31 Days Before Your CCNP and CCIE Enterprise Core Exam

A Day-By-Day Review Guide for the ENCOR 350-401 Certification Exam

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Example 23-5 Verifying the Routing Table

```
SP1# show ip route
<. . . output omitted . . .>
Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
B        10.0.1.0/24 [20/0] via 192.168.1.11, 00:20:31
B        10.0.2.0/24 [20/0] via 192.168.2.11, 00:20:14
C        10.0.3.0/24 is directly connected, Loopback0
L        10.0.3.1/32 is directly connected, Loopback0
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/1
L        192.168.1.10/32 is directly connected, GigabitEthernet0/1
      192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.2.0/24 is directly connected, GigabitEthernet0/2
L        192.168.2.10/32 is directly connected, GigabitEthernet0/2
```

Both customer networks are in the routing table via BGP, as indicated with the letter B:

- Network 10.0.1.0/24 is the simulated LAN in AS 65100 advertised by R1.
- Network 10.0.1.2.0/24 is the simulated LAN in AS 65200 advertised by R2.

Study Resources

For today's exam topics, refer to the following resources for more study.

Resource	Module, Chapter, or Link
CCNP and CCIE Enterprise Core ENCOR 350-401 Official Cert Guide	11, 12
CCNP and CCIE Enterprise Core & CCNP Advanced Routing Portable Command Guide	7

Day 22

First-Hop Redundancy Protocols

ENCOR 350-401 Exam Topics

Architecture

- Explain the different design principles used in an enterprise network
  - High availability techniques such as redundancy, FHRP, and SSO

Infrastructure

- IP Services
  - Configure first hop redundancy protocols, such as HSRP and VRRP

Key Topics

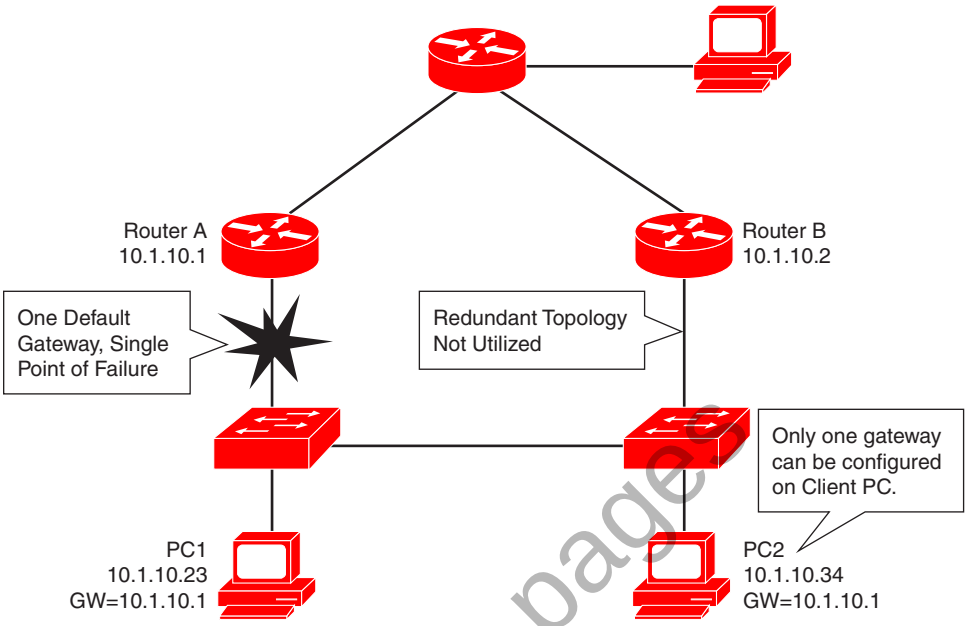
Today we review concepts related to first-hop redundancy protocols (FHRPs). Hosts on an enterprise network have only a single gateway address configured for use when they need to communicate with hosts on a different network. If that gateway fails, hosts are not able to send any traffic to hosts that are not in their own broadcast domain. Building network redundancy at the gateway is a good practice for network reliability. Today we explore network redundancy, including the router redundancy protocols Hot Standby Router Protocol (HSRP) and Virtual Router Redundancy Protocol (VRRP).

Default Gateway Redundancy

When a host determines that a destination IP network is not on its local subnet, it forwards the packet to the default gateway. Although an IP host can run a dynamic routing protocol to build a list of reachable networks, most IP hosts rely on a gateway that is statically configured or a gateway learned using Dynamic Host Configuration Protocol (DHCP).

Having redundant equipment alone does not guarantee uptime. In Figure 22-1, both Router A and Router B are responsible for routing packets for the 10.1.10.0/24 subnet. Because the routers are deployed as a redundant pair, if Router A becomes unavailable, the Interior Gateway Protocol (IGP) can quickly and dynamically converge and determine that Router B should now transfer packets that would otherwise have gone through Router A. Most workstations, servers, and printers, however, do not receive this type of dynamic routing information.

Figure 22-1 Default Gateway Redundancy Example



Each end device is configured with a single default gateway Internet Protocol (IP) address that does not dynamically update when the network topology changes. If the default gateway fails, the local device is unable to send packets off the local network segment. As a result, the host is isolated from the rest of the network. Even if a redundant router exists that could serve as a default gateway for that segment, there is no dynamic method by which these devices can determine the address of a new default gateway.

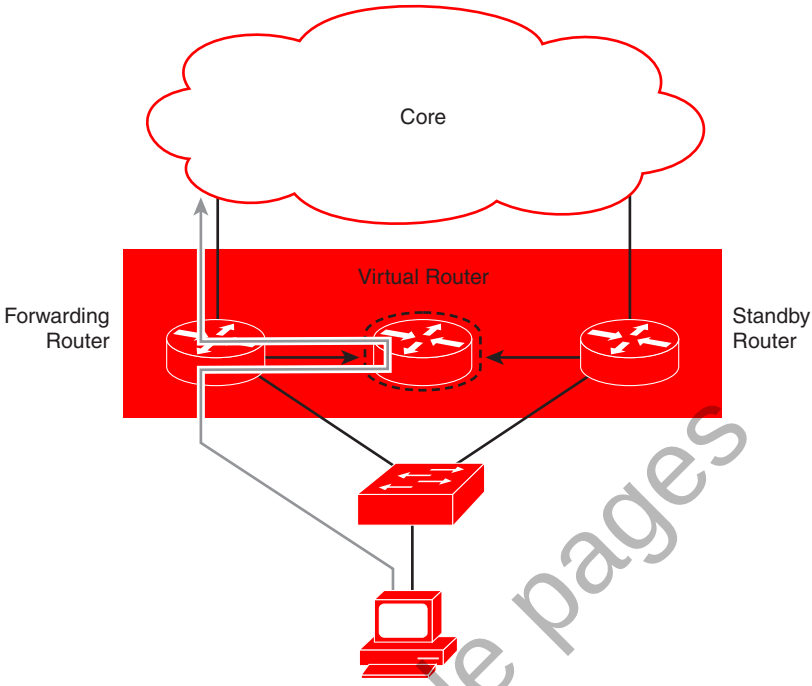
First Hop Redundancy Protocol

Figure 22-2 represents a generic router FHRP with a set of routers working together to present the illusion of a single router to the hosts on the local-area network (LAN). By sharing an IP (Layer 3) address and a Media Access Control (MAC) (Layer 2) address, two or more routers can act as a single "virtual" router.

Hosts that are on the local subnet configure the IP address of the virtual router as their default gateway. When a host needs to communicate to another IP host on a different subnet, it uses Address Resolution Protocol (ARP) to resolve the MAC address of the default gateway. The ARP resolution returns the MAC address of the virtual router. The packets that devices send to the MAC address of the virtual router can then be routed to their destination by any active or standby router that is part of that virtual router group.

You use an FHRP to coordinate two or more routers as the devices that are responsible for processing the packets that are sent to the virtual router. The host devices send traffic to the address of the virtual router. The actual (physical) router that forwards this traffic is transparent to the end stations.

Figure 22-2 FHRP Operations



The redundancy protocol provides the mechanism for determining which router should take the active role in forwarding traffic and determining when a standby router should take over that role. The transition from one forwarding router to another is also transparent to the end devices.

Cisco routers and switches can support three different FHRP technologies:

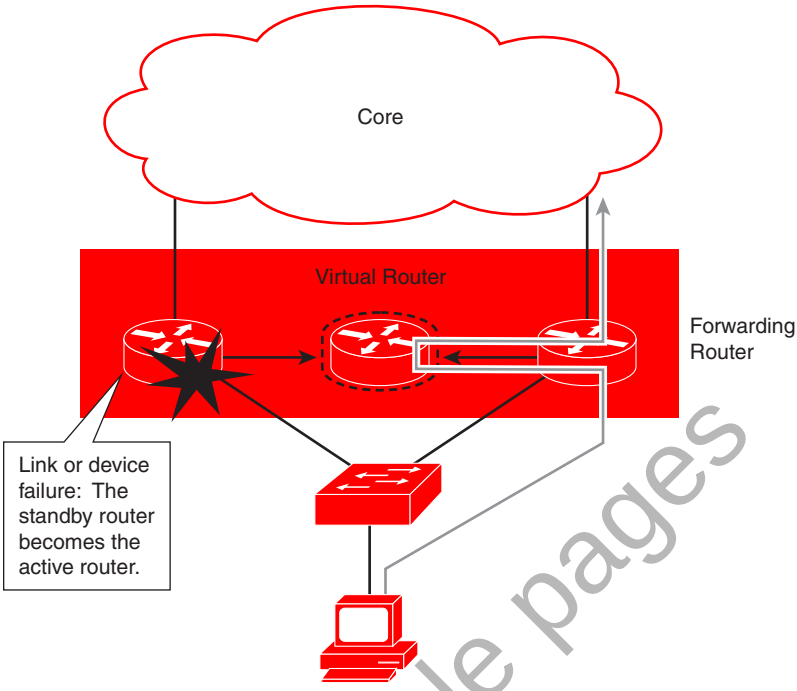
- **Hot Standby Router Protocol (HSRP):** HSRP is an FHRP that Cisco designed to create a redundancy framework between network routers or multilayer switches to achieve default gateway failover capabilities. Only one router forwards traffic. HSRP is defined in RFC 2281.
- **Virtual Router Redundancy Protocol (VRRP):** VRRP is an open FHRP standard that offers the ability to add more than two routers for additional redundancy. Only one router forwards traffic.VRRP is defined in RFC 5798.
- **Gateway Load Balancing Protocol (GLBP):** GLBP is an FHRP that Cisco designed to allow multiple active forwarders to handle load balancing for outgoing traffic. (GLBP is beyond the scope of the ENCOR exam and is therefore not covered in this book.)

A common feature of FHRPs is to provide default gateway failover that is transparent to hosts.

Figure 22-3 illustrates what occurs when the active device or active forwarding link fails:

1. The standby router stops seeing hello messages from the forwarding router.
2. The standby router assumes the role of the forwarding router.
3. Because the new forwarding router assumes both the IP and MAC addresses of the virtual router, the end stations see no disruption in service.

Figure 22-3 FHRP Failover Process



HSRP

HSRP is a Cisco-proprietary protocol that was developed to allow several multilayer switches or routers to appear as a single gateway IP address. HSRP allows two physical routers to work together in an HSRP group to provide a virtual IP address and an associated virtual MAC address.

The end hosts use the virtual IP address as their default gateway and learn the virtual MAC address via ARP. One of the routers in the group is active and responsible for the virtual addresses. The other router is in a standby state and monitors the active router.

If there is a failure on the active router, the standby router assumes the active state. The virtual addresses are always functional, regardless of which physical router is responsible for them. The end hosts are not aware of any changes in the physical routers.

HSRP defines a standby group of routers, as illustrated in Figure 22-4, with one router that is designated as the active router. HSRP provides gateway redundancy by sharing IP and MAC addresses between redundant gateways. The protocol consists of virtual MAC and IP addresses that two routers that belong to the same HSRP group share with each other.

Figure 22-4 HSRP Standby Group

The HSRP active router has the following characteristics:

- Responds to default gateway ARP requests with the virtual router MAC address
- Assumes active forwarding of packets for the virtual router
- Sends hello messages
- Knows the virtual router IP address

The HSRP standby router has the following characteristics:

- Sends hello messages
- Listens for periodic hello messages
- Knows the virtual IP address
- Assumes active forwarding of packets if it does not hear from the active router

Hosts on the IP subnet that are serviced by HSRP configure their default gateway with the HSRP group virtual IP address. The packets that are received on the virtual IP address are forwarded to the active router.

The function of the HSRP standby router is to monitor the operational status of the HSRP group and to quickly assume the packet-forwarding responsibility if the active router becomes inoperable.

HSRP Group

You assign routers to a common HSRP group by using the following interface configuration command:

```
Router(config-if)# standby group-number ip virtual-ip
```

If you configure HSRP on a multilayer switch, it is a good practice to configure the HSRP group number equal to the VLAN number. Doing so makes troubleshooting easier. HSRP group numbers are locally significant to an interface. For example, HSRP Group 1 on interface VLAN 22 is independent from HSRP Group 1 on interface VLAN 33.

One of the two routers in a group is elected as active and the other will be elected as standby. In an HSRP group with more routers, the other routers are in the listen state. Roles are elected based on the exchange of HSRP hello messages. When the active router fails, the other HSRP routers stop seeing hello messages from the active router. The standby router then assumes the role of the active