Link to R8 router in lab 1 wg1
  no frame-relay route 111 interface Serial4/1 111
  no frame-relay route 112 interface Serial5/0 112
  shut

interface Serial4/1
  description Link to R6 router in lab 1 wg1
  no frame-relay route 102 interface Serial2/3 102
  no frame-relay route 111 interface Serial5/1 111
  shut

interface Serial2/3
  description Link to all R4 router in lab 1 wg1
  no frame-relay route 102 interface Serial4/1 102
  no frame-relay route 101 interface Serial2/2 101
  shut

interface Serial2/2
  description Link to all R3 router in lab 1 wg1
  no frame-relay route 101 interface Serial2/3 101
  shut

interface Serial2/4
  description Link to all R1 router in lab 1 wg2
  no frame-relay route 101 interface Serial2/5 101
  shut

interface Serial2/5
  no frame-relay route 102 interface Serial4/2 102
  no frame-relay route 101 interface Serial2/4 101
  shut

interface Serial4/2
  no frame-relay route 102 interface Serial2/5 102
  no frame-relay route 111 interface Serial5/2 111
  shut

interface Serial5/2
  description Link to R7 router in lab 1 wg2
  no frame-relay route 111 interface Serial4/2 111
  no frame-relay route 112 interface Serial5/3 112
  shut

interface Serial5/3
  description Link to R8 router in lab 1 wg2
  no frame-relay route 111 interface Serial4/3 111
  no frame-relay route 112 interface Serial5/2 112
  shut

interface Serial4/3
  description Link to R6 router in lab 1 wg2
  no frame-relay route 102 interface Serial2/7 102
  no frame-relay route 111 interface Serial5/3 111
  shut

interface Serial2/7
  description Link to R4 router in lab 1 wg2

```

```

no frame-relay route 102 interface Serial4/3 102
no frame-relay route 101 interface Serial2/6 101
shut

interface Serial2/6
description Link to R3 router in lab 1 wg2
bandwidth 128
no frame-relay route 101 interface Serial2/7 101
shut

end

copy run start

```

Set Exercise 4 Frame Relay Routes

```

en
conf t

no service password-encryption

hostname FrameSwitch

enable password slpm

frame-relay switching

ip cef

interface Serial1/0
description Interface supporting R9 in lab 1
bandwidth 128
no ip address
encapsulation frame-relay
no fair-queue
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 211 interface Serial5/0 211
frame-relay route 212 interface Serial5/1 212
frame-relay route 221 interface Serial5/2 221
frame-relay route 222 interface Serial5/3 222
no shut

interface Serial2/0
description Link to wg 1 R1 router in lab 1
bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial4/0 101
no shut

interface Serial2/1
description Link to wg 1 R2 router in lab 1
bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco

```

```

frame-relay intf-type dce
frame-relay route 102 interface Serial4/0 102
no shut

interface Serial2/2
description Link to all wg 1 R3 router in lab 1
bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial4/1 101
no shut

interface Serial2/3
description Link to all wg 1 R4 router in lab 1
bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/1 102
no shut

interface Serial2/4
description Link to all wg 2 R1 router in lab 1
bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial4/2 101
no shut

interface Serial2/5
description Link to wg 2 R2 router in lab 1
bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/2 102
no shut

interface Serial2/6
description Link to wg 2 R3 router in lab 1
bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial4/3 101
no shut

interface Serial2/7
description Link to wg 2 R4 router in lab 1

```

```

bandwidth 128
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/3 102
no shut

interface Serial4/0
description Link to wg 1 R5 router in lab 1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial2/0 101
frame-relay route 102 interface Serial2/1 102
frame-relay route 111 interface Serial5/0 111
no shut

interface Serial4/1
description Link to wg 1 R6 router in lab 1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial2/2 101
frame-relay route 102 interface Serial2/3 102
frame-relay route 111 interface Serial5/1 111
no shut

interface Serial4/2
description Link to wg 2 R5 router in lab 1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial2/4 101
frame-relay route 102 interface Serial2/5 102
frame-relay route 111 interface Serial5/2 111
no shut

interface Serial4/3
description Link to wg 2 R6 router in lab 1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial2/6 101
frame-relay route 102 interface Serial2/7 102
frame-relay route 111 interface Serial5/3 111
no shut

interface Serial5/0

```

```

description Link to wg 1 R7 router in lab 1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/0 111
frame-relay route 112 interface Serial5/1 112
frame-relay route 211 interface Serial1/0 211
no shut

interface Serial5/1
description Link to wg 1 R8 router in lab 1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/1 111
frame-relay route 112 interface Serial5/0 112
frame-relay route 212 interface Serial1/0 212
no shut

interface Serial5/2
description Link to wg 2 R7 router in lab 1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/2 111
frame-relay route 112 interface Serial5/3 112
frame-relay route 221 interface Serial1/0 221
no shut

interface Serial5/3
description Link to wg 2 R8 router in lab 1
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/3 111
frame-relay route 112 interface Serial5/2 112
frame-relay route 222 interface Serial1/0 222
no shut

line con 0
exec-timeout 999 0
logging synchronous
line aux 0
line vty 0 4
login

exit

copy run start

```

Lab 2

Clear Exercise 2 Frame Relay Routes

```
en
conf t

interface Serial3/0
description Link to R1 router in lab 2 wg1
no frame-relay route 101 interface Serial3/1 101
shut

interface Serial3/1
description Link to R2 router in lab 2 wg1
no frame-relay route 101 interface Serial3/0 101
shut

interface Serial3/2
description Link to R3 router in lab 2 wg1
no frame-relay route 101 interface Serial3/3 101
shut

interface Serial3/3
description Link to R4 router in lab 2 wg1
no frame-relay route 102 interface Serial4/5 102
no frame-relay route 101 interface Serial3/2 101
shut

interface Serial3/4
description Link to R1 router in lab 2 wg2
no frame-relay route 101 interface Serial3/5 101
shut

interface Serial3/5
description Link to R2 router in lab 2 wg2
no frame-relay route 102 interface Serial4/6 102
no frame-relay route 101 interface Serial3/4 101
shut

interface Serial3/6
description Link to R3 router in lab 2 wg2
no frame-relay route 101 interface Serial3/7 101
shut

interface Serial3/7
description Link to R4 router in lab 2 wg2
no frame-relay route 102 interface Serial4/7 102
no frame-relay route 101 interface Serial3/6 101
shut

interface Serial4/4
description Link to R5 router in lab 2 wg1
no frame-relay route 102 interface Serial3/1 102
no frame-relay route 111 interface Serial5/4 111
shut

interface Serial4/5
description Link to R6 router in lab 2 wg1
no frame-relay route 102 interface Serial3/3 102
no frame-relay route 111 interface Serial5/5 111
```

```

shut

interface Serial4/6
description Link to R5 router in lab 2 wg2
no frame-relay route 102 interface Serial3/5 102
no frame-relay route 111 interface Serial5/6 111
shut

interface Serial4/7
description Link to all R6 router in lab 2 wg2
no frame-relay route 102 interface Serial3/7 102
no frame-relay route 111 interface Serial5/7 111
shut

interface Serial5/4
description Link to R7 router in lab 2 wg1
no frame-relay route 111 interface Serial4/4 111
no frame-relay route 112 interface Serial5/5 112
shut

interface Serial5/5
description Link to R8 router in lab 2 wg1
no frame-relay route 111 interface Serial4/5 111
no frame-relay route 112 interface Serial5/4 112
shut

interface Serial5/6
description Link to R6 router in lab 2 wg2
no frame-relay route 111 interface Serial4/6 111
no frame-relay route 112 interface Serial5/7 112
shut

interface Serial5/7
description Link to R8 in lab 2 wg2
no frame-relay route 111 interface Serial4/7 111
no frame-relay route 112 interface Serial5/6 112
shut

end
copy run start

```

Set Exercise 4 Frame Relay Routes

```

en
conf t

no service password-encryption

hostname FrameSwitch

enable password slpm

frame-relay switching

ip cef
interface Serial1/1
description Interface supporting R9 in lab 2
bandwidth 128
no ip address
encapsulation frame-relay
no fair-queue
clockrate 128000

```

```

frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 211 interface Serial5/4 211
frame-relay route 212 interface Serial5/5 212
frame-relay route 221 interface Serial5/6 221
frame-relay route 222 interface Serial5/7 222
no shut

interface Serial3/0
description Link to wg 1 R1 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial4/4 101
no shut

interface Serial3/1
description Link to wg 1 R2 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/4 102
no shut

interface Serial3/2
description Link to wg 1 R3 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial4/5 101
no shut

interface Serial3/3
description Link to wg 1 R4 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/5 102
no shut

interface Serial3/4
description Link to wg 2 R1 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial4/6 101
no shut

interface Serial3/5
description Link to wg 2 R2 router in lab 2
no ip address

```

```

encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/6 102
no shut

interface Serial3/6
description Link to wg R3 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial4/7 101
no shut

interface Serial3/7
description Link to wg 2 R4 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 102 interface Serial4/7 102
no shut

interface Serial4/4
description Link to wg 1 R5 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial3/0 101
frame-relay route 102 interface Serial3/1 102
frame-relay route 111 interface Serial5/4 111
no shut

interface Serial4/5
description Link to wg 1 R6 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial3/2 101
frame-relay route 102 interface Serial3/3 102
frame-relay route 111 interface Serial5/5 111
no shut

interface Serial4/6
description Link to wg 2 R5 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial3/4 101
frame-relay route 102 interface Serial3/5 102
frame-relay route 111 interface Serial5/6 111

```

```

no shut

interface Serial4/7
description Link to all wg 2 R6 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 101 interface Serial3/6 101
frame-relay route 102 interface Serial3/7 102
no shut

interface Serial5/4
description Link to wg 1 R7 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/4 111
frame-relay route 112 interface Serial5/5 112
frame-relay route 211 interface Serial1/1 211
no shut

interface Serial5/5
description Link to wg 1 R8 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/5 111
frame-relay route 112 interface Serial5/4 112
frame-relay route 212 interface Serial1/1 212
no shut

interface Serial5/6
description Link to wg 2 R7 router in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/6 111
frame-relay route 112 interface Serial5/7 112
frame-relay route 221 interface Serial1/1 221
no shut

interface Serial5/7
description Link to wg 2 R8 in lab 2
no ip address
encapsulation frame-relay
clockrate 128000
frame-relay lmi-type cisco
frame-relay intf-type dce
frame-relay route 111 interface Serial4/7 111
frame-relay route 112 interface Serial5/6 112
frame-relay route 222 interface Serial1/1 222
no shut

```

```
line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  login

exit

copy run start
```

Router Baseline Configuration Files

Note The variable `wg` must be replaced with the appropriate workgroup number.

R1 Baseline

```
en

conf t

hostname R1

interface Loopback0
  ip address 10.1.1.49 255.255.255.255

interface Loopback10
  ip address 10.1.1.17 255.255.255.240

interface Loopback20
  ip address 10.1.1.65 255.255.255.240

interface Serial0/0
  no ip address
  bandwidth 128000
  encapsulation frame-relay
  frame-relay lmi-type cisco
  no shut

interface Serial0/0.101 point-to-point
  description Link to R5
  ip address 150.wg.1.17 255.255.255.240
  frame-relay interface-dlci 101
  no shut

router ospf 1
  network 150.wg.0.0 0.0.255.255 area 0
  network 10.1.1.49 0.0.0.0 area 0
  network 10.1.1.16 0.0.0.15 area 1
  network 10.1.wg1.64 0.0.0.15 area 1
  redistribute bgp 65011 subnets
  exit

router bgp 65011
  nei 150.wg.1.18 remote-as 65001
  no auto-summary
  redistribute ospf 1
  exit
```

```
line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  no login

exit
exit
copy run start
```

R2 Baseline

```
ena
conf t

hostname R2

interface Loopback0
  ip address 10.2.1.49 255.255.255.255

interface Loopback10
  ip address 10.2.1.17 255.255.255.240

interface Loopback20
  ip address 10.2.1.65 255.255.255.240

interface Serial0/0
  no ip address
  bandwidth 128000
  encapsulation frame-relay
  no fair-queue
  frame-relay lmi-type cisco
  no shut

interface Serial0/0.102 point-to-point
  desc link to R5
  ip address 150.wg.1.33 255.255.255.240
  frame-relay interface-dlci 102

router ospf 2
  network 150.wg.0.0 0.0.255.255 area 0
  network 10.2.1.49 0.0.0.0 area 0
  network 10.2.1.16 0.0.0.15 area 1
  redistribute bgp 65012 subnets
exit

router bgp 65012
  nei 150.wg.1.34 remote-as 65001
  no auto-summary
  redistribute ospf 2

line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  no login
exit
exit
copy run start
```

R3 Baseline

```
en

conf t

hostname R3

interface Loopback0
 ip address 10.1.2.49 255.255.255.255

interface Loopback10
 ip address 10.1.2.17 255.255.255.240

interface Loopback20
 ip address 10.1.2.65 255.255.255.240

interface Serial0/0
 no ip address
 bandwidth 128000
 encapsulation frame-relay
 frame-relay lmi-type cisco
 no shut

interface Serial0/0.101 point-to-point
 no desc link to R8
 ip address 150.wg.2.17 255.255.255.240
 frame-relay interface-dlci 101
 no shut

router ospf 1
 network 150.wg.0.0 0.0.255.255 area 0
 network 10.1.2.49 0.0.0.0 area 0
 network 10.1.2.16 0.0.0.15 area 1
 redistribute bgp 65011 subnets
 exit

router bgp 65011
 nei 150.wg.2.18 remote-as 65001
 no auto-summary
 redistribute ospf 1
 exit

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
 no login
!
exit
exit
copy run start
```

R4 Baseline

```
ena
conf t

hostname R4

interface Loopback0
 ip address 10.2.2.49 255.255.255.255

interface Loopback10
 ip address 10.2.2.17 255.255.255.240

interface Loopback20
 ip address 10.2.2.65 255.255.255.240

interface Serial0/0
 no ip address
 bandwidth 128000
 encapsulation frame-relay
 no fair-queue
 frame-relay lmi-type cisco
 no shut

interface Serial0/0.102 point-to-point
 desc link to R5
 ip address 150.wg.2.33 255.255.255.240
 frame-relay interface-dlci 102

router ospf 2
 network 150.wg.0.0 0.0.255.255 area 0
 network 10.2.2.49 0.0.0.0 area 0
 network 10.2.2.16 0.0.0.15 area 1
 redistribute bgp 65012 subnets
 exit

router bgp 65012
 nei 150.wg.2.34 remote-as 65001
 no auto-summary
 redistribute ospf 2
 exit

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
 no login
exit
exit
copy run start
```

R5 Baseline

```
en

conf t

hostname R5

ip cef
```

```

ip vrf Green
  rd wg:10
  route-target both wg:10
exit

ip vrf Orange
  rd wg:20
  route-target both wg:20
exit

interface Loopback0
  ip address 192.168.wg.17 255.255.255.255
  ip router isis

interface Serial0/0
  no ip address
  bandwidth 128000
  encapsulation frame-relay
  no fair-queue
  frame-relay lmi-type cisco
  no shut

interface Serial0/0.101 point-to-point
  ip vrf forwarding Green
  ip address 150.wg.1.18 255.255.255.240
  frame-relay interface-dlci 101

interface Serial0/0.102 point-to-point
  ip vrf forwarding Orange
  ip address 150.wg.1.34 255.255.255.240
  frame-relay interface-dlci 102

interface Serial0/0.111 point-to-point
  ip address 192.168.wg.49 255.255.255.240
  ip router isis
  mpls label protocol ldp
  mpls ip
  frame-relay interface-dlci 111

router isis
  net 39.0440.0000.0000.wg500
  metric-style wide
exit

router bgp 65001
  no synchronization
  neighbor 192.168.wg.33 remote-as 65001
  neighbor 192.168.wg.33 update-source Loopback0
  no auto-summary
  address-family vpnv4
    neighbor 192.168.wg.33 activate
    neighbor 192.168.wg.33 next-hop-self
    neighbor 192.168.wg.33 send-community both
    no auto-summary
  exit

  address-family ipv4 vrf Orange
    nei 150.wg.1.33 remote-as 65012
    nei 150.wg.1.33 activate
    nei 150.wg.1.33 as-override
    no auto-summary

```

```

    no synchronization
    exit

    address-family ipv4 vrf Green
    nei 150.wg.1.17 remote-as 65011
    nei 150.wg.1.17 activate
    nei 150.wg.1.17 as-override
    no auto-summary
    exit

exit

line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  no login

exit
exit

copy run start

```

R6 Baseline

```

ena
conf t

hostname R6

ip cef

ip vrf Green
  rd wg:10
  route-target both wg:10
exit

ip vrf Orange
  rd wg:20
  route-target both wg:20
exit

interface Loopback0
  ip address 192.168.wg.33 255.255.255.255
  ip router isis
!

interface Serial0/0
  no ip address
  bandwidth 128000
  encapsulation frame-relay
  no fair-queue
  frame-relay lmi-type cisco
  no shut

interface Serial0/0.101 point-to-point
  ip vrf forwarding Green
  ip address 150.wg.2.18 255.255.255.240
  frame-relay interface-dlci 101

interface Serial0/0.102 point-to-point

```

```

ip vrf forwarding Orange
ip address 150.wg.2.34 255.255.255.240
frame-relay interface-dlci 102

interface Serial0/0.111 point-to-point
ip address 192.168.wg.65 255.255.255.240
ip router isis
mpls label protocol ldp
mpls ip
frame-relay interface-dlci 111

interface FastEthernet0/1
no ip address
shutdown
duplex auto
speed auto
no cdp enable

router isis
net 39.0440.0000.0000.wg600
metric-style wide
exit

router bgp 65001
no synchronization
neighbor 192.168.wg.17 remote-as 65001
neighbor 192.168.wg.17 update-source Loopback0
no auto-summary

address-family vpnv4
neighbor 192.168.wg.17 activate
neighbor 192.168.wg.17 next-hop-self
neighbor 192.168.wg.17 send-community both
no auto-summary
exit-address-family

address-family ipv4 vrf Orange
neighbor 150.wg.2.33 remote-as 65012
neighbor 150.wg.2.33 activate
neighbor 150.wg.2.33 as-override
no auto-summary
no synchronization
exit-address-family

address-family ipv4 vrf Green
neighbor 150.wg.2.17 remote-as 65011
neighbor 150.wg.2.17 activate
neighbor 150.wg.2.17 as-override
no auto-summary
no synchronization
exit-address-family
exit

line con 0
exec-timeout 999 0
logging synchronous
line aux 0
line vty 0 4
no login

```

R7 Baseline

```
exit
exit
copy run start

en

conf t

hostname R7

ip cef

interface Loopback0
 ip address 192.168.wg.81 255.255.255.255
 ip router isis

interface Serial0/0
 no ip address
 bandwidth 128000
 encapsulation frame-relay
 no fair-queue
 frame-relay lmi-type cisco
 no shut

interface Serial0/0.111 point-to-point
 ip address 192.168.wg.50 255.255.255.240
 ip router isis
 mpls label protocol ldp
 mpls ip
 frame-relay interface-dlci 111

interface Serial0/0.112 point-to-point
 ip router isis
 ip address 192.168.wg.113 255.255.255.240
 mpls label protocol ldp
 mpls ip
 frame-relay interface-dlci 112

int s0/0.2wg1 point-to-point
 ip address 192.168.wg.129 255.255.255.248
 ip router isis
 mpls ip
 mpls label protocol ldp
 frame-relay interface-dlci 2wg1
 no shut

router isis
 net 39.0440.0000.0000.wg700
 metric-style wide

exit

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
```

```
no login

exit
exit

copy run start
```

R8 Baseline

```
ena
conf t

hostname R8

ip cef

interface Loopback0
 ip address 192.168.wg.97 255.255.255.255
 ip router isis

interface Serial0/0
 no ip address
 bandwidth 128000
 encapsulation frame-relay
 no fair-queue
 frame-relay lmi-type cisco
 no shut

interface Serial0/0.111 point-to-point
 ip address 192.168.wg.66 255.255.255.240
 ip router isis
 mpls label protocol ldp
 mpls ip
 frame-relay interface-dlci 111

interface Serial0/0.112 point-to-point
 ip address 192.168.wg.114 255.255.255.240
 ip router isis
 mpls label protocol ldp
 mpls ip
 frame-relay interface-dlci 112

int s0/0.2wg2 point-to-point
 ip address 192.168.wg.145 255.255.255.248
 ip router isis
 mpls ip
 mpls label protocol ldp
 frame-relay interface-dlci 2wg2
 no shut

router isis
 net 39.0440.0000.0000.wg800
 metric-style wide

exit

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
```

```
no login
exit
exit
copy run start
```

R9 Baseline

```
en

conf t

hostname R9

enable password slpm

ip cef
mpls traffic-eng tunnels
mpls traffic-eng logging lsp setups
mpls traffic-eng reoptimize timers frequency 30

class-map match-all BUSINESS-MPLS
  match mpls experimental topmost 1 2
class-map match-all PREMIUM-MPLS
  match mpls experimental topmost 5

policy-map OUT-POLICY
  class PREMIUM-MPLS
    priority percent 5
  class BUSINESS-MPLS
    bandwidth percent 50
  random-detect
  random-detect precedence 1 100 300 100
  random-detect precedence 2 300 500 10
  class class-default
    fair-queue
    random-detect

map-class frame-relay FRAME-OUT
  frame-relay cir 128000
  frame-relay mincir 128000
  service-policy output OUT-POLICY

interface Loopback0
  ip address 192.168.10.17 255.255.255.255
  ip router isis

interface Serial0/0
  no ip address
  encapsulation frame-relay
  no fair-queue
  frame-relay lmi-type cisco
  ip rsvp bandwidth 128 128
  no shut

interface Serial0/0.211 point-to-point
  desc link to R7 in wg 1
  ip address 192.168.1.130 255.255.255.248
  ip router isis
  mpls label protocol ldp
  tag-switching ip
  mpls traffic-eng tunnels
  ip rsvp bandwidth 128 128
```

```

    frame-relay class FRAME-OUT
    frame-relay interface-dlci 211

interface Serial0/0.212 point-to-point
  desc link to R8 in wg 1
  ip address 192.168.1.146 255.255.255.248
  ip router isis
  mpls label protocol ldp
  tag-switching ip
  mpls traffic-eng tunnels
  ip rsvp bandwidth 128 128
  frame-relay class FRAME-OUT
  frame-relay interface-dlci 212

interface Serial0/0.221 point-to-point
  desc link to R7 in wg 2
  ip address 192.168.2.130 255.255.255.248
  ip router isis
  mpls label protocol ldp
  tag-switching ip
  mpls traffic-eng tunnels
  frame-relay class FRAME-OUT
  ip rsvp bandwidth 128 128
  frame-relay interface-dlci 221

interface Serial0/0.222 point-to-point
  desc link to R8 in wg 2
  ip address 192.168.2.146 255.255.255.248
  ip router isis
  mpls label protocol ldp
  tag-switching ip
  mpls traffic-eng tunnels
  ip rsvp bandwidth 128 128
  frame-relay class FRAME-OUT
  frame-relay interface-dlci 222

router isis
  net 39.0440.0000.0000.0009.00
  metric-style wide
  mpls traffic-eng router-id Loopback0
  mpls traffic-eng level-1
exit

line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  no login

exit
exit

copy run start

```

Lab Exercise 5 Baseline Configurations

Router Baseline Configuration Files

R1 Baseline

```
en

conf t

hostname R1

interface Loopback0
 ip address 10.1.1.49 255.255.255.255

interface Loopback10
 ip address 10.1.1.17 255.255.255.240

interface Serial0/0
 no ip address
 bandwidth 128000
 encapsulation frame-relay
 frame-relay lmi-type cisco
 no shut

interface Serial0/0.101 point-to-point
 description Link to R5
 ip address 150.wg.1.17 255.255.255.240
 frame-relay interface-dlci 101
 no shut

router ospf 1
 network 150.wg.0.0 0.0.255.255 area 0
 network 10.1.1.49 0.0.0.0 area 0
 network 10.1.1.16 0.0.0.15 area 1
 network 10.1.wg1.64 0.0.0.15 area 1
 redistribute bgp 65011 subnets
 exit

router bgp 65011
 nei 150.wg.1.18 remote-as 65001
 no auto-summary
 redistribute ospf 1
 exit

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
 no login

exit
exit
copy run start
```

R2 Baseline

```
ena
conf t

hostname R2

interface Loopback0
 ip address 10.2.1.49 255.255.255.255

interface Loopback10
 ip address 10.2.1.17 255.255.255.240

interface Serial0/0
 no ip address
 bandwidth 128000
 encapsulation frame-relay
 no fair-queue
 frame-relay lmi-type cisco
 no shut

interface Serial0/0.102 point-to-point
 desc link to R5
 ip address 150.wg.1.33 255.255.255.240
 frame-relay interface-dlci 102

router ospf 2
 network 150.wg.0.0 0.0.255.255 area 0
 network 10.2.1.49 0.0.0.0 area 0
 network 10.2.1.16 0.0.0.15 area 1
 redistribute bgp 65012 subnets
 exit

router bgp 65012
 nei 150.wg.1.34 remote-as 65001
 no auto-summary
 redistribute ospf 2

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
 no login
exit
exit
copy run start
```

R3 Baseline

```
en

conf t

hostname R3

interface Loopback0
 ip address 10.1.2.49 255.255.255.255

interface Loopback10
 ip address 10.1.2.17 255.255.255.240
```

```

interface Serial0/0
  no ip address
  bandwidth 128000
  encapsulation frame-relay
  frame-relay lmi-type cisco
  no shut

interface Serial0/0.101 point-to-point
  no desc link to R8
  ip address 150.wg.2.17 255.255.255.240
  frame-relay interface-dlci 101
  no shut

router ospf 1
  network 150.wg.0.0 0.0.255.255 area 0
  network 10.1.2.49 0.0.0.0 area 0
  network 10.1.2.16 0.0.0.15 area 1
  redistribute bgp 65011 subnets
  exit

router bgp 65011
  nei 150.wg.2.18 remote-as 65001
  no auto-summary
  redistribute ospf 1
  exit

line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  no login
!
exit
exit
copy run start

```

R4 Baseline

```

ena
conf t

hostname R4

interface Loopback0
  ip address 10.2.2.49 255.255.255.255

interface Loopback10
  ip address 10.2.2.17 255.255.255.240

interface Serial0/0
  no ip address
  bandwidth 128000
  encapsulation frame-relay
  no fair-queue
  frame-relay lmi-type cisco
  no shut

interface Serial0/0.102 point-to-point
  desc link to R5

```

```

ip address 150.wg.2.33 255.255.255.240
frame-relay interface-dlci 102

router ospf 2
network 150.wg.0.0 0.0.255.255 area 0
network 10.2.2.49 0.0.0.0 area 0
network 10.2.2.16 0.0.0.15 area 1
redistribute bgp 65012 subnets
exit

router bgp 65012
nei 150.wg.2.34 remote-as 65001
no auto-summary
redistribute ospf 2
exit

line con 0
exec-timeout 999 0
logging synchronous
line aux 0
line vty 0 4
no login
exit
exit
copy run start

```

R5 Baseline

```

en

conf t

hostname R5

ip cef
mpls traffic-eng tunnels

ip vrf Green
rd wg:10
route-target both wg:10
exit

ip vrf Orange
rd wg:20
route-target both wg:20
exit

interface Loopback0
ip address 192.168.wg.17 255.255.255.255
ip router isis

interface Tunnel1
ip unnumbered Loopback0
tag-switching ip
tunnel destination 192.168.1.33
tunnel mode mpls traffic-eng
tunnel mpls traffic-eng priority 0 0
tunnel mpls traffic-eng bandwidth 100
tunnel mpls traffic-eng path-option 1 explicit name via_R9

interface Serial0/0
no ip address

```

```

bandwidth 128000
encapsulation frame-relay
no fair-queue
ip rsvp bandwidth 128 128
frame-relay lmi-type cisco
no shut

interface Serial0/0.101 point-to-point
ip vrf forwarding Green
ip address 150.wg.1.18 255.255.255.240
frame-relay interface-dlci 101

interface Serial0/0.102 point-to-point
ip vrf forwarding Orange
ip address 150.wg.1.34 255.255.255.240
frame-relay interface-dlci 102

interface Serial0/0.111 point-to-point
ip address 192.168.wg.49 255.255.255.240
ip router isis
mpls label protocol ldp
mpls ip
ip rsvp bandwidth 128 128
mpls traffic-eng tunnels
frame-relay interface-dlci 111

router isis
net 39.0440.0000.0000.wg500
metric-style wide
mpls traffic-eng router-id Loopback0
mpls traffic-eng level-2
exit

router bgp 65001
no synchronization
neighbor 192.168.wg.33 remote-as 65001
neighbor 192.168.wg.33 update-source Loopback0
no auto-summary
address-family vpnv4
neighbor 192.168.wg.33 activate
neighbor 192.168.wg.33 next-hop-self
neighbor 192.168.wg.33 send-community both
no auto-summary
exit

address-family ipv4 vrf Orange
nei 150.wg.1.33 remote-as 65012
nei 150.wg.1.33 activate
nei 150.wg.1.33 as-override
no auto-summary
no synchronization
exit

address-family ipv4 vrf Green
nei 150.wg.1.17 remote-as 65011
nei 150.wg.1.17 activate
nei 150.wg.1.17 as-override
no auto-summary
exit

exit

```

```

ip route 192.168.1.33 255.255.255.255 Tunnel1

ip explicit-path name via_R9 enable
  next-address 192.168.1.81
  next-address 192.168.10.17
  next-address 192.168.1.97
  next-address 192.168.1.33
exit
line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  no login

exit
exit

copy run start

```

R6 Baseline

```

ena
conf t

hostname R6

ip cef
mpls traffic-eng tunnels

ip vrf Green
  rd wg:10
  route-target both wg:10
exit

ip vrf Orange
  rd wg:20
  route-target both wg:20
exit

interface Loopback0
  ip address 192.168.wg.33 255.255.255.255
  ip router isis
!

interface Tunnel1
  ip unnumbered Loopback0
  tag-switching ip
  tunnel destination 192.168.1.17
  tunnel mode mpls traffic-eng
  tunnel mpls traffic-eng priority 0 0
  tunnel mpls traffic-eng bandwidth 100
  tunnel mpls traffic-eng path-option 1 explicit name via_R9

interface Serial0/0
  no ip address
  bandwidth 128000
  encapsulation frame-relay
  no fair-queue
  frame-relay lmi-type cisco
  ip rsvp bandwidth 128 128
  no shut

```

```

interface Serial0/0.101 point-to-point
 ip vrf forwarding Green
 ip address 150.wg.2.18 255.255.255.240
 frame-relay interface-dlci 101

interface Serial0/0.102 point-to-point
 ip vrf forwarding Orange
 ip address 150.wg.2.34 255.255.255.240
 frame-relay interface-dlci 102

interface Serial0/0.111 point-to-point
 ip address 192.168.wg.65 255.255.255.240
 ip router isis
 mpls label protocol ldp
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 128 128
 frame-relay interface-dlci 111

router isis
 net 39.0440.0000.0000.wg600
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2

exit

router bgp 65001
 no synchronization
 neighbor 192.168.wg.17 remote-as 65001
 neighbor 192.168.wg.17 update-source Loopback0
 no auto-summary

 address-family vpnv4
 neighbor 192.168.wg.17 activate
 neighbor 192.168.wg.17 next-hop-self
 neighbor 192.168.wg.17 send-community both
 no auto-summary
 exit-address-family

 address-family ipv4 vrf Orange
 neighbor 150.wg.2.33 remote-as 65012
 neighbor 150.wg.2.33 activate
 neighbor 150.wg.2.33 as-override
 no auto-summary
 no synchronization
 exit-address-family

 address-family ipv4 vrf Green
 neighbor 150.wg.2.17 remote-as 65011
 neighbor 150.wg.2.17 activate
 neighbor 150.wg.2.17 as-override
 no auto-summary
 no synchronization
 exit-address-family
exit

ip route 192.168.1.17 255.255.255.255 Tunnel1

```

```
ip explicit-path name via_R9 enable
  next-address 192.168.1.97
  next-address 192.168.10.17
  next-address 192.168.1.81
  next-address 192.168.1.17
exit
```

```
line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  no login
exit
exit
copy run start
```

R7 Baseline

```
en
```

```
conf t
```

```
hostname R7
```

```
ip cef
mpls traffic-eng tunnels
```

```
interface Loopback0
  ip address 192.168.wg.81 255.255.255.255
  ip router isis
```

```
interface Serial0/0
  no ip address
  bandwidth 128000
  encapsulation frame-relay
  no fair-queue
  frame-relay lmi-type cisco
  no shut
```

```
interface Serial0/0.111 point-to-point
  ip address 192.168.wg.50 255.255.255.240
  ip router isis
  mpls label protocol ldp
  mpls ip
  mpls traffic-eng tunnels
  ip rsvp bandwidth 128 128
  frame-relay interface-dlci 111
```

```
interface Serial0/0.112 point-to-point
  ip router isis
  ip address 192.168.wg.113 255.255.255.240
  mpls label protocol ldp
  mpls ip
  mpls traffic-eng tunnels
  ip rsvp bandwidth 128 128
  frame-relay interface-dlci 112
```

```

int s0/0.2wg1 point-to-point
 ip address 192.168.wg.129 255.255.255.248
 ip router isis
 mpls ip
 mpls label protocol ldp
  mpls traffic-eng tunnels
 ip rsvp bandwidth 128 128
 frame-relay interface-dlci 2wg1
 no shut

router isis
 net 39.0440.0000.0000.wg700
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2

exit

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
 no login

exit
exit

copy run start

```

R8 Baseline

```

ena
conf t

hostname R8

ip cef
mpls traffic-eng tunnels

interface Loopback0
 ip address 192.168.wg.97 255.255.255.255
 ip router isis

interface Serial0/0
 no ip address
 bandwidth 128000
 encapsulation frame-relay
 no fair-queue
 frame-relay lmi-type cisco
 no shut

interface Serial0/0.111 point-to-point
 ip address 192.168.wg.66 255.255.255.240
 ip router isis
 mpls label protocol ldp
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 128 128
 frame-relay interface-dlci 111

```

```

interface Serial0/0.112 point-to-point
 ip address 192.168.wg.114 255.255.255.240
 ip router isis
 mpls label protocol ldp
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 128 128
 frame-relay interface-dlci 112

int s0/0.2wg2 point-to-point
 ip address 192.168.wg.145 255.255.255.248
 ip router isis
 mpls ip
 mpls label protocol ldp
 mpls traffic-eng tunnels
 ip rsvp bandwidth 128 128
 frame-relay interface-dlci 2wg2
 no shut

router isis
 net 39.0440.0000.0000.wg800
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2

exit

line con 0
 exec-timeout 999 0
 logging synchronous
line aux 0
line vty 0 4
 no login
exit
exit
copy run start

```

R9 Baseline

```

en

conf t

hostname R9

enable password slpm

ip cef
 mpls traffic-eng tunnels
 mpls traffic-eng logging lsp setups
 mpls traffic-eng reoptimize timers frequency 30

class-map match-all BUSINESS-MPLS
 match mpls experimental topmost 1 2
class-map match-all PREMIUM-MPLS
 match mpls experimental topmost 5

policy-map OUT-POLICY
 class PREMIUM-MPLS
  priority percent 5
 class BUSINESS-MPLS

```

```

    bandwidth percent 50
    random-detect
    random-detect precedence 1    100    300    100
    random-detect precedence 2    300    500    10
class class-default
    fair-queue
    random-detect

map-class frame-relay FRAME-OUT
    frame-relay cir 128000
    frame-relay mincir 128000
    service-policy output OUT-POLICY

interface Loopback0
    ip address 192.168.10.17 255.255.255.255
    ip router isis

interface Serial0/0
    no ip address
    encapsulation frame-relay
    no fair-queue
    frame-relay lmi-type cisco
    ip rsvp bandwidth 128 128
    no shut

interface Serial0/0.211 point-to-point
    desc link to R7 in wg 1
    ip address 192.168.1.130 255.255.255.248
    ip router isis
    mpls label protocol ldp
    tag-switching ip
    mpls traffic-eng tunnels
    ip rsvp bandwidth 128 128
    frame-relay class FRAME-OUT
    frame-relay interface-dlci 211

interface Serial0/0.212 point-to-point
    desc link to R8 in wg 1
    ip address 192.168.1.146 255.255.255.248
    ip router isis
    mpls label protocol ldp
    tag-switching ip
    mpls traffic-eng tunnels
    ip rsvp bandwidth 128 128
    frame-relay class FRAME-OUT
    frame-relay interface-dlci 212

interface Serial0/0.221 point-to-point
    desc link to R7 in wg 2
    ip address 192.168.2.130 255.255.255.248
    ip router isis
    mpls label protocol ldp
    tag-switching ip
    mpls traffic-eng tunnels
    frame-relay class FRAME-OUT
    ip rsvp bandwidth 128 128
    frame-relay interface-dlci 221

interface Serial0/0.222 point-to-point
    desc link to R8 in wg 2
    ip address 192.168.2.146 255.255.255.248

```

```
ip router isis
mpls label protocol ldp
tag-switching ip
mpls traffic-eng tunnels
ip rsvp bandwidth 128 128
  frame-relay class FRAME-OUT
  frame-relay interface-dlci 222

router isis
net 49.0001.0000.0000.0009.00
metric-style wide
mpls traffic-eng router-id Loopback0
mpls traffic-eng level-2
exit

line con 0
  exec-timeout 999 0
  logging synchronous
line aux 0
line vty 0 4
  no login

exit
exit

copy run start
```

Post-Course Evaluations

Cisco uses a post-course evaluation system, Metrics That Matter (MTM), for its instructor-led courses. The instructor must ensure that each student is aware of a confidential evaluation process and that all students submit an evaluation for each course. There are two options for students to complete the evaluation.

For Classes with Internet Access

A URL will be made available specific to each CLP. Obtain the URL from your respective MTM system administrator before the last day of class.

1. Upon completion of the course, instruct the students to enter the URL into their browser.
2. Make sure that the students input their e-mail address (used only for a follow-up evaluation).

Note Sixty days following a learning event, students will receive a brief, follow-up evaluation, and, again, responses will be kept confidential. E-mail addresses will not be used for marketing purposes. (If students do not have e-mail addresses, they may type in a “dummy” address.)

3. Instruct the students to select the appropriate course from the drop-down list.
4. Instruct the students to complete the course evaluation and click **Submit** one time only.
5. Advise the students to wait for “Thank you” to appear on screen before leaving.

For Classes Without Internet Access

A paper-based version of the post-course evaluation is available. Your MTM system administrator can provide you with copies.

1. Distribute paper-based evaluations at the beginning of the last day of class.
2. Instruct the students to complete the survey only after completing the course.
3. Collect the evaluations and submit them to your MTM system administrator.

To View Evaluation Results

To view your post-course evaluation results:

1. Go to www.metricsthatmatter.com/client. (Reminder: *All* data is confidential; you will see only your own data.)
2. Log in using your ID and the password sent to you from MTM or provided by your company MTM system administrator to ensure confidentiality.
3. Choose Menu Option – Learner Evaluation Reports:
 - Evaluation Retrieval Tool
 - Class Evaluation Summary Report
4. Search for and select the appropriate class.

