

SPROUTE

Deploying Cisco Service Provider Network Routing

Course Administration Guide

Version 1.2

Part Number: 97-3415-01 and 97-3416-01



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Table of Contents

Course High Level Design	1
Course Goal	1
Job Tasks and Domain and Skill Objectives	1
Course Flow Diagram	2
Required Classroom Environment	3
Instructor Certification Requirements	3
General Information	3
Laboratory Topology (Delivery)	3
Laboratory Topology	4
Lab Topology Diagram (Backbone Pod View)	4
Lab Topology Diagram (Student Pod View)	4
Laboratory Equipment	5
Software List	5
Initial Lab Build	6
General Lab Setup	7
Notes on Delivery Lab Equipment	7
Development Lab Equipment Requirements	7
Required Materials Laboratory Topology (Development)	7
Notes on Development Lab Equipment	7
Course Management	9
Course Description	9
Curricula	10
Course Goal and Objectives	10
Target Audiences	10
Target Theaters and Locales	11
Prerequisite Skills and Knowledge	11
Course Differences (Delta) Information	11
Executive Summary	11
Lab Equipment Changes	12
Configuration Files Summary	12
Lab Topology Changes	13
Course Instruction Details	15
Instructor Certification Requirements	15
Required Classroom Environment	15
Detailed Course Flow	15
Course Outlines	19
High Level Course Outline	19
Detailed Course Outline	20
Course Introduction	21
Module 1: Service Provider Routing	22
Module 2: Implement OSPF in the Service Provider Network	23
Module 3: Implement Integrated IS-IS in the Service Provider Network	26
Module 4: Implement BGP in the Service Provider Network	28
Module 5: Routing Protocol Tools and Route Manipulation	30
Course Evaluation	35
Curriculum Evaluation	35
Lab Setup	37
General Information	37

Laboratory Topology (Delivery).....	38
Laboratory Topology.....	39
Lab Topology Diagram (Backbone Pod View).....	40
Lab Topology Diagram (Student Pod View).....	41
Laboratory Equipment.....	42
Software List.....	43
Initial Lab Build.....	44
General Lab Setup.....	45
Notes on Delivery Lab Equipment.....	46
Configuration Files Summary.....	46
Lab Addressing.....	47
Lab Details.....	49
Hardware Lab 1: Implement OSPF Routing.....	50
Hardware Lab 2: Implement OSPF Special Area Types.....	51
Hardware Lab 3: Implement Integrated IS-IS Routing.....	52
Hardware Lab 4: Implement Basic BGP Routing.....	53
Hardware Lab 5: Implement Route Redistribution.....	54
Hardware Lab 6: Influence BGP Route Selection.....	55

Course High Level Design

Course Goal

The goal of the course is to train service provider network professionals on the techniques to plan, implement, and monitor a scalable IP routing.

Job Tasks and Domain and Skill Objectives

These are the job tasks (domains and skill objectives from the audience, as well as job definition and job task analyses that will be taught and practiced in the course).

Domain 2	Domain Name	Skill Objectives/Job Tasks
2.00	Implement and troubleshoot IPv4 and IPv6 addressing schemes	
2.01		Implement and troubleshoot subnetting, CIDR, VLSM, summarization, and configuration of IP addressing
Domain 4	Domain Name	Skill Objectives/Job Tasks
4.00	Implement and troubleshoot routed network technologies	
4.05		Design, implement, and troubleshoot OSPFv2 and OSPFv3
4.06		Design, implement, and troubleshoot IS-IS
4.07		Design, implement, and troubleshoot route redistribution (route maps and filters)
4.08		Implement policy-based routing
4.10		Implement and troubleshoot BGP

4.12		Implement and troubleshoot BGP filters (AS path, prefix-list, outbound route filtering, route maps, and RPL)
4.13		Implement and troubleshoot selection (path attributes, local preference, MED, and communities)
Domain 9	Domain Name	Skill Objectives/Job Tasks
9.00	Implement and troubleshoot security in the network	
9.02		Implement and troubleshoot ACL
9.05		Implement and troubleshoot routing protocol security
Domain 13	Domain Name	Skill Objectives/Job Tasks
13.00	Implement high availability	
13.01		Implement NSF, NSR, graceful restart, RPR, SSO, and card redundancy
13.02		Implement and troubleshoot routing redundancy (Layer 3 high availability) (BFD, multi homing, and MPLS TE FRR)

Course Flow Diagram

This section illustrates the flow of the course.

	AM	PM
Day 1	Course Introduction Module 1: Service Provider Routing	Module 2: Implement OSPF in the Service Provider Network
Day 2	Module 2 (Cont.)	Module 2 (Cont.) Module 3: Implement Integrated IS-IS in the Service Provider Network
Day 3	Module 3 (Cont.)	Module 4: Implement BGP in the Service Provider Network
Day 4	Module 5: Routing Protocol Tools and Route Manipulation	Module 5 (Cont.)
Day 5	Module 5 (Cont.)	Module 5 (Cont.)

Required Classroom Environment

Room setup, layout, logistics, and equipment:

The course requires a typical classroom for instructor-led training delivery of Cisco training (for example, whiteboard, projector, Internet access, and sufficient seating with tables).

Instructor Certification Requirements

Credentials to teach this version of the course are as follows:

- Be a Cisco CCSI certified instructor in good standing
- Attend the SPROUTE v1.2 Train-the-Trainer (TTT) session (live or on-demand) or an SPROUTE v1.2 course that is delivered by a certified instructor
- Pass the 642-883 SPROUTE exam at the instructor cut score rate
- Be CCNP SP certified

General Information

This topic provides a high-level description of the lab environment.

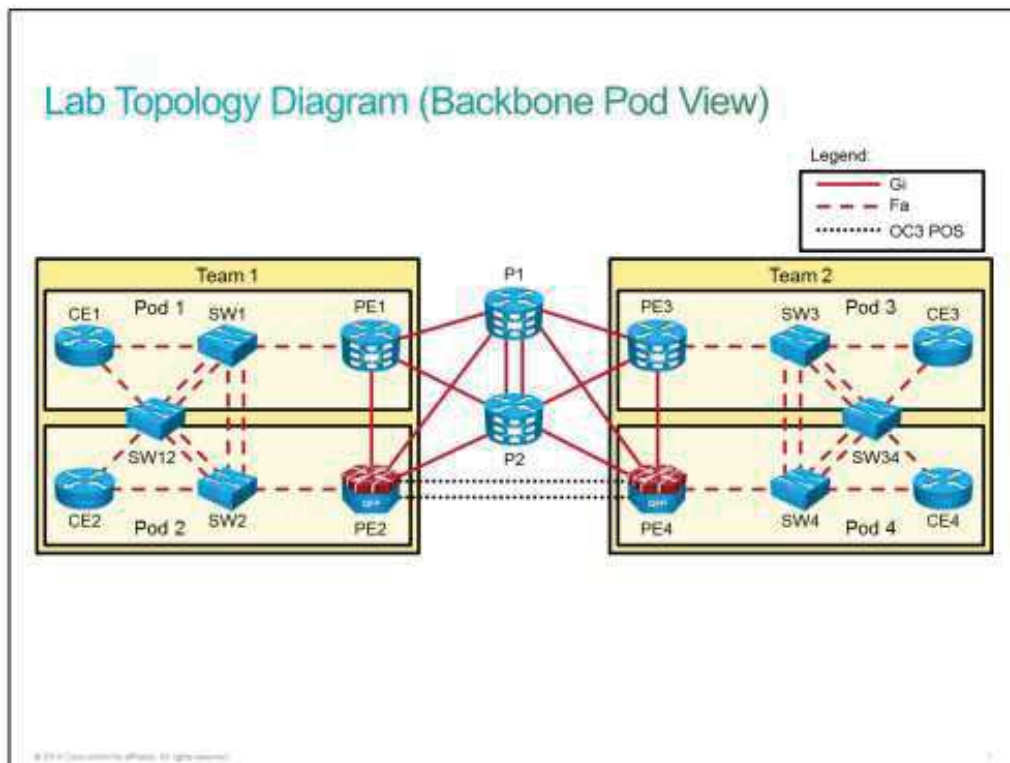
Laboratory Topology (Delivery)

This lab topology consists of two (2) teams and four (4) pods, with each team using two pods. Two students will usually configure one pod. Each pod has one switch and two routers. Two pods may share one additional switch, which is not used in this course. All teams share the same core routers (P1 and P2).

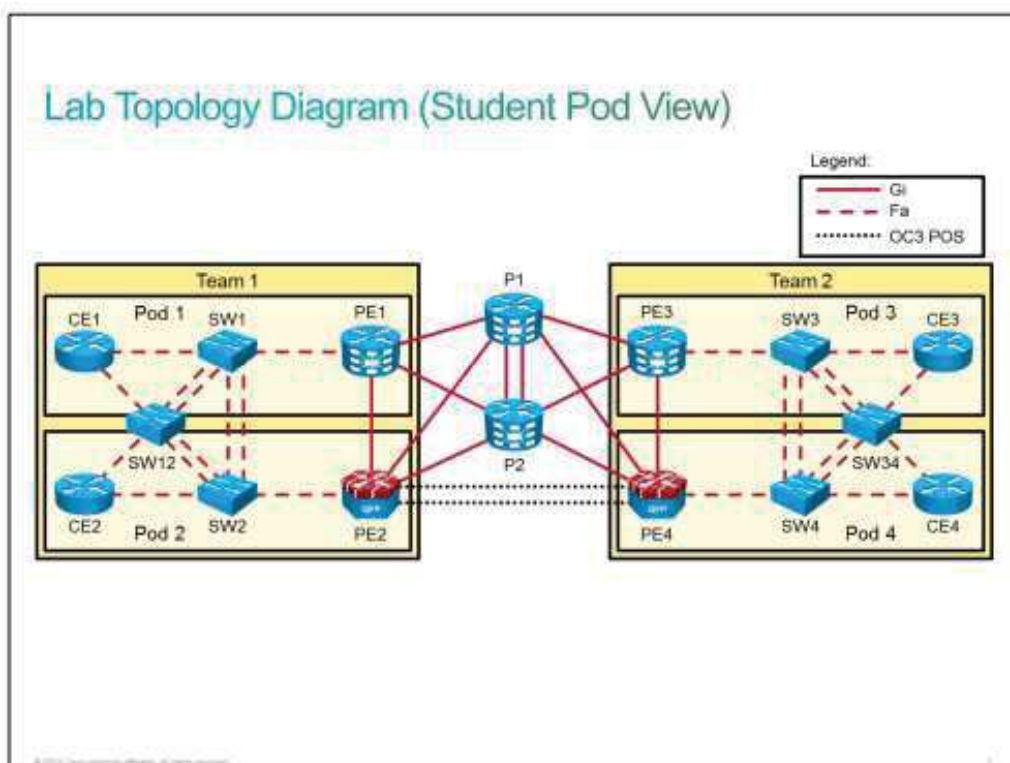
The CE routers in both pods are running Cisco IOS software. The first pod within a team (pod 1 or 3) will work on PE routers running Cisco IOS XR software, and the second pod within the same team (pod 2 or 4) will work on PE routers running Cisco IOS XE software.

Laboratory Topology

Lab Topology Diagram (Backbone Pod View)



Lab Topology Diagram (Student Pod View)



Laboratory Equipment

These tables list the recommended equipment to support the lab activities. These tables assume a class size of eight students.

Description	Mfr.	Part Number	Total Qty.
CE router - ISR 2901	Cisco	CISCO2901/K9	4
PE router running IOS XR – ASR 9006 with route processor and line card (with SFPs)	Cisco	ASR-9006-AC A9K-RSP-4G A9K-40GE-L	2
PE route running IOS XE – ASR1001	Cisco	ASR1001-2XOC3POS	2
Switch - ME-3400E-24TS-M	Cisco	ME340x- METROACCESSK9-M	6
P1 router running IOS XR – ASR 9006 with route processor and line card (with SFPs)	Cisco	ASR-9006-AC A9K-RSP-4G A9K-40GE-L	1
P2 router running IOS XR – ASR 9001 with route processor and line card (with SFPs)	Cisco	ASR-9001-S	1

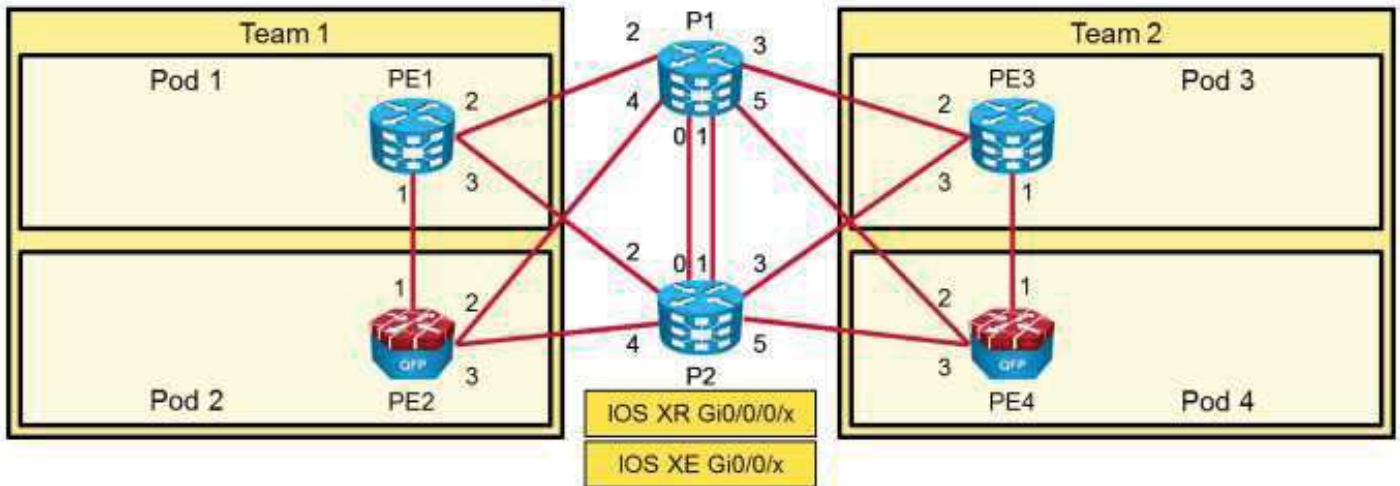
Software List

Description	Mfr.	Part Number	Total Qty.	Notes
Cisco IOS Software, ME340x Software, Version 12.2(60)EZ3, RELEASE SOFTWARE (fc2)	Cisco	ME340x- METROACCESSK9-M	6	me340x-metroaccessk9- mz.122-60.EZ3.bin
Cisco IOS Software, C2900 Software, Version 15.3(3)S2, RELEASE SOFTWARE (fc1)	Cisco	C2900- UNIVERSALK9-M	4	c2900-universalk9- mz.SPA.153-3.S2.bin
Cisco IOS Software, IOS-XE Software, Version 15.3(3)S, RELEASE SOFTWARE (fc1)	Cisco	X86_64_LINUX_IOSD- UNIVERSALK9-M	2	asr1001- universalk9.03.02.00.S.153- 3.S.bin
Cisco IOS XR Software, Version 5.1.1	Cisco		4	ASR9K-iosxr-5.1.1.tar

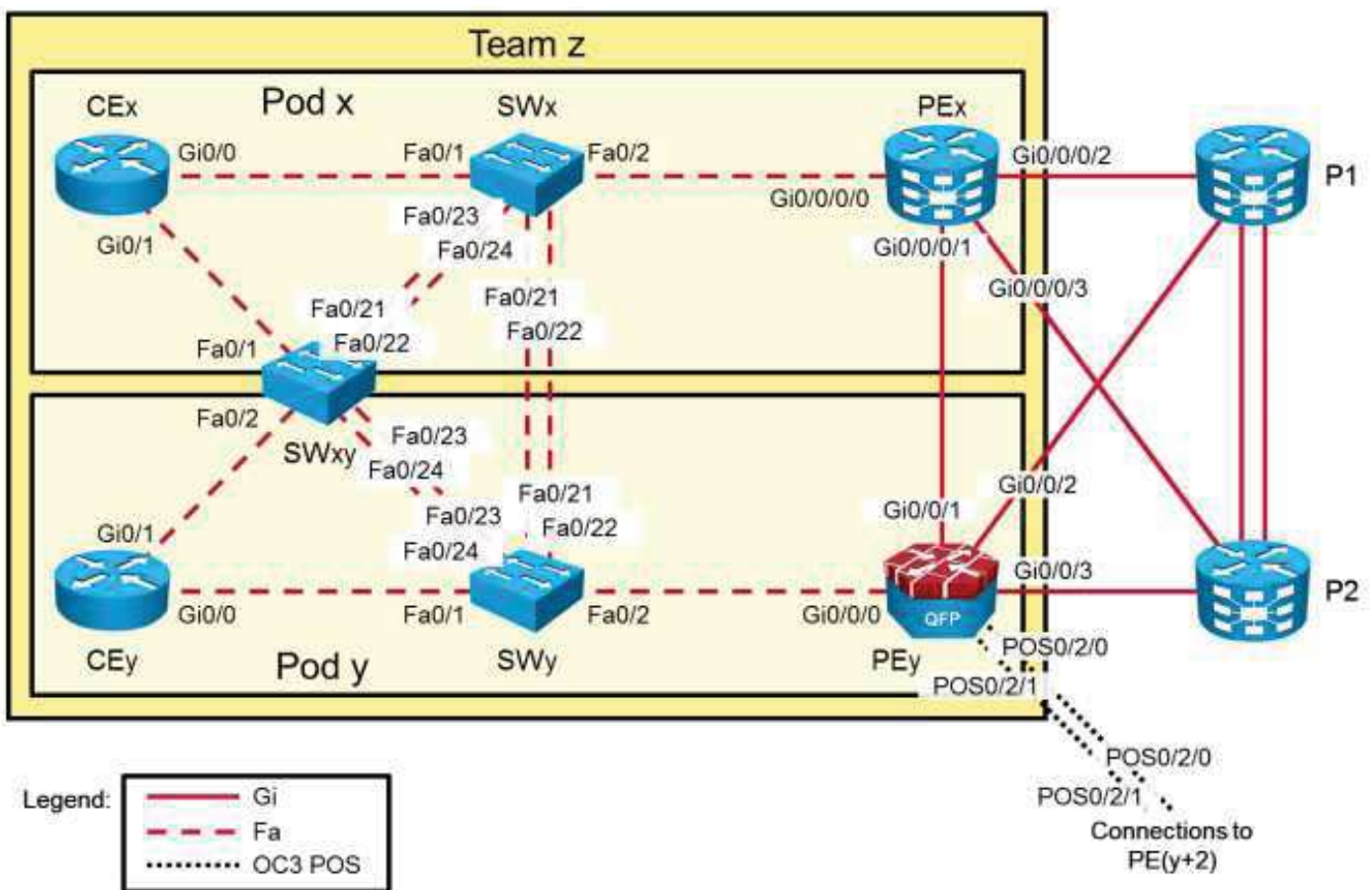
Initial Lab Build

This topic contains the information required to interconnect lab equipment.

The following figure shows core lab interface identification:



Following figure shows POD lab interface identification:



General Lab Setup

This topic details the procedure to set up and configure the lab equipment at the beginning of each class.

Notes on Delivery Lab Equipment

On the Cisco IOS XR Software routers (Cisco ASR 9006 and Cisco ASR 9001), it is recommended to install all single-package PIEs that are included in the TAR file. It is required to install at least `asr9k-mini-px-5.1.1` and `asr9k-mpls-px-5.1.1` packages.

Development Lab Equipment Requirements

This section details the resources and requirements needed to develop and test the course labs.

Required Materials Laboratory Topology (Development)

Lab equipment for the development should be the same as the one for the delivery. The requirement is to have at least two development pods. Developer pod consist of two teams.

Notes on Development Lab Equipment

Lab development requires two developer pods or four teams. The pods can be remotely available to the developers. For the review, the pods must be remotely available for Cisco TEC reviewers to review the labs in a live environment.

The software and hardware list is the same as for production pods.

Course Management

Course Description

The Deploying Cisco Service Provider Network Routing (SPROUTE) v1.2 course is designed to help students prepare for the Cisco CCNP SP certification. The SPROUTE course is a component of the CCNP SP curriculum.

The SPROUTE course is designed to provide service provider professionals with information on the use of advanced routing in implementing scalability for Cisco routers that are connected to LANs and WANs. The goal is to train professionals to dramatically increase the number of routers and sites using these techniques instead of redesigning the network when additional sites or wiring configurations are added. The SPROUTE training reinforces the instruction by providing students with hands-on labs to ensure that they thoroughly understand how to implement advanced routing within their networks.

The course also includes classroom activities with remote labs that are useful to gain practical skills on deploying Cisco IOS, IOS XE, and IOS XR features to operate and support the service provider network.

Full Title of Course	Deploying Cisco Service Provider Network Routing
Course Order Code	SPROUTE
Course Version Number	1.2
New Course?	no
Replaces	1.01

Curricula

The course is used in the following curricula, certifications, specializations, and learning maps:

Certifications:

- Cisco Certified Network Professional Service Provider (CCNP SP)

Curricula, specializations, and learning maps:

- N/A

Course Goal and Objectives

This topic describes the course goal and objectives.

Upon completing this course, you will be able to meet these objectives:

- Identify the typical routing requirements, and list the routing protocols that are used in service provider networks
- Describe the steps that are needed to implement OSPF in a service provider network
- Describe the importance of the Integrated IS-IS routing protocol for internal routing, and list the steps to follow when you are implementing Integrated IS-IS in a service provider network
- Implement BGP to connect an enterprise to a service provider and to connect a service provider to an upstream service provider
- Describe the tools that are used for routing protocol manipulation, route redistribution, and BGP route selection

Target Audiences

This section specifies the primary and secondary target audiences of this course by job roles and notes the relevance to each job role.

Primary target audience:

- This course is intended primarily for network administrators, network engineers, network managers, and systems engineers who would like to implement IP routing in service provider environments.

Secondary target audience:

- This course is intended for network designers and project or program managers. This course is also recommended to all individuals preparing for CCNP SP certification.

Target Theaters and Locales

The primary target theaters for the course follow:

- Americas

Secondary target theaters follow:

- EMEAR

Tertiary theaters follow:

- AJPC

Prerequisite Skills and Knowledge

This section lists the skills and knowledge that learners must possess to benefit fully from the course. It includes recommended Cisco learning offerings that the learners may complete to benefit fully from this course.

The knowledge and skills that a learner must have before attending this course are as follows:

- Intermediate to advanced knowledge of Cisco IOS, IOS XE, and IOS XR Software configuration
- Skills and knowledge equivalent to those learned in the following:
 - *Building Cisco Service Provider Next-Generation Networks, Part 1* (SPNGN1) v1.2 course
 - *Building Cisco Service Provider Next-Generation Networks, Part 2* (SPNGN2) v1.2 course

Course Differences (Delta) Information

This section provides a summary of the most significant differences between the previous version, SPROUTE v1.01, and this one, SPROUTE v1.2.

Executive Summary

Overview

The course structure stays exactly as it is. What is added is an update to the latest software. There are new technologies added, and EOL technologies are removed. All printouts in the student guide and labs are updated to reflect the latest software versions.

Course Objectives

This table shows new features that were added to the course:

Module/Lesson/Lab	New Feature
SPROUTE modules and labs	Outputs are updated with the latest IOS, IOS XE, and IOS XR versions.
SPROUTE labs	Steps are added in the verification sections. An answer key was added to each step.
SPROUTE Module 2 Lesson 3	Topic was divided into two topics: Cisco Nonstop Forwarding and Cisco Nonstop Routing.
SPROUTE Module 3 Lesson 2	Topic "Configuring IS-IS to Support IPv6" was merged with topic "Steps to configure IS-IS for IPv6."

Lab Equipment Changes

This table provides a comparison of the lab equipment.

Devices	Description
CE routers (Cisco 2901): CE1, CE2, CE3, CE4	Upgraded software to Cisco IOS 15.3.3M(ED)
Pod switches (ME3400E): SW1, SW2, SW3, SW4	Upgraded software to Cisco IOS 12.2(60)EZ3(ED)
Shared switches (ME3400E): SW12, SW34	Upgraded software to Cisco IOS 12.2(60)EZ3(ED)
PE1 and PE3 (ASR9006)	Upgraded software to Cisco IOS XR 5.1.1
PE2 and PE4 (ASR1001)	Upgraded software to Cisco IOS XE 15.3(3)S2/3.10.2S
P1 (ASR9006)	Upgraded software to Cisco IOS XR 5.1.1
P2 (ASR9001)	Upgraded software to Cisco IOS XR 5.1.1

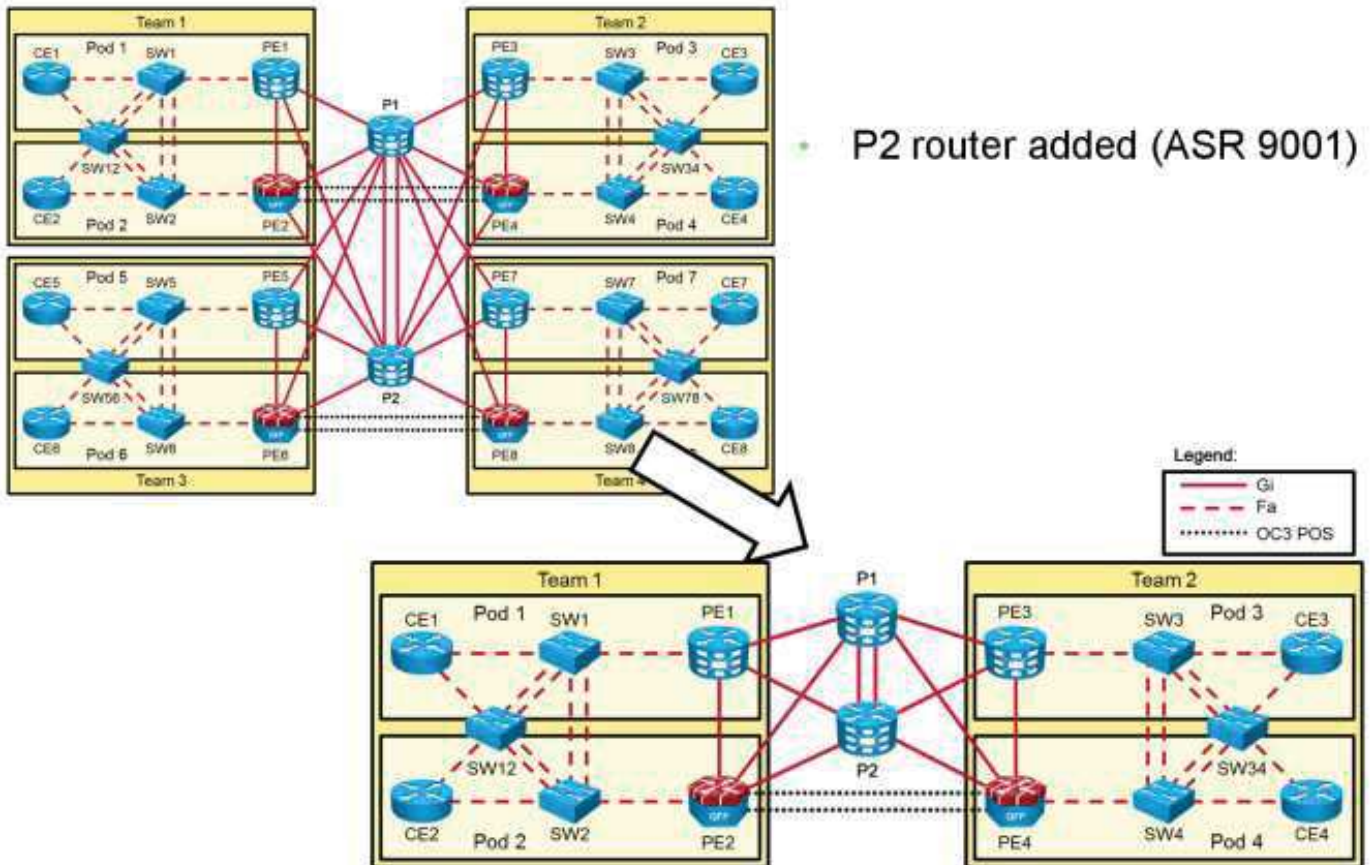
Configuration Files Summary

This topic details the course configuration files, which provide information about the starting condition of each lab.

Configuration Filename	Comments
SPROUTE12_CE1_initial.txt	Initial configuration for CE1
SPROUTE12_CE2_initial.txt	Initial configuration for CE2
SPROUTE12_CE3_initial.txt	Initial configuration for CE3
SPROUTE12_CE4_initial.txt	Initial configuration for CE4
SPROUTE12_SW1_initial.txt	Initial configuration for SW1
SPROUTE12_SW2_initial.txt	Initial configuration for SW2
SPROUTE12_SW3_initial.txt	Initial configuration for SW3
SPROUTE12_SW4_initial.txt	Initial configuration for SW4
SPROUTE12_SW12_initial.txt	Initial configuration for SW12
SPROUTE12_SW34_initial.txt	Initial configuration for SW34
SPROUTE12_PE1_initial.txt	Initial configuration for PE1
SPROUTE12_PE2_initial.txt	Initial configuration for PE2
SPROUTE12_PE3_initial.txt	Initial configuration for PE3
SPROUTE12_PE4_initial.txt	Initial configuration for PE4
SPROUTE12_P1_initial.txt	Initial configuration for P1
SPROUTE12_P2_initial.txt	Initial configuration for P2

Lab Topology Changes

These figures provide a comparison of the lab topologies.



Course Instruction Details

Instructor Certification Requirements

Credentials to teach this version of the course are as follows:

- Be a Cisco CCSI certified instructor in good standing
- Attend the SPROUTE v1.2 Train-the-Trainer (TTT) session (live or on-demand) or an SPROUTE v1.2 course that is delivered by a certified instructor
- Pass the 642-883 SPROUTE exam at the instructor cut score rate
- Be CCNP SP certified

Required Classroom Environment

Room setup, layout, logistics, and equipment:

The course requires a typical classroom for instructor-led training delivery of Cisco training (for example, whiteboard, projector, Internet access, and sufficient seating with tables).

Detailed Course Flow

The course schedule specifies the recommended teaching time for each lesson, lab, and activity. Optionally, indicate breaks and starting and ending times for each day.

Day 1: Service Provider Routing, Implement OSPF in the Service Provider Network

8:30–9:00 (0830–0900)	Course Introduction
9:00–10:30 (0900–1030)	Lesson 1-1: Understanding Service Provider Routing Protocols
10:30–10:45 (1030–1045)	Break
10:45–12:45 (1045–1245)	Lesson 2-1: Introducing OSPF Routing
12:45–1:45 (1245–1345)	Lunch
1:45–3:30 (1345–1530)	Lesson 2-2: Implementing OSPF Operation
3:30–3:45 (1530–1545)	Break
3:45–5:25 (1545–1725)	Lesson 2-3: Implementing OSPF Routing
5:25–5:45 (1725–1745)	Lab Setup
5:45 (1745)	Day ends

Day 2: Implement OSPF in the Service Provider Network

8:00–8:30 (0800–0830)	Review of Day 1
8:30–10:20 (0830–1020)	Lab 2-1: Implementing OSPF Routing
10:20–10:30 (1020–1030)	Break
10:30–12:00 (1030–1200)	Lab 2-1: Implementing OSPF Routing (Cont.)
12:00–1:00 (1200–1300)	Lunch
1:00–2:15 (1300–1415)	Lesson 2-4: Implementing OSPF Special Area Types
2:15–2:30 (1415–1430)	Break

2:30–4:00 (1430–1600)	Lab 2-2: Implementing OSPF Special Area Types
4:00 (1600)	Day ends

Day 3: Implement Integrated IS-IS in the Service Provider Network, Implement BGP in the Service Provider Network

8:00–8:30 (0800–0830)	Review of Day 2
8:30–10:30 (0830–1030)	Lesson 3-1: Introducing IS-IS Routing
10:30–10:45 (1030–1045)	Break
10:45–12:00 (1045–1200)	Lesson 3-2: Implementing Integrated IS-IS Routing
12:00–1:00 (1200–1300)	Lunch
1:00–2:30 (1300–1430)	Lab 3-1: Implementing Integrated IS-IS routing
2:30–2:45 (1430–1445)	Break
2:45–4:15 (1445–1615)	Lesson 4-1: Introducing BGP Routing
4:15–5:45 (1615–1745)	Lesson 4-2: Implementing Basic BGP routing
5:45–7:15 (1745–1915)	Lab 4-1: Implementing Basic BGP routing
7:15 (1915)	Day ends

Day 4: Routing Protocol Tools and Route Manipulation

8:00–8:30 (0830–0830)	Review of Day 3
8:30–10:30 (0830–1030)	Lesson 5-1: Introducing Routing Protocol Tools
10:30–10:45 (1030–1045)	Break
10:45–12:15 (1045–1215)	Lesson 5-1: Introducing Routing Protocol Tools (Cont.)

12:15–1:15 (1215–1315)	Lunch
1:15–2:45 (1315–1445)	Lesson 5-2: Implementing Route Redistribution
2:45–3:00 (1445–1500)	Break
3:00–4:30 (1500–1630)	Lab 5-1: Implementing Route Redistribution
4:30 (1630)	Day ends

Day 5: Routing Protocol Tools and Route Manipulation

8:00–8:30 (0800–0830)	Review of Day 4
8:30–10:30 (0830–1030)	Lesson 5-3: Influencing BGP Route Selection
10:30–10:45 (1030–1045)	Break
10:45–11:30 (1045–1130)	Lesson 5-3: Influencing BGP Route Selection (Cont.)
11:30–12:30 (1130–1230)	Lunch
12:30–2:00 (1230–1400)	Lab 5-2: Influencing BGP Route Selection
2:00–2:15 (1400–1415)	Break
2:15–3:45 (1415–1545)	Lab 5-2: Influencing BGP Route Selection (Cont.)
3:45–4:45 (1545–1645)	Wrap-up

Course Outlines

High Level Course Outline

This subtopic provides an overview of how the course is organized. The course contains these components:

- Module 1: Service Provider Routing
- Module 2: Implement OSPF in the Service Provider Network
- Module 3: Implement Integrated IS-IS in the Service Provider Network
- Module 4: Implement BGP in the Service Provider Network
- Module 5: Routing Protocol Tools and Route Manipulation
- Hardware Lab 1: Implement OSPF Routing
- Hardware Lab 2: Implement OSPF Special Area Types
- Hardware Lab 3: Implement Integrated IS-IS Routing
- Hardware Lab 4: Implement Basic BGP Routing
- Hardware Lab 5: Implement Route Redistribution
- Hardware Lab 6: Influence BGP Route Selection

Detailed Course Outline

This in-depth outline of the course structure lists each module, lesson, and topic.

Course Introduction

The Course Introduction provides learners with the course objectives and prerequisite learner skills and knowledge. The Course Introduction presents the course flow diagram and the icons that are used in the course illustrations and figures. This course component also describes the curriculum for this course, providing learners with the information that they need to make decisions regarding their specific learning path.

- Overview
- Course Goal and Objectives
- Course Flow
- Additional References
- Your Training Curriculum

Module 1: Service Provider Routing

Objective: Identify the main characteristics of routing protocols that are used in a service provider environment.

Lesson 1: Understanding Service Provider Routing Protocols

Objective: Identify the main characteristics of routing protocols that are used in service provider environments

This lesson includes these topics:

- Cisco IP NGN Architecture
- Overview of Routing Protocols
- Interior Gateway Protocols
- Routing Example
- Overview of OSPF
- Link-State Data Structures
- OSPF Area Terminology and Router Types
- OSPF Areas
- OSPF Metric
- Typical OSPF Designs
- Overview of IS-IS
- IS-IS Hierarchical Design
- IS-IS Characteristics
- IS-IS Router and Link Types
- BGP Overview
- BGP Architecture
- BGP Characteristics
- BGP AS Number
- BGP Sessions
- BGP in Customer Connections: Single-Homed Customers
- BGP in Customer Connections: Dual-Attached Customers
- BGP in Customer Connections: Multihomed Customers
- BGP in Customer Connections: Upstream ISP
- BGP in Customer Connections: Transit ISP

Module 2: Implement OSPF in the Service Provider Network

Objective: Build a scalable multiarea network with OSPF in a service provider environment

Lesson 1: Introducing OSPF Routing

Objective: Describe OSPF routing functions and the importance of OSPF in a service provider network

This lesson includes these topics:

- OSPF in the Cisco IP NGN Architecture
- OSPF and OSPFv3 Key Characteristics
- OSPF Route Entry Creation
- OSPF Data Structures
- Structure of OSPF Network
- Hierarchical Structure of OSPF in a Service Provider Environment
- OSPF LSA Types
- OSPF Stub Areas
- OSPF Not-So-Stubby Areas
- OSPF Operation
- OSPF Best Path Calculation
- OSPF Metric
- Building the LSDB
- LSA Operation
- OSPF Link-State Database
- OSPF Intra-Area Routing
- OSPF Inter-Area Routing
- OSPF External Routes
- OSPF Virtual Link
- Interpreting OSPF Routes in the Routing Table
- Calculating Costs for E1 and E2 OSPF Routes
- OSPF LSDB Overload Protection

Lesson 2: Understanding OSPF Operation

Objective: Describe how OSPF improves packet processes and optimizes routing performance in a service provider network

This lesson includes these topics:

- OSPF Functions
- OSPF Packet Format
- OSPF Packet Types
- OSPF Neighbor States
- OSPF Link-State Flooding
- Debug OSPF Packets
- OSPF Network Types
- Electing the OSPF DR and BDR
- OSPF over NBMA Network Types
- OSPF Adjacency over Metro Ethernet and EoMPLS
- OSPF Adjacency over Layer 3 MPLS VPN
- Enabling OSPF on a Link with NBMA Mode
- Subinterfaces over Multiaccess WAN Networks
- Enabling OSPF on a Link with Point-to-Point Mode
- Enabling OSPF on a Link with Point-to-Multipoint Mode
- Enabling OSPF on a Link with Point-to-Multipoint Nonbroadcast Mode
- IPv6 Support for OSPF Modes
- Summary

Lesson 3: Implementing OSPF Routing

Objective: Explain how to configure OSPF single-area and multiarea routing and how to configure several advanced features

This lesson includes these topics:

- Implement OSPF
- OSPF Router ID
- OSPF Passive Interface
- Verifying Basic OSPF
- OSPF Virtual Links
- Configuring OSPF Virtual Links
- OSPF Cost
- Cisco Nonstop Forwarding
- Cisco Nonstop Routing
- Cisco NSF and NSR for OSPF
- Graceful Restart for OSPFv3
- Bidirectional Forwarding Detection

- Bidirectional Forwarding Detection for OSPF
- OSPF Authentication Overview
- Configuring OSPF Authentication

Hardware Lab 1: Implement OSPF Routing

This activity includes these tasks:

- Enabling OSPF on the Routers
- Influencing OSPF DR and BDR Election
- Influencing OSPF Route Selection by Changing the OSPF Link Cost
- Configuring OSPF Authentication
- Configuring OSPF Virtual Links

Lesson 4: Implementing OSPF Special Area Types

Objective: Implement OSPF route summarization and different OSPF area types

This lesson includes these topics:

- OSPF Summarization
- OSPF Interarea Route Summarization
- OSPF External Route Summarization
- Default Routes in OSPF
- OSPF Area Types
- Configuring OSPF Area Types
- OSPF Router and LSA Types
- OSPF Stub Area and Totally Stubby Area
- Configuring OSPF Stub Areas
- OSPF Not-So-Stubby Area and Totally Not-So-Stubby Area
- Configuring OSPF NSSA and Totally NSSA

Hardware Lab 2: Implement OSPF Special Area Types

This activity includes these tasks:

- Enabling OSPF Summarization
- Configuring the OSPF Stub Area

Module 3: Implement Integrated IS-IS in the Service Provider Network

Objective: Configure Integrated IS-IS in the service provider network

Lesson 1: Introducing IS-IS Routing

Objective: Explain the features, benefits, and operation of IS-IS protocol running in service provider networks

This lesson includes these topics:

- IS-IS in the Cisco IP NGN
- Integrated IS-IS Routing
- Integrated IS-IS Design Principles
- Similarities Between IS-IS and OSPF
- IS-IS Addressing
- IS-IS Router Types
- IS-IS Routing Logic
- Asymmetric IS-IS Routing
- Symmetric IS-IS Routing
- IS-IS Packets
- Integrated IS-IS for IPv6
- IS-IS Network Types
- IS-IS Operations
- IS-IS LSP Flooding
- IS-IS LSDB Synchronization
- IS-IS Adjacencies
- IS-IS Single Topology Restrictions
- Multitopology IS-IS for IPv6
- Summary

Lesson 2: Implementing Integrated IS-IS Routing

Objective: Implement Integrated IS-IS in a service provider network

This lesson includes these topics:

- Implement OSI Area Routing
- Implement IS-IS Routing
- Optimizing the IS-IS Processes

- Bidirectional Forwarding Detection for IS-IS
- Nonstop Forwarding for IS-IS
- IP Route Summarization Configurations in IS-IS Networks
- Verification of IS-IS
- Troubleshooting IS-IS Commands
- Configuring IS-IS to Support IPv6

Hardware Lab 3: Implement Integrated IS-IS Routing

This activity includes these tasks:

- Enabling Integrated IS-IS on the Routers
- IS-IS Route Summarization
- Enabling IPv6 IS-IS Routing

Module 4: Implement BGP in the Service Provider Network

Objective: Implement and verify BGP to connect a service provider with customers and other service providers

Lesson 1: Enterprise Connectivity to Service Providers

Objective: Use different connectivity options to connect an enterprise network to a service provider

This lesson includes these topics:

- Enterprise Connectivity Requirements
- Routing Method Selection
- Connection Options
- Single-Homed Enterprises
- Dual-Homed Enterprises
- Multihomed Enterprises
- Dual-Multihomed Enterprises

Lesson 2: Introducing BGP Routing

Objective: Explain the advantages of using BGP to connect an enterprise network to a service provider

This lesson includes these topics:

- BGP Terminology
- Autonomous System and BGP
- BGP Routing Between Autonomous Systems
- BGP Path Vector Functionality
- BGP Routing Policies
- BGP Features
- BGP Databases
- BGP Message Types
- Multiprotocol Extensions for BGP4
- MPLS VPN Overview

Lesson 3: Implementing Basic BGP Routing

Objective: Implement internal and external BGP sessions to enable service provider routing

This lesson includes these topics:

- Planning for BGP
- Configure Basic EBGP
- Advertising BGP Networks
- Configure Basic IBGP
- Full-Mesh IBGP
- BGP Support for IPv6
- Shutting Down a BGP Neighbor
- BGP Next-Hop Behavior
- BGP Next Hop Self
- Cisco IOS XR BGP Configuration Templates
- BGP Neighbor States
- BGP Neighbor Authentication
- Clearing the BGP Session
- Monitoring BGP Routes
- BGP Path Selection
- BGP Route Selection Decision Process
- BGP Weight Attribute
- BGP Local Preference Attribute
- BGP AS Path Attribute
- BGP Multi-Exit Discriminator Attribute

Hardware Lab 4: Implement Basic BGP Routing

This activity includes these tasks:

- Configuring External BGP
- Configuring Internal BGP

Module 5: Routing Protocol Tools and Route Manipulation

Objective: Describe the tools, features, and implementation steps for routing protocol manipulation

Lesson 1: Introducing Routing Protocol Tools

Objective: Identify the main characteristics of routing protocols that are used in service provider environments

This lesson includes these topics:

- Routing Protocol Tools Overview
- Example: OSPF Filtering
- Example: BGP Filtering
- Route Filtering Tools
- Typical Filtering Objectives in OSPF
- Typical Filtering Objectives in IS-IS
- Typical Filtering Objectives in BGP
- Typical Routing Objectives
- Prefix Lists Overview
- Prefix List Syntax in Cisco IOS or IOS XE Software
- Prefix List Example: Match Any Host Route
- Prefix List Example: Match Default Route
- Prefix List Example: Match All Routes
- Prefix List Example: Match Small Routes
- Prefix List Example: Match Core Loopbacks
- Prefix List Example: Match Private Networks
- Prefix List Syntax in Cisco IOS XR Software
- Prefix List Examples in Cisco IOS XR Software
- AS Path-Based Filtering
- AS Path Access List Syntax in Cisco IOS or IOS XE Software
- Regular Expressions, Special Characters
- Commonly Used Regular Expressions
- AS Path Access List Example: Permit All Routes
- Example of AS Path Access List: Permit Local Routes
- Example of AS Path Access List: Permit Routes From a Neighbor
- Example of AS Path Access List: Permit Routes Originating in a Specific AS
- Example of AS Path Access List: Permit Neighboring Local Routes

- Example of AS Path Access List: Allow AS Path Prepending

Lesson 2: Introducing Route Maps and Routing Policy Language

Objective: Describe route maps and routing policy language

This lesson includes these topics:

- Route Maps Overview
- Route Map Processing
- Route Maps Syntax
- Example of Route Maps
- Routing Policy Language
- RPL Example
- RPL Pass and Drop Actions
- RPL Conditions
- RPL Operators
- RPL Boolean Operators
- RPL Nesting
- RPL Setting Attributes and Parameters
- RPL Setting BGP Attributes and Parameters
- Example: Setting BGP Attributes and Parameters
- RPL Setting OSPF and IS-IS Parameters
- RPL Parameterization
- Applying Routing Policies
- Maintaining Routing Policies
- Value Sets
- AS Path Sets
- Standard Community Sets
- Prefix Sets
- Monitoring Routing Policies
- Testing Routing Policies
- Translating Route Maps to Routing Policies

Lesson 3: Implementing Route Redistribution

Objective: Explain what route redistribution is, why it is necessary, and how to configure route redistribution

This lesson includes these topics:

- The Need for Redistribution
- Route Redistribution
- Using Seed Metrics in Route Redistribution
- Default Seed Metrics in Route Redistribution
- One-Point Route Redistribution
- Multipoint Route Redistribution
- Route Redistribution Techniques
- Redistribution Implementation Considerations
- Implement Redistribution
- Redistribution into OSPF
- Redistribution into IS-IS
- Redistribution into BGP
- Administrative Distance
- Modifying OSPF Administrative Distance
- Modifying IS-IS and BGP Administrative Distance
- Example: Redistribution Using Administrative Distance
- Redistribution to Prevent Routing Loops

Hardware Lab 5: Implement Route Redistribution

This activity includes these tasks:

- Redistributing between OSPF and IS-IS
- Modifying Administrative Distance

Lesson 4: Influencing BGP Route Selection

Objective: Complete the correct BGP configuration to successfully connect the service provider network to the customer or upstream service provider

This lesson includes these topics:

- BGP Weight
- Configuring Per-Neighbor Weights
- Changing Weights with RPLs or Route Maps
- BGP Weight Attachment Points
- BGP Local Preference
- Changing Local Preference

- Monitoring Local Preference
- AS Path Prepending
- AS Path Prepending Design Considerations
- Configuring AS Path Prepending
- Monitoring AS Path Prepending
- AS Path Filtering Concerns: AS Path Prepending
- BGP Multi-Exit Discriminators
- Changing the MED
- Monitoring the MED
- BGP Communities
- Steps for Designing a BGP solution around BGP communities
- Configuring BGP Communities
- BGP Named Community Lists
- BGP Support for Sequenced Entries in Extended Community Lists
- Matching BGP Communities
- Monitoring BGP Communities
- BGP Community Examples

Hardware Lab 6: Influence BGP Route Selection

This activity includes these tasks:

- Setting the Second Link between the CE and PE Routers
- Configuring BGP Weight and Local Preference
- Configuring BGP Multiexit Discriminator
- Configuring the BGP Community

Course Evaluation

Curriculum Evaluation

Effectiveness of the course will be evaluated at these Levels of Kirkpatrick's performance evaluation.

- Level 1: Reaction to the course
 - Course effects: This assessment level gauges learner satisfaction, that is, feedback from participants regarding their levels of satisfaction with the offering. This assessment will consist of the Cisco standard program evaluation and will be completed by the learner.
 - Course evaluation: Required (via MTM).
- Level 2: Learning retained
 - Course effects: This assessment level tests for learner achievement following a portion, or all, of an instructional offering. The strategy for learner assessment calls for the use of written tests in support of the instructional program. Written tests will be administered in accordance with L@C standards through proctored certification exams. This assessment will consist of the laboratory exercises and the Cisco Certification Exam.
 - Course evaluation: Required.
- Level 3: Performance changes after the course
 - Course effects: N/A
 - Course evaluation: N/A
- Level 4: Results on the job, after the course
 - Course effects: N/A
 - Course evaluation: N/A

Lab Setup

General Information

This topic provides a high-level description of the lab environment.

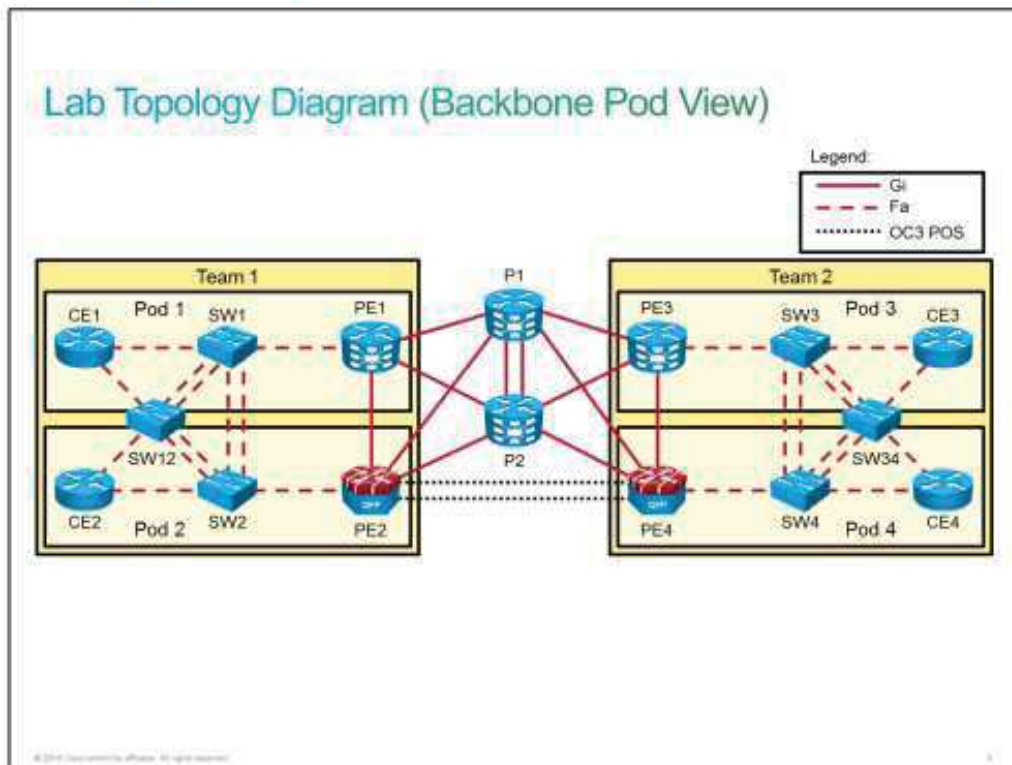
Laboratory Topology (Delivery)

This lab topology consists of two (2) teams and four (4) pods, with each team using two pods. Two students will usually configure one pod. Each pod has one switch and two routers. Two pods may share one additional switch, which is not used in this course. All teams share the same core routers (P1 and P2).

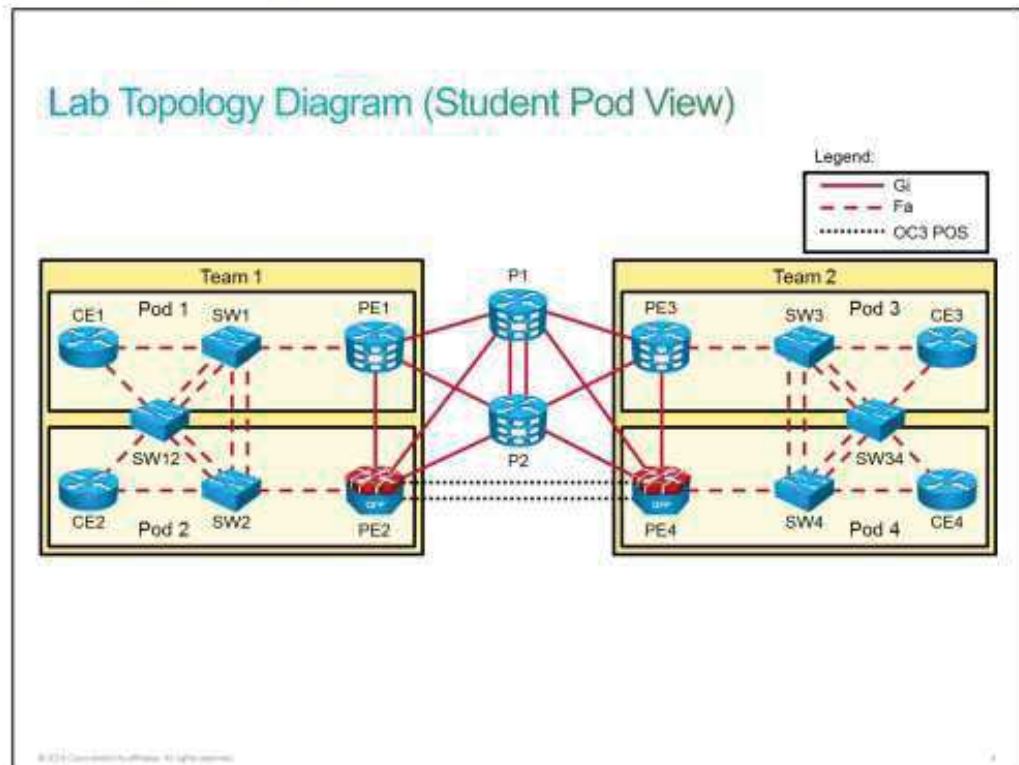
The CE routers in both pods are running Cisco IOS software. The first pod within a team (pod 1 or 3) will work on PE routers running Cisco IOS XR software, and the second pod within the same team (pod 2 or 4) will work on PE routers running Cisco IOS XE software.

Laboratory Topology

Lab Topology Diagram (Backbone Pod View)



Lab Topology Diagram (Student Pod View)



Laboratory Equipment

These tables list the recommended equipment to support the lab activities. These tables assume a class size of eight students.

Description	Mfr.	Part Number	Total Qty.
CE router - ISR 2901	Cisco	CISCO2901/K9	4
PE router running IOS XR – ASR 9006 with route processor and line card (with SFPs)	Cisco	ASR-9006-AC A9K-RSP-4G A9K-40GE-L	2
PE route running IOS XE – ASR1001	Cisco	ASR1001-2XOC3POS	2
Switch - ME-3400E-24TS-M	Cisco	ME340x- METROACCESSK9-M	6
P1 router running IOS XR – ASR 9006 with route processor and line card (with SFPs)	Cisco	ASR-9006-AC A9K-RSP-4G A9K-40GE-L	1
P2 router running IOS XR – ASR 9001 with route processor and line card (with SFPs)	Cisco	ASR-9001-S	1

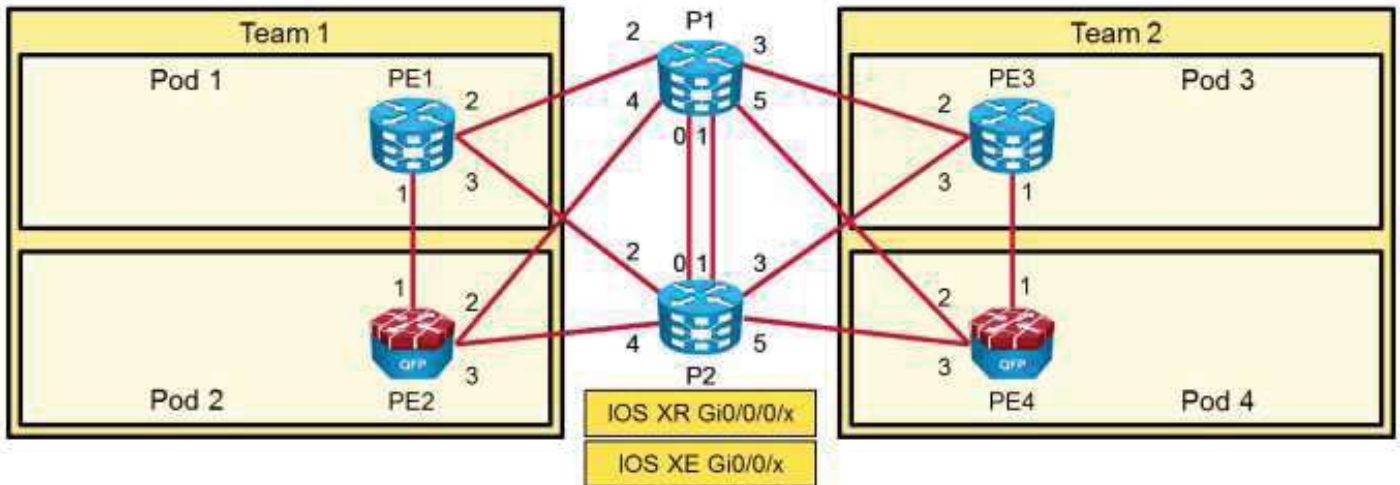
Software List

Description	Mfr.	Part Number	Total Qty.	Notes
Cisco IOS Software, ME340x Software, Version 12.2(60)EZ3, RELEASE SOFTWARE (fc2)	Cisco	ME340x-METROACCESSK9-M	6	me340x-metroaccessk9-mz.122-60.EZ3.bin
Cisco IOS Software, C2900 Software, Version 15.3(3)S2, RELEASE SOFTWARE (fc1)	Cisco	C2900-UNIVERSALK9-M	4	c2900-universalk9-mz.SPA.153-3.S2.bin
Cisco IOS Software, IOS-XE Software, Version 15.3(3)S, RELEASE SOFTWARE (fc1)	Cisco	X86_64_LINUX_IOSD-UNIVERSALK9-M	2	asr1001-universalk9.03.02.00.S.153-3.S.bin
Cisco IOS XR Software, Version 5.1.1	Cisco		4	ASR9K-iosxr-5.1.1.tar

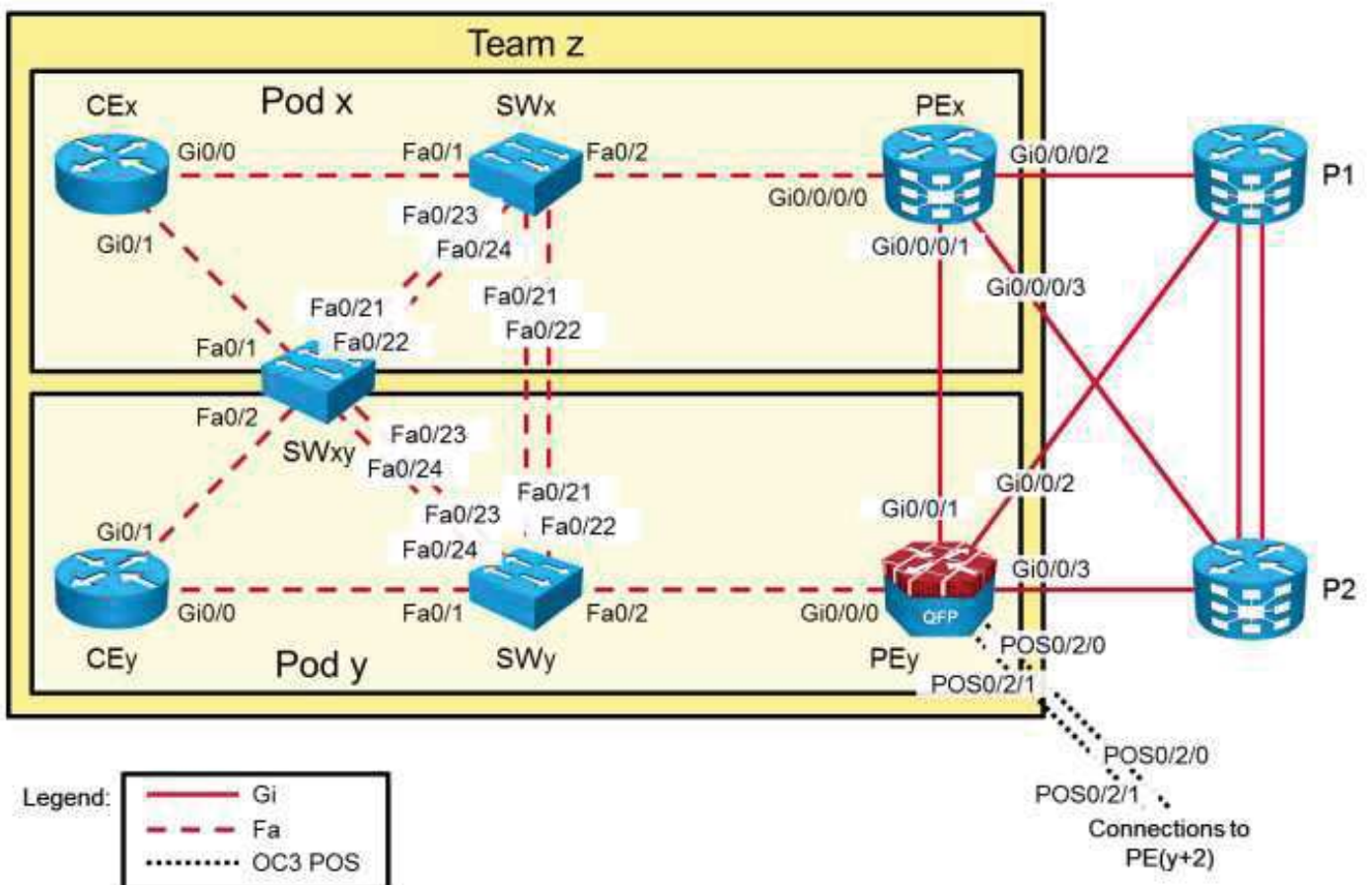
Initial Lab Build

This topic contains the information required to interconnect lab equipment.

The following figure shows core lab interface identification:



Following figure shows POD lab interface identification:



General Lab Setup

This topic details the procedure to set up and configure the lab equipment at the beginning of each class.

Notes on Delivery Lab Equipment

On the Cisco IOS XR Software routers (Cisco ASR 9006 and Cisco ASR 9001), it is recommended to install all single-package PIEs that are included in the TAR file. It is required to install at least asr9k-mini-px-5.1.1 and asr9k-mpls-px-5.1.1 packages.

Configuration Files Summary

This topic details the course configuration files, which provide information about the starting condition of each lab.

Configuration Filename	Comments
SPROUTE12_CE1_initial.txt	Initial configuration for CE1
SPROUTE12_CE2_initial.txt	Initial configuration for CE2
SPROUTE12_CE3_initial.txt	Initial configuration for CE3
SPROUTE12_CE4_initial.txt	Initial configuration for CE4
SPROUTE12_SW1_initial.txt	Initial configuration for SW1
SPROUTE12_SW2_initial.txt	Initial configuration for SW2
SPROUTE12_SW3_initial.txt	Initial configuration for SW3
SPROUTE12_SW4_initial.txt	Initial configuration for SW4
SPROUTE12_SW12_initial.txt	Initial configuration for SW12
SPROUTE12_SW34_initial.txt	Initial configuration for SW34
SPROUTE12_PE1_initial.txt	Initial configuration for PE1
SPROUTE12_PE2_initial.txt	Initial configuration for PE2
SPROUTE12_PE3_initial.txt	Initial configuration for PE3
SPROUTE12_PE4_initial.txt	Initial configuration for PE4
SPROUTE12_P1_initial.txt	Initial configuration for P1
SPROUTE12_P2_initial.txt	Initial configuration for P2

Lab Addressing

Loopback IP Addressing

Device Name	Device Role	Lo0 IPv4 Address	Lo0 IPv6 Address
CEx CEy	Cisco 2900 pod router	10.x.10.1/32 10.y.10.1/32	2001:db8:10:x:10::1/128 2001:db8:10:y:10::1/128
PEx PEy	Cisco ASR 9000 or Cisco ASR 1000 pod router	10.x.1.1/32 10.y.1.1/32	2001:db8:10:x:1::1/128 2001:db8:10:y:1::1/128
SWx SWy	Cisco ME340x pod switch	10.x.0.1/32 10.y.0.1/32	2001:db8:10:x:0::1/128 2001:db8:10:y:0::1/128
SWxy	Cisco ME340x pod switch not used in the service provider courses	10.xy.0.1/32	2001:db8:10:xy:0::1/128
P1	Cisco ASR 9006 core router	10.0.1.1/32	2001:db8:10:0:1::1/128
P2	Cisco ASR 9001 core router	10.0.2.1/32	2001:db8:10:0:2::1/128

Pod IP Addressing

Device	Interface	IPv4 Address	IPv6 Address
CEx	Gi0/0	192.168.10x.x1/24	2001:db8:192:168:10x::x1/80
CEy	Gi0/0	192.168.10y.y1/24	2001:db8:192:168:10y::y1/80
P1		192.168.x1.1/24	2001:db8:192:168:x1::1/80
		192.168.y1.1/24	2001:db8:192:168:y1::1/80
P2		192.168.x2.2/24	2001:db8:192:168:x2::2/80
		192.168.y2.2/24	2001:db8:192:168:y2::2/80
PE2	POS0/2/0	192.168.211.20/24	2001:db8:192:168:211::20/80
	POS0/2/1	192.168.212.20/24	2001:db8:192:168:212::20/80
PE4	POS0/2/0	192.168.211.40/24	2001:db8:192:168:211::40/80
	POS0/2/1	192.168.212.40/24	2001:db8:192:168:212::40/80
PEx	Gi0/0/0/0	192.168.10x.x0/24	2001:db8:192:168:10x::x0/80
	Gi0/0/0/1	192.168.1xy.x0/24	2001:db8:192:168:1xy::x0/80
	Gi0/0/0/2	192.168.x1.x0/24	2001:db8:192:168:x1::x0/80
	Gi0/0/0/3	192.168.x2.x0/24	2001:db8:192:168:x2::x0/80
PEy	Gi0/0/0	192.168.10y.y0/24	2001:db8:192:168:10y::y0/80
	Gi0/0/1	192.168.1xy.y0/24	2001:db8:192:168:1xy::y0/80
	Gi0/0/2	192.168.y1.y0/24	2001:db8:192:168:y1::y0/80
	Gi0/0/3	192.168.y2.y0/24	2001:db8:192:168:y2::y0/80

Core IP Addressing

Device	Device IP Address	Peer	Peer IP Address
P1	192.168.1.1/24 2001:db8:192:168:1::1/80	P2	192.168.1.2/24 2001:db8:192:168:1::2/80
	192.168.2.1/24 2001:db8:192:168:2::1/80		192.168.2.2/24 2001:db8:192:168:2::2/80

Lab Details

Hardware Lab 1: Implement OSPF Routing

This topic details the lab activity for Hardware Lab 1: Implement OSPF Routing.

In this lab activity, you will configure OSPF routing by enabling OSPF Area 0 to run in the backbone and other nonbackbone areas to run in your pod.

Note	Students from two different pods are working as a team. The CE routers in both pods are running Cisco IOS Software. The first pod in the team will work on the PE router running Cisco IOS XR Software, and the second pod in the same team will work on the PE router running Cisco IOS XE Software. Students in the same team should coordinate their lab activity.
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Hardware Lab 2: Implement OSPF Special Area Types

This topic details the lab activity for Hardware Lab 2: Implement OSPF Special Area Types.

In this lab activity, you will configure OSPF summarization. You will configure the nonbackbone OSPF area to be a stub and totally stubby area. You will also adjust the cost of the injected default route on an ABR router.

Note Students from two different pods are working as a team. The CE routers in both pods are running Cisco IOS Software. The first pod in the team will work on the PE router running Cisco IOS XR Software, and the second pod in the same team will work on the PE router running Cisco IOS XE Software. Students in the same team should coordinate their lab activity.

Hardware Lab 3: Implement Integrated IS-IS Routing

This topic details the lab activity for Hardware Lab 3: Implement Integrated IS-IS Routing.

In this lab activity, you will configure Integrated IS-IS routing by enabling IS-IS to run in Level 1 and Level 2.

Note	Students from two different pods are working as a team. The CE routers in both pods are running Cisco IOS Software. The first pod in the team will work on the PE router running Cisco IOS XR Software, and the second pod in the same team will work on the PE router running Cisco IOS XE Software. Students in the same team should coordinate their lab activity.
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Hardware Lab 4: Implement Basic BGP Routing

This topic details the lab activity for Hardware Lab 4: Implement Basic BGP Routing.

In this lab activity, you will configure internal and external BGP routing.

Students from two different pods are working as a team. The CE routers in both pods are running Cisco IOS Software. The first pod in the team will work on the PE router running Cisco IOS XR Software, and the second pod in the same team will work on the PE router running Cisco IOS XE Software. Students in the same team should coordinate their lab activity.

Hardware Lab 5: Implement Route Redistribution

This topic details the lab activity for Hardware Lab 5: Implement Route Redistribution.

In this lab activity, you will enable connectivity between two routing domains by configuring route redistribution between IS-IS and OSPF. You will configure two-way redistribution, and you will protect the network from routing information loops. By modifying the administrative distance, you will enable the pod PE router to use the optimal path to the backbone. Finally, you will reduce the number of routing updates that is sent to the pod CE router by configuring one-way redistribution.

Students from two different pods are working as a team. The CE routers in both pods are running Cisco IOS Software. The first pod in the team will work on the PE router running Cisco IOS XR Software, and the second pod in the same team will work on the PE router running Cisco IOS XE Software. Students in the same team should coordinate their lab activity.

When having students on different pods, make sure that all students coordinate their lab activity and do the lab step by step. First, all must finish task 1 and then move onto task 2 and so on.

Hardware Lab 6: Influence BGP Route Selection

This topic details the lab activity for Hardware Lab 6: Influence BGP Route Selection.

In this lab activity, you will configure BGP to influence route selection by using the weight, local preference, MED, and community attributes in a situation where support for connections to multiple service providers is needed.

Students from two different pods are working as a team. The CE routers in both pods are running Cisco IOS Software. The first pod in the team will work on the PE router running Cisco IOS XR Software, and the second pod in the same team will work on the PE router running Cisco IOS XE Software. Students in the same team should coordinate their lab activity.

When having students on different pods, make sure that *all* students coordinate their lab activity and do the lab step by step. First, *all* must finish task 1, and then *all* must move onto task 2 and so on.

