



CCIE Routing and Switching

TECCCIE-3610



Agenda

Section 1	CCIE Program Overview
Section 2	CCIE Routing and Switching Version 4
Section 3	Study plan: Content topics review and Sample questions
Section 4	Study plan: Preparation materials
Section 5	Lab Exam: Tips and tricks
Section 6	Troubleshooting Case Studies
Section 7	Conclusion

Disclaimer

- Not all the topics discussed today appear on every exam
- For time reasons, we're unable to discuss every feature and topic possible on the exam

“Know what you don’t know”

Agenda

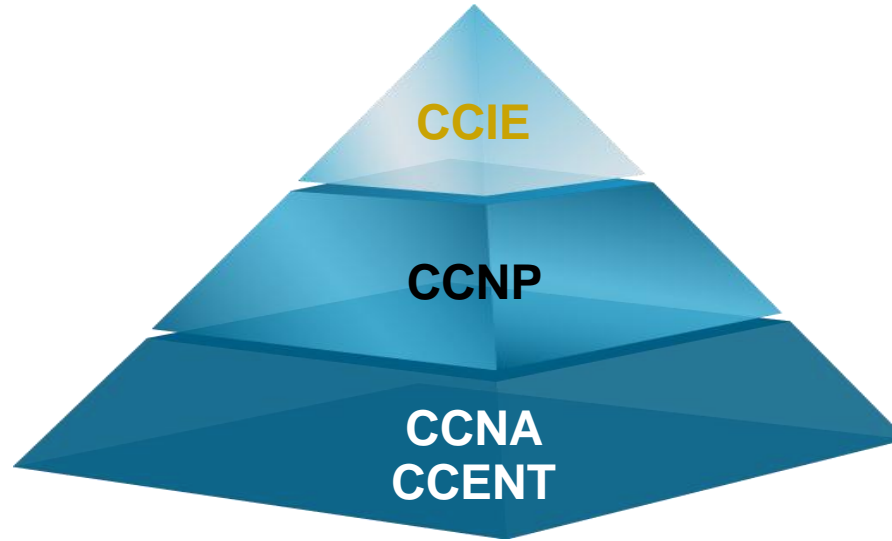
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CCIEs Worldwide



- Most highly respected IT certification for more than 15 years
- Industry standard for validating expert skills and experience
- More than 22,000 CCIEs worldwide—less than 3% of all professionals certified by Cisco
- Demonstrate strong commitment and investment to networking career, life-long learning, and dedication to remaining an active CCIE

Cisco CCIE Certification



learningnetwork.cisco.com

Cisco CCIE Certifications

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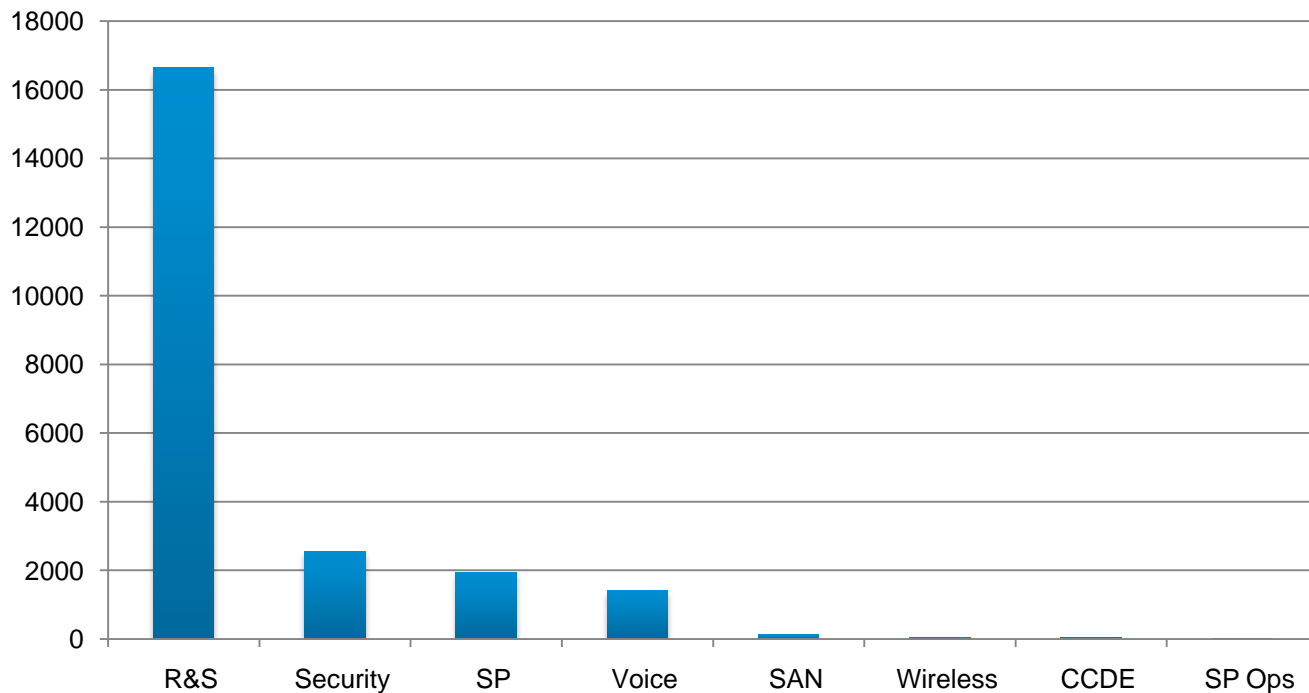
CCIE Track	Major skills
R&S	Configure and troubleshoot complex converged networks
Security	Configure complex, end-to-end secure networks, troubleshoot environments, and anticipate and respond to network attacks
Service Provider	Configure and troubleshoot advanced technologies to support service provider networks
Storage	Configure and troubleshoot storage area networks over a variety of interfaces
Voice	Configure complex, end-to-end telephony, as well as network, troubleshoot, and resolve VoIP-related problems
Wireless	Plan, design, implement, operate, and troubleshoot wireless network and mobility infrastructure
SP Operation	Troubleshoot network performance problems, identify implementation plans problems, manage network fault management system and operation processes

CCIE Information World Wide

* Updated on 02/17/2011

Total	22,741*
RS	16,647
Security	2,537
SP	1,951
Voice	1,414
SAN	145
Wireless	42
CCDE	39
SP Ops	5

CCIE Cert per Tracks

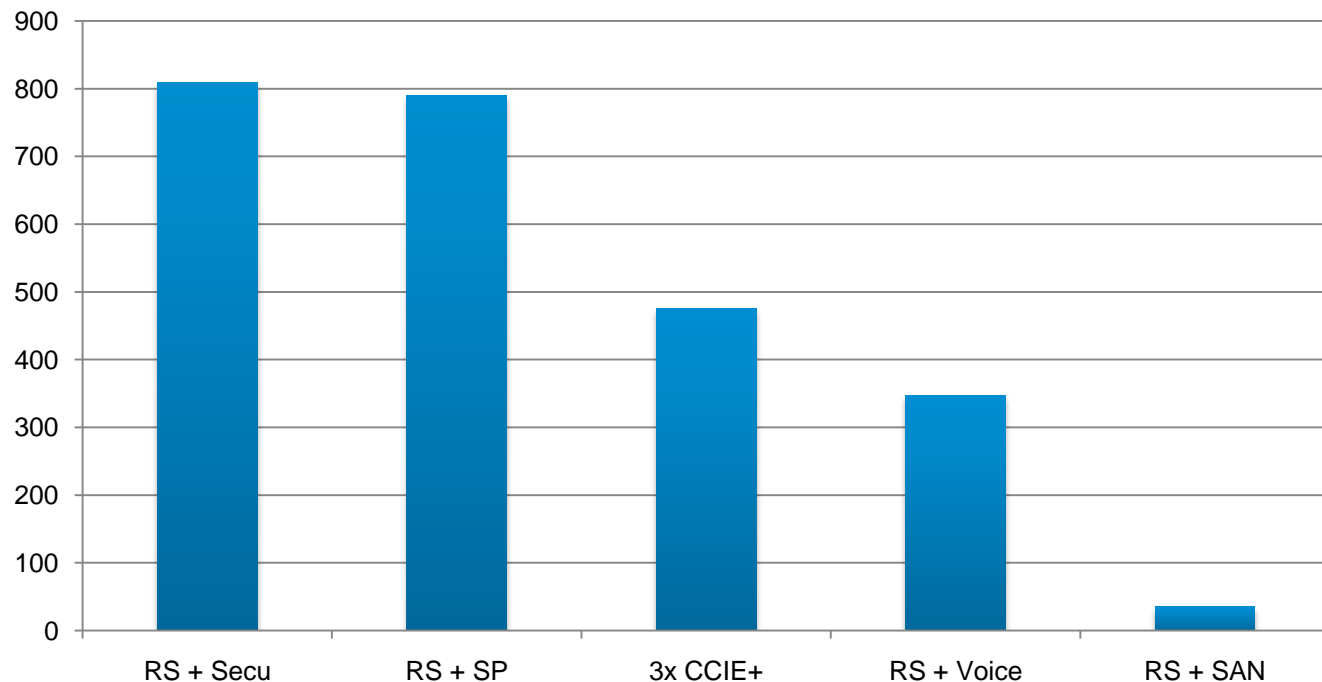


CCIE Information World Wide

Updated on 02/17/2011

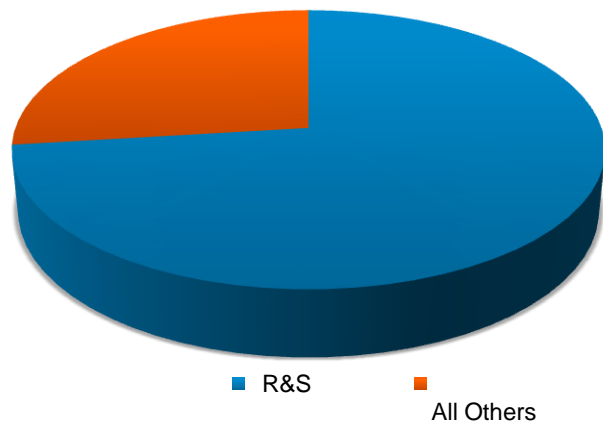
Multiple CCIEs	2,650
RS + Security	809
RS + SP	790
RS + SAN	35
RS + Voice	347
3+ xCCIE	476

Multiple CCIE vs R&S

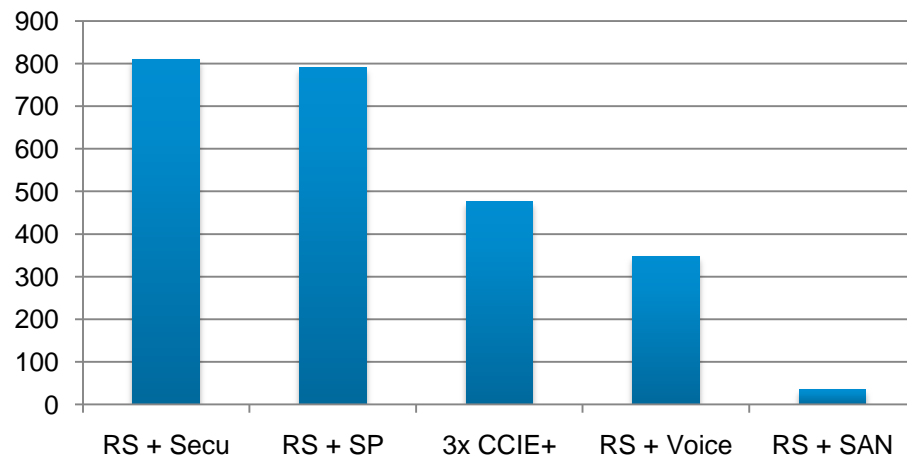


CCIE Information World Wide

CCIE R&S vs all other tracks



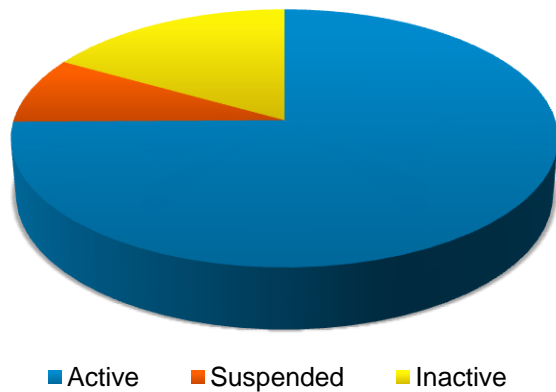
Multiple CCIE vs R&S



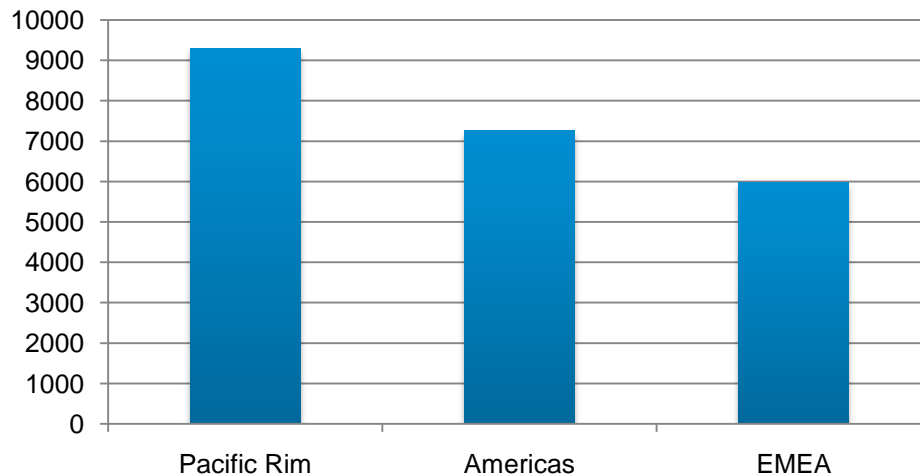
Updated on 02/17/2011

CCIE Information World Wide

World wide CCIE per status



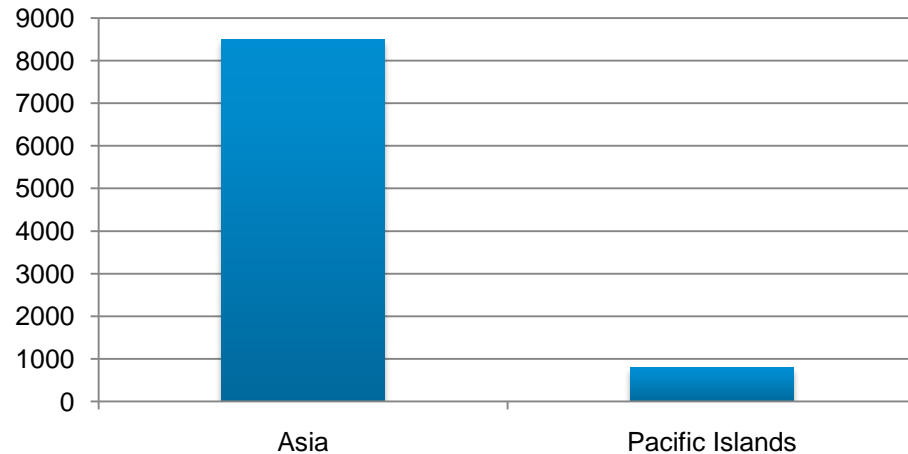
Total CCIE per region



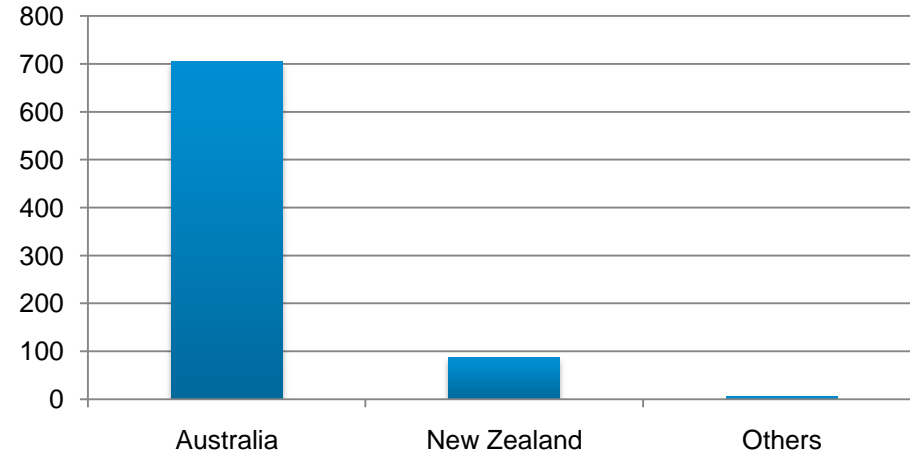
Updated on 02/17/2011

CCIE Information World Wide

Total CCIE in Pacific Rim

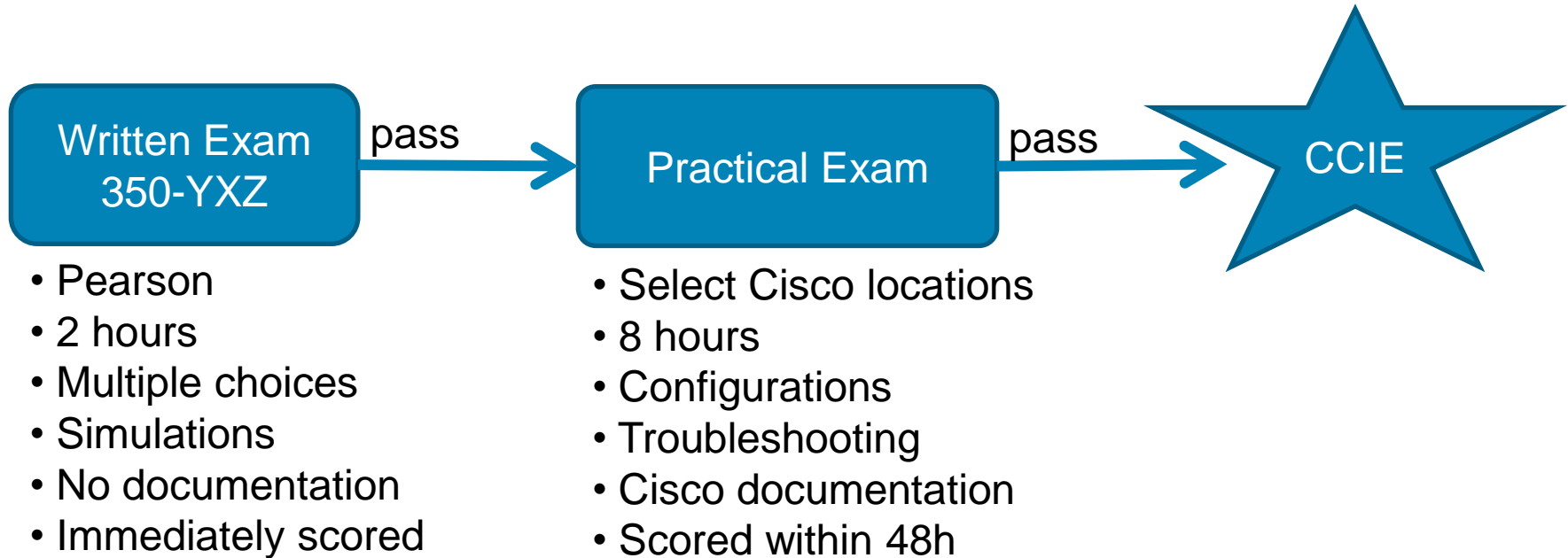


Total CCIE in Pacific Islands

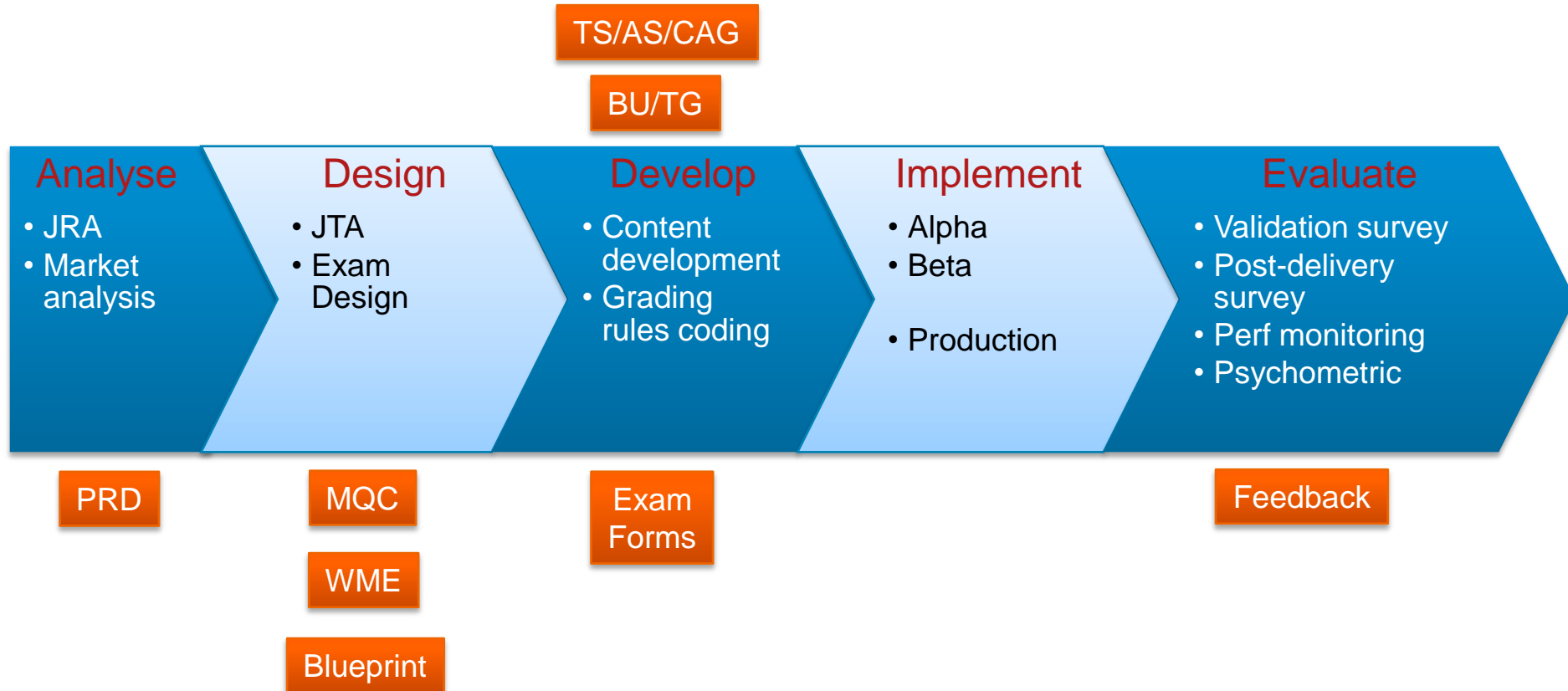


Updated on 02/17/2011

Certification Process



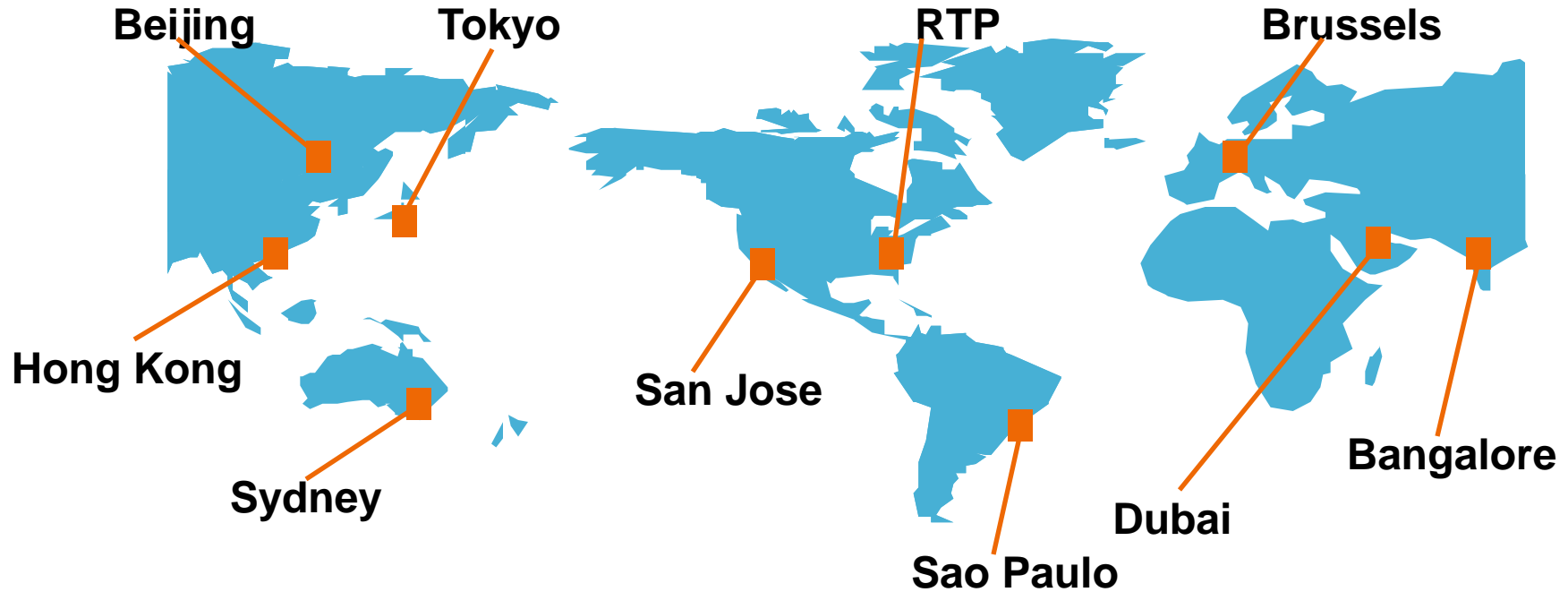
CCIE Exam Development Process



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Section 1	CCIE Program Overview
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CCIE Permanent Lab Locations: R&S



Permanent CCIE R&S Lab Locations

CCIE Routing and Switching Version 4

- Most popular track, over 80% of CCIE candidates attempt R&S first
- Expert-level knowledge of LAN and WAN interfaces, Routing Protocols, and variety of routers and switches
- Expert-level in troubleshooting to solve complex connectivity problems and apply solutions to increase bandwidth, improve response times, maximise performance, improve security, and support global applications

Recent Changes to CCIE R&S

- New certification standards released on May 5, 2009
- Reflect growth of network as a service platform
- Align to employer expectations and job tasks of expert level network engineers
- No topics removed; less coverage of lower level skills

Recent Changes to CCIE R&S

- New areas include:

- Planning and evaluating network changes

- MPLS and VPN networking

- Implementing performance routing and optimised edge routing

- EIGRPv6

- IPv6 multicast

- PPPoE

- ...

CCIE R&S v4.0 Certification

- V4.0 exams released October 18, 2009
- Written and lab exams refreshed with new questions
- Added coverage of MPLS and VPN
- Written exam added simulations
- Lab exam added hands-on troubleshooting
- Exam durations and pricing remained same

CCIE R&S Mobile Labs: 2011

Lab Locations	2010 Dates	Status	Lab
Johannesburg, South Africa	Apr 19-23	R	Routing & Switching, Security
Shanghai, PR China	May 10 - 14 +	C	Routing & Switching, Security
Riyadh, Saudi Arabia	May 15 - 19	R	Routing & Switching, Security
Moscow, Russia	May 31 - Jun 4	R	Routing & Switching, Security
Lagos, Nigeria	Jun 14 - 18	R	Routing & Switching, Security
Warsaw, Poland	Jun 28 - Jul 2	R	Routing & Switching, Security
Toronto, Canada	Jul 12 - 16	R	Routing & Switching, Security
Dalian, China	Jul 26 - 30	C	Routing & Switching, Security
Nairobi, Kenya	Aug 9-13	R	Routing & Switching, Security
Seoul, Korea	Aug 23 - 27	R	Routing & Switching, Security
Johannesburg, South Africa	Sep 6 - 10	R	Routing & Switching, Security
Cairo, Egypt	Sep 19 - 24	R	Routing & Switching, Security
Moscow, Russia	Oct 4 - 9	R	Routing & Switching, Security
Istanbul, Turkey	Oct 18 - 22	R	Routing & Switching, Security
Riyadh, Saudi Arabia	Oct 30 - Nov 3	R	Routing & Switching, Security
Singapore, Singapore	Nov 15 - 19	R	Routing & Switching, Security
Johannesburg, South Africa	Nov 29 - Dec 3	R	Routing & Switching, Security
Lagos, Nigeria	Dec 13 - 17	R	Routing & Switching, Security

R=Open for Registration

N=Newly announced, not confirmed

C=Canceled due to low enrollment

Dates for 2011 available at: <https://learningnetwork.cisco.com/docs/DOC-3224>

CCIE R&S Exam Philosophy

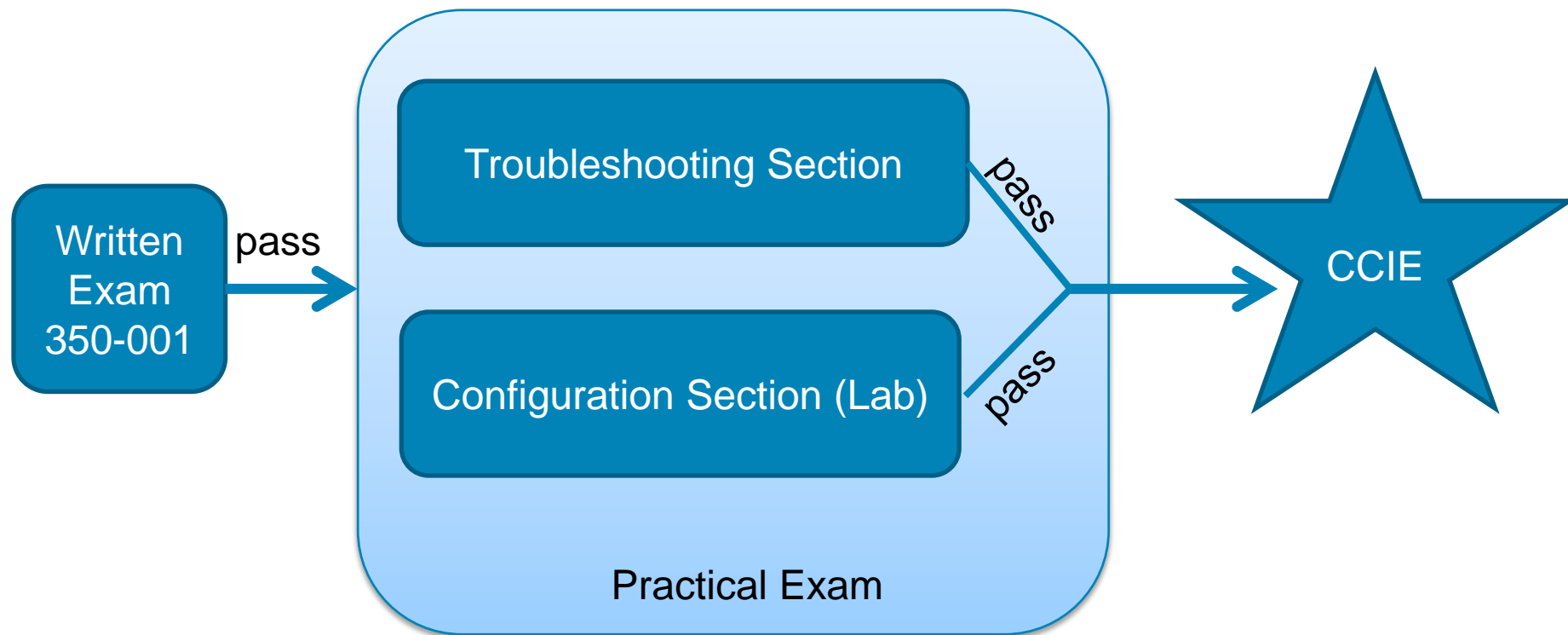
- The routing and switching exam tests your ability to apply configuration knowledge, troubleshoot skills and skill to new situations; it is not a design test, nor is it always a test of “best practices” for use in the field

CCIE R&Sv4: Minimally Qualified Candidate

“The minimally qualified Routing and Switching CCIE can **abstract** functional elements of a complex network environment, **understand** how infrastructure components **interoperate**, grasp **subtle issues**, **perceive** problem areas, and quickly **resolve** problems.

The expert’s fluency makes them ideally suited for **configuring** and **validating** implementations, **troubleshooting** critical network issues, and participating in network **design** teams. ”

CCIE R&Sv4: Certification Process



CCIE R&Sv4: Written Exam Topics

- **Implement Layer 2 Technologies**
- **Implement IPv4 – includes BGP**
- **Implement IPv6**
- **Implement MPLS Layer 3 VPNs**
- **Implement IP Multicast**
- **Implement Network Services**
- **Implement Quality of Service**
- **Implement Network Security**
- **Troubleshoot a Network**
- **Optimise the Network**
- **Evaluate proposed changes to a Network**

Same as for the Lab exam!

CCIE R&Sv4: Lab Exam Structure

Modular structure

- **Independent modules:**

2h-Troubleshooting

6h-Configuration

- **Composite cutscore:**

Must pass **both** modules, each with min 80%



CCIE R&Sv4: TS Module

2h Troubleshooting

- Separate topology of ~30 **virtual** routers and switches*
- Scenario is fully preconfigured but contains faults
- Composed of ~10 independent incidents, worth 22/100 points
- 2h maximum (visible countdown timer + 15min warning)
- Questions are “symptom-based”
- Verifications are “result-based”

CCIE R&Sv4: TS Module

Virtual infrastructure

- Virtual router = IOU: separate platforms for IOS (Solaris)
- Virtual switch = L2IOU: based on IOU + Switching code
- Mixing L2 and L3 links, like in real
- No Ethernet controller (yet)
 - interfaces always up/up, never up/down
- L2IOU: More features under development

CCIE R&Sv4: CFG Module

6h Configuration

- Separate topology of 9 **hardware** devices (5x ISR routers + 4x 3560 switches)
- Unique 6h-scenario based on a static rack (physical cabling is the same for all content)
- Composed of ~28 questions* worth 78/100 points
- Any time gained in TS is granted to CFG

CCIE R&Sv4: CFG Module

Hardware infrastructure

- Almost same rack as R&Sv3:
 - No Frame-relay switch (only back to back serials)
 - 5 ISR routers compared to 6
 - All identical 3560 switches (no mix of 3550 and 3560)
- 2x c1841 + 3x c3825 running 12.4T
- 4x c3560 running 12.2S

R&S Lab Exam Overview

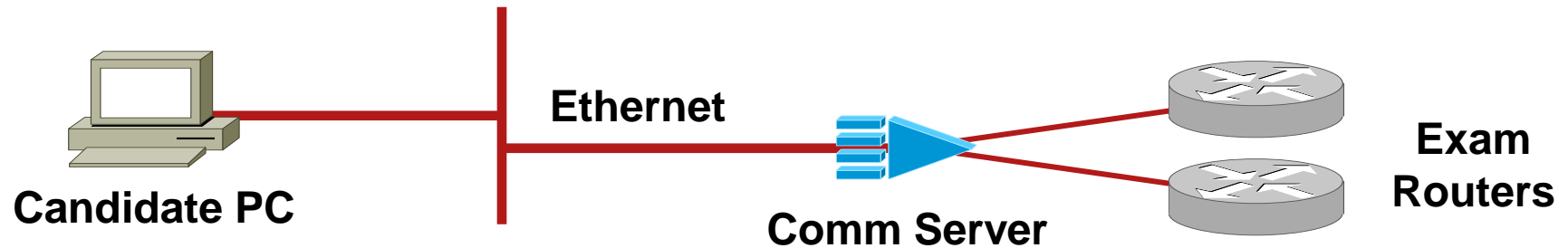
- Candidates build a network to a series of supplied specifications
- The point values for each question are shown on the exam
- Some questions depend upon completion of previous parts of the network
- Each candidate has his/her own PC and dedicated rack of equipment, which may or may not be located in lab

R&S Lab Exam Overview

- Equipment should not require hardware configuration or cabling. Contact proctor if you discover a problem requiring intervention of this kind
- Report any suspected equipment issues to the proctor as soon as possible; adjustments cannot be made once the exam is over

Rack Access

Rack Connection Method



- The Comm Server is pre-configured
- The Candidate PC has the terminal emulator pre-configured to access all routers and switches, browsers and any other needed application (calc, notepad, ...)

Passwords

- All routers and switches have a startup configuration: hostnames, passwords, line setup, and IP addresses for primary interfaces are already configured; since all tests require the router to be accessible via the VTY and AUX ports, do not change these established configurations

Standard Restrictions

Unless specified within the exam you are **NOT** allowed to use

- Static routes (of any kind)
- Default routes
- **Dynamic routes to null are permitted

CCIE R&Sv4: Lab Exam Topics

- **Implement Layer 2 Technologies**
- **Implement IPv4 – includes BGP**
- **Implement IPv6**
- **Implement MPLS Layer 3 VPNs**
- **Implement IP Multicast**
- **Implement Network Services**
- **Implement Quality of Service**
- **Implement Network Security**
- **Troubleshoot a Network**
- **Optimise the Network**

Same as for the Written exam!

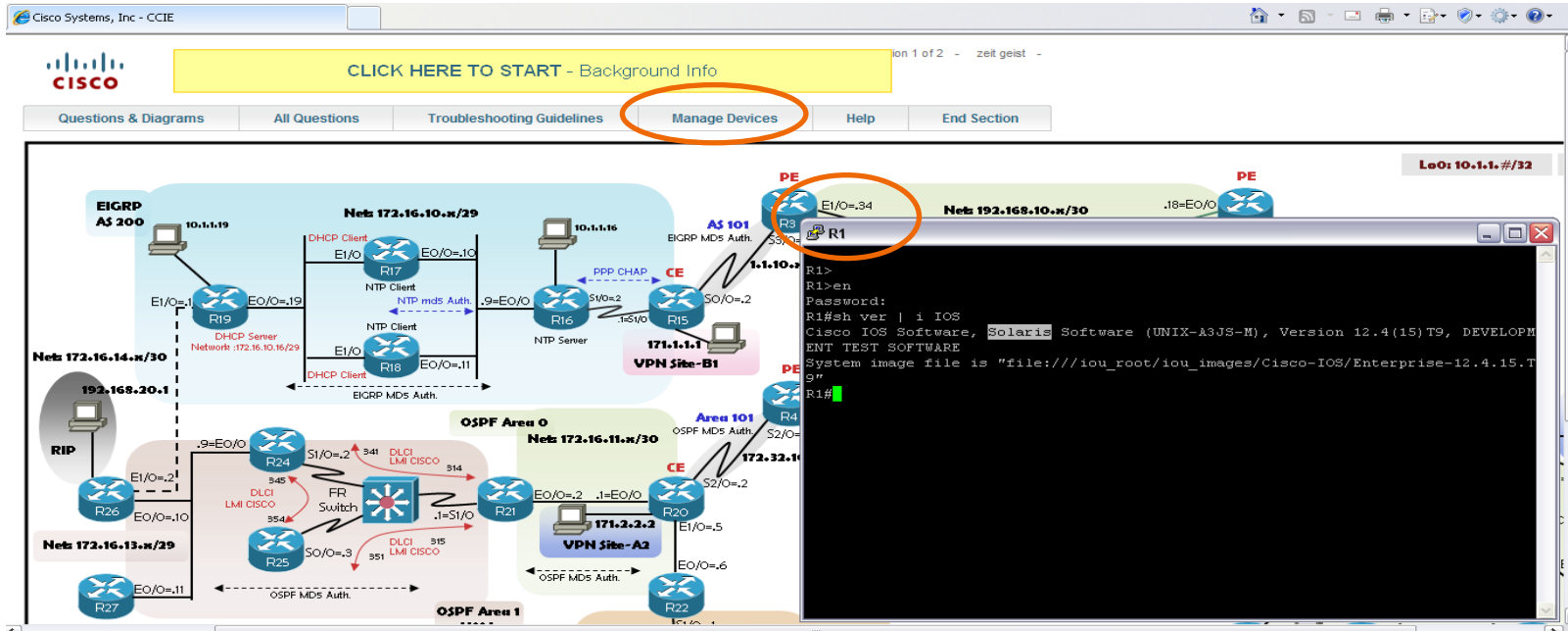
CCIE R&Sv4: Lab Delivery System

LDS

- Web GUI delivering all the exam content
(questions, diagrams, guidelines, access to devices, documentation ...)
- Transparent servers backend managing the user sessions and holding the IOU instances for each users
- Benefits:
 - Flexibility in content delivery format
 - Content updates effective globally immediately
- No printed exam workbook

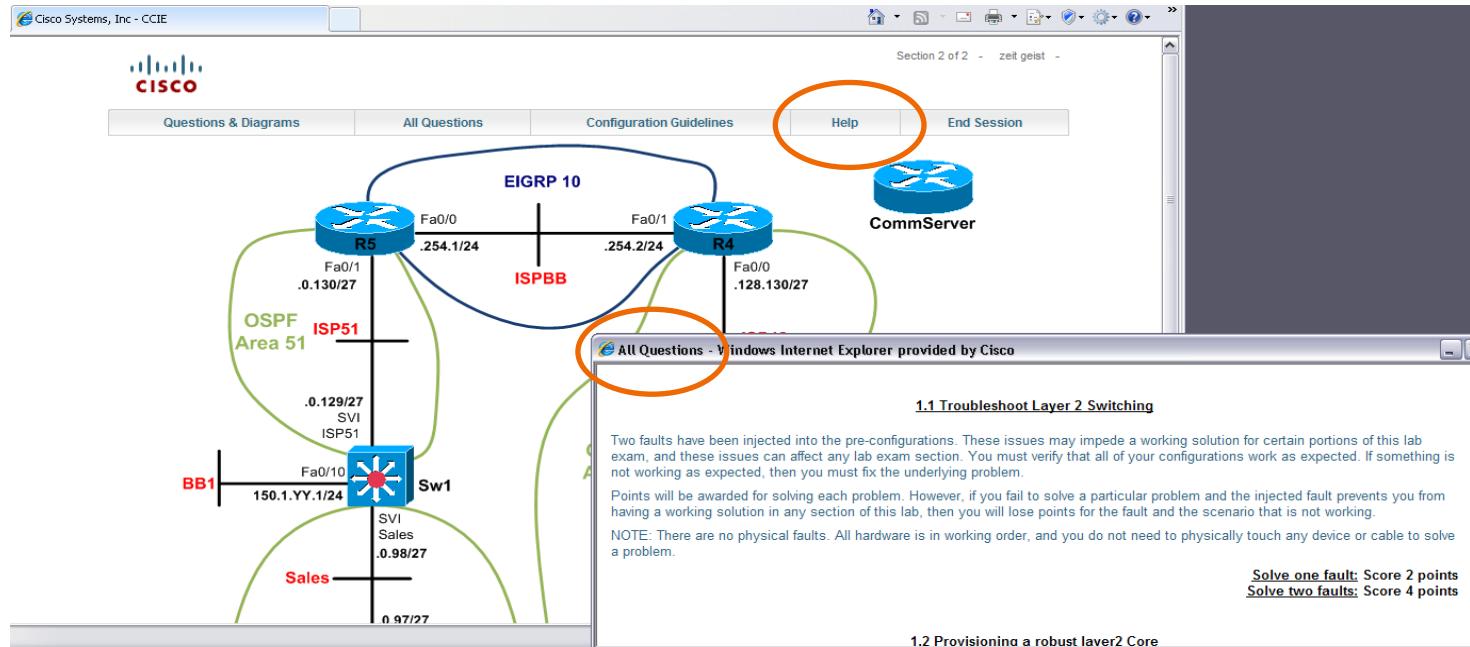
CCIE R&Sv4: Lab Delivery System

LDS: Example of TS session



CCIE R&Sv4: Lab Delivery System

LDS: Example of CFG session



CCIE Lab Exam: Grading

- Proctors grade all lab exams
- Automatic tools aid proctors with simple grading tasks
- Automatic tools are never solely responsible for lab exam grading
- Completed and submitted within 48 hours
- Partial credit is not awarded on questions
- Points are awarded for working solutions only
- Some questions have multiple solutions

CCIE R&Sv4: Automated Grading tool

CCIE360

- Data collection engine :
 - Collects data from any devices in any order (any scenario)
- Grading rules engine :
 - Run grading scripts against collected output (regex)
 - Maintain a detailed report for each candidate attempt
- Benefits :
 - Faster and more consistent grading due to automation
 - Scalable and supporting expansion objectives
- Critical point in Content quality

CCIE R&Sv4: Automated grading tool

CCIE360: Example of report (script output)

Grading Report		[?]
+ Expand All - Collapse All		
-	1 Layer 2 Technologies	8 / 22
+ 1.1	VTP misconfig add an issue	0 / 2
	1.2 Flexlink enabled on a switch port add an issue	2 / 2
+ 2	Implement the access switchports add an issue	0 / 4
	3 Traffic control protection from the BB add an issue	3 / 3
+ 4	Trunking manipulations add an issue	0 / 4
+ 5	Spanning-Tree add an issue	0 / 4
	6 Implement Frame-Relay add an issue	3 / 3

CCIE R&Sv4: Automated grading tool

CCIE360: Example of report (script output)

 1.1 | VTP misconfig | [add an issue](#) 0 / 2

updated by at 07/26/10 04:32am PDT

was transparent!*

SW2 : The VTP Operating Mode is not set to client or server

Proctor Guide:

- [SW2# show vtp status](#)

[Comment](#) | [Remove](#)

CCIE R&Sv4: Automated grading tool

CCIE360: Example of report (script output)

Grading Report: [2010-07-26-sj12-215165368-ccie-rs-cfq-15.3-report.xml](#)

Router/Switch:

Command Line:

Run →

List ↓

← Subsection - Issue on SW2

The VTP Operating Mode is not set to client or server

R1 R2 R3 R4 R5 R6 FRS SW1 **SW2** SW3 SW4

```
SW2#show vtp status
VTP Version                : running VTP2
Configuration Revision      : 10 <= differs
Maximum VLANs supported locally : 1005
Number of existing VLANs    : 14
VTP Operating Mode          : Client <= differs
VTP Domain Name             : CCIE360andSwitching06
VTP Pruning Mode            : Disabled
VTP V2 Mode                 : Enabled
VTP Traps Generation        : Disabled
MD5 digest                  : 0xC1 0x68 0xB4 0xF4 0x38 0x8A 0xBE 0xAC <= differs
Configuration last modified by 0.0.0.0 at 3-1-93 00:02:28
SW2#

! Output was collected @ Sat Jul 24 09:04:47 2010 with *show vtp status* command. <= differs
```

Master
Configuration

```
SW2#show vtp status
VTP Version                : running VTP2
Configuration Revision      : 0 <= differs
Maximum VLANs supported locally : 1005
Number of existing VLANs    : 14
VTP Operating Mode          : Transparent <= differs
VTP Domain Name             : CCIE360andSwitching12
VTP Pruning Mode            : Disabled
VTP V2 Mode                 : Enabled
VTP Traps Generation        : Disabled
MD5 digest                  : 0xE9 0xFA 0x57 0x49 0x2B 0x28 0x2A 0x7D <= differs
Configuration last modified by 12.12.8.8 at 0-0-00 00:00:00
SW2#

! Output was collected @ Mon Jul 26 02:47:01 2010 with *show vtp status* command. <= differs
```

Candidate
Configuration

Copy Master Output | Copy Candidate Output | Differences | Style: **Green** White Black | Font: A A A

v1.04 (beta)

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CCIE R&Sv4: Lab exam's General Guidelines

Read them at least once!

- Configuration exam's principles

 - Embedded troubleshooting

 - Incidents' or questions' dependency

- Rules of exam's format

 - Variables due to POD number

- Configuration restrictions

 - Console line and passwords

CCIE R&Sv4: Lab exam's General Guidelines

Read them at least once!

- Troubleshooting exam's principles

Do not remove any feature preconfigured!

Resolve the misconfiguration!!

Ex. ACL, PBR, CoPP, MQC, etc

Study plan: Content topics review

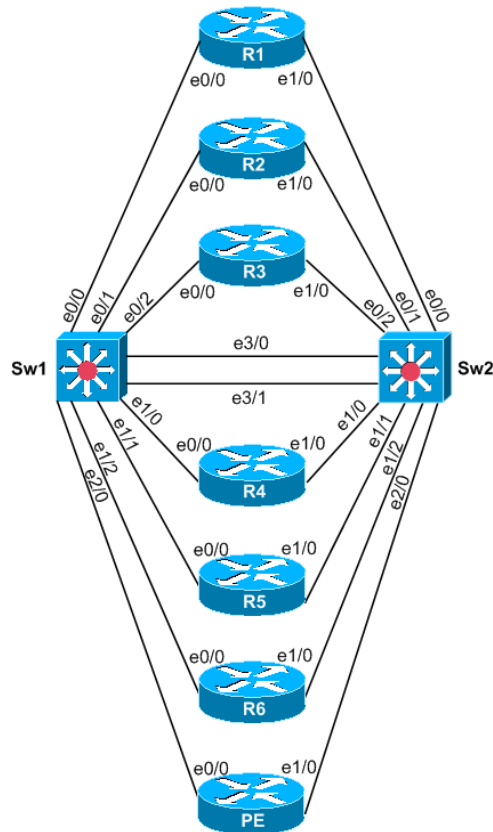
Approach

- Quick review of the essential concepts for each main topics
Organised as per the Configuration exam' sections
- Sample question per main topic using a sample topology
Discussion on question's reading and interpretation
Review of Solution and Verification steps
- Frequently missed topic
- References

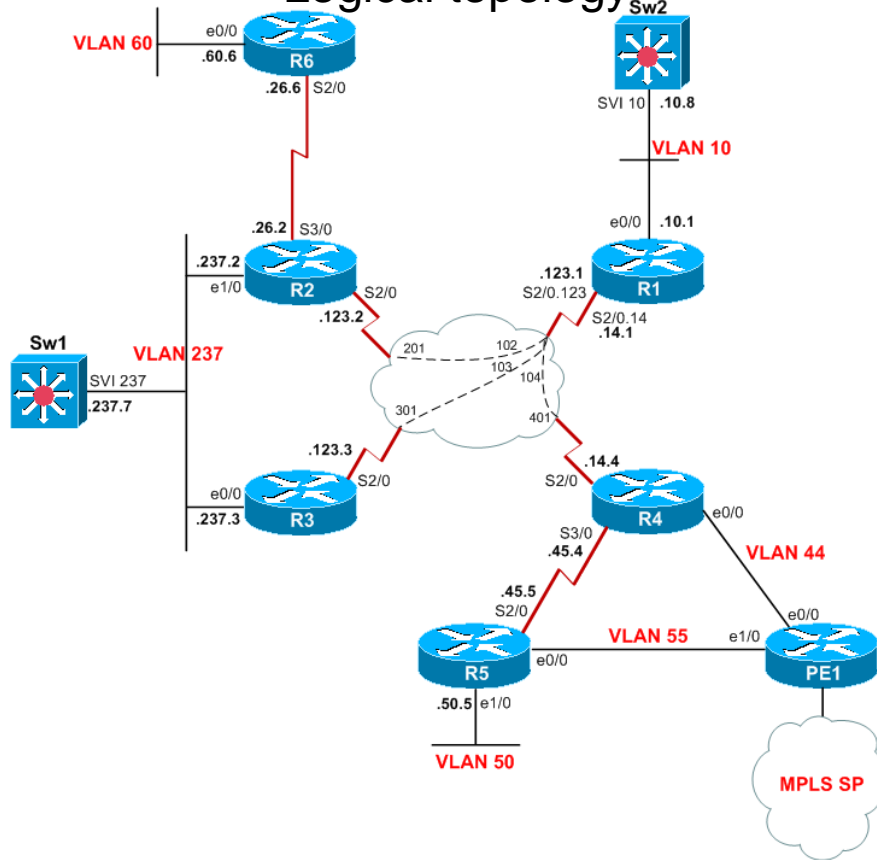
<https://learningnetwork.cisco.com/docs/DOC-4375>

Practice Lab: Sample topology

Router-Switch connections

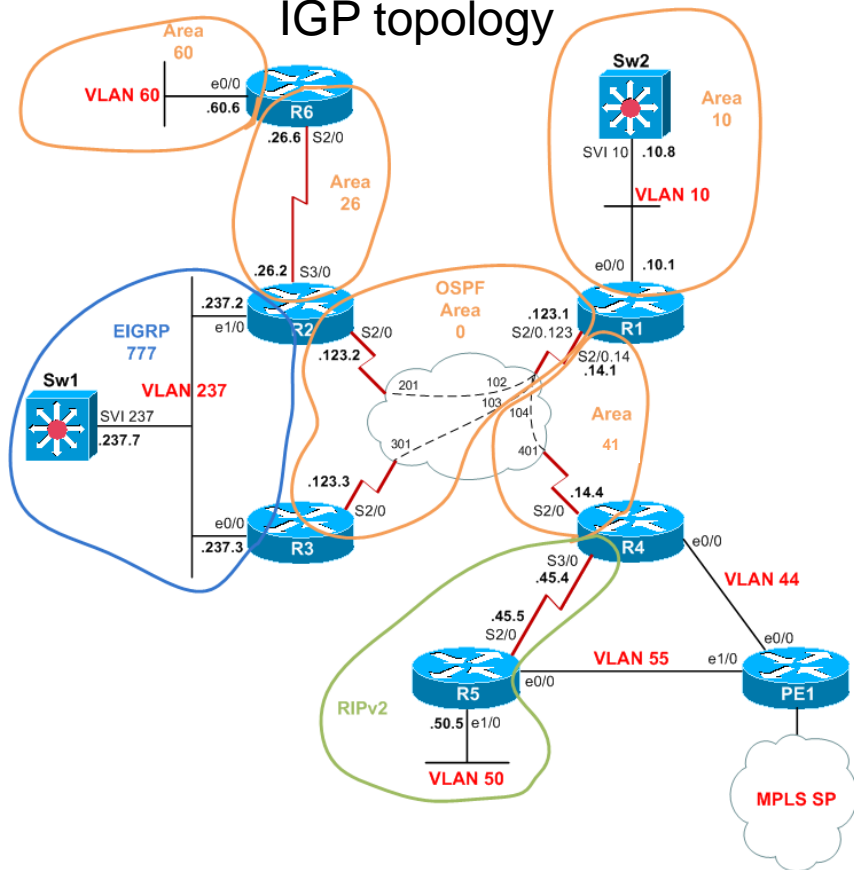


Logical topology

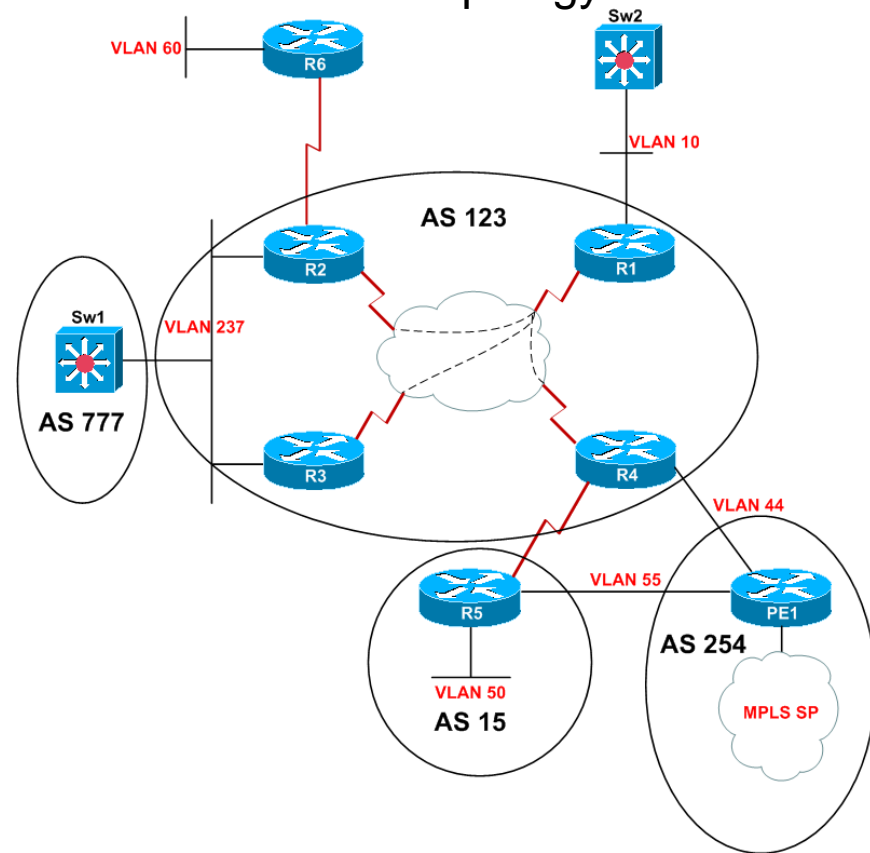


Practice Lab: Sample topology

IGP topology



BGP topology



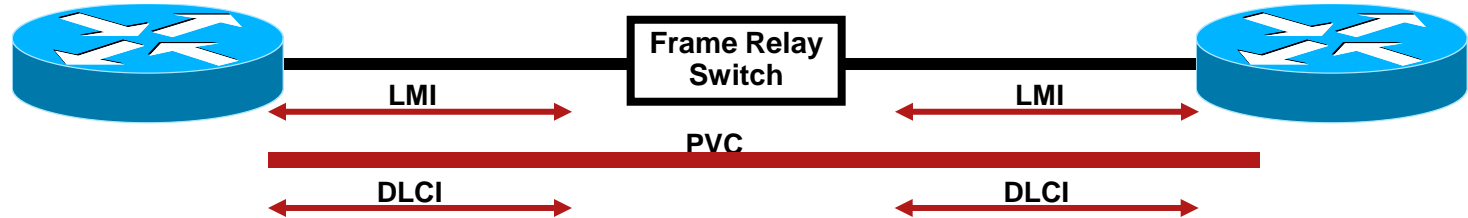
Section 3: Study plan: Content topics

Part 1	Switching
Part 2	Routing
Part 3	Advanced Services
Part 4	Optimisation
Part 5	Troubleshooting

Section 3: Study plan: Content topics

Part 1	Switching:
2.1	Frame-Relay
2.2	LAN Switching
Part 2	Routing
Part 3	Advanced Services
Part 4	Optimisation
Part 5	Troubleshooting

Frame Relay Concepts



- **DLCI** Data-link connection identifier
- **LMI** Local Management Interface
- **PVC** Permanent Virtual Circuit
- **CIR** Committed Information Rate
- **Bc** Committed Burst
- **Be** Excess Burst
- **DE** Discard Eligible
- **BECN** Backward Explicit Congestion Notification
- **FECN** Forward Explicit Congestion Notification

Frame Relay Concepts

- Layer 2 to Layer 3 mapping

 - Inverse ARP

 - Static Mapping

- Topologies

 - Hub and Spoke

 - Point-to-point

 - Multipoint

- QoS

Sample Lab Question – Frame-Relay

■ Frame Relay Configuration

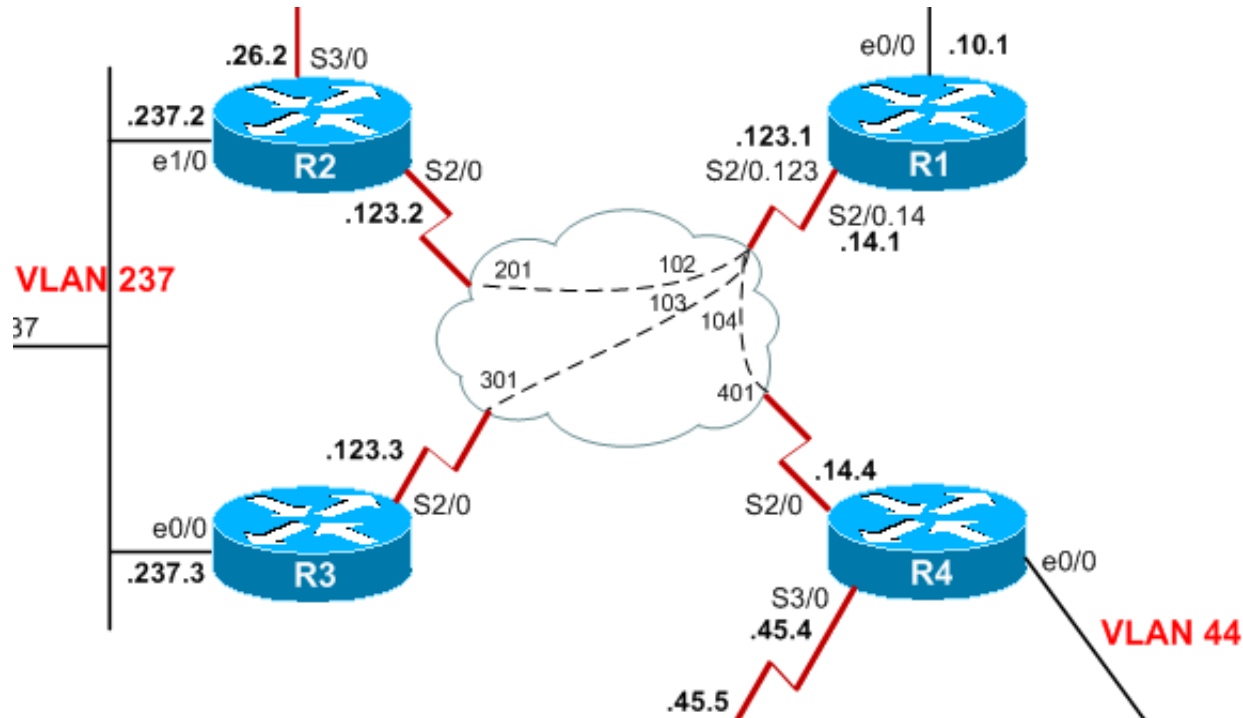
Refer to the network diagram for frame-relay DLCIs and PVC information. Subinterfaces are pre-configured and numbered according to the third octet of the IP address configured on that interface.

- Configure the frame-relay network between R1, R2 and R3 so that you can ping between all routers over the R1-R2-R3 frame-relay cloud.
- Configure the point-to-point link between R1 and R4. Do not create a subinterface on R4. Ping between R1 and R4 when completed.

Score: 2 Points

Practice Lab: Sample topology

Focus on Frame-Relay cloud



Sample Lab Question – Frame-Relay

- **Hints, requirements and constraints in the stem:**

Refer to the network diagram for frame-relay DLCIs and PVC information. (...)

- Do not change the DLCIs!

Sample Lab Question – Frame-Relay

- **Hints, requirements and constraints in the stem:**
 - (...) Subinterfaces are pre-configured and numbered according to the third octet of the IP address configured on that interface.(...)
- Do not change the pre-configured IP addresses and sub-interface's numbers!

Sample Lab Question – Frame-Relay

- **Hints, requirements and constraints in the stem:**
 - Configure the frame-relay network between R1, R2 and R3 so that you can ping between all routers over the R1-R2-R3 frame-relay cloud.(...)
- Only requirement is to be able to ping between the 3 devices!
- Can use inverse-arp or static mapping

Sample Lab Question – Frame-Relay

- **Hints, requirements and constraints in the stem:**
 - Configure the point-to-point link between R1 and R4. Do not create a subinterface on R4. Ping between R1 and R4 when completed.
- Notice the constraint about R4's subinterface!
- Can use inverse-arp or static mapping on R4

Sample Lab Question – Frame-Relay

■ Verification steps:

1. Successful ping from/to all devices
2. FR map on R1 and R4: sub-if, IP, DLCI and PVC active

R1#sh fram map

Serial2/0.123 (up): ip 172.16.123.2 dlci 102(0x66,0x1860), static,
broadcast,
CISCO, status defined, active

Serial2/0.123 (up): ip 172.16.123.3 dlci 103(0x67,0x1870), static,
broadcast,
CISCO, status defined, active

Serial2/0.14 (up): point-to-point dlci, dlci 104(0x68,0x1880), broadcast
status defined, active

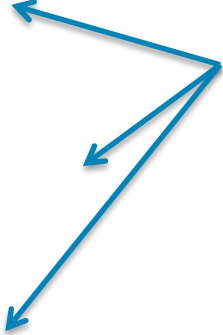
R1#

R4#sh fram map

Serial2/0 (up): ip 172.16.14.1 dlci 401(0x191,0x6410), dynamic,
broadcast,
CISCO, status defined, active

R4#

Not checked
at this point



Sample Lab Question – Frame-Relay

- **Frequently missed points:**

- Requirement missed

- Constraints not respected

- Main guidelines not respected

References

- CiscoPress®

Cisco Frame Relay Solutions Guide, Chin

- Technology Handbook:

http://docwiki.cisco.com/wiki/Frame_Relay

- CCO Documentation:

http://www.cisco.com/en/US/tech/tk713/tk237/tsd_technology_support_protocol_home.html

http://www.cisco.com/en/US/docs/ios/wan/configuration/guide/wan_cfg_frm_rly_ps6441_TS_D_Products_Configuration_Guide_Chapter.html

Section 3: Study plan: Content topics

Part 1	Switching:
2.1	Frame-Relay
2.2	LAN Switching
Part 2	Routing
Part 3	Advanced Services
Part 4	Optimisation
Part 5	Troubleshooting

LAN Switching Concepts & Protocols

- Layer 2 VLAN's (Normal, Extended, Native)
- Layer 2 Ethernet Trunk
IEEE 802.1q, ISL (Cisco Proprietary)
- CDP
- DTP (Dynamic Trunking Protocol)
- VLAN Trunk Protocol (VTP)
- EtherChannels
Access Ports, L2 Trunks or L3 Links
PAgP, IEEE 802.3ad LACP

LAN Switching Features

- Spanning Tree
 - PVST, MSTP, RSTP
- Spanning Tree Features
 - Portfast
 - Bpduguard, Bpdufilter
 - Uplinkfast, Backbonefast
 - Etherchannelguard
 - Rootguard, Loopguard
- SVI (Switched Virtual Interface)

LAN Switching Features

- Private VLAN
- (R)SPAN
- SVI (Switched Virtual Interface)

Sample Written Question - DTP

- What trunk mode combination would not produce an operational ISL trunk?
 - A. Local: auto Remote: auto
 - B. Local: on Remote: auto
 - C. Local: nonegociate Remote: on
 - D. Local: nonegociate Remote: nonegociate
 - E. Local: auto Remote: desirable

Sample Lab Question – LAN Switching

■ VTP Configuration

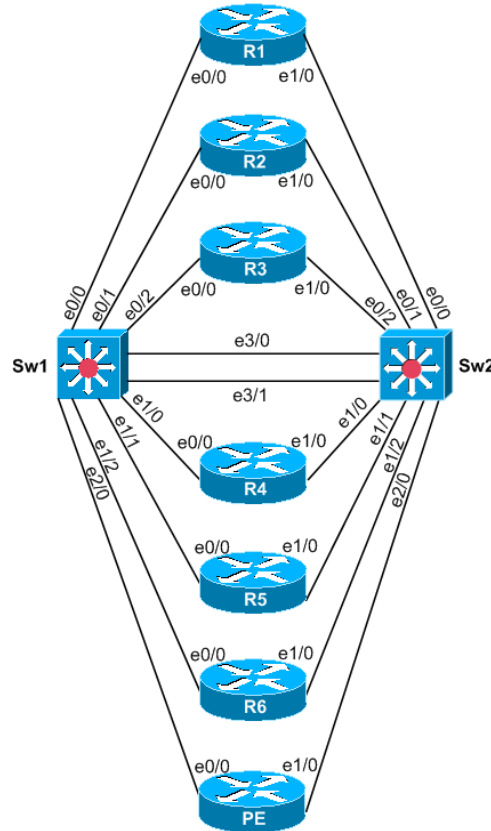
Configure VLAN Trunking Protocol (VTP) as per the following requirements:

- The VTP domain name is "CCIE".
- Secure the VTP advertisements to be sent. Use "CCIE" as your key.
- SW1 will propagate all VLAN configuration changes to SW2.
- In the future, these four switches will be configured as VTP transparent hosts. They should NOT inspect the VTP domain name and version, and they should support unrecognised type, length, value (TLV).
- DO NOT Use VTP v3.

Score: 2 Points

Practice Lab: Sample topology

Router-Switch connections



Sample Lab Question – LAN Switching

- **Hints, requirements and constraints in the stem:**
 - The VTP domain name is "CCIE".
 - Secure the VTP advertisements to be sent. Use "CCIE" as your key.
 - SW1 will propagate all VLAN configuration changes to SW2.(...)
- Very clear requirements about VTP config !
- SW1 must be VTP server and SW2 VTP client or server

Sample Lab Question – LAN Switching

- **Hints, requirements and constraints in the stem:**

(...)

- In the future, these four switches will be configured as VTP transparent hosts. They should NOT inspect the VTP domain name and version, and they should support unrecognised type, length, value (TLV).
 - DO NOT Use VTP v3.
- “In the future” means not yet! This would violate the previous requirement...
- Requirement describes a specificity of VTP version 2


Sample Lab Question – LAN Switching

■ Verification steps: SW1

Check VTP config: domain, version, password and mode

```
SW1#sh vtp status
VTP Version          : 3 (capable)
Configuration Revision : 6
Maximum VLANs supported locally : 1005
Number of existing VLANs : 9
VTP Operating Mode    : Server
VTP Domain Name       : CCIE
VTP Pruning Mode      : Disabled (Operationally Disabled)
VTP V2 Mode           : Enabled
VTP Traps Generation  : Disabled
MD5 digest            : 0xEC 0x05 0x97 0x80 0x3C 0x74 0xF7 0xA1
Configuration last modified by 0.0.0.0 at 2-24-11 14:44:31
Local updater ID is 0.0.0.0 (no valid interface found)
VTP version running   : 2
SW1#
SW1#sh vtp password
VTP Password: CCIE
SW1#
```

Can be any number
but must match on SW1



Sample Lab Question – LAN Switching

■ Verification steps: SW2

Check if VTP config is identical as Sw1 (mode can be client)

```
SW2#sh vtp status
VTP Version          : 3 (capable)
Configuration Revision : 6
Maximum VLANs supported locally : 1005
Number of existing VLANs : 9
VTP Operating Mode    : Client
VTP Domain Name       : CCIE
VTP Pruning Mode      : Disabled (Operationally Disabled)
VTP V2 Mode           : Enabled
VTP Traps Generation  : Disabled
MD5 digest            : 0xEC 0x05 0x97 0x80 0x3C 0x74 0xF7 0xA1
Configuration last modified by 0.0.0.0 at 2-24-11 14:44:31
Local updater ID is 0.0.0.0 (no valid interface found)
VTP version running   : 2
SW2#
SW2#sh vtp password
VTP Password: CCIE
SW2#
```

Can be Client or Server



Sample Lab Question – LAN Switching

■ Spanning Tree Protocol

Configure Spanning-tree protocol on SW1 and SW2 as per the following requirements:

- Configure SW1 and SW2 so that SW1 is the root for all even* VLANs, and SW2 is the root for all odd* VLANs.
- SW1 and SW2 should also serve as backup root switches for their respective VLANs.

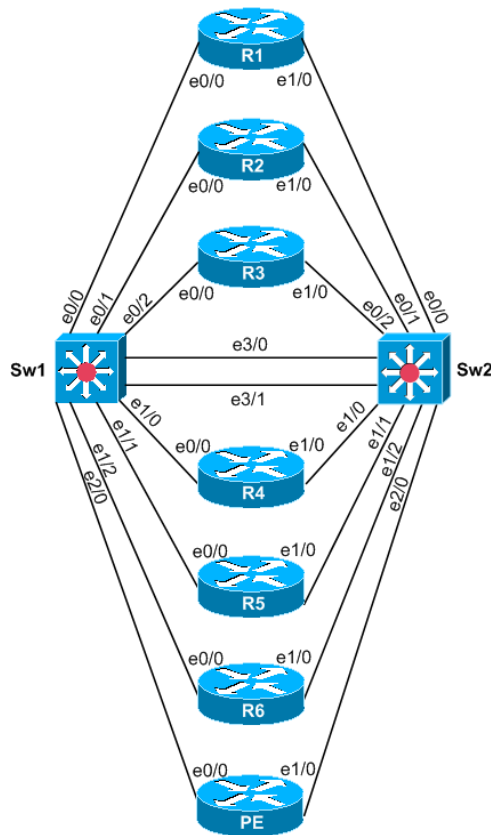
NOTE:

- Your solution must affect only the VLANs used in this topology.
- Odd numbers are not divisible by 2, for example: 1, 3, 5, 7, and so on.
- Even numbers are divisible by 2, for example: 2, 4, 6, 8, and so on.

Score: 2 Points

Practice Lab: Sample topology

Router-Switch connections



Sample Lab Question – LAN Switching

- **Hints, requirements and constraints in the stem:**
 - Configure SW1 and SW2 so that SW1 is the root for all even* VLANs, and SW2 is the root for all odd* VLANs.
 - SW1 and SW2 should also serve as backup root switches for their respective VLANs.
- Very clear requirements about STP config

spanning-tree vlan [VLAN LIST] priority root
spanning-tree vlan [VLAN LIST] priority secondary

Sample Lab Question – LAN Switching

- **Hints, requirements and constraints in the stem:**
(...)
 - Your solution must affect only the VLANs used in this topology.
 - Check which VLANs are used
 - => VLAN 1, 10, 44, 50, 55, 60, 237
 - SW1 = root for 10, 44, 50, 60
 - SW2 = root for 1, 55, 237
- DO NOT FORGET VLAN 1 !

Sample Lab Question – LAN Switching

■ Verification steps: SW1

Check current STP Priority for ALL vlans:

```
SW1#sh span s | i Root
Root bridge for: VLAN0010, VLAN0044, VLAN0050, VLAN0060
SW1#
SW1#sh spanning-tree vlan 55 | i Priority
  Root ID   Priority  24631
  Bridge ID Priority  28727 (priority 28672 sys-id-ext 55)
SW1#sh spanning-tree vlan 44 | i Priority
  Root ID   Priority  24620
  Bridge ID Priority  24620 (priority 24576 sys-id-ext 44)
SW1#
```

Both must not match
for **odd** VLANs and
Bridge ID Priority
must be <32768!

Both must match
for **even** VLANs

Sample Lab Question – LAN Switching

■ Verification steps: SW2

Check current STP Priority for ALL vlans:

```
SW2#sh span s | i Root
Root bridge for: VLAN0001, VLAN0055, VLAN0237
SW2#
SW2#sh spanning-tree vlan 55 | i Priority
  Root ID   Priority   24631
  Bridge ID Priority   24631 (priority 24576 sys-id-ext 55)
SW2#
SW2#sh spanning-tree vlan 44 | i Priority
  Root ID   Priority   24620
  Bridge ID Priority   28716 (priority 28672 sys-id-ext 44)
SW2#
```

Both must match
for **odd** VLANs

Both must not match
for **even** VLANs and
Bridge ID Priority
must be <32768!

Sample Lab Question – LAN Switching

- **Frequently missed points:**

- Requirement missed or not fully configured (ex. VLAN 1!)

- Constraints not respected

- Main guidelines not respected

- VTP Configuration revision not matching as expected

- Access ports not configured in proper VLAN

- Ports shut down by software (err-disabled)

References

- Cisco Press®

 - Cisco LAN Switching, Kennedy Clark

 - Cisco Field Manual: Catalyst Switch Configuration, David Hucaby, Stephen McQuerry

- Interconnections, 2nd edition, Radia Perlman

- CCO Documentation

 - Cisco Catalyst 3560 configuration guide CCO

 - http://www.cisco.com/en/US/products/hw/switches/ps5528/tsd_products_support_series_home.html

Section 3: Study plan: Content topics

Part 1	Switching
Part 2	Routing:
2.1	Routing Concepts
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2.3	IGP Redistribution
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2.6	MPLS-VPN
Part 3	Advanced Services
Part 4	Optimisation
Part 5	Troubleshooting

IP Routing Concepts

- Classless and Classful
- Static and Dynamic routing
- Policy-based Routing
 - Forwarding decisions based on criteria other than destination IP address
- Administrative Distance
 - Determining the priority of different sources of routing updates
- Passive Interfaces
 - Interfaces that participate in routing to learn but not advertise routes

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Disclaimer—Reminder

- With the time allocated, we can **only review** the cornerstones of the most important IGPs

EIGRP and OSPF

EIGRP Topics

- Neighbour Relationships
 - Packet Types
 - Establishment Process
 - Instability
- DUAL (Route Computation)
 - Reported and Feasible Distance
 - (Feasible) Successor
 - Internal vs External Distance

EIGRP Topics

- Summarisation
 - EIGRP Stub
- Load Balancing
 - Equal Cost
 - Unequal Cost

Sample Lab Question – EIGRP

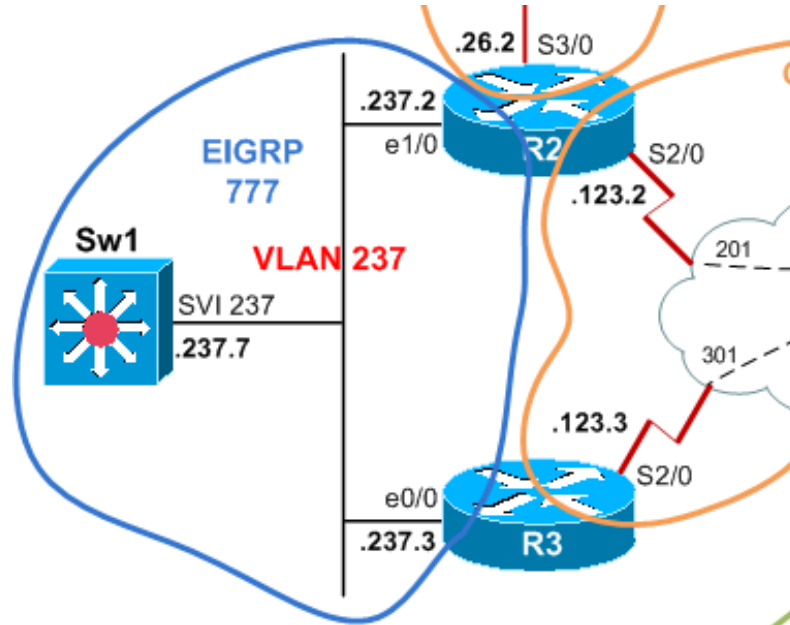
■ EIGRP AS 777

Configure EIGRP Autonomous System 777 on R2, R3 and SW1 for VLAN 237 as per the following requirements:

- Do not activate EIGRP on the serial interfaces.
- Do not use the passive- interface command on any EIGRP router.
- Disable automatic summarisation for EIGRP.
- Without using the network command advertise Loopback0 on SW1 into EIGRP.
- Configure R3 so that it will only accept EIGRP updates from R7

Practice Lab: Sample topology

Focus on EIGRP AS777



Sample Lab Question – EIGRP

- **Hints, requirements and constraints in the stem:**
 - (...) Disable automatic summarisation for EIGRP.
 - Do not use the passive-interface command on any EIGRP router.
 - Do not activate EIGRP on the serial interfaces. (...)
- These requirements imply that only the VLAN 237 interfaces are running EIGRP

```
router eigrp 777  
no auto-summary  
network 172.16.237.0 0.0.0.255
```

Sample Lab Question – EIGRP

- **Hints, requirements and constraints in the stem:**

(...)

- Without using the network command advertise Loopback0 on SW1 into EIGRP.

- This requirement implies to redistribute the prefix

```
access-list 7 permit 7.7.7.7 0.0.0.0
```

```
!
```

```
route-map LO0 permit 10
```

```
match ip address 7
```

```
router eigrp 777
```

```
redistribute connected route-map LO0
```

Sample Lab Question – EIGRP

- Hints, requirements and constraints in the stem:

(...)

- Configure R3 so that it will only accept EIGRP updates from R7

- This requirement points to using the gateway option:

```
ip prefix-list ALLOWED-NEIGH seq 5 permit 172.16.237.7/32
```

```
ip prefix-list ALLOWED-NEIGH seq 10 deny 0.0.0.0/0 le 32
```

```
ip prefix-list ALLOWED-PREF seq 5 permit 0.0.0.0/0 le 32
```

```
!
```

```
router eigrp 777
```

```
  distribute-list prefix ALLOWED-PREF gateway ALLOWED-NEIGH in
```

Sample Lab Question – EIGRP

■ Verification steps:

1. Check EIGRP 777 neighbours and interfaces (No Serial seen)

```
R3#sh ip protocol | s eigrp
Automatic network summarisation is not in effect
=> NO passive interface section seen at all
```

2. Check for SW1.lo0 to be seen as D EX on R2 and R3

```
R2#sh ip ro 7.7.7.7 | i via
Known via "eigrp 777", distance 170, metric 409600, type external
Redistributing via eigrp 777
* 172.16.237.7, from 172.16.237.7, 00:06:39 ago, via Ethernet1/0
```

1. Check R3 for proper Incoming filter with gateway option

```
R3#sh ip protocol | s eigrp
Incoming update filter list for all interfaces is (prefix-list) ALLOWED-PREF gateway ALLOWED-NEIGH
```

Sample Lab Question – EIGRP

- **Frequently missed points:**

- Requirement not fully configured (ex. Passive-int)

- Requirement missing (ex. Filter with Gateway option)

- Constraints not respected

- Main guidelines not respected

References

- CiscoPress®
Routing TCP/IP Volume I & II, Jeff Doyle
- CCO Documentation

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OSPF Topics

- OSPF Areas

 - Area 0

 - Normal

 - NSSA, Stubby, Totally Stubby

- OSPF Router Types

 - ABR, ASBR

- OSPF Link States

 - Router

 - Network

 - Externals (Type 1 and 2)

OSPF Topics

- OSPF over NBMA

Point-to-point, point-to-multipoint, broadcast, non-broadcast

- OSPF over broadcast

DR & BDR, Wildcard masks

- Virtual link

- OSPF Route Selection

- Summarisation

- Authentication

Peer and area

Sample Lab Questions – OSPF

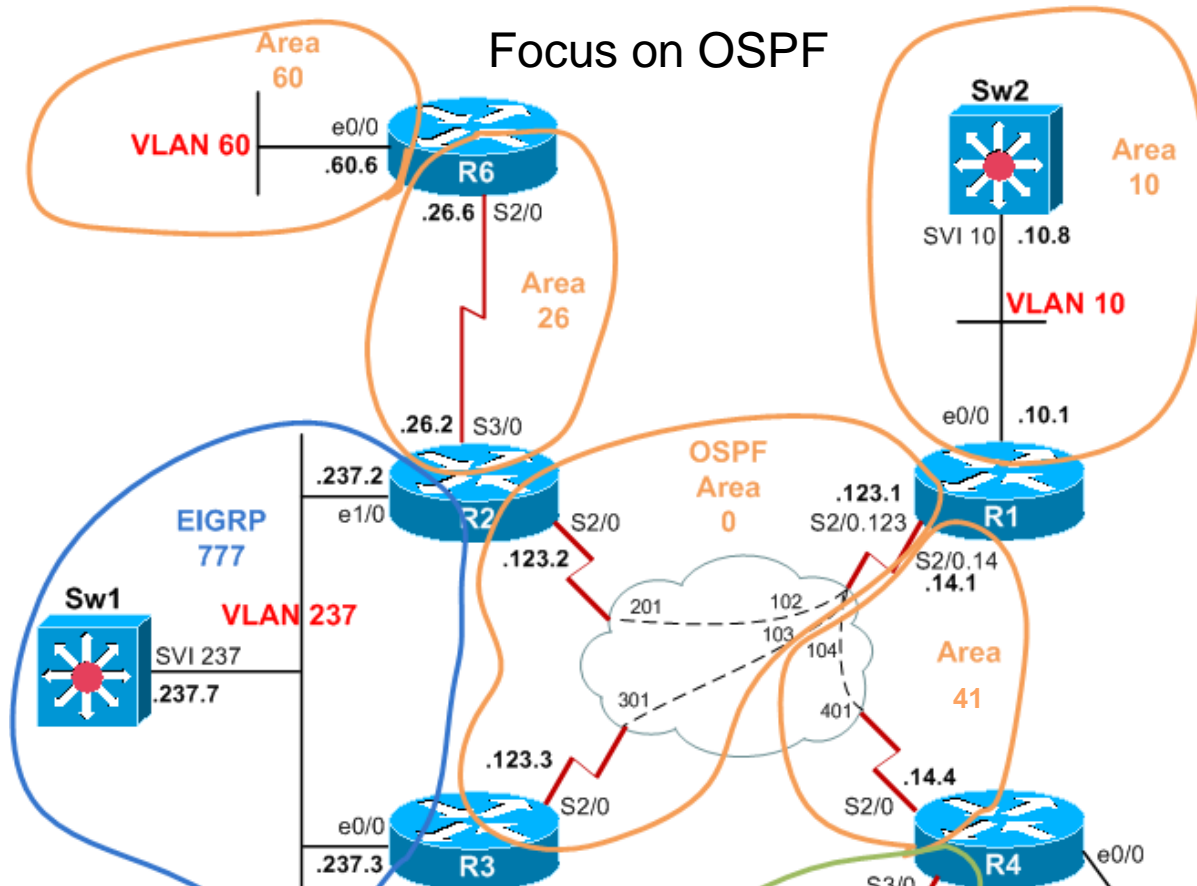
...Aggregated...

■ OSPF Areas configuration

Configure the OSPF domain as per the IGP topology diagram and the following requirements:

- In Area 0, use the OSPF point-to-multipoint network type on the serial interfaces of each router.
- In Area 41, do not change the OSPF network type on R1's S2/0.14 subinterface.
- Change the OSPF network type on R4's S2/0 interface to point-to-multipoint.
- Permit OSPF inter area routing information into Area 41
- Permit external type 7 link state advertisements into Area 41
- Permit OSPF inter area routing information into Area 10 and ensure that external routing information is not flooded into Area 10
- R1 must inject a default route into area 10. Do not use the 'default-information-originate' command.

Practice Lab: Sample topology



Sample Lab Question – OSPF

- **Hints, requirements and constraints in the stem:**
 - (...) In Area 0, use the OSPF point-to-multipoint network type on the serial interfaces of each router.(...)
- This requirements is very explicit, no tricks

```
interface Serial2/0
 ip ospf network-type point-to-multipoint
!
router ospf 1
 network 172.16.123.0
```

Sample Lab Question – OSPF

- **Hints, requirements and constraints in the stem:**
 - (...) In Area 41, do not change the OSPF network type on R1's S2/0.14 subinterface.
 - Change the OSPF network type on R4's S2/0 interface to point-to-multipoint. (...)
- This requirements implies to tune the timer (R1 or R4)

R1: interface Serial2/0.14 point-to-point
ip ospf hello-interval 30

OR

R4: interface Serial2/0
ip ospf hello-interval 10

Sample Lab Question – OSPF

- **Hints, requirements and constraints in the stem:**
 - (...) Permit OSPF inter area routing information into Area 41
 - Permit external type 7 link state advertisements into Area 41
 - Inject a default route into Area 41
- This requirement implies that Area 41 is NSSA

```
router ospf 1  
area 41 nssa default-information originate
```

Sample Lab Question – OSPF

- **Hints, requirements and constraints in the stem:**
 - (...) Permit OSPF inter area routing information into Area 10 and ensure that external routing information is not flooded into Area 10
 - R1 must inject a default route into area 10. Do not use the 'default-information-originate' command.
- This requirement implies that Area 10 is stub

```
router ospf 1  
area 10 stub
```

Sample Lab Question – OSPF

■ Verification steps:

1. Check OSPF neighbours, interfaces and area

```
R1#sh ip ospf int bri
Interface  PID  Area      IP Address/Mask  Cost  State Nbrs F/C
Lo0        1   0         1.1.1.1/32       1    LOOP 0/0
Se2/0.123  1   0         172.16.123.1/24  64    P2MP 2/2
Et0/0      1  10         172.16.10.1/24   10    BDR  1/1
Se2/0.14   1  41         172.16.14.1/24   64    P2P  1/1
R1#
```

2. Check for reachability

```
SW2#ping 172.16.60.6
```

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.60.6, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 60/60/60 ms

```
SW2#
```

Sample Lab Question – OSPF

- **Frequently missed points:**

- Requirement not fully configured (ex. prefix missing)

- Constraints not respected

- Main guidelines not respected

References

- CiscoPress®

Routing TCP/IP Volume I & II, Jeff Doyle

Cisco OSPF Command and Configuration Handbook, William R. Parkhurst

OSPF Network Design Solutions, Thomas M. Thomas

- CCO Documentation

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IPv6 Addressing Topics

- Addressing

Structure

Types

- Link Local
- Global Unicast
- Unique Local Unicast
- Multicast/Anycast
- IPv4 Compatible/Mapped

IPv6 Addressing Topics

- Neighbour Discovery Protocol
 - Router Solicitation/Advertisement
 - Neighbour Solicitation/Advertisement
 - Link layer mapping
 - Duplicate Address Detection
- Address Assignment
 - Static
 - Stateless Autoconfig

IPv6 Routing Topics

- OSPFv3
- EIGRPv6
- Filtering and Route redistribution

OSPFv3 Topics

- Adjacency Formation

 - Per-link vs per-subnet

 - Link-local address

 - Multi-topology via instance-id

- LSA Flooding

 - IPv6 specific multicast addresses

 - New LSA types

 - Renamed LSA types

- Configuration

 - Explicit router-id

 - Per-interface vs per-process

 - IPv6 security replaces OSPF security

Sample Lab Questions – IPv6

■ IPv6 Addressing

Configure IPv6 on R1, R2, R3 and R7 using the following addressing structure:

- Assign an IPv6 address to all IPv4 enabled interfaces except additional loopbacks created in the lab. (enable IPv6 on loopback 0 interfaces and omit the additional loopbacks)
- Use the assigned prefix of 2001:ABC:123::/48 on all interfaces.
- All subnets are 64 bits.
- Use EUI-64 to generate the host portion of the address.
- Complete the network portion of the address from the third octet in the IPv4 address for that interface. For example, use 237 for R7 E0/0.

Sample Lab Questions – IPv6

■ OSPFv3

Configure OSPFv3 on the frame-relay network (R1, R2, R3) for area 0.

- Do not enable OSPFv3 on VLAN 237 but ensure it is advertised as an IPv6 prefix to R1 as an external route
- Ensure that you can IPv6 ping all interfaces and OSPF adjacencies are established.

Sample Lab Question – OSPFv3

- **Frequently missed points:**

- Typo in IPv6 address

- EUI Addressing mismatch

- Requirement not fully configured

- Constraints not respected

- Main guidelines not respected

References

- CiscoPress®

Implementing Cisco IPv6 Networks, Regis Desmeules

Deploying IPv6 Networks, Popoviciu, Levy-Abengnoli,
Grossetete

- CCO Documentation

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IGP Redistribution topics

- Protocol Metrics

 - Defaults

 - Redistribution

- Filtering

 - Route-maps

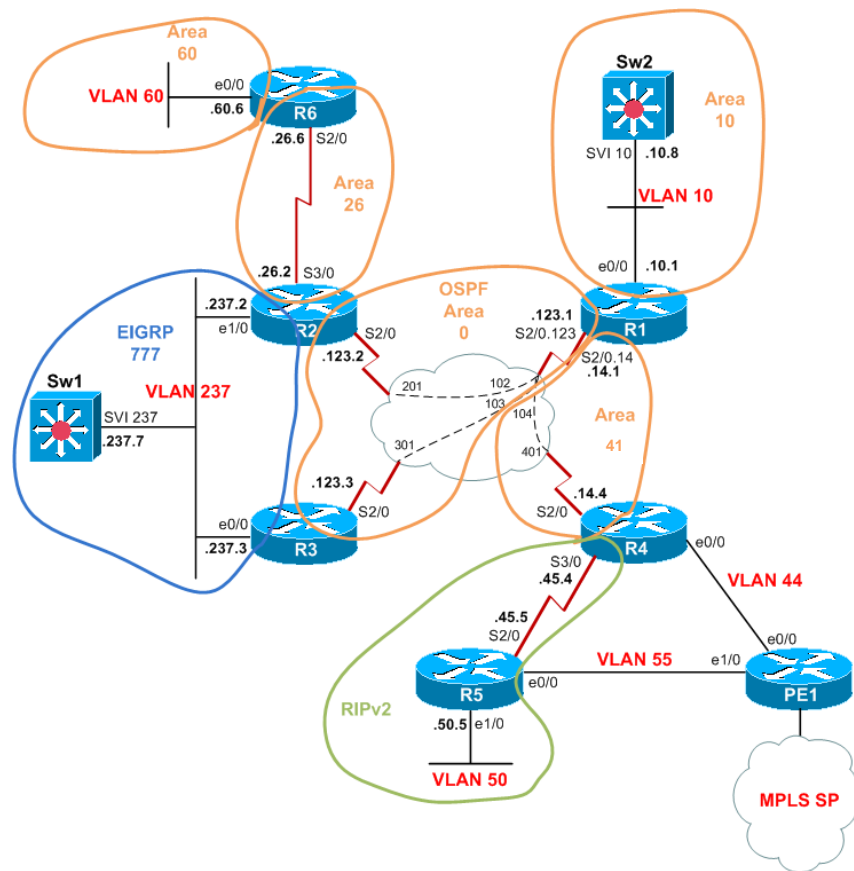
 - Tags

Sample Lab Question – IGP Redistribution

■ EIGRP AS 777 and OSPF

- Mutually redistribute between the RIP and OSPF domains.
- Mutually redistribute EIGRP AS 777 into the OSPF backbone area on R2 and R3
- Filter to avoid routing loops
- Your solution must ensure that any future external EIGRP prefixes redistributed by SW1 will not require configuration changes in R2 and R3

Practice Lab: Sample topology



Sample Lab Question – IGP Redistribution

- **Hints, requirements and constraints in the stem:**
 - Mutually redistribute between the RIP and OSPF domains.(...)
- No tricks here, don't forget the 'subnet' and 'metric' keywords and VERIFY reachability!

```
router rip
  redistribute ospf 1 metric 1
router ospf 1
  redistribute rip subnet
```

Sample Lab Question – IGP Redistribution

- **Hints, requirements and constraints in the stem:**
 - (...) **Mutually** redistribute EIGRP AS 777 into the OSPF (...)
 - Filter to **avoid routing loops**
 - Your solution must ensure that any future external EIGRP prefixes redistributed by SW1 will **not** require **configuration changes** in R2 and R3
- Routing loops easily happen with two redistribution points between the same protocols due to **route feedback**

Sample Lab Question – IGP Redistribution

- **Route feedback filtering with tags account for any future EIGRP external prefixes:**
 - Mark prefixes per protocol before redistributing them
 - Filter prefixes marked by the other

R2 & R3

```
route-map EIGRP2OSPF deny 10
  match tag 88
route-map EIGRP2OSPF permit 20
  set tag 77
route-map OSPF2EIGRP deny 10
  match tag 77
route-map OSPF2EIGRP permit 20
  set tag 88
!
router eigrp 777
  redistribute ospf 1 metric 1 1 1 1 1 route-map OSPF2EIGRP
router ospf 1
  redistribute eigrp 777 subnet route-map EIGRP2OSPF
```

Sample Lab Question – IGP Redistribution

■ Verification steps:

1. Check if SW1.Io0 is seen tagged in R1

```
R1#sh ip ro 7.7.7.7 | i via|tag|ext
Known via "ospf 1", distance 110, metric 20
Tag 77, type extern 2, forward metric 64
* 172.16.123.3, from 3.3.3.3, 00:15:07 ago, via Serial2/0.123
Route tag 77
R1#
```

2. Check for reachability to VLAN60 from SW1 and R1

```
R2#sh ip ro 7.7.7.7 | i via
Known via "eigrp 777", distance 170, metric 409600, type external
Redistributing via eigrp 777
* 172.16.237.7, from 172.16.237.7, 00:06:39 ago, via Ethernet1/0
```

1. Check for keywords on R2 and R3

```
R2#sh run | i router |redist
router eigrp 777
  redistribute ospf 1 metric 1 1 1 1 1 route-map OSPF2EIGRP
router ospf 1
  redistribute eigrp 777 subnets route-map EIGRP2OSPF
R2#
```

Sample Lab Question – IGP Redistribution

- **Frequently missed points:**

- Requirement missing (ex. Route feedback filter, routing loop)

- Prefix not reachable

- Constraints not respected

- Main guidelines not respected

References

- CiscoPress®
Routing TCP/IP Volume I & II, Jeff Doyle
- CCO Documentation
Check protocol documentation

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BGP topics

- Peering

 - iBGP

 - eBGP

 - Directly connected vs multi-hop

 - Neighbour Local-AS

- BGP Path Selection

 - IGP Synchronisation

 - Intra-AS attributes

 - Inter-AS attributes

 - Multipath

BGP topics

- BGP Attributes

 - Atomic Aggregate
 - Communities

- Filtering

 - Route-maps
 - Prefix-lists
 - AS Path Lists
 - Regular Expressions

- Scaling

 - Route Reflectors
 - Confederations

Sample Written Exam Question

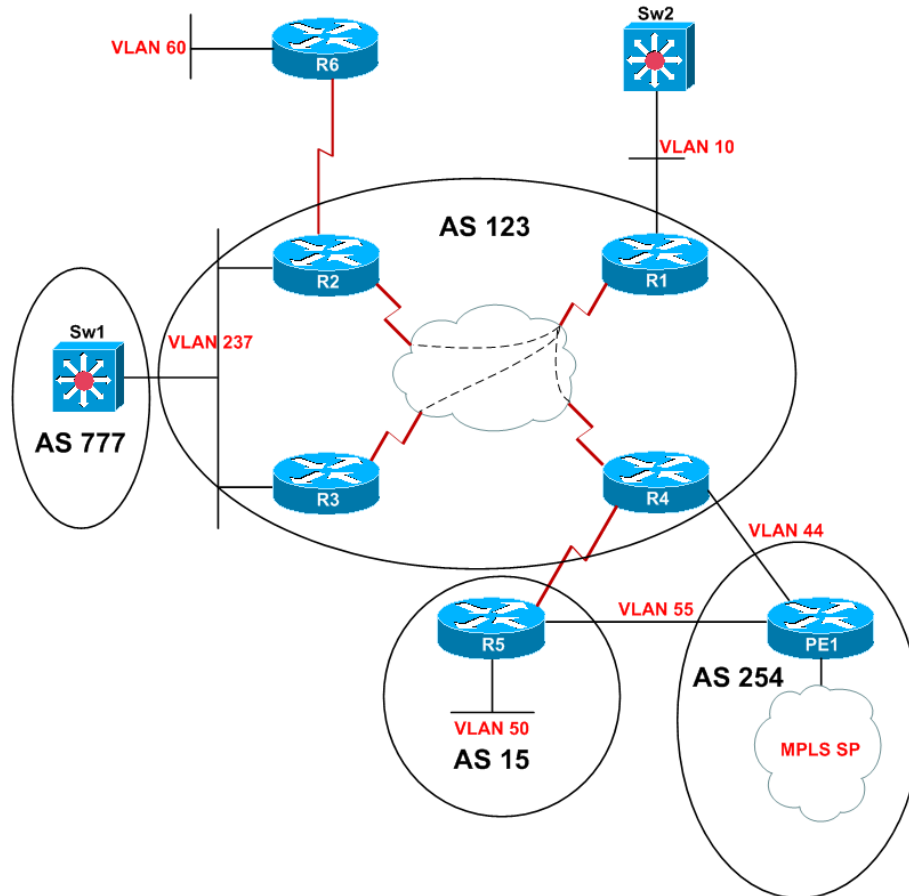
- Which types of prefixes will a router running BGP advertise to an iBGP peer? Consider that this router is not configured as router reflector. Select the best option
 - A. Prefixes received from any other BGP peer and prefixes locally originated via network statements or redistributed
 - B. All prefixes of its routing table
 - C. Prefixes received from eBGP peers and prefixes locally originated via network statements or redistribute
 - D. Prefixes received from eBGP peers and prefixes received from Router Reflectors
 - E. Prefixes received from other iBGP peers, prefixes received from eBGP peers and prefixes redistributed to BGP
 - F. Prefixes received from other iBGP peers and prefixes received from Router Reflectors

Sample Lab Question – BGP

■ IBGP

- Configure BGP on R2, R3 and R4 for AS 123.
- Use a full mesh.
- Establish all peering sessions using the loopback0 interfaces of each router.
- Do not configure BGP on R1.
- On R4 create a Loopback interface and assign it the IP address 99.99.99.1/24
- Inject the 99.99.99.0/24 prefix into BGP using the network command.
- Verify the route appears in the routing tables of all routers running BGP.

Practice Lab: Sample topology



Sample Lab Question – BGP

■ EBGW

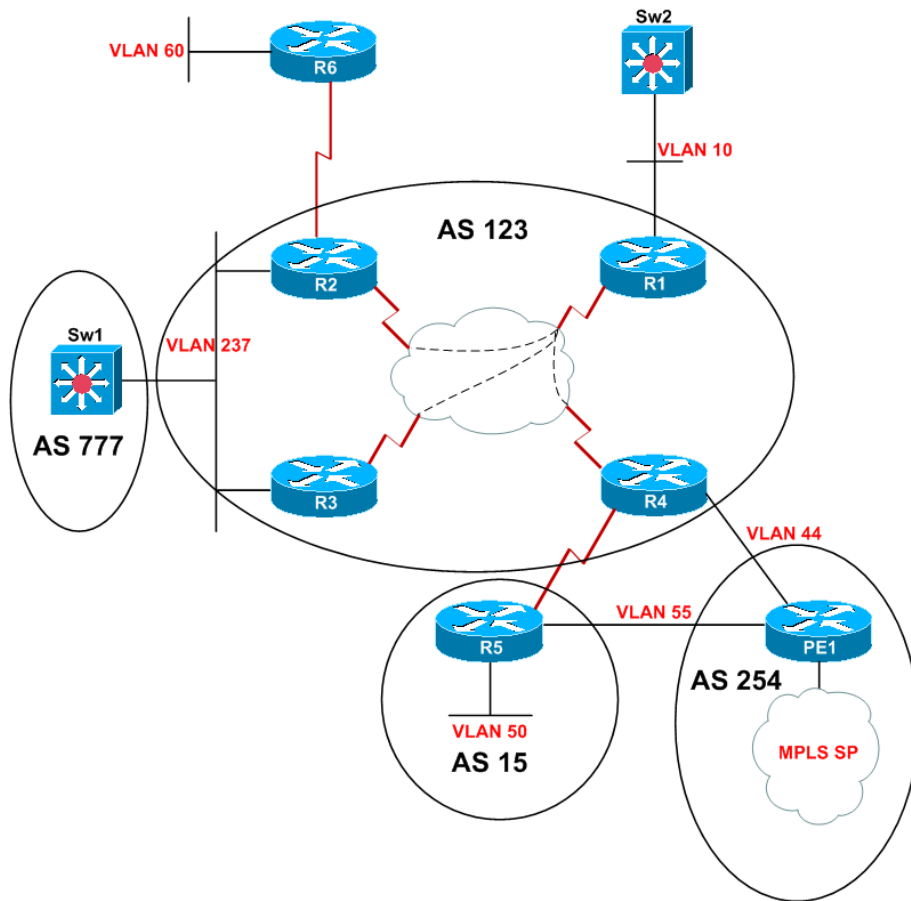
AS 777

- Configure BGP AS 777 on SW1
- Configure SW1 to peer with R2 and R3 in AS 123.

AS 15

- Configure BGP AS 15 on R5.
- Configure R5 to peer with R4 in AS 123
- Advertise the loopback0 interface on R5 via BGP.
- Ensure that network 99.99.99.0/24 is in the BGP and routing tables of SW1 and R5

Practice Lab: Sample topology

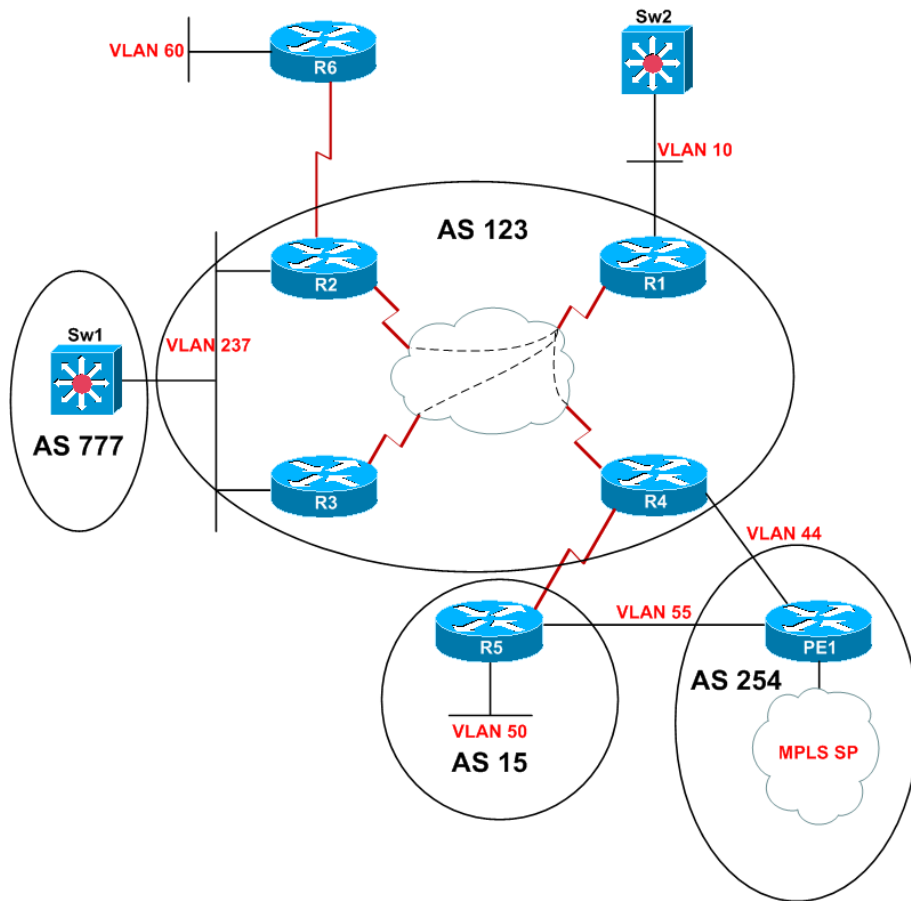


Sample Lab Question – BGP

■ BGP Policy

- The administrator of AS 123 wants to influence how traffic from AS 777 enters the network for certain prefixes.
- Configure R2 such that the 99.99.99.0/24 prefix advertised to AS 777 has the AS path ^123 123 123\$.
- Ensure that other BGP routes are not affected by this policy and will be forwarded to AS 777 unmodified.

Practice Lab: Sample topology



Sample Lab Question – BGP

- **Hints, requirements and constraints in the stem:**
 - Configure R2 such that the 99.99.99.0/24 prefix advertised to AS 777 has the AS path ^123 123 123\$.
 - Ensure that **other BGP routes are not affected by this policy** and will be forwarded to AS 777 unmodified.

!! Watch out for hidden bombs !!

Sample Lab Question – BGP

- **Solution seems easy...**

```
access-list 100 permit ip 99.99.99.0 0.0.0.255 any
!
route-map BGP_policy permit 10
  match ip address 100
  set as-path prepend 123 123
route-map BGP_policy permit 20
!
router bgp 123
  neighbor 172.16.237.7 route-map BGP_policy out
end
clear ip bgp *
```

Sample Lab Question – BGP

- **Before the policy is applied:**
 - SW1 points both prefixes to R2 (lowest router-id):

```
SW1#sh ip bgp
```

```
BGP table version is 21, local router ID is 77.77.77.77
```

```
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,  
r RIB-failure, S Stale
```

```
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
* 5.5.5.5/32	172.16.237.3		0	123	15 i
*>	172.16.237.2		0	123	15 i
* 99.99.99.0/24	172.16.237.3		0	123	i
*>	172.16.237.2		0	123	i

```
SW1#
```

Sample Lab Question – BGP

- **After the policy is applied:**
 - **SW1 MUST point 99.99.99.0 to R3 and 5.5.5.5 to R2!**

SW1#sh ip bgp

BGP table version is 30, local router ID is 77.77.77.77

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
r RIB-failure, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
* 5.5.5.5/32	172.16.237.3		0	123 15	i
*>	172.16.237.2		0	123 15	i
*> 99.99.99.0/24	172.16.237.3		0	123	i
*	172.16.237.2		0	123 123 123	i

SW1#

Sample Lab Question – BGP

- **IF only R2 BGP is cleared:**
 - **SW1 WILL** point 5.5.5.5 to R3 as the path is the oldest!

SW1#sh ip bgp

BGP table version is 31, local router ID is 77.77.77.77

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
r RIB-failure, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
* 5.5.5.5/32	172.16.237.2		0	123 15	i
*>	172.16.237.3		0	123 15	i
* 99.99.99.0/24	172.16.237.2		0	123 123 123	i
*>	172.16.237.3		0	123	i

SW1#

Sample Lab Question – BGP

- **Solution:**

1. Configure R2
2. Clear BGP 'simultaneously' on both sides
3. **Verify resulting state!**

Sample Lab Question – BGP

■ Verification steps:

1. Check best path on SW1's BGP table
2. Check R2 and R3 for expected config

```
R3#sh ip bgp nei 172.16.237.7 | i outgoing
R3#
```

```
R2#sh ip bgp nei 172.16.237.7 | i outgoing
Route map for outgoing advertisements is BGP_policy
R2#sh route-map BGP_policy
route-map BGP_policy, permit, sequence 10
Match clauses:
  ip address (access-lists): 100
Set clauses:
  as-path prepend 123 123
Policy routing matches: 0 packets, 0 bytes
route-map BGP_policy, permit, sequence 20
Match clauses:
Set clauses:
Policy routing matches: 0 packets, 0 bytes
R2#
```

Sample Lab Question – BGP

- **Frequently missed points:**

- Requirement missed (ex. Prefix not affected by policy)

- Password not in use (session not cleared after config)

- Constraints not respected

- Main guidelines not respected

References

- CiscoPress®

Internet Routing Architectures, Bassam Halabi

Cisco BGP-4 Command and Configuration Handbook,
William Parkhurst

- CCO Documentation

Section 3: Study plan: Content topics

Part 1	Switching
Part 2	Routing:
2.1	Routing Concepts
2.2	Routing Protocols: IGP (EIGRP & OSPF)
2.3	Routing Protocols: EGP (BGP)
2.4	Multicast Routing
2.5	MPLS-VPN
Part 3	Advanced Services
Part 4	Optimisation
Part 5	Troubleshooting

Multicast topics

- Multicast Forwarding
 - RPF
 - Shared Tree
 - Source Tree
 - IGMP
- Protocol Independent Multicast (PIM)
 - Messages

Multicast topics

- Multicast Forwarding

 - RPF

 - Shared Tree

 - Source Tree

 - IGMP

- Protocol Independent Multicast (PIM)

 - Messages

 - Dense Mode

 - Sparse Mode

Sample Written Question - Multicast

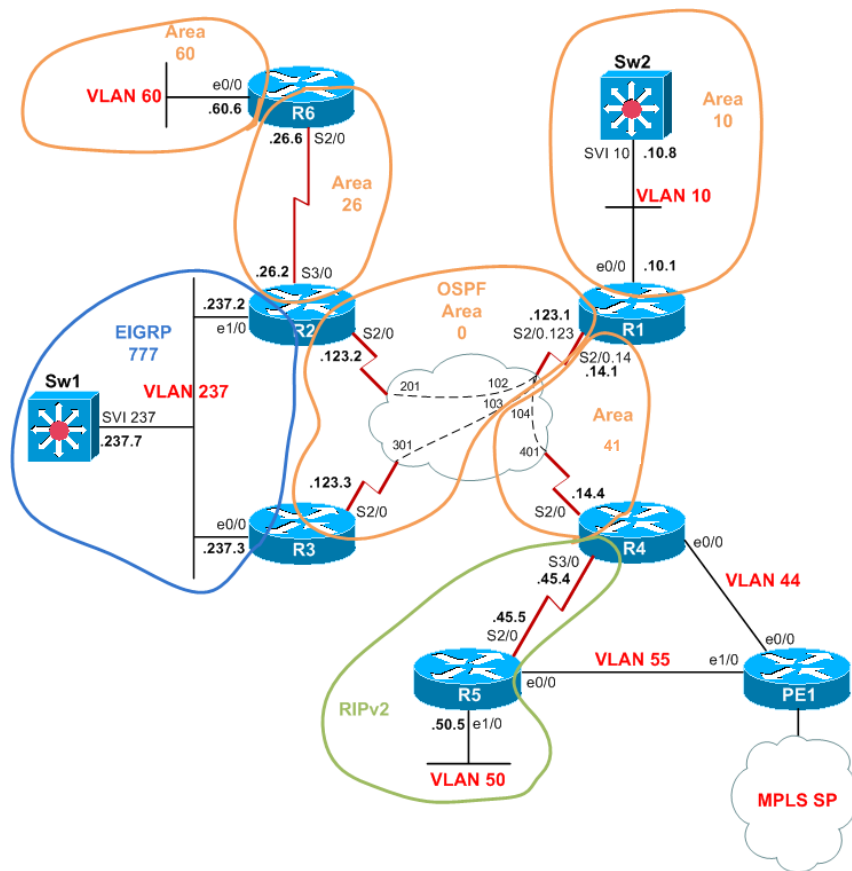
- Which of the following is NOT true of IP Multicast Addressing?
 1. Multicast Group addresses comprise the range 224.0.0.0–239.255.255.255
 2. The Link-Local Address Range is 224.0.0.0–224.0.0.255
 3. Administratively Scoped Addresses (239.0.0.0– 239.255.255.255) are assigned to user applications by IANA
 4. EIGRP Hello's to 224.0.0.10 have a TTL = 1
 5. Scope Relative Addresses are the top 256 addresses of a scoped address range

Sample Lab Question – Multicast

■ Auto RP

- Configure PIM Sparse-mode on R1, R2, R3, SW1.
- Multicast servers are located on VLAN 10.
- Multicast receivers are located on VLAN 237.
- Use auto RP and define loopback0 on R3 as the rendezvous point (RP) for all multicast groups.
- Configure the VLAN10 interface on SW1 to join IGMP group 227.1.1.1
- Ensure you can ping the group address from all PIM routers and VLAN 10.

Practice Lab: Sample topology



Sample Lab Question – Multicast

- Hints, requirements and constraints in the stem:
 - Configure **PIM Sparse-mode** on R1, R2, R3, SW1.
 - Multicast servers are located on VLAN 10, receivers are located on VLAN 237.
 - Use **auto RP** and define loopback0 on **R3 as the rendezvous point (RP)** for all multicast groups.
- PIM Sparse-mode and Auto RP are ‘exclusive’...
 - ip pim multicast-routing
 - (R3)ip pim send-rp-announce Loopback0 scope 16
 - (Any)ip pim send-rp-discovery Loopback0 scope 16
 - ip pim autorp listener
 - interface X/Y
 - ip pim sparse-mode
 - (Sw1)ip igmp join-group 227.1.1.1

Sample Lab Question – Multicast

■ Verification steps:

1. Check if R1 can ping the group

```
R1#ping 227.1.1.1 source 172.16.10.1
```

Type escape sequence to abort.

Sending 1, 100-byte ICMP Echos to 227.1.1.1, timeout is 2 seconds:

Packet sent with a source address of 172.16.10.1

```
Reply to request 0 from 172.16.237.7, 52 ms
```

```
R1#
```

1. Check if R3 is the RP for all groups

```
SW1#sh ip pim rp map | i Group|Auto-RP
```

```
PIM Group-to-RP Mappings
```

```
Group(s) 224.0.0.0/4
```

```
Info source: 3.3.3.3 (?), elected via Auto-RP
```

```
SW1#
```

2. Check if Sw1 has joined the group

Sample Lab Question – Multicast

- **Frequently missed points:**

- Requirement missing

- RPF Failure

- Constraints not respected

- Main guidelines not respected

References

- CiscoPress®
Developing IP Multicast Networks, Beau Williamson
Routing TCP/IP Volume II, Jeff Doyle
- <ftp://ftpeng.cisco.com/ipmulticast/training/index.html>
- CCO Documentation

Section 3: Study plan: Content topics

Part 1	Switching
Part 2	Routing:
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2.5	MPLS-VPN
Part 3	Advanced Services
Part 4	Optimisation
Part 5	Troubleshooting

MPLS/VPN topics

- Network devices

 - P (Provider) routers

 - PE (Provider Edge) routers

 - CE (Customer Edge) routers

- Protocols

 - IGP: core routing protocols: OSPF, EIGRP, IS-IS

 - Label Distribution Protocol (LDP)

 - Resource reservation (RSVP) protocol

- MPLS labels

 - Forwarding Equivalence Class (FEC)

 - MPLS label encapsulation

 - MPLS label stacking

MPLS/VPN topics

- MPLS planes

 - MPLS control planes

 - MPLS forwarding planes

- Layer 3 VPNs

 - VRFs

 - Route Distinguishers

 - Route Targets

 - Multiprotocol BGP

 - PE-CE routing protocols: eBGP, OSPF, EIGRP, RIPv2

Sample Lab Question – MPLS/VPN

Configure the Provider Edge (PE) router and R4/R5 to connect to the MPLS network and receive VPN routes from the service provider (SP) network.

■ LDP

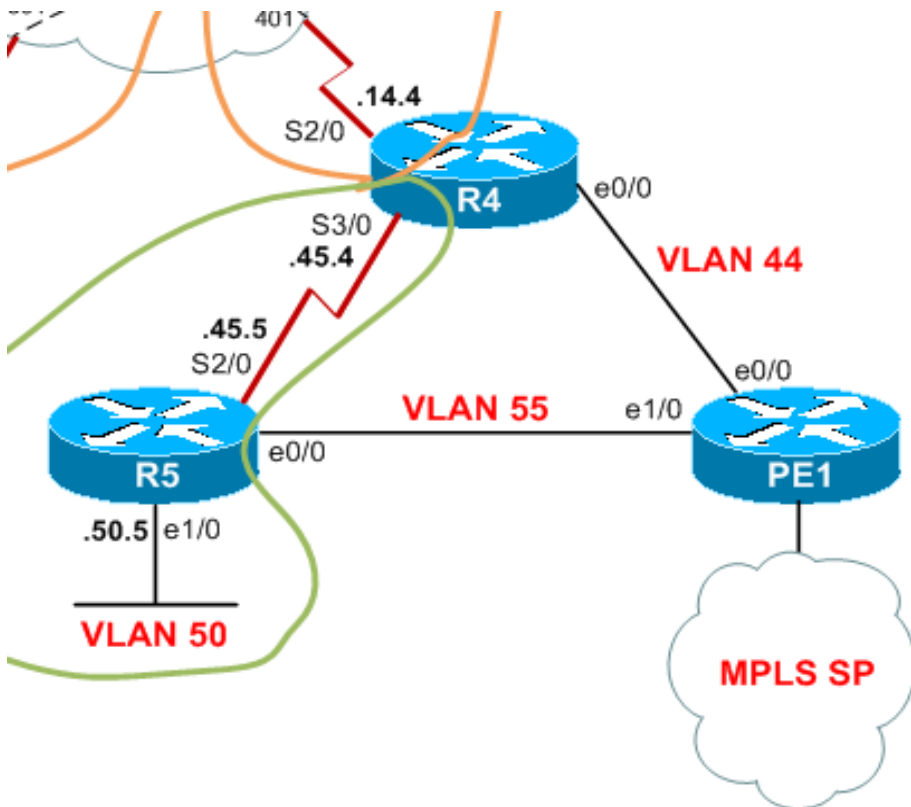
- Configure MPLS label switching on the PE router interface E2/0 and verify an LDP session is established into the SP core.

■ Multi-protocol BGP

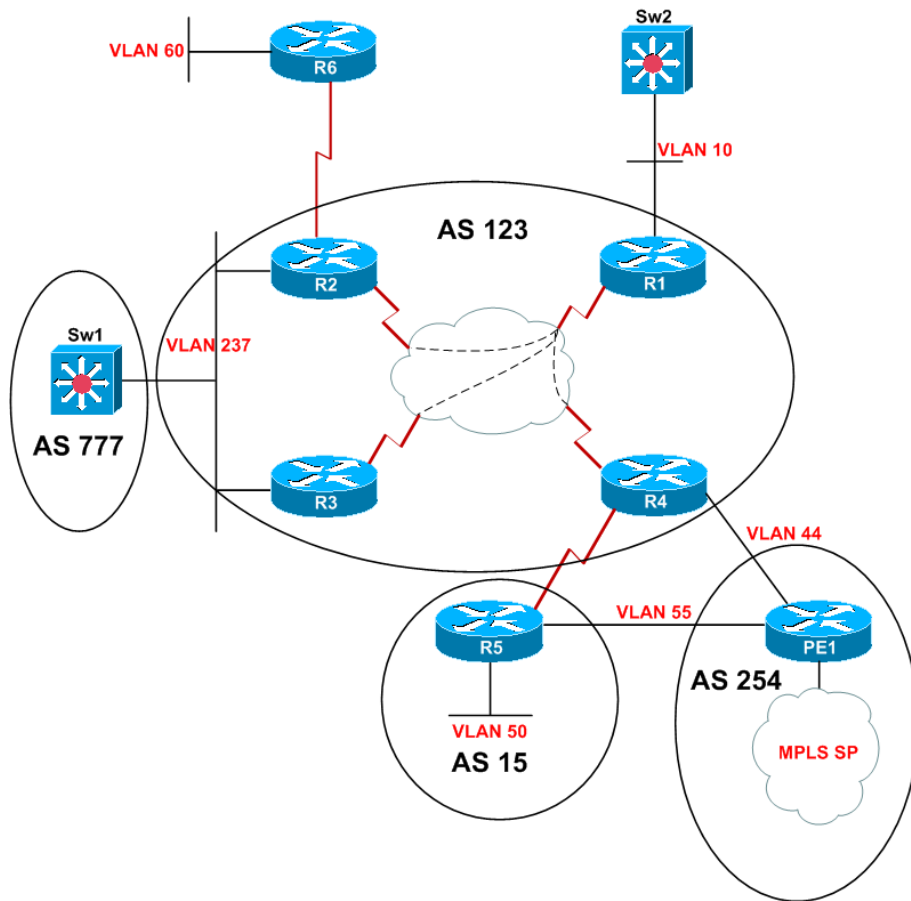
- Configure multi-protocol BGP on the PE router to support MPLS Layer 3 VPNs.
- The service provider is in AS 254 as is the PE router.
- Peer with address 11.11.11.11
- Peering source must be loopback 0

Practice Lab: Sample topology

Focus on the PE-CE and MPLS



Practice Lab: Sample topology



Sample Lab Question – MPLS/VPN

- MPLS Layer 3 VPN
 - Configure two VRFs on the PE router with the following parameters:
 - Create VRF ABC and accept routes with the RD 5.125.16.1:254 into the VPN
 - Create VRF XYZ and accept routes with the RD 254:254 into the VPN.
 - To ensure end-to-end connectivity export using the same route-targets listed above.

Sample Lab Question – MPLS/VPN

- Provider Edge to Customer Edge
 - Advertise the VPN prefixes to R4 and R5 as follows:
 - Insert the link between PE and R4 into the ABC VPN and advertise the ABC VPN routes to R4 via eBGP
 - Insert the link between PE and R5 into the XYZ VPN and advertise the XYZ routes to R5 via eBGP.
 - Configure PE so that VPN routes do not leak between AS 15 and AS 123

Sample Lab Question – MPLS/VPN

- **Hints, requirements and constraints in the stem:**
 - LDP
 - MP-BGP
 - MPLS L3VPN
- Not much tricks here...
- CEF is required but IOS reminds it when configuring VRF:

% Enable CEF globally before configuring VRF on any interface

Sample Lab Question – MPLS/VPN

- Hints, requirements and constraints in the stem:
 - PE-CE:
 - **Configure PE** so that VPN routes do **not leak** between AS 15 and AS 123
- If nothing is done: ZYX routes are seen in R4 and vice versa!

```
R4#sh ip ro 10.125.16.0
Routing entry for 10.125.16.0/24
  Known via "bgp 123", distance 20, metric 0
  Tag 15, type external
  Last update from 172.16.45.5 00:46:04 ago
  Routing Descriptor Blocks:
    * 172.16.45.5, from 172.16.45.5, 00:46:04 ago
      Route metric is 0, traffic share count is 1
      AS Hops 2
      Route tag 15
```

R4#

```
R5#sh ip ro 10.125.16.0
Routing entry for 10.125.16.0/24
  Known via "bgp 15", distance 20, metric 0
  Tag 254, type external
  Last update from 192.168.5.254 00:43:53 ago
  Routing Descriptor Blocks:
    * 192.168.5.254, from 192.168.5.254, 00:43:53 ago
      Route metric is 0, traffic share count is 1
      AS Hops 1
      Route tag 254
```

R5#

Sample Lab Question – MPLS/VPN

- If nothing is done: ZYX routes are seen in R4 and vice versa!

```
R4#sh ip bgp
```

```
BGP table version is 13, local router ID is 99.99.99.1
```

```
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
```

```
               r RIB-failure, S Stale
```

```
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 5.5.5.5/32	172.16.45.5	0		0 15	i
*> 5.125.16.0/24	192.168.4.254			0 254	i
*> 10.125.16.0/24	172.16.45.5			0 15 254	i <<<<<
*> 99.99.99.0/24	0.0.0.0	0		32768	i
*> 192.168.4.0	0.0.0.0	0		32768	i
*> 192.168.5.0	172.16.45.5	0		0 15	i

```
R4#
```

```
R4#
```

Sample Lab Question – MPLS/VPN

- Configure PE to prevent eBGP propagation in downstream
- Set community no-export on PE!

```
route-map noexport permit 10
  set community no-export
!
router bgp 254
  address-family ipv4 vrf XYZ
    neighbor 192.168.5.1 route-map noexport out
  !
  address-family ipv4 vrf ABC
    neighbor 192.168.4.1 route-map noexport out
```

Sample Lab Question – MPLS/VPN

■ Verification steps:

Check if **legitimate** VPN routes are seen in R4

```
R4#sh ip bgp 5.125.16.0
```

```
BGP routing table entry for 5.125.16.0/24, version 16
```

```
Paths: (1 available, best #1, table Default-IP-Routing-Table, not advertised to EBGp peer)
```

```
Advertised to update-groups:
```

```
2
```

```
254
```

```
192.168.4.254 from 192.168.4.254 (9.9.9.9)
```

```
Origin IGP, localpref 100, valid, external, best
```

```
Community: no-export
```

```
Extended Community: RT:5.125.16.1:254
```

```
R4#
```

Sample Lab Question – MPLS/VPN

■ Verification steps:

Check if **legitimate** VPN routes are seen in R5

```
R5#sh ip bgp 10.125.16.0
```

```
BGP routing table entry for 10.125.16.0/24, version 16
```

```
Paths: (1 available, best #1, table Default-IP-Routing-Table, not advertised to EBGp peer)
```

```
Not advertised to any peer
```

```
254
```

```
192.168.5.254 from 192.168.5.254 (9.9.9.9)
```

```
Origin IGP, localpref 100, valid, external, best
```

```
Community: no-export
```

```
Extended Community: RT:254:254
```

```
R5#
```

Sample Lab Question – MPLS/VPN

- **Verification steps:**

Check if **non-legitimate** VPN routes are **not** seen

```
R4#sh ip ro 10.125.16.0
% Network not in table
R4#
R4#sh ip bgp 10.125.16.0
% Network not in table
R4#
```

```
R5#sh ip ro 5.125.16.0
% Subnet not in table
R5#
R5#sh ip bgp 5.125.16.0
% Network not in table
R5#
```

Sample Lab Question – MPLS/VPN

- **Frequently missed points:**

- Requirement missed

- Constraints not respected

- Main guidelines not respected

References

- CiscoPress®

MPLS and VPN Architectures – Jim Guichard, Ivan Papelnjak

Traffic Engineering with MPLS – Eric Osborne, Ajay Simha

Layer 2 VPN Architectures – Wei Luo, Carlos Pignataro, Dmitry Bokotey, Anthony Chan

MPLS QoS – Santiago Alvarez

MPLS Fundamentals – Luc DeGhein

- CCO Documentation:

http://www.cisco.com/en/US/products/ps6557/products_ios_technology_home.html

Section 3: Study plan: Content topics

Part 1	Switching
Part 2	Routing
Part 3	Advanced Services:
3.1	Quality of Services
3.2	Security
3.3	Services
Part 4	Optimisation
Part 5	Troubleshooting

Quality of Service topics

- QoS Models
 - Diffserv
 - Intserv/RSVP
- QoS Operations
 - Classification/Marking
 - Queuing
 - Policing/Shaping
- Cisco Implementation
 - Modular QoS Command Line (MQC)
 - Catalyst Switch Specifics

Sample Lab Question – Quality of Service

■ Congestion Avoidance

- Configure the E0/0 interface on R7 for congestion avoidance.
- Ensure R7 will drop TCP packets prior to periods of congestion.
- Do not use the modular CLI.
- Change the minimum queue depth for all IP precedence values to 100.
- Change the maximum queue depth for all IP precedence values to 250.
- Use the command show queuing to verify your solution

Sample Lab Question – Quality of Service

- **Frequently missed points:**

- Requirement missing

- Prefix not reachable

- Constraints not respected

- Main guidelines not respected

References

- CiscoPress®

End-to-End QoS Network Design Quality of Service in LANs, WANs, and VPNs, by Tim Szigeti, Christina Hattingh

- CCO Documentation:

IOS 12.4

http://www.cisco.com/en/US/products/ps6350/tsd_products_support_series_home.html

Catalyst 3560

http://www.cisco.com/en/US/products/hw/switches/ps5528/tsd_products_support_series_home.html

Multicast Technologies

http://www.cisco.com/en/US/products/ps6558/products_ios_technology_home.html

Section 3: Study plan: Content topics

Part 1	Switching
Part 2	Routing
Part 3	Advanced Services:
3.1	Quality of Services
3.2	Security
3.3	Services
Part 4	Optimisation
Part 5	Troubleshooting

Network Security topics

- Access-Control List (ACL)
- Unicast Reverse Path Forwarding (uRPF)
- IP Source Guard
- Authentication, Authorisation, and Accounting (AAA)
- Control Plane Policing (CoPP)
- Context-Based Access Control (CBAC)
- Zone Based Firewall

Network Security topics

- Cisco IOS Intrusion Prevention System (IPS)
- Secure Shell (SSH)
- 802.1x
- Routing Protocol Authentication
- LAN Switching security
 - VLAN Access map
 - Private VLAN
 - DAI
 - DHCP snooping

Sample Lab Question – Network Security

■ Access-list

- Configure an out-going access list on the S2/0.123 interface of R1 such that:
- Mail servers on VLAN 237 cannot connect to mail servers on VLAN 10 (SMTP) but mail servers on VLAN 10 can connect to mail servers on VLAN 237
- Restrict UDP traffic from VLAN 10 such that only hosts using source ports in the range 6000 to 7000 (inclusive) can reach hosts on VLAN 237.
- Prevent SW1 from successfully pinging the R4's loopback0 interface. R4 should be able to ping SW1.

References

- CiscoPress®

Network Security Technologies and Solutions, Bhaiji

CCO Documentation:

http://www.cisco.com/en/US/tech/tk713/tk237/tsd_technology_support_protocol_home.html

http://www.cisco.com/en/US/docs/ios/wan/configuration/guide/wan_cfg_frm_rly_ps6441_TS_D_Products_Configuration_Guide_Chapter.html

Section 3: Study plan: Content topics

Part 1	Switching
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3.2	Security
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Network services topics

- Services

HSRP

GLBP

VRRP

NTP

DHCP

WCCP

Section 3: Study plan: Content topics

Part 1	Switching
Part 2	Routing
Part 3	Advanced Services
Part 4	Optimisation
Part 5	Troubleshooting

Network optimisation topics

- Network management

 - SNMP

 - EEM

 - (T)FTP, SCP, HTTP(S), Telnet

- Network monitoring

 - Syslog and logging

 - Netflow

 - (R)SPAN

 - IPSLA

 - RMON

Section 3: Study plan: Content topics

Part 1	Switching
Part 2	Routing
Part 3	Advanced Services
Part 4	Optimisation
Part 5	Troubleshooting

Network Troubleshooting topics

- Layer 2 network issues
- Layer 3 network issues
- Application response issues
- Network services issues
- Network security issues

Sample Lab Question – Troubleshooting

- Symptom based question wording
- Explicit validation test
- Optional constraints
- Pointer to the general guidelines

Lets wait for the Case studies section for examples

“Know what you don’t know”

Agenda

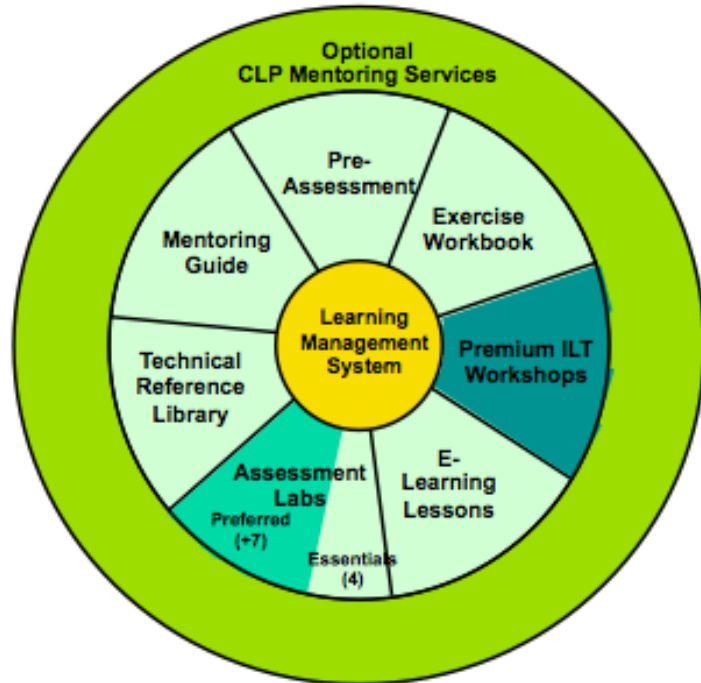
Section 1	CCIE Program Overview
Section 2	CCIE Routing and Switching Version 4
Section 3	Study plan: Content topics review and Sample questions
Section 4	Study plan: Preparation materials
Section 5	Lab Exam: Tips and tricks
Section 6	Troubleshooting Case Studies
Section 7	Conclusion

Study plan: Preparation materials

- Cisco 360 Learning Program for CCIE R&S
- Written exam
- Lab exam
- Troubleshooting

Cisco 360 for CCIE R&S

A 360-degree, blended learning program to accelerate expert-level **competency** and build the **skills** required for CCIE R&S certification



	<u>Learning Management System</u> Available to all Cisco 360 students
	<u>Essentials Package:</u> <ul style="list-style-type: none">▪Pre-Assessment▪Exercise Workbook▪E-Learning Lessons▪4 Assessment Labs▪Technical Reference Library▪Mentoring Guide
	<u>Preferred Package:</u> <ul style="list-style-type: none">▪Essentials Package, plus...▪6 additional Assessment Labs
	<u>Premium Package</u> <ul style="list-style-type: none">▪Preferred Package, plus...▪2 Instructor Workshops
	Mentoring Services available from authorised CLPs, to support any package

Written Exam Preparation

- Study the [CCIE R&S Written Exam Topics](#) posted on the Cisco Learning Network (CLN). Some topics-such as 'planning and evaluating network changes-will only appear on the written exam.
- Reading list is only suggested.
- Refer to online resources and Cisco documentation.

Written Exam Preparation

- Use Cisco 360 Learning Program or other training courses to fill holes in your knowledge.
- Written Exam stresses procedures and concepts more than configuration skills.

Lab Exam Preparation, General

- PRACTICE
- EXPLORE
- CONFIGURE
- INVENT
- VERIFY
- ANTICIPATE
- TROUBLESHOOT

Lab Exam Preparation, General

- Study the [CCIE R&S Lab Exam Topics](#) posted on the Cisco Learning Network (CLN).
- Evaluate your skills against the exam requirements.
- For areas of strength—review and practice for speed. Speed and accuracy is vital on exam.
- For weaker areas—increase knowledge with training or books first, then practice with equipment.

Agenda

Section 1	CCIE Program Overview
Section 2	CCIE Routing and Switching Version 4
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Section 7	Conclusion

Lab Exam: Tips and Tricks

- READ the whole exam before starting anything
- READ the question
- RE-READ the question
- THINK about the solution and expected result
- Use NOTEPAD to build your configurations
- VERIFY the effects of your solution on previous questions
- SAVE running configurations frequently

Lab Exam: Tips and Tricks

- Reduce stress - arrive early
- Leave yourself time - exam can run over
- Read entire exam
- Redraw topology to clarify scenario
- Manage your time

Lab Exam: Tips and Tricks

- Make no assumptions
- Keep a checklist
- Work questions as a unit
- Test your work
- Save configurations often
- Minimise last-minute changes

Lab Exam: Tips and Tricks

- Once full reachability is established, keep a continuous ping spanning the longest path to easily monitor reachability issue during later questions
- Don't lose too much time on 2 points questions
Move ahead with topics you are more comfortable with
Better use a prohibited solution and lose one question rather than losing ALL dependent questions (Ex. PPPoE...)

Lab Exam: Tips and Tricks

- Know how/when to use debugs
- Remember to enable console logging
- Use aliases and CLI shortcuts (ctrl-A; -W; -E)
- Organise your terminal windows

Lab Exam: Tips and tricks

- Beware of **rumors**
- Visit the Cisco Learning Network for more on CCIE R&S certification and interaction with other candidates

www.cisco.com/go/learningnetwork

- Contact support:

www.cisco.com/go/certsupport

- Report cheating:

ccie-nda-enforcement@cisco.com

Lab Exam: Tips and tricks

- Proctor's role is to keep exam fair
- Ask the proctor to clarify questions
Don't ask or fish for answers
- Report any equipment or technical problems to proctor
As soon as it occurs but expect he will ask for evidences

Agenda

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Section 7	Conclusion

Troubleshooting Case Studies

- Switching issue

MST issue messing up VLAN connectivity

Troubleshooting Case Studies

- Routing issue

SW2 can't ping host in VLAN60 due to EIGRP AD for external set lower than 110 in R2/R3

Troubleshooting Case Studies

- MPLS issue

R4 can't ping remote host in VPN due to LDP down

Agenda

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Section 5	Lab Exam: Tips and tricks
Section 6	Troubleshooting Case Studies
Section 7	Conclusion

Q & A

“Know what you don’t know”

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