

## CCIE R&S Written Bootcamp

### COURSE OVERVIEW:

CCIE 400-101 Routing and Switching Written Bootcamp - The CCIE Routing and Switching Written (CCIE Written) Bootcamp is a five-day course that prepares students for the CCIE R&S Written exam. The exam assesses technical knowledge on topics such as IP, IP routing, bridging and switch-related technologies and some equipment commands.

### PREREQUISITES:

- A valid CCNP certification is recommended.
- 2 years of Cisco networking experience is recommended.

### COURSE OBJECTIVES:

Upon completing the course, students will be able to meet the following objectives:

- Describe Cisco Business Video components and architectures
- Implement Cisco Collaboration endpoints
- Implement Cisco TelePresence endpoints
- Implement multipoint conferencing on Cisco collaboration endpoints
- Implement Cisco DMP endpoints

### COURSE OUTLINE:

#### 1.0 Network Principles

##### 1.1 Network theory

- 1.1.a Describe basic software architecture differences between IOS and IOS XE
  - 1.1.a (i) Control plane and Forwarding plane
  - 1.1.a (ii) Impact to troubleshooting and performances
  - 1.1.a (iii) Excluding specific platform's architecture
- 1.1.b Identify Cisco express forwarding concepts
  - 1.1.b (i) RIB, FIB, LFIB, Adjacency table
  - 1.1.b (ii) Load balancing Hash
  - 1.1.b (iii) Polarization concept and avoidance
- 1.1.c Explain general network challenges
  - 1.1.c (i) Unicast flooding
  - 1.1.c (ii) Out of order packets
  - 1.1.c (iii) Asymmetric routing
  - 1.1.c (iv) Impact of micro burst
- 1.1.d Explain IP operations
  - 1.1.d (i) ICMP unreachable, redirect
  - 1.1.d (ii) IPv4 options, IPv6 extension headers
  - 1.1.d (iii) IPv4 and IPv6 fragmentation
  - 1.1.d (iv) TTL
  - 1.1.d (v) IP MTU

- 1.1.e Explain TCP operations
  - 1.1.e (i) IPv4 and IPv6 PMTU
  - 1.1.e (ii) MSS
  - 1.1.e (iii) Latency
  - 1.1.e (iv) Windowing
  - 1.1.e (v) Bandwidth delay product
  - 1.1.e (vi) Global synchronization
  - 1.1.e (vii) Options
- 1.1.f Explain UDP operations
  - 1.1.f (i) Starvation
  - 1.1.f (ii) Latency
  - 1.1.f (iii) RTP/RTCP concepts

### **1.2 Network implementation and operation**

- 1.2.a Evaluate proposed changes to a network
  - 1.2.a (i) Changes to routing protocol parameters
  - 1.2.a (ii) Migrate parts of a network to IPv6
  - 1.2.a (iii) Routing protocol migration
  - 1.2.a (iv) Adding multicast support
  - 1.2.a (v) Migrate spanning tree protocol
  - 1.2.a (vi) Evaluate impact of new traffic on existing QoS design

### **1.3 Network troubleshooting**

- 1.3.a Use IOS troubleshooting tools
  - 1.3.a (i) debug, conditional debug
  - 1.3.a (ii) ping, traceroute with extended options
  - 1.3.a (iii) Embedded packet capture
  - 1.3.a (iv) Performance monitor
- 1.3.b Apply troubleshooting methodologies
  - 1.3.b (i) Diagnose the root cause of networking issue (analyze symptoms, identify and describe root cause)
  - 1.3.b (ii) Design and implement valid solutions according to constraints
  - 1.3.b (iii) Verify and monitor resolution
- 1.3.c Interpret packet capture
  - 1.3.c (i) Using Wireshark trace analyzer
  - 1.3.c (ii) Using IOS embedded packet capture

## **2.0 Layer 2 Technologies**

### **2.1 LAN switching technologies**

- 2.1.a Implement and troubleshoot switch administration
  - 2.1.a (i) Managing MAC address table
  - 2.1.a (ii) errdisable recovery
  - 2.1.a (iii) L2 MTU
- 2.1.b Implement and troubleshoot layer 2 protocols
  - 2.1.b (i) CDP, LLDP
  - 2.1.b (ii) UDLD
- 2.1.c Implement and troubleshoot VLAN
  - 2.1.c (i) Access ports
  - 2.1.c (ii) VLAN database
  - 2.1.c (iii) Normal, extended VLAN, voice VLAN

- 2.1.d Implement and troubleshoot trunking
  - 2.1.d (i) VTPv1, VTPv2, VTPv3, VTP pruning
  - 2.1.d (ii) dot1Q
  - 2.1.d (iii) Native VLAN
  - 2.1.d (iv) Manual pruning
- 2.1.e Implement and troubleshoot EtherChannel
  - 2.1.e (i) LACP, PAgP, manual
  - 2.1.e (ii) Layer 2, layer 3
  - 2.1.e (iii) Load-balancing
  - 2.1.e (iv) EtherChannel misconfiguration guard
- 2.1.f Implement and troubleshoot spanning-tree
  - 2.1.f (i) PVST+/RPVST+/MST
  - 2.1.f (ii) Switch priority, port priority, path cost, STP timers
  - 2.1.f (iii) port fast, BPDUguard, BPDUfilter
  - 2.1.f (iv) loopguard, rootguard
- 2.1.g Implement and troubleshoot other LAN switching technologies
  - 2.1.g (i) SPAN, RSPAN, ERSPAN
- 2.1.h Describe chassis virtualization and aggregation technologies
  - 2.1.h (i) Multichassis
  - 2.1.h (ii) VSS concepts
  - 2.1.h (iii) Alternative to STP
  - 2.1.h (iv) Stackwise
  - 2.1.h (v) Excluding specific platform implementation
- 2.1.i Describe spanning-tree concepts
  - 2.1.i (i) Compatibility between MST and RSTP
  - 2.1.i (ii) STP dispute, STP bridge assurance

## **2.2 Layer 2 multicast**

- 2.2.a Implement and troubleshoot IGMP
  - 2.2.a (i) IGMPv1, IGMPv2, IGMPv3
  - 2.2.a (ii) IGMP snooping
  - 2.2.a (iii) IGMP querier
  - 2.2.a (iv) IGMP filter
  - 2.2.a (v) IGMP proxy
- 2.2.b Explain MLD
- 2.2.c Explain PIM snooping

## **2.3 Layer 2 WAN circuit technologies**

- 2.3.a Implement and troubleshoot HDLC
- 2.3.b Implement and troubleshoot PPP
  - 2.3.b (i) Authentication (PAP, CHAP)
  - 2.3.b (ii) PPPoE
  - 2.3.b (iii) MLPPP
- 2.3.c Describe WAN rate-based ethernet circuits
  - 2.3.c (i) Metro and WAN Ethernet topologies
  - 2.3.c (ii) Use of rate-limited WAN ethernet services

### **3.0 Layer 3 Technologies**

#### **3.1 Addressing technologies**

- 3.1.a Identify, implement and troubleshoot IPv4 addressing and subnetting
  - 3.1.a (i) Address types, VLSM
  - 3.1.a (ii) ARP
- 3.1.b Identify, implement and troubleshoot IPv6 addressing and subnetting
  - 3.1.b (i) Unicast, multicast
  - 3.1.b (ii) EUI-64
  - 3.1.b (iii) ND, RS/RA
  - 3.1.b (iv) Autoconfig/SLAAC, temporary addresses (RFC4941)
  - 3.1.b (v) Global prefix configuration feature
  - 3.1.b (vi) DHCP protocol operations
  - 3.1.b (vii) SLAAC/DHCPv6 interaction
  - 3.1.b (viii) Stateful, stateless DHCPv6
  - 3.1.b (ix) DHCPv6 prefix delegation

#### **3.2 Layer 3 multicast**

- 3.2.a Troubleshoot reverse path forwarding
  - 3.2.a (i) RPF failure
  - 3.2.a (ii) RPF failure with tunnel interface
- 3.2.b Implement and troubleshoot IPv4 protocol independent multicast
  - 3.2.b (i) PIM dense mode, sparse mode, sparse-dense mode
  - 3.2.b (ii) Static RP, auto-RP, BSR
  - 3.2.b (iii) BiDirectional PIM
  - 3.2.b (iv) Source-specific multicast
  - 3.2.b (v) Group to RP mapping
  - 3.2.b (vi) Multicast boundary
- 3.2.c Implement and troubleshoot multicast source discovery protocol
  - 3.2.c (i) Intra-domain MSDP (anycast RP)
  - 3.2.c (ii) SA filter
- 3.2.d Describe IPv6 multicast
  - 3.2.d (i) IPv6 multicast addresses
  - 3.2.d (ii) PIMv6

#### **3.3 Fundamental routing concepts**

- 3.3.a Implement and troubleshoot static routing
- 3.3.b Implement and troubleshoot default routing
- 3.3.c Compare routing protocol types
  - 3.3.c (i) Distance vector
  - 3.3.c (ii) Link state
  - 3.3.c (iii) Path vector
- 3.3.d Implement, optimize and troubleshoot administrative distance
- 3.3.e Implement and troubleshoot passive interface
- 3.3.f Implement and troubleshoot VRF lite
- 3.3.g Implement, optimize and troubleshoot filtering with any routing protocol
- 3.3.h Implement, optimize and troubleshoot redistribution between any routing protocol
- 3.3.i Implement, optimize and troubleshoot manual and auto summarization with any routing protocol
- 3.3.j Implement, optimize and troubleshoot policy-based routing
- 3.3.k Identify and troubleshoot sub-optimal routing
- 3.3.l Implement and troubleshoot bidirectional forwarding detection

- 3.3.m Implement and troubleshoot loop prevention mechanisms
  - 3.3.m (i) Route tagging, filtering
  - 3.3.m (ii) Split horizon
  - 3.3.m (iii) Route poisoning
- 3.3.n Implement and troubleshoot routing protocol authentication
  - 3.3.n (i) MD5
  - 3.3.n (ii) Keychain
  - 3.3.n (iii) EIGRP HMAC SHA2-256bit
  - 3.3.n (iv) OSPFv2 SHA1-196bit
  - 3.3.n (v) OSPFv3 IPsec authentication

### **3.4 RIP (v2 and v6)**

- 3.4.a Implement and troubleshoot RIPv2
- 3.4.b Describe RIPv6 (RIPng)

### **3.5 EIGRP (for IPv4 and IPv6)**

- 3.5.a Describe packet types
  - 3.5.a (i) Packet types (hello, query, update, and such)
  - 3.5.a (ii) Route types (internal, external)
- 3.5.b Implement and troubleshoot neighbor relationship
  - 3.5.b (i) Multicast, unicast EIGRP peering
  - 3.5.b (ii) OTP point-to-point peering
  - 3.5.b (iii) OTP route-reflector peering
  - 3.5.b (iv) OTP multiple service providers scenario
- 3.5.c Implement and troubleshoot loop free path selection
  - 3.5.c (i) RD, FD, FC, successor, feasible successor
  - 3.5.c (ii) Classic metric
  - 3.5.c (iii) Wide metric
- 3.5.d Implement and troubleshoot operations
  - 3.5.d (i) General operations
  - 3.5.d (ii) Topology table, update, query, active, passive
  - 3.5.d (iii) Stuck in active
  - 3.5.d (iv) Graceful shutdown
- 3.5.e Implement and troubleshoot EIGRP stub
  - 3.5.e (i) Stub
  - 3.5.e (ii) Leak-map
- 3.5.f Implement and troubleshoot load-balancing
  - 3.5.f (i) equal-cost
  - 3.5.f (ii) unequal-cost
  - 3.5.f (iii) add-path
- 3.5.g Implement EIGRP (multi-address) named mode
  - 3.5.g (i) Types of families
  - 3.5.g (ii) IPv4 address family
  - 3.5.g (iii) IPv6 address family
- 3.5.h Implement, troubleshoot and optimize EIGRP convergence and scalability
  - 3.5.h (i) Describe fast convergence requirements
  - 3.5.h (ii) Control query boundaries
  - 3.5.h (iii) IP FRR/fast reroute (single hop)
  - 3.5.8 (iv) Summary leak-map
  - 3.5.h (v) Summary metric



### 3.6 OSPF (v2 and v3)

- 3.6.a Describe packet types
  - 3.6.a (i) LSA types (1, 2, 3, 4, 5, 7, 9)
  - 3.6.a (ii) Route types (N1, N2, E1, E2)
- 3.6.b Implement and troubleshoot neighbor relationship
- 3.6.c Implement and troubleshoot OSPFv3 address-family support
  - 3.6.c (i) IPv4 address-family
  - 3.6.c (ii) IPv6 address-family
- 3.6.d Implement and troubleshoot network types, area types and router types
  - 3.6.d (i) Point-to-point, multipoint, broadcast, non-broadcast
  - 3.6.d (ii) LSA types, area type: backbone, normal, transit, stub, NSSA, totally stub
  - 3.6.d (iii) Internal router, ABR, ASBR
  - 3.6.d (iv) Virtual link
- 3.6.e Implement and troubleshoot path preference
- 3.6.f Implement and troubleshoot operations
  - 3.6.f (i) General operations
  - 3.6.f (ii) Graceful shutdown
  - 3.6.f (iii) GTSM (Generic TTL Security Mechanism)
- 3.6.g Implement, troubleshoot and optimize OSPF convergence and scalability
  - 3.6.g (i) Metrics
  - 3.6.g (ii) LSA throttling, SPF tuning, fast hello
  - 3.6.g (iii) LSA propagation control (area types, ISPF)
  - 3.6.g (iv) IP FRR/fast reroute (single hop)
  - 3.6.g (v) LFA/loop-free alternative (multi hop)
  - 3.6.g (vi) OSPFv3 prefix suppression

### 3.7 BGP

- 3.7.a Describe, implement and troubleshoot peer relationships
  - 3.7.a (i) Peer-group, template
  - 3.7.a (ii) Active, passive
  - 3.7.a (iii) States, timers
  - 3.7.a (iv) Dynamic neighbors
- 3.7.b Implement and troubleshoot IBGP and EBGP
  - 3.7.b (i) EBGP, IBGP
  - 3.7.b (ii) 4 bytes AS number
  - 3.7.b (iii) Private AS
- 3.7.c Explain attributes and best-path selection
- 3.7.d Implement, optimize and troubleshoot routing policies
  - 3.7.d (i) Attribute manipulation
  - 3.7.d (ii) Conditional advertisement
  - 3.7.d (iii) Outbound route filtering
  - 3.7.d (iv) Communities, extended communities
  - 3.7.d (v) Multi-homing
- 3.7.e Implement and troubleshoot scalability
  - 3.7.e (i) Route-reflector, cluster
  - 3.7.e (ii) Confederations
  - 3.7.e (iii) Aggregation, AS set
- 3.7.f Implement and troubleshoot multiprotocol BGP
  - 3.7.f (i) IPv4, IPv6, VPN address-family

- 3.7.g Implement and troubleshoot AS path manipulations
  - 3.7.g (i) Local AS, allow AS in, remove private AS
  - 3.7.g (ii) Prepend
  - 3.7.g (iii) Regexp
- 3.7.h Implement and troubleshoot other features
  - 3.7.h (i) Multipath
  - 3.7.h (ii) BGP synchronization
  - 3.7.h (iii) Soft reconfiguration, route refresh
- 3.7.i Describe BGP fast convergence features
  - 3.7.i (i) Prefix independent convergence
  - 3.7.i (ii) Add-path
  - 3.7.i (iii) Next-hop address tracking

### **3.8 ISIS (for IPv4 and IPv6)**

- 3.8.a Describe basic ISIS network
  - 3.8.a (i) Single area, single topology
- 3.8.b Describe neighbor relationship
- 3.8.c Describe network types, levels and router types
  - 3.8.c (i) NSAP addressing
  - 3.8.c (ii) Point-to-point, broadcast
- 3.8.d Describe operations
- 3.8.e Describe optimization features
  - 3.8.e (i) Metrics, wide metric

## **4.0 VPN Technologies**

### **4.1 Tunneling**

- 4.1.a Implement and troubleshoot MPLS operations
  - 4.1.a (i) Label stack, LSR, LSP
  - 4.1.a (ii) LDP
  - 4.1.a (iii) MPLS ping, MPLS traceroute
- 4.1.b Implement and troubleshoot basic MPLS L3VPN
  - 4.1.b (i) L3VPN, CE, PE, P
  - 4.1.b (ii) Extranet (route leaking)
- 4.1.c Implement and troubleshoot encapsulation
  - 4.1.c (i) GRE
  - 4.1.c (ii) Dynamic GRE
  - 4.1.c (iii) LISP encapsulation principles supporting EIGRP OTP
- 4.1.d Implement and troubleshoot DMVPN (single hub)
  - 4.1.d (i) NHRP
  - 4.1.d (ii) DMVPN with IPsec using preshared key
  - 4.1.d (iii) QoS profile
  - 4.1.d (iv) Pre-classify
- 4.1.e Describe IPv6 tunneling techniques
  - 4.1.e (i) 6in4, 6to4
  - 4.1.e (ii) ISATAP
  - 4.1.e (iii) 6RD
  - 4.1.e (iv) 6PE/6VPE
- 4.1.g Describe basic layer 2 VPN-wireline
  - 4.1.g (i) L2TPv3 general principals
  - 4.1.g (ii) ATOM general principals

- 4.1.h Describe basic L2VPN “ LAN services
  - 4.1.h (i) MPLS-VPLS general principals
  - 4.1.h (ii) OTV general principals

#### **4.2 Encryption**

- 4.2.a Implement and troubleshoot IPsec with preshared key
  - 4.2.a (i) IPv4 site to IPv4 site
  - 4.2.a (ii) IPv6 in IPv4 tunnels
  - 4.2.a (iii) Virtual tunneling Interface (VTI)
- 4.2.b Describe GET VPN

### **5.0 Infrastructure Security**

#### **5.1 Device security**

- 5.1.a Implement and troubleshoot IOS AAA using local database
- 5.1.b Implement and troubleshoot device access control
  - 5.1.b (i) Lines (VTY, AUX, console)
  - 5.1.b (ii) SNMP
  - 5.1.b (iii) Management plane protection
  - 5.1.b (iv) Password encryption
- 5.1.c Implement and troubleshoot control plane policing
- 5.1.d Describe device security using IOS AAA with TACACS+ and RADIUS
  - 5.1.d (i) AAA with TACACS+ and RADIUS
  - 5.1.d (ii) Local privilege authorization fallback

#### **5.2 Network security**

- 5.2.a Implement and troubleshoot switch security features
  - 5.2.a (i) VACL, PACL
  - 5.2.a (ii) Stormcontrol
  - 5.2.a (iii) DHCP snooping
  - 5.2.a (iv) IP source-guard
  - 5.2.a (v) Dynamic ARP inspection
  - 5.2.a (vi) port-security
  - 5.2.a (vii) Private VLAN
- 5.2.b Implement and troubleshoot router security features
  - 5.2.b (i) IPv4 access control lists (standard, extended, time-based)
  - 5.2.b (ii) IPv6 traffic filter
  - 5.2.b (iii) Unicast reverse path forwarding
- 5.2.c Implement and troubleshoot IPv6 first hop security
  - 5.2.c (i) RA guard
  - 5.2.c (ii) DHCP guard
  - 5.2.c (iii) Binding table
  - 5.2.c (iv) Device tracking
  - 5.2.c (v) ND inspection/snooping
  - 5.2.c (vii) Source guard
  - 5.2.c (viii) PACL
- 5.2.d Describe 802.1x
  - 5.2.d (i) 802.1x, EAP, RADIUS
  - 5.2.d (ii) MAC authentication bypass



## **6.0 Infrastructure Services**

### **6.1 System management**

- 6.1.a Implement and troubleshoot device management
  - 6.1.a (i) Console and VTY
  - 6.1.a (ii) telnet, HTTP, HTTPS, SSH, SCP
  - 6.1.a (iii) (T)FTP
- 6.1.b Implement and troubleshoot SNMP
  - 6.1.b (i) v2c, v3
- 6.1.c Implement and troubleshoot logging
  - 6.1.c (i) Local logging, syslog, debug, conditional debug
  - 6.1.c (ii) Timestamp

### **6.2 Quality of service**

- 6.2.a Implement and troubleshoot end-to-end QoS
  - 6.2.a (i) CoS and DSCP mapping
- 6.2.b Implement, optimize and troubleshoot QoS using MQC
  - 6.2.b (i) Classification
  - 6.2.b (ii) Network based application recognition (NBAR)
  - 6.2.b (iii) Marking using IP precedence, DSCP, CoS, ECN
  - 6.2.b (iv) Policing, shaping
  - 6.2.b (v) Congestion management (queuing)
  - 6.2.b (vi) HQoS, sub-rate ethernet link
  - 6.2.b (vii) Congestion avoidance (WRED)
- 6.2.c Describe layer 2 QoS
  - 6.2.c (i) Queuing, scheduling
  - 6.2.c (ii) Classification, marking

### **6.3 Network services**

- 6.3.a Implement and troubleshoot first-hop redundancy protocols
  - 6.3.a (i) HSRP, GLBP, VRRP
  - 6.3.a (ii) Redundancy using IPv6 RS/RA
- 6.3.b Implement and troubleshoot network time protocol
  - 6.3.b (i) NTP master, client, version 3, version 4
  - 6.3.b (ii) NTP Authentication
- 6.3.c Implement and troubleshoot IPv4 and IPv6 DHCP
  - 6.3.c (i) DHCP client, IOS DHCP server, DHCP relay
  - 6.3.c (ii) DHCP options
  - 6.3.c (iii) DHCP protocol operations
  - 6.3.c (iv) SLAAC/DHCPv6 interaction
  - 6.3.c (v) Stateful, stateless DHCPv6
  - 6.3.c (vi) DHCPv6 prefix delegation
- 6.3.d Implement and troubleshoot IPv4 network address translation
  - 6.3.d (i) Static NAT, dynamic NAT, policy-based NAT, PAT
  - 6.3.d (ii) NAT ALG
- 6.3.e Describe IPv6 network address translation
  - 6.3.e (i) NAT64
  - 6.3.e (ii) NPTv6

### **6.4 Network optimization**

- 6.4.a Implement and troubleshoot IP SLA
  - 6.4.a (i) ICMP, UDP, Jitter, VoIP

- 6.4.b Implement and troubleshoot tracking object
  - 6.4.b (i) Tracking object, tracking list
  - 6.4.b (ii) Tracking different entities (e.g. interfaces, routes, IPSLA, and such)
- 6.4.c Implement and troubleshoot netflow
  - 6.4.c (i) Netflow v5, v9
  - 6.4.c (ii) Local retrieval
  - 6.4.c (iii) Export (configuration only)
- 6.4.d Implement and troubleshoot embedded event manager
  - 6.4.d (i) EEM policy using applet
- 6.4.e Identify performance routing (PfR)
  - 6.4.e (i) Basic load balancing
  - 6.4.e (ii) Voice optimization

## **7.0 Evolving Technologies**

### **7.1 Cloud**

- 7.1.a Compare and contrast Cloud deployment models
  - 7.1.a (i) Infrastructure, platform, and software services (XaaS)
  - 7.1.a (ii) Performance and reliability
  - 7.1.a (iii) Security and privacy
  - 7.1.a (iv) Scalability and interoperability
- 7.1.b Describe Cloud implementations and operations
  - 7.1.b (i) Automation and orchestration
  - 7.1.b (ii) Workload mobility
  - 7.1.b (iii) Troubleshooting and management
  - 7.1.b (iv) OpenStack components

### **7.2 Network programmability (SDN)**

- 7.2.a Describe functional elements of network programmability (SDN) and how they interact
  - 7.2.a (i) Controllers
  - 7.2.a (ii) APIs
  - 7.2.a (iii) Scripting
  - 7.2.a (iv) Agents
  - 7.2.a (v) Northbound vs. Southbound protocols
- 7.2.b Describe aspects of virtualization and automation in network environments
  - 7.2.b (i) DevOps methodologies, tools and workflows
  - 7.2.b (ii) Network/application function virtualization (NFV, AFV)
  - 7.2.b (iii) Service function chaining
  - 7.2.b (iv) Performance, availability, and scaling considerations

### **7.3 Internet of Things**

- 7.3.a Describe architectural framework and deployment considerations for Internet of Things (IoT)
  - 7.3.a (i) Performance, reliability and scalability
  - 7.3.a (ii) Mobility
  - 7.3.a (iii) Security and privacy
  - 7.3.a (iv) Standards and compliance
  - 7.3.a (v) Migration
  - 7.3.a (vi) Environmental impacts on the network

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