CCNP ROUTE
Portable Command Guide

All the ROUTE 642-902 Commands in
One Compact, Portable Resource

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Introduction

Welcome to *CCNP ROUTE Portable Command Guide*! When Cisco Press approached me about updating the four-volume *CCNP Portable Command Guides*, two thoughts immediately jumped into my head: "Is it time for revisions already?" and "Yikes! I am in the middle of pursuing my master's degree. Where will I find the time?" Because of those thoughts, two more soon followed: "I wonder what Hans is up to?" and "I hope Carol is in a good mood, as I am about to ask to take Hans away again…." The result is what you now have before you; a new *Portable Command Guide* for the latest version of the CCNP exam that focuses on routing: CCNP ROUTE.

For those of you who have worked with my books before, thank you for looking at this one. I hope that it will help you as you prepare for the vendor exam, or assist you in your daily activities as a Cisco network administrator/manager. For those of you who are new to my books, you are reading what is essentially a cleaned-up version of my own personal engineering journals—a small notebook that I carry around with me that contains little nuggets of information; commands that I use but then forget; IP address schemes for the parts of the network I work with only occasionally; and quick refreshers for those concepts that I work with only once or twice a year. Although I teach these topics to postsecondary students, the classes I teach sometimes occur only once a year; as you can attest to, it is extremely difficult to remember all those commands all the time. Having a journal of commands at your fingertips, without having to search the Cisco website, can be a real time-saver (or a job-saver if the network is down and you are responsible for getting it back online).

With the creation of the new CCNP exam objectives, there is always something new to read; or a new podcast to listen to; or another slideshow from Cisco Live that you missed or want to review. The engineering journal can be that central repository of information that won't weigh you down as you carry it from the office or cubicle to the server and infrastructure rooms in some remote part of the building or some branch office.

To make this guide a more realistic one for you to use, the folks at Cisco Press have decided to continue with an appendix of blank pages—pages on which you can write your own personal notes, such as your own configurations, commands that are not in this book but are needed in your world, and so on. That way, this book will look less like the authors' journals and more like your own.

Networking Devices Used in the Preparation of This Book

To verify the commands that are in this new series of *CCNP Portable Command Guides*, many different devices were used. The following is a list of the equipment used in the preparation of these books:

- C2620 router running Cisco IOS Release 12.3(7)T, with a fixed Fast Ethernet interface, a WIC 2A/S serial interface card, and an NM-1E Ethernet interface
- C2811 ISR bundle with PVDM2, CMME, a WIC-2T, FXS and FXO VICs, running Cisco IOS Release 12.4(3g)

- C2821 ISR bundle with HWICD 9ESW, a WIC 2A/S, running 12.4(16) Advanced Security IOS
- WS-C3560-24-EMI Catalyst Switch, running Cisco IOS Release 12.2(25)SE
- WS-C3550-24-EMI Catalyst Switch, running Cisco IOS Release 12.1(9)EA1c
- WS-2960-24TT-L Catalyst Switch, running Cisco IOS Release 12.2(25)SE
- WS-2950-12 Catalyst Switch, running version C2950-C3.0(5.3)WC(1) Enterprise Edition Software
- WS-C3750-24TS Catalyst Switches, running ipservicesk9 release 12.2(52)SE
- C1760-V Voice Router with PVDM-256K-20, WIC-4ESW, VIC-2FXO, VIC-2FXS running ENTSERVICESK9 release 12.4(11)T2

You might notice that some of the devices were not running the latest and greatest IOS. Some of them are running code that is quite old.

Those of you familiar with Cisco devices will recognize that a majority of these commands work across the entire range of the Cisco product line. These commands are not limited to the platforms and IOS versions listed. In fact, in most cases, these devices are adequate for someone to continue their studies beyond the CCNP level as well. We have endeavored to identify throughout the book commands that are specific to a platform and/or IOS version.

Who Should Read This Book?

This book is for those people preparing for the CCNP ROUTE exam, whether through self-study, on-the-job training and practice, study within the Cisco Academy Program, or study through the use of a Cisco Training Partner. This book includes some handy hints and tips along the way to make life a bit easier for you in this endeavor. It is small enough that you will find it easy to carry around with you. Big, heavy textbooks might look impressive on your bookshelf in your office, but can you really carry them all around with you when you are working in some server room or equipment closet somewhere?

Strategies for Exam Preparation

The strategy that you use for CCNP ROUTE might be slightly different from strategies that other readers use, mainly based on the skills, knowledge, and experience you already have obtained. For instance, if you have attended the ROUTE course, you might take a different approach than someone who learned routing via on-the-job training. Regardless of the strategy you use or the background you have, the book is designed to help you get to the point where you can pass the exam with the least amount of time required. For instance, there is no need for you to practice or read about EIGRP or OSPF if you fully understand it already. However, many people like to make sure that they truly know a topic and thus read over material that they already know. Several book features will help you not only to gain the confidence that you need to be convinced that you know some material already, but also to determine which topics you need to study more.

Organization of This Book

Although this book could be read cover-to-cover, we strongly advise against it. The book is designed to be a simple listing of those commands that you need to understand to pass the ROUTE exam. Very little theory is included in the *Portable Command Guides*; they are designed to list commands needed at this level of study.

This book follows the list of objectives for the CCNP ROUTE exam:

- **Chapter 1: "Network Design Requirements"**—This chapter shows the Cisco Hierarchical Model of Network Design; the Cisco Enterprise Composite Network Model; the Cisco Service-Oriented Network Architecture (SONA); a comparison of routing protocols; a chart outlining where protocols should be implemented; and the PPDIOO network lifecycle.
- **Chapter 2: "Implementing an EIGRP-based Solution"**—This chapter covers EIGRP, including the design, implementation, verification, and troubleshooting of this protocol.
- **Chapter 3: "Implementing a Scalable Multiarea Network OSPF-based Solution"**—This chapter deals with OSPF, including a review of configuring OSPF, both single area (as a review) and multiarea. Topics include the design, implementation, verification, and troubleshooting of the protocol.
- **Chapter 4: "Implementing an IPv4-based Redistribution Solution"**—This chapter shows how to manipulate routing information. Topics include prefix lists, distribution lists, route maps, route redistribution, administrative distances, and static routes.
- **Chapter 5: "Implementing Path Control"**—This chapter deals with those tools and commands that can be used to help evaluate network performance issues and control the path. Topics include offset lists, Cisco IOS IP Service Level Agreements (SLAs), and policy-based routing using route maps.
- **Chapter 6: "Enterprise to ISP Connectivity"**—This chapter deals with the use of BGP to connect an enterprise network to a service provider. Topics include the configuration, verification, and troubleshooting of a BGP-based solution; BGP attributes; regular expressions; and BGP route filtering using access lists.
- **Chapter 7: "Implementing IPv6"**—This chapter provides information and commands regarding the implementation of IPv6. Topics include assigning IPv6 addresses; CEF and dCEF for IPv6; RIPng; OSPFv3; IPv6 and EIGRP; route redistribution; IPv6 transition techniques; NAT-PC for IPv6; static routes; and verifying and troubleshooting IPv6.
- **Chapter 8: "Routing for Branch Offices and Mobile Workers"**—This chapter deals with the connection, verification, and troubleshooting of remote locations within your network. Topics include verifying existing services; configuring DSL; configuring PPPoA; configuring a cable modem connection; connecting a teleworker to a branch office VPN; configuring IPsec site-to-site VPNs; and configuring GRE tunnels over IPsec.

Did We Miss Anything?

As educators, we are always interested to hear how our students, and now readers of our books, do on both vendor exams and future studies. If you would like to contact either of us and let us know how this book helped you in your certification goals, please do so. Did we miss anything? Let us know. Contact us at ccnpguide@empson.ca or through the Cisco Press website, www.ciscopress.com.

CHAPTER 5

Implementing Path Control

This chapter provides information concerning the following topics related to implementing path control:

- Offset lists
- Cisco IOS IP Service Level Agreements
- Policy routing using route maps
- Configuration example: route maps

NOTE: Path control is the mechanism that changes default packet forwarding across a network. It is not quality of service (QoS) or MPLS Traffic Engineering (MPLS-TE). Path control is a collection of tools or a set of commands that is able to manipulate the routing protocol forwarding table or to bypass default packet forwarding. The manipulation of routing information may be required to obtain better resiliency, performance, or availability in your network.

There are other filters or tools available to assist in the manipulation of the routing table. These include

- Route maps
- Prefix lists
- Distribute lists
- Administrative distance
- Route tagging

These are mostly protocol dependent and have been covered in other chapters in this book.

Offset Lists

NOTE: The **offset-list** command is only applicable to EIGRP and RIP routing protocols. The **offset-list** command is used to add an offset to incoming and outgoing metrics to routes learned using these protocols. The offset value is added to the metric.

TIP: An offset list with an interface type and number is considered to be extended and will take precedence over an offset list that is not extended. This means that if an entry passes the extended offset list and the normal offset list, the offset of the extended offset list is added to the metric.

`Router(config)#router eigrp 11`	Enables EIGRP routing process with an autonomous system number of 11.
`Router(config-router)#offset-list 21 out 10`	Applies an offset list of 10 to the delay component (outgoing metrics) of a router to networks matching ACL 21.
`Router(config-router)#offset-list 21 in 10 fastethernet 0/0`	Applies an offset list of 10 to the incoming metrics of routes matching ACL 21 learned from interface FastEthernet 0/0.

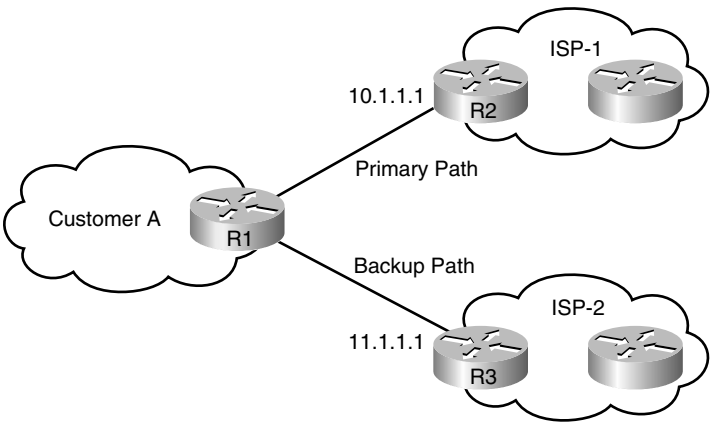
Cisco IOS IP Service Level Agreements

NOTE: Cisco IOS IP Service Level Agreements (SLAs) are used to perform network performance measurements within Cisco Systems devices using active traffic monitoring.

TIP: SLAs use timestamp information to calculate performance metrics such as jitter, latency, network and server response times, packet loss, and mean opinion score.

Figure 5-1 shows the network topology for the configuration that follows, which shows the use of Cisco IOS IP SLA functionality for path control.

Figure 5-1 Cisco IOS IP Service Level Agreements



Customer requirements:

- Customer A is multihoming to ISP-1 and ISP-2.
- The link to ISP-1 is the primary link for all traffic.
- Customer A is using default routes to the ISPs instead of BGP.
- Customer A is using static routes with different administrative distances to make ISP-1 the preferred route.

Potential problem: If ISP-1 is having uplink connectivity problems to the Internet, Customer A will still be sending all of its traffic to ISP-1, only to have that traffic lost.

Solution: IOS IP SLA will be used to announce conditionally the default route to ensure reachability of a specific destination.

Follow these steps to configure Cisco IOS IP SLA functionality:

Step 1. Define one (or more) probes.

Step 2. Define one (or more) tracking objects.

Step 3. Define the action on the tracking object(s).

Step 4. Verify IP SLA operations.

Step 1: Define One (or More) Probes

`R1(config)#ip sla monitor 22`	Begins configuration for an IP SLA operation and enters SLA monitor configuration mode. 22 is the operation number and is a number between 1–2147483647.
`R1(config-sla-monitor)#type echo protocol ipIcmpEcho 10.1.1.1 source-interface fastethernet 0/0`	Defines an ICMP Echo operation to destination address 10.1.1.1 through source interface of FastEthernet 0/0 and enters ICMP Echo configuration mode.
`R1(config-sla-monitor-echo)#frequency 10`	Sets the rate at which the operation repeats. Measured in seconds from 1–604800 (7 days).
`R1(config-sla-monitor-echo)#exit`	Exits IP SLA Monitor ICMP Echo configuration mode and returns to global configuration mode.
`R1(config)#ip sla monitor schedule 22 life forever start-time now`	Sets a schedule for IP SLA monitor 22. Packets will be sent out immediately and will continue forever.

Step 2: Define One (or More) Tracking Objects

`R1(config)#track 1 sla 22 reachability`	Configures the tracking process to track the reachability of IP SLAs operation 22.
	NOTE: This command was introduced in Cisco IOS Release 12.4(20)T and replaces the **track rtr** command.

Step 3: Define the Action on the Tracking Object(s)

`R1(config)#ip route 0.0.0.0 0.0.0.0 11.1.1.1 3 track 1`	Announces a default route to 11.1.1.1 with an administrative distance of 3 if the tracking object 1 is true.

Step 4: Verify IP SLA Operations

`R1#show ip sla configuration`	Displays SLA components such as frequency, target address, scheduling, and other parameters.
`R1#show ip sla statistics 22`	Displays number of successful and failed probes, last operation, start time, and last return code for SLA monitor 22.
`R1#show ip sla statistics 22 detail`	Displays more in-depth output for SLA monitor 22.

Policy Routing Using Route Maps

`Router(config)#route-map ISP1 permit 20`	Creates a route map named ISP1. This route map will permit traffic based on subsequent criteria. A sequence number of 20 is assigned.
	NOTE: In route maps, the default action is to permit.
	NOTE: The *sequence-number* is used to indicate what position the route map is to have in a list of route maps configured with the same name. If no sequence number is given, the first condition in the route map is automatically numbered as 10.
`Router(config-route-map)#match ip address 1`	Specifies the match criteria (the conditions that should be tested); in this case, match addresses filtered using ACL 1.
`Router(config-route-map)#set ip next hop 6.6.6.6`	Specifies that packets that pass a match are output to the router at IP address 6.6.6.6.
`Router(config-route-map)#set interface serial 0/0/0`	Specifies the set actions (what action is to be performed if the match criteria is met); in this case, forward packets out interface serial 0/0/0.
	NOTE: If no explicit route exists in the routing table for the destination network address of the packet (that is, the packet is a broadcast packet or destined to an unknown address), the **set interface** command has no effect and is ignored.
	NOTE: A default route in the routing table will not be considered an explicit route for an unknown destination address.

`Router(config-route-map)#set ip default next hop 6.6.6.6`	Defines where to output packets that pass a match clause of a route map for policy routing and for which the Cisco IOS software has no explicit route to a destination.
`Router(config-route-map)#set default interface serial 0/0/0`	Defines where to output packets that pass a match clause of a route map for policy routing and have no explicit route to the destination.
	NOTE: This is recommended for point-to-point links only.
`Router(config-route-map)#exit`	Returns to global configuration mode.
`Router(config)#interface fastethernet 0/0`	Moves to interface configuration mode.
`Router(config-if)#ip policy route-map ISP1`	Specifies a route map to use for policy routing on an incoming interface that is receiving the packets that need to be policy routed.
`Router(config-if)#exit`	Returns to global configuration mode.
`Router(config)#ip local policy route-map ISP1`	Specifies a route map to use for policy routing on all packets originating on the router.

TIP: Packets that are generated by the router are not normally policy routed. Using the **ip local policy route-map** [*map-name*] command will make these packets adhere to a policy. For example, you may want packets originating at the router to take a route other than the obvious shortest path.

`Router(config)#interface fastethernet 0/0`	Moves to interface configuration mode.
`Router(config-if)#ip route-cache policy`	Enables fast-switched policy routing.

NOTE: Policy-based routing (PBR) must be configured before PBR fast switching can be enabled. Fast switching of PBR is disabled by default. CEF-switched PBR is enabled by default.

A fast-switched PBR supports all the **match** commands and most of the **set** commands except for the following:

- The **set ip default next-hop** command is not supported.
- The **set interface** command is supported over point-to-point links, unless a route cache entry exists that uses the same interface that is specified in the **set interface** command in the route map.

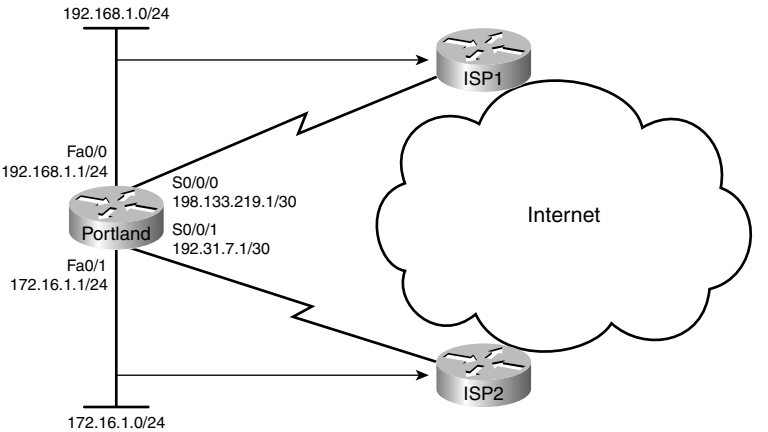
NOTE: The **ip route-cache policy** command is strictly for fast-switched PBR, and therefore not required for a CEF-switched PBR.

`Router#show ip policy`	Displays route maps that are configured on the interfaces.
`Router#show route-map [map-name]`	Displays route maps.
`Router#debug ip policy`	Enables the display of IP policy routing events.
`Router#traceroute`	Enables the extended **traceroute** command, which allows the specification of the source address.
`Router#ping`	Enables the extended **ping** command, which allows for the specification of the source address.

Configuration Example: Route Maps

Figure 5-2 shows the network topology for the configuration that follows, which demonstrates how to configure route maps using the commands covered in this chapter.

Figure 5-2 Network Topology for Route Map Configuration



Assume for this example that you want to enforce the following policy:

- Internet-bound traffic from 192.168.1.0/24 is to be routed to ISP1.
- Internet-bound traffic from 172.16.1.0/24 is to be routed to ISP2.
- All other traffic to be routed normally according to their destination addresses.

Portland Router

`Router>enable`	Moves to privileged mode.
`Router#configure terminal`	Moves to global configuration mode.
`Router(config)#hostname Portland`	Sets the hostname of this router.
`Portland(config)#access-list 1 permit 192.168.1.0 0.0.0.255`	Creates ACL 1, which will filter out addresses for our first route map.
`Portland(config)#access-list 2 permit 172.16.1.0 0.0.0.255`	Creates ACL 2, which will filter out addresses for our second route map.
`Portland(config)#access-list 101 permit ip 192.168.1.0 0.0.0.255 172.16.1.0 0.0.0.255`	Creates an extended ACL, resulting in a filter based on both source and destination IP address.

`Portland(config)#access-list 102 permit ip 172.16.1.0 0.0.0.255 192.168.1.0 0.0.0.255`	Creates an extended ACL, resulting in a filter based on both source and destination IP address.
`Portland(config)#route-map ISP1 permit 10`	Creates a route map called ISP1. This route map will permit traffic based on subsequent criteria. A sequence number of 10 is assigned.
`Portland(config-route-map)#match ip address 1`	Specifies the match criteria—match addresses filtered from ACL 1.
`Portland(config-route-map)#set interface serial 0/0/0`	Specifies the set actions (what action is to be performed if the match criteria is met); in this case, forward packets out interface s0/0.
`Portland(config-route-map)#exit`	Returns to global configuration mode.
`Portland(config)#route-map ISP2 permit 10`	Creates a route map called ISP2.
`Portland(config-route-map)#match ip address 2`	Specifies the match criteria—match addresses filtered from ACL 2.
`Portland(config-route-map)#set interface serial 0/0/1`	Specifies the set actions (what action is to be performed if the match criteria is met); in this case, forward packets out interface s0/1.
`Portland(config-route-map)#exit`	Returns to global configuration mode.
`Portland(config)#route-map 192To172 permit 10`	Creates a route map named 192To172. This route map will permit traffic based on subsequent criteria. A sequence number of 10 is assigned.
`Portland(config-route-map)#match ip address 101`	Specifies the match criteria—match addresses filtered from ACL 101.

`Portland(config-route-map)#set interface fastethernet 0/1`	Specifies the set actions—forward packets out interface FastEthernet 0/1.
`Portland(config-route-map)#exit`	Returns to global configuration mode.
`Portland(config)#route-map 172To192 permit 10`	Creates a route map named 172To192.
`Portland(config-route-map)#match ip address 102`	Specifies the match criteria—match addresses filtered from ACL 102.
`Portland(config-route-map)#set interface fastethernet 0/0`	Specifies the set actions—forward packets out interface FastEthernet 0/0.
`Portland(config-route-map)#exit`	Returns to global configuration mode.
`Portland(config)#interface serial 0/0/0`	Moves to interface configuration mode.
`Portland(config-if)#description link to ISP1`	Sets a locally significant description of the interface.
`Portland(config-if)#ip address 198.133.219.1 255.255.255.252`	Assigns an IP address and netmask.
`Portland(config-if)#no shutdown`	Enables the interface.
`Portland(config)#interface serial 0/0/1`	Moves to interface configuration mode.
`Portland(config-if)#description link to ISP2`	Sets a locally significant description of the interface.
`Portland(config-if)#ip address 192.31.7.1 255.255.255.252`	Assigns an IP address and netmask.
`Portland(config-if)#no shutdown`	Enables the interface.
`Portland(config)#interface fastethernet 0/0`	Moves to interface configuration mode.
`Portland(config-if)#ip address 192.168.1.1 255.255.255.0`	Configures an IP address and netmask.

`Portland(config-if)#ip policy route-map ISP1`	Applies the route map named ISP1 to this interface.
`Portland(config-if)#ip policy route-map 192To172`	Applies the route map named 192To172 to this interface.
`Portland(config-if)#no shutdown`	Enables the interface.
`Portland(config-if)#exit`	Returns to global configuration mode.
`Portland(config)#interface fastethernet 0/1`	Moves to interface configuration mode.
`Portland(config-if)#ip address 172.16.1.1 255.255.255.0`	Configures an IP address and netmask.
`Portland(config-if)#ip policy route-map ISP2`	Applies the route map named ISP2 to this interface.
`Portland(config-if)#ip policy route-map 172To192`	Applies the route map named 172To192 to this interface.
`Portland(config-if)#no shutdown`	Enables the interface.
`Portland(config-if)#exit`	Returns to global configuration mode.
`Portland(config)#exit`	Returns to privileged mode.
`Portland#copy running-config startup-config`	Saves the configuration to NVRAM.

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