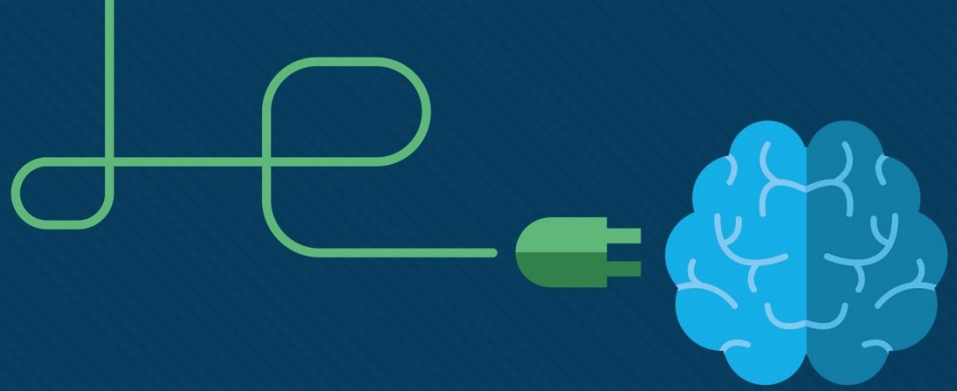

Chapter 2: Static Routing

CCNA Routing and Switching

Routing and Switching Essentials v6.0

2.1 Implement Static Routes

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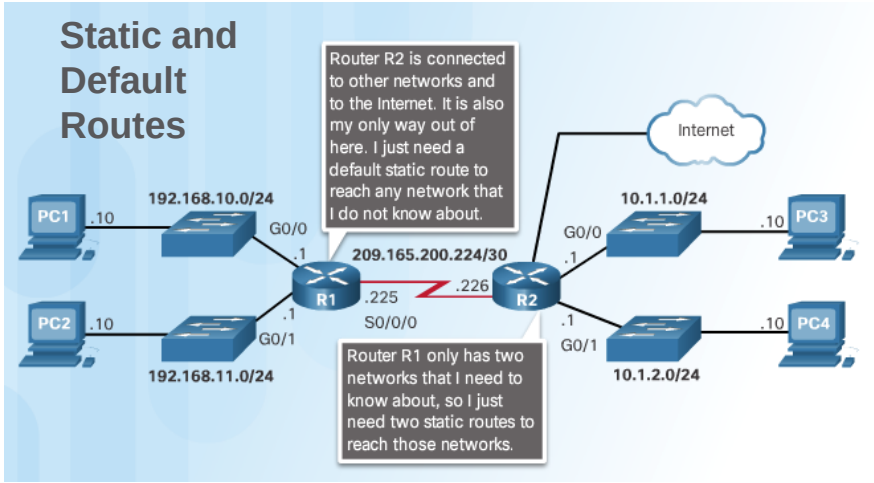
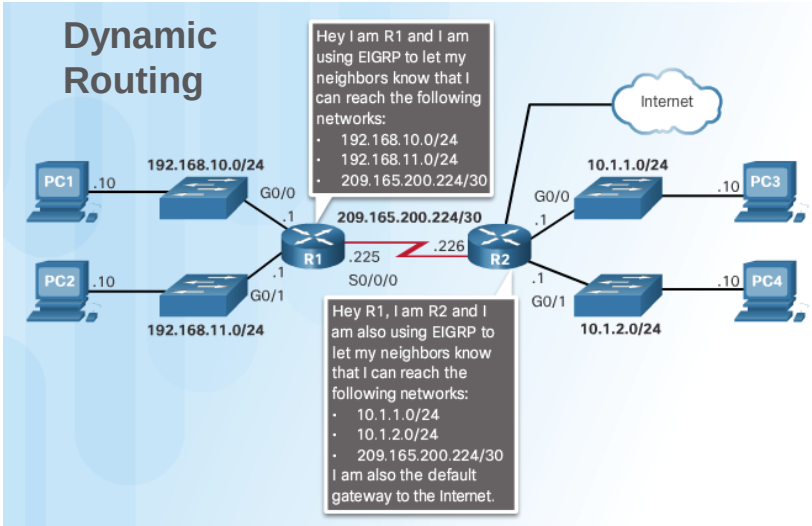
Reach Remote Networks

- A router learns about remote networks in two ways:
  - Manually entered into the route table using static routes
    - Static routes are not automatically updated and must be reconfigured when topology changes
  - Dynamically (Automatically) learned using a routing protocol





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Why Use Static Routing?

Dynamic versus Static Routing

	Dynamic Routing	Static Routing
Configuration Complexity	Generally independent of the network size	Increases with network size
Topology Changes	Automatically adapts to topology changes	Administrator intervention required
Scaling	Suitable for simple and complex topologies	Suitable for simple topologies
Security	Less secure	More secure
Resource Usage	Uses CPU, memory, link bandwith	No extra resources needed
Predictability	Route depends on the current topology	Route to destination is always the same

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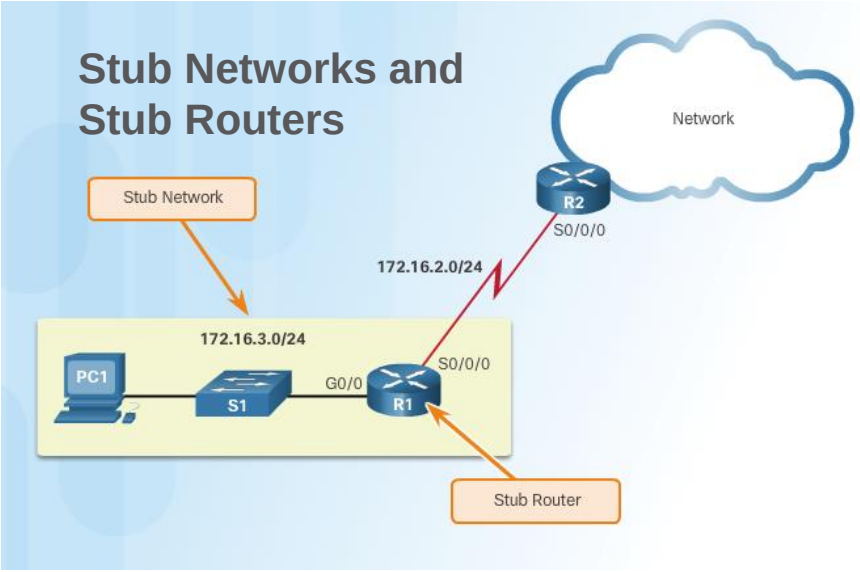
When to Use Static Routes

Three uses for static routes:

- Smaller networks that are not expected to grow
- Routing to and from stub networks
  - Stub network accessed by a single route and has one neighbor
  - 172.16.3.0 is a stub network
- A single default route to represent a path to any network not found in the routing table
  - Use default route on R1 to point to R2 for all other networks



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Static Route Applications

Use Static Routes To:

- Connect to a specific network
- Connect a stub router
- Summarize routing table entries which reduces size of routing advertisements
- Create a backup route in case a primary route link fails

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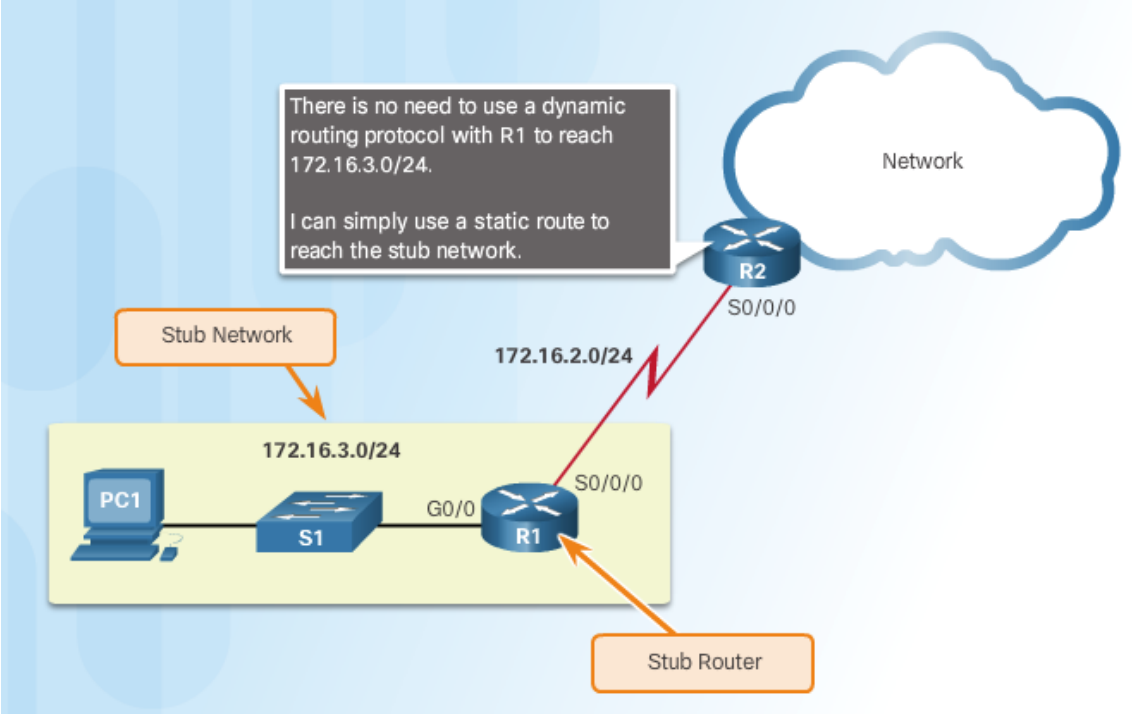
Standard Static Route

- R2 configured with a static route to reach the stub network 172.16.3.0/24



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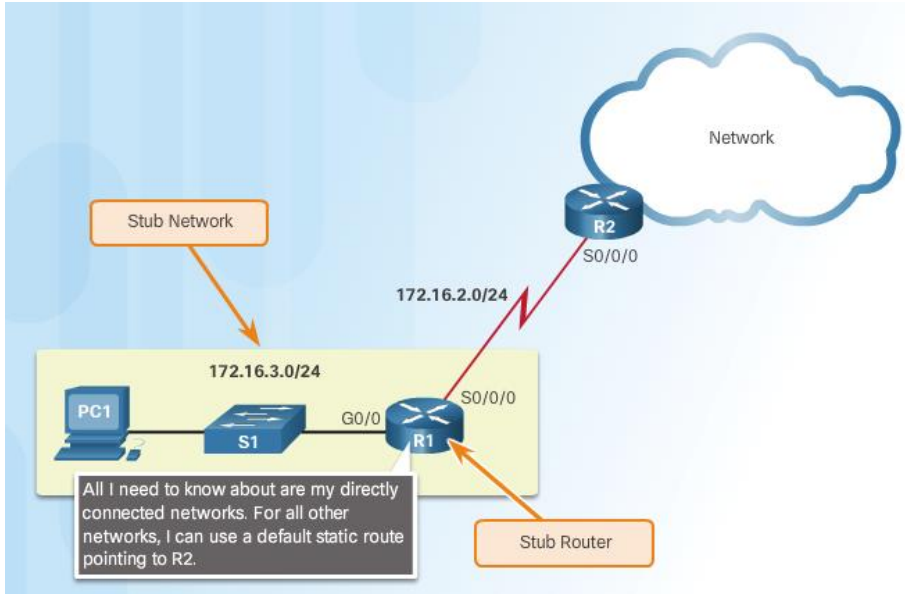
Default Static Route

- Default route matches all packets and is used when a packet does not match a specific route in the routing table
- Can be dynamically learned or statically configured
- Default Static route uses 0.0.0.0/0 as the destination IPv4 address
- Creates a Gateway of Last Resort
- Common use is when connecting a company's edge router to the ISP network
- Router has only one router to which it is connected



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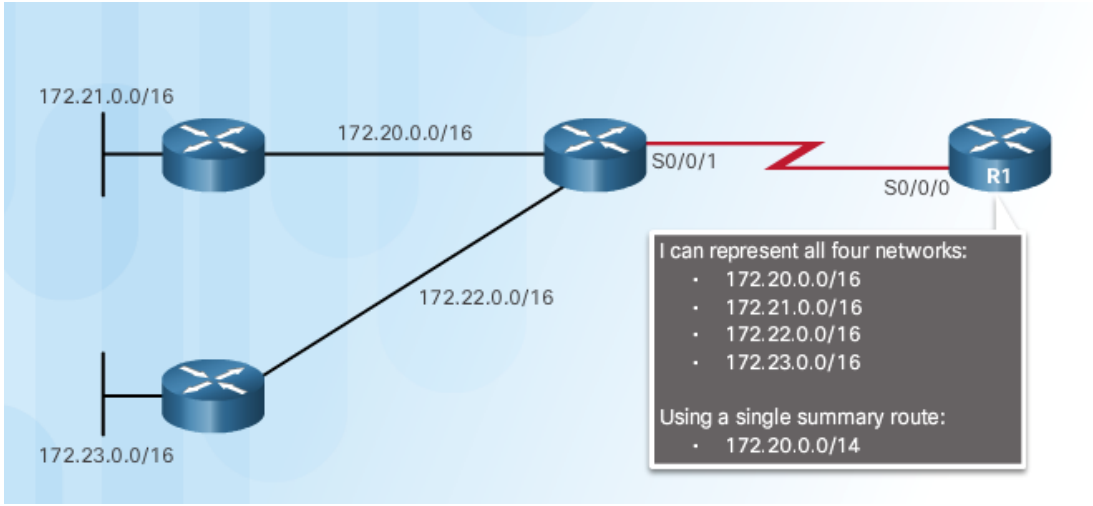
Summary Static Route

- Multiple static routes can be summarized into a single network address
  - Destination networks must be contiguous
  - Multiple static routes must use the same exit interface or next hop
  - In figure, four networks is summarized into one summary static route



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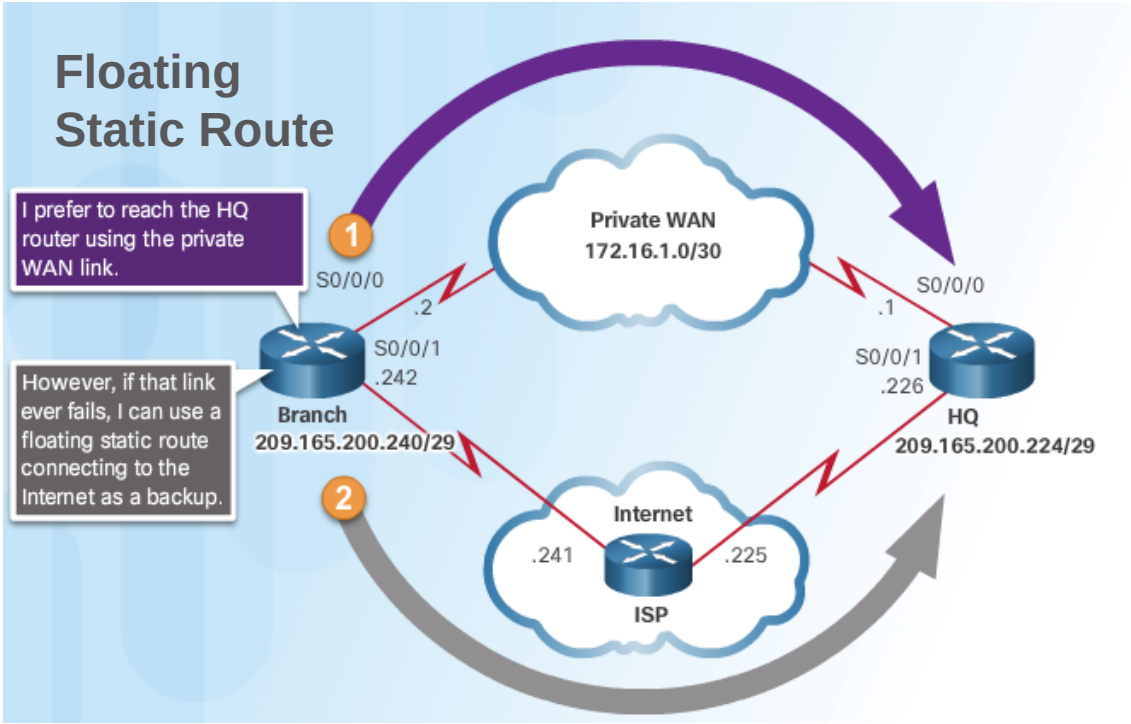
Floating Static Route

- Static routes that are used to provide a backup path
- Used when primary route is not available
- Configured with a higher administrative distance (trustworthiness) than the primary route
- Example: EIGRP administrative distance equals 90. A floating static route with an AD of 91 or higher would serve as backup route and will be used if EIGRP route goes down.



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2.2 Configure Static and Default Routes

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ip route Command

ip route Command Syntax

```
Router(config)# ip route network-address subnet-mask {ip-address | exit-intf}
```

Parameter	Description
network-address	Destination network address of the remote network to be added to the routing table
subnet-mask	• Subnet mask of the remote network to be added to the routing table. • The subnet mask can be modified to summarize a group of networks.
ip-address	• Commonly referred to as the next-hop router's IP address. • Typically used when connecting to a broadcast media (i.e., Ethernet). • Commonly creates a recursive lookup
exit-intf	• Use the outgoing interface to forward packets to the destination network. • Also referred to as a directly attached static route. • Typically used when connecting in a point-to-point configuration.
distance	• (Optional) Configures an administrative distance. • Typically used to configure a floating static route.

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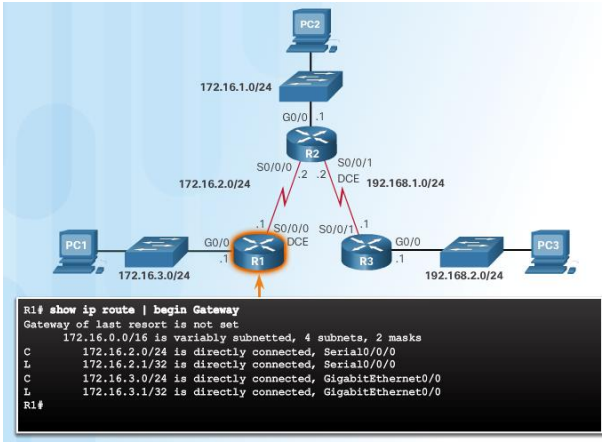
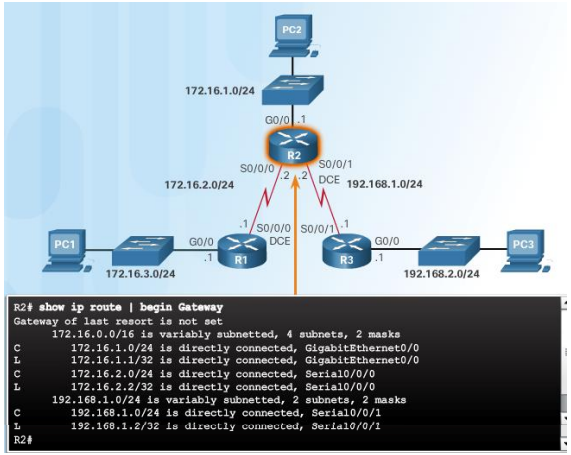
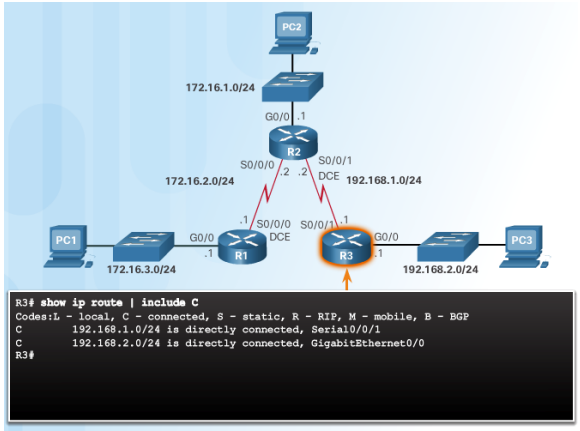
Next-Hop Options

- In this example, each router only has entries for directly connected network







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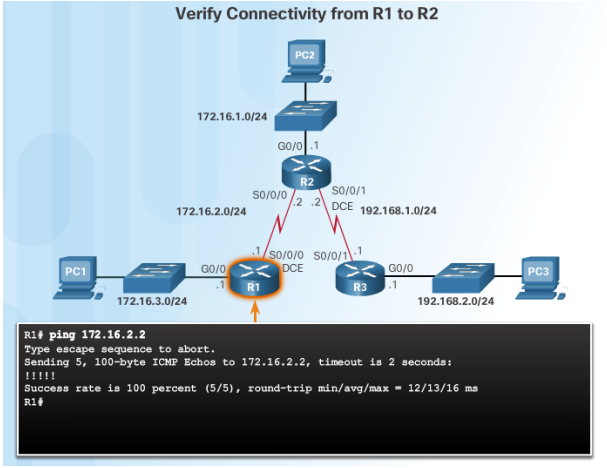
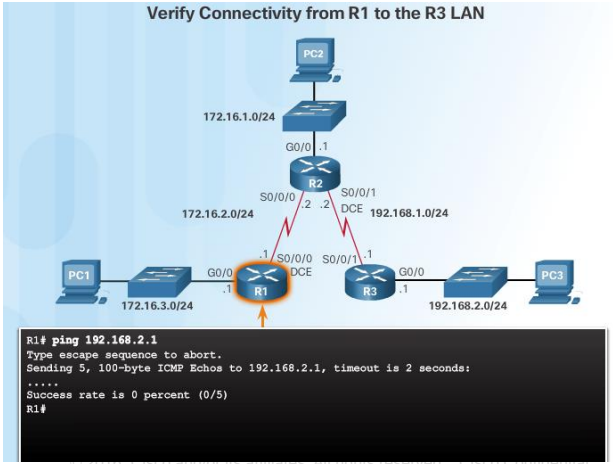
Next-Hop Options (Cont.)

- R1 does not have an entry in its routing table for the R3 LAN network
- In a static route next-hop can be identified by
  - Next-hop IP address
  - Router exit interface
  - Next-hop IP address and exit interface





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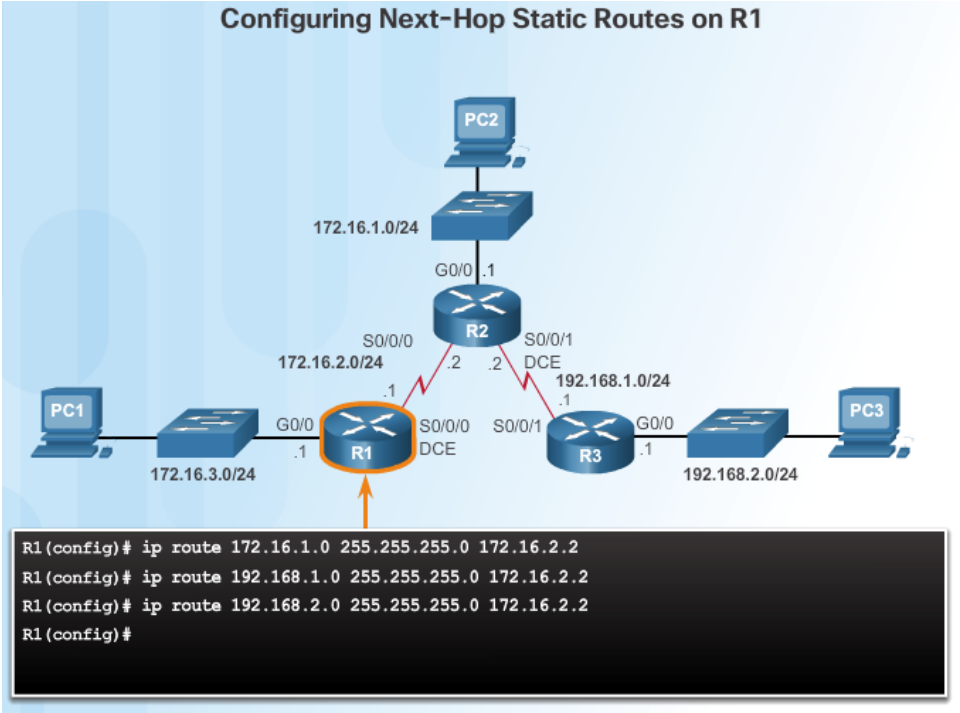
Configure a Next-Hop Static Route

- In this example, only the next-hop IP address is specified
- Before packet is forwarded the router must determine the exit interface to use (route resolvability)



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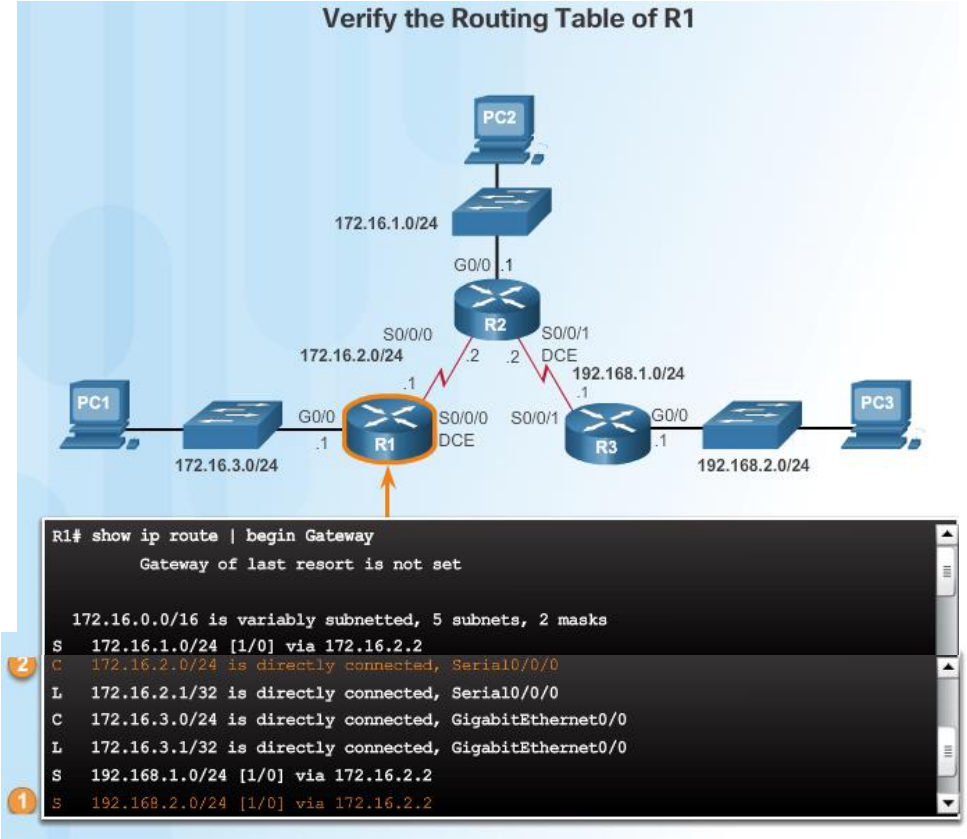
Configure a Next-Hop Static Route (Cont.)

- In example, when a packet is destined for 192.168.2.0/24 network, R1:
  - Looks for match (#1) and needs to forward packets to 172.16.2.2
  - R1 must determine how to reach 172.16.2.2 first
  - Searches a second time for 172.16.2.0/24 (#2) and matches to exit interface s0/0/0
  - Takes two routing table lookups, process referred to as recursive lookup
  - If the exit interface is “down” or “administratively down” then the static route configured with next-hop will not be installed in routing table



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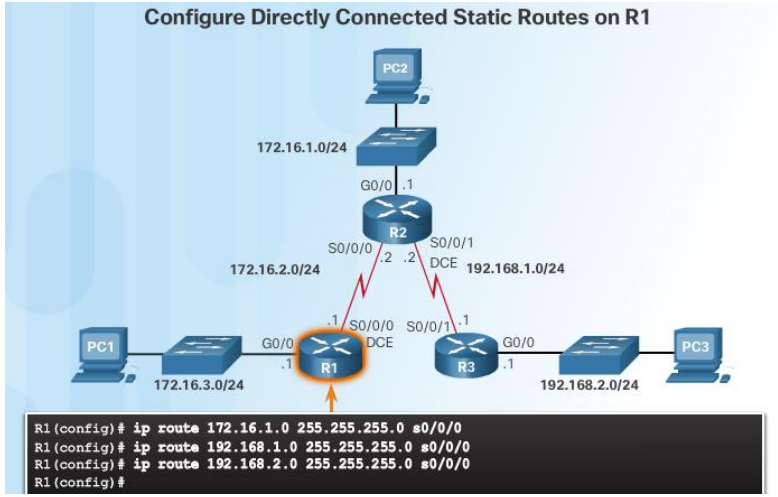
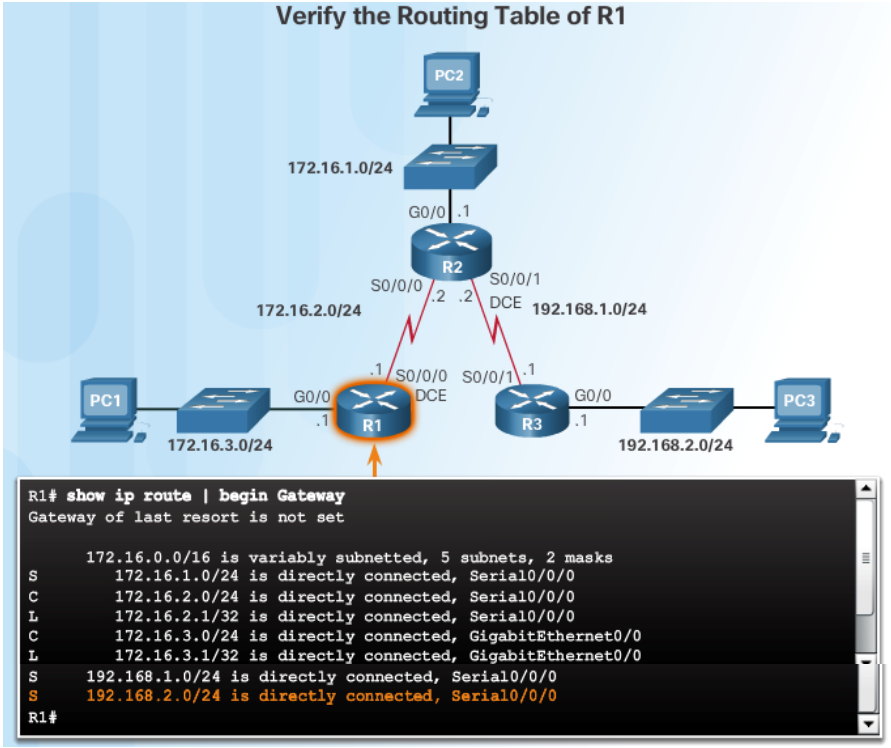
Configure a Directly Connected Static Route

- Use the exit interface to specify next-hop so no other lookups are required
- Administrative distance of static route is 1





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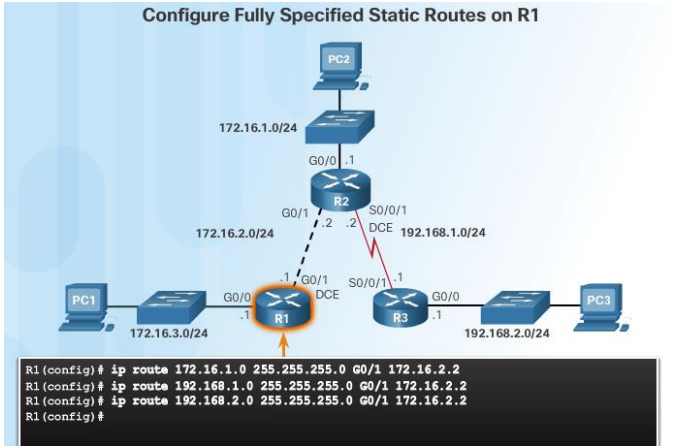
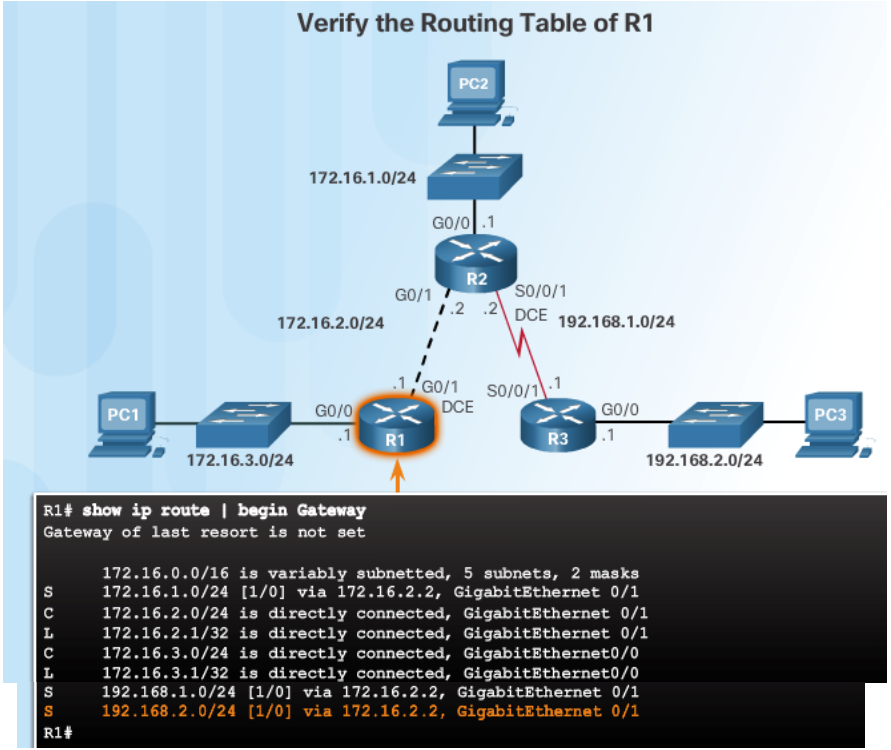
Configure a Fully Specified Static Route

- Both the exit interface and the next-hop IP address are specified
- When exit interface is an Ethernet network, fully specified static route is used
- Note: With CEF, a next-hop address could be used instead





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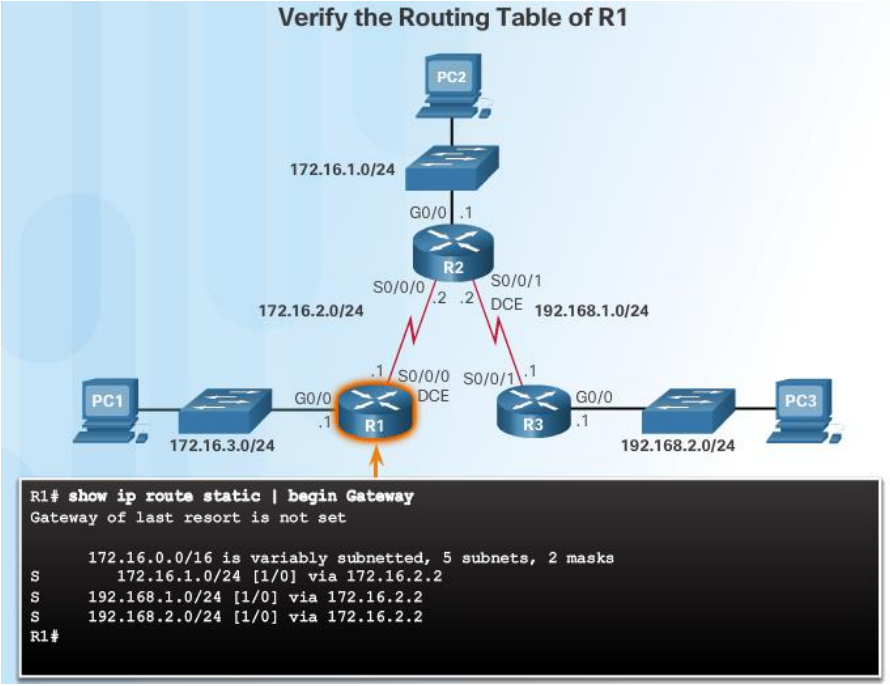
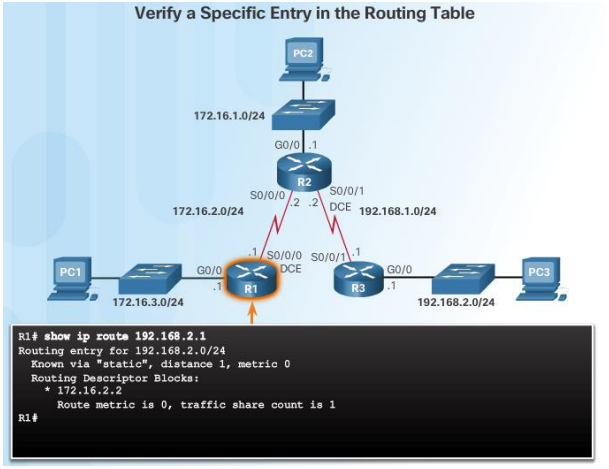
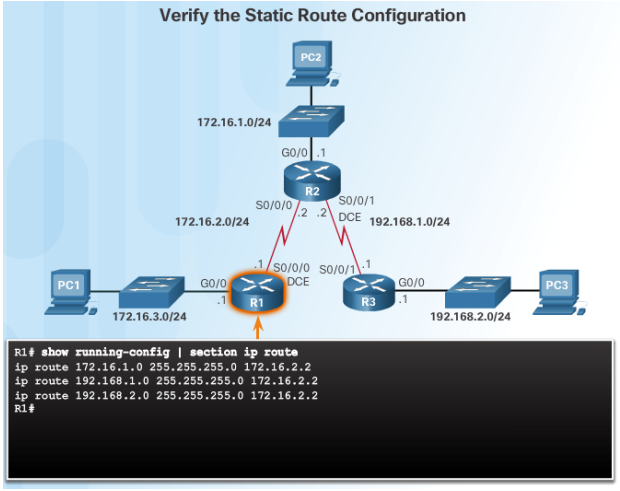
Verify a Static Route







Default Static Route

- Default static routes are commonly used when connecting:
  - An edge router to a service provider network
  - A stub router (a router with only one upstream neighbor router)
- Default route is used when no other routes in the routing table match the destination IP

Default Static Route Syntax

```
Router(config)#ip route 0.0.0.0 0.0.0.0 {ip-address | exit-intf}
```

Parameter	Description
0.0.0.0 0.0.0.0	Matches any network address.
ip-address	• Commonly referred to as the next-hop router's IP address. • Typically used when connecting to a broadcast media (i.e., Ethernet). • Commonly creates a recursive lookup.
exit-intf	• Use the outgoing interface to forward packets to the destination network. • Also referred to as a directly attached static route. • Typically used when connecting in a point-to-point configuration.

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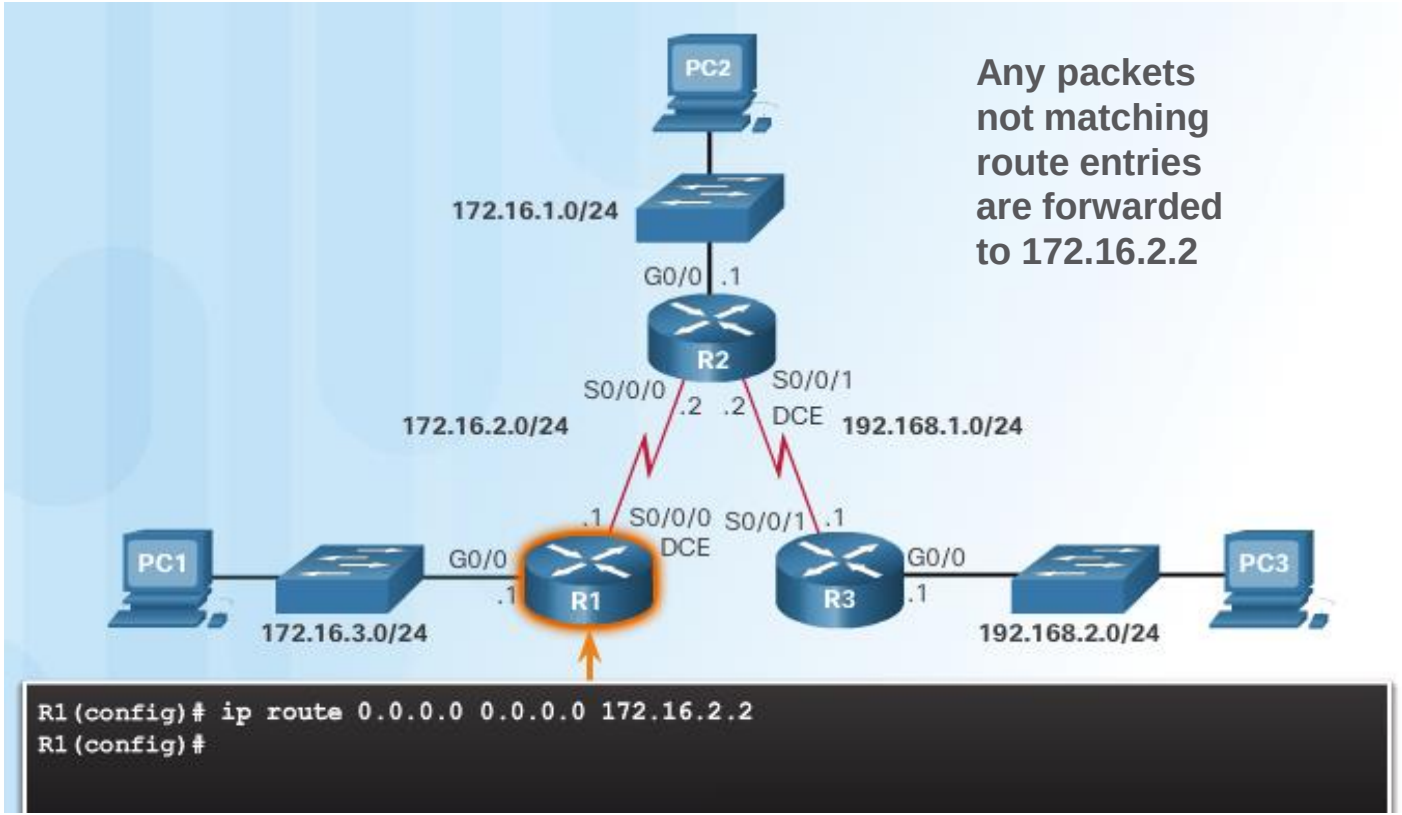
Configure a Default Static Route



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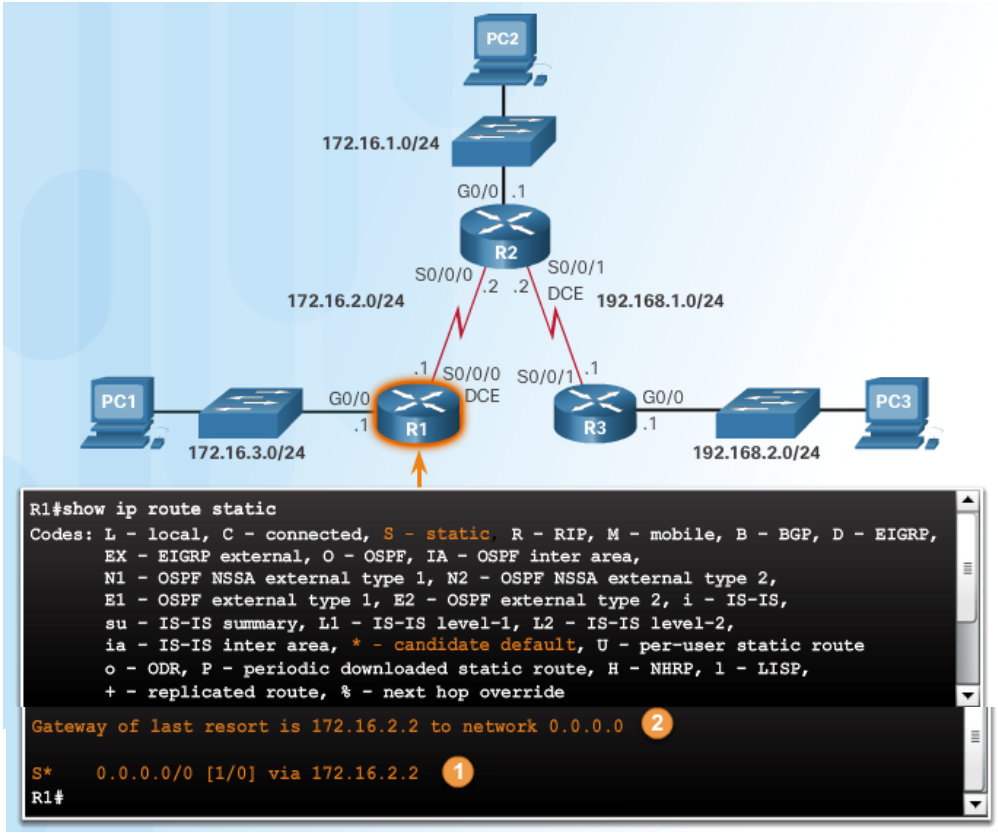
Verify a Default Static Route

- **show ip route static** displays just the static routes
  - **S** indicates static route
  - candidate default route indicated by *
  - /0 mask in route entry indicates none of the bits are required to match



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The ipv6 route Command

```
Router(config)# ipv6 route ipv6-prefix/prefix-length {ipv6-address | exit-intf}
```

Parameter	Description
ipv6-prefix	Destination network address of the remote network to be added to the routing table.
prefix-length	Prefix length of the remote network to be added to the routing table.
ipv6-address	• Commonly referred to as the next-hop router's IP address. • Typically used when connecting to a broadcast media (i.e., Ethernet). • Commonly creates a recursive lookup.
exit-intf	• Use the outgoing interface to forward packets to the destination network. • Also referred to as a directly attached static route. • Typically used when connecting in a point-to-point configuration.

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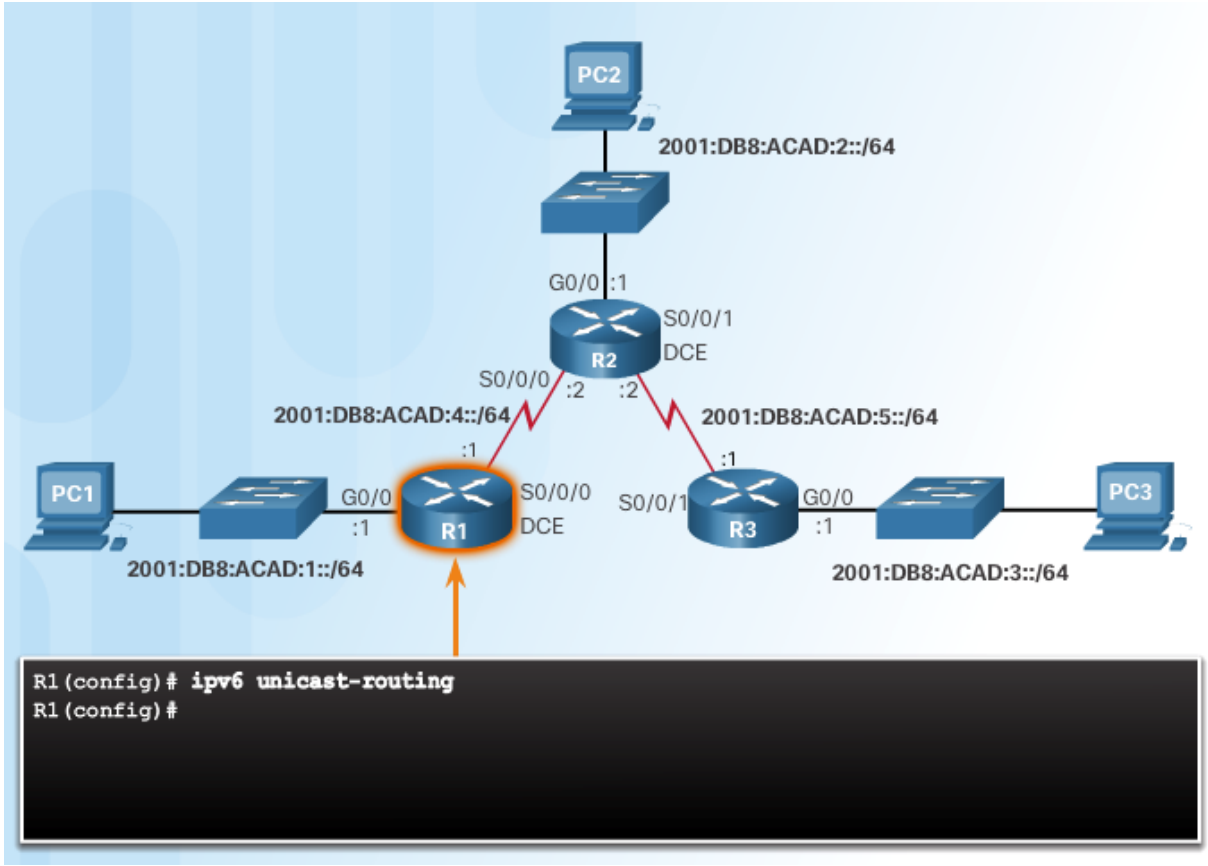
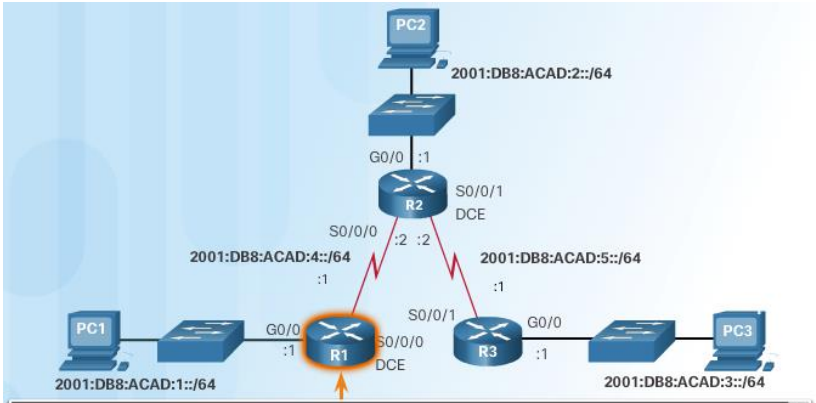
The ipv6 route Command (Cont.)

- **ipv6 unicast-routing** enables the router to forward IPv6 packets



Next-Hop Options

- Each router only knows about directly connected networks
  - R1 can **ping** R2 (ipv6 2001:DB8:ACAD:4::2) but cannot **ping** R3 (ipv6 2001:DB8:ACAD:3::2)




```
R1#show ipv6 route

 <output omitted>

C   2001:DB8:ACAD:1::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:DB8:ACAD:1::1/128 [0/0]
     via GigabitEthernet0/0, receive
C   2001:DB8:ACAD:4::/64 [0/0]
     via Serial0/0/0, directly connected
L   2001:DB8:ACAD:4::1/128 [0/0]
     via Serial0/0/0, receive
L   FF00::/8 [0/0]
     via Null0, receive
R1#
```

```
R2#show ipv6 route

 <output omitted>

C   2001:DB8:ACAD:2::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:DB8:ACAD:2::1/128 [0/0]
     via GigabitEthernet0/0, receive
C   2001:DB8:ACAD:4::/64 [0/0]
     via Serial0/0/0, directly connected
L   2001:DB8:ACAD:4::2/128 [0/0]
     via Serial0/0/0, receive
C   2001:DB8:ACAD:5::/64 [0/0]
     via Serial0/0/1, directly connected
L   2001:DB8:ACAD:5::2/128 [0/0]
     via Serial0/0/1, receive
L   FF00::/8 [0/0]
     via Null0, receive
R2#
```

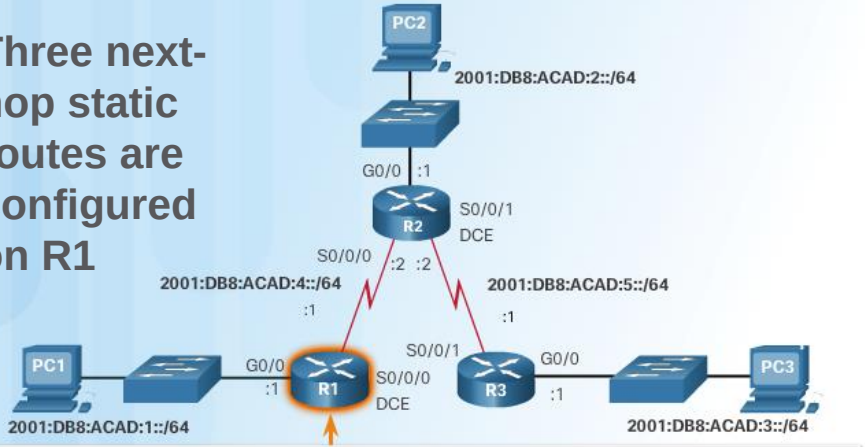
```
R3#show ipv6 route

 <output omitted>

C   2001:DB8:ACAD:3::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:DB8:ACAD:3::1/128 [0/0]
     via GigabitEthernet0/0, receive
C   2001:DB8:ACAD:5::/64 [0/0]
     via Serial0/0/1, directly connected
L   2001:DB8:ACAD:5::1/128 [0/0]
     via Serial0/0/1, receive
L   FF00::/8 [0/0]
     via Null0, receive
R3#
```

Configure a Next Hop Static IPv6 Route

Three next-hop static routes are configured on R1




```
R1(config)# ipv6 route 2001:DB8:ACAD:2::/64  2001:DB8:ACAD:4::2
R1(config)# ipv6 route 2001:DB8:ACAD:5::/64  2001:DB8:ACAD:4::2
R1(config)# ipv6 route 2001:DB8:ACAD:3::/64  2001:DB8:ACAD:4::2
R1(config)#
```

As with IPv4, must resolve the route to determine the exit interface to use to forward the packet

```
R1# show ipv6 route
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route, B - BGP,
       R - RIP, H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea,
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, ND - ND Default,
       NDp - ND Prefix, DCE - Destination, NDr - Redirect, O - OSPF Intra,
       OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1,
       ON2 - OSPF NSSA ext 2

C   2001:DB8:ACAD:1::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:DB8:ACAD:1::1/128 [0/0]
     via GigabitEthernet0/0, receive
1 S   2001:DB8:ACAD:2::/64 [1/0]
     via 2001:DB8:ACAD:4::2
2 S   2001:DB8:ACAD:3::/64 [1/0]
     via 2001:DB8:ACAD:4::2
C   2001:DB8:ACAD:4::/64 [0/0]
     via Serial0/0/0, directly connected
L   2001:DB8:ACAD:4::1/128 [0/0]
     via Serial0/0/0, receive
S   2001:DB8:ACAD:5::/64 [1/0]
     via 2001:DB8:ACAD:4::2
L   FF00::/8 [0/0]
     via Null0, receive
R1#
```

The IPv6 address matches the route for the directly connected network 2001:DB8:ACAD:4::/64 with the exit interface Serial 0/0/0.

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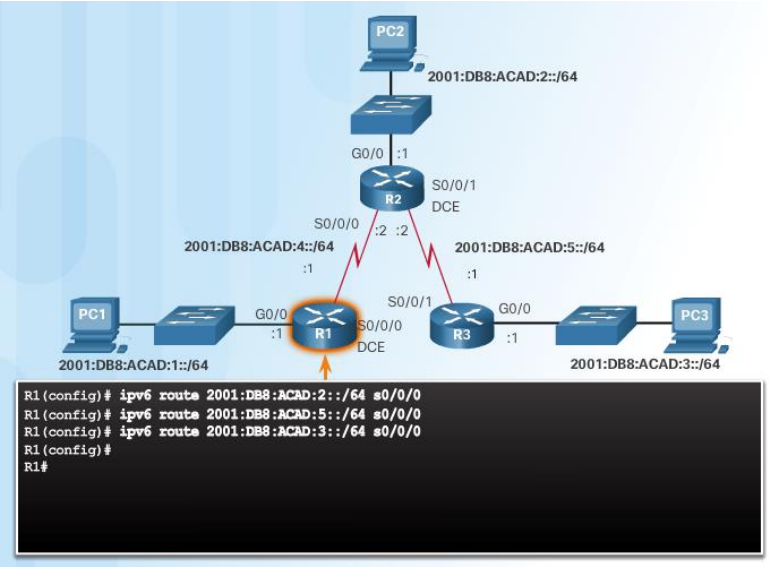
Configure a Directly Connected Static IPv6 Route

- Alternative to next hop is to specify the exit interface
- Packet destined for 2001:DB8:ACAD:3::/64 network, forwarded out Serial 0/0/0 – no other lookups needed




```
R1# show ipv6 route
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C   2001:DB8:ACAD:1::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:DB8:ACAD:1::1/128 [0/0]
     via GigabitEthernet0/0, receive
S   2001:DB8:ACAD:2::/64 [1/0]
     via Serial0/0/0, directly connected
S   2001:DB8:ACAD:3::/64 [1/0]
     via Serial0/0/0, directly connected
C   2001:DB8:ACAD:4::/64 [0/0]
     via Serial0/0/0, directly connected
L   2001:DB8:ACAD:4::1/128 [0/0]
     via Serial0/0/0, receive
S   2001:DB8:ACAD:5::/64 [1/0]
     via Serial0/0/0, directly connected
L   FF00::/8 [0/0]
     via Null0, receive
R1#
```

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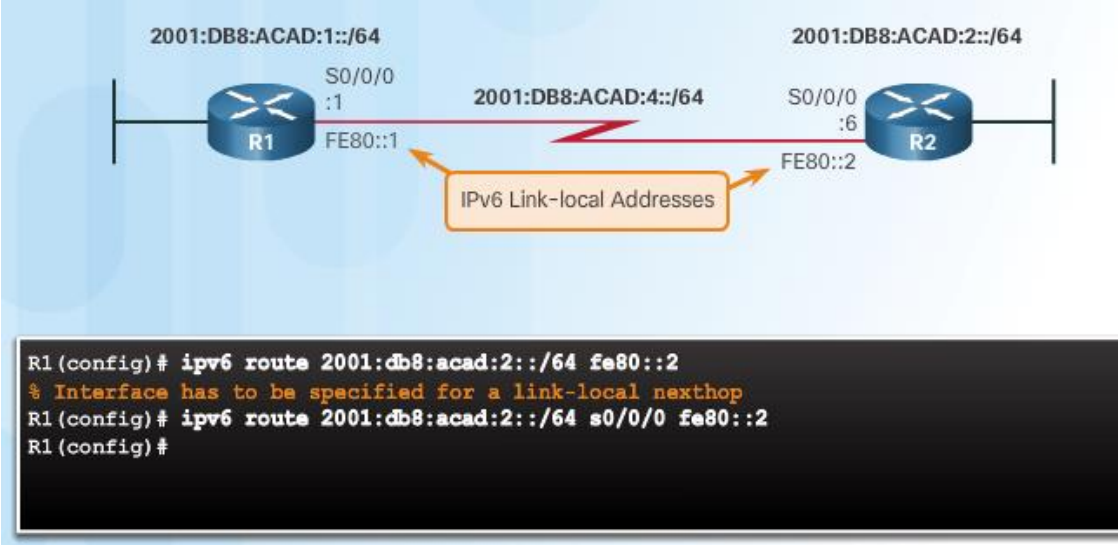
Configure a Fully Specified Static IPv6 Route

- Fully specified static route must be used if IPv6 link-local address is used as next-hop




```
R1(config)# ipv6 route 2001:db8:acad:2::/64 fe80::2
% Interface has to be specified for a link-local nexthop
R1(config)# ipv6 route 2001:db8:acad:2::/64 s0/0/0 fe80::2
R1(config)#
```

```
R1# show ipv6 route static | begin 2001:DB8:ACAD:2::/64
S   2001:DB8:ACAD:2::/64 [1/0]
     via FE80::2, Serial0/0/0
```

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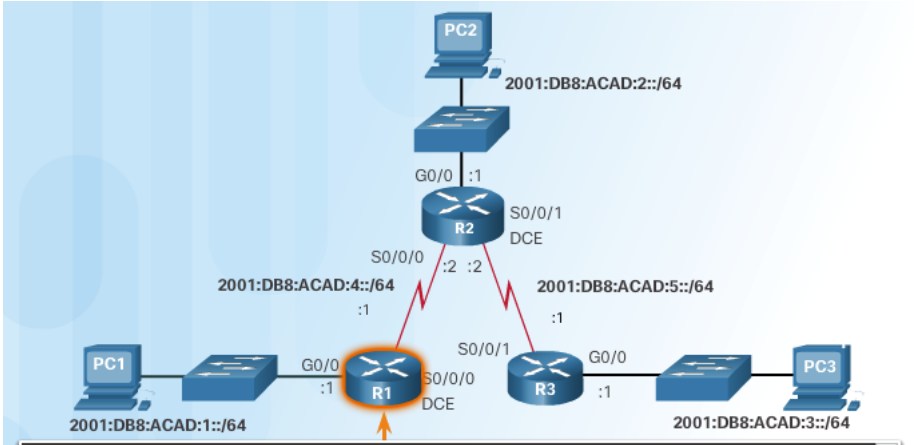
Verify IPv6 Static Routes




```
R1# show ipv6 route static
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route, B - BGP,
       R - RIP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary,
       D - EIGRP, EX - EIGRP external, ND - ND Default, NDp - ND Prefix,
       DCE - Destination, NDr - Redirect, O - OSPF Intra, OI - OSPF Inter,
       OE1 - OSPF ext 1, OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1,
       ON2 - OSPF NSSA ext 2
S   2001:DB8:ACAD:2::/64 [1/0]
     via 2001:DB8:ACAD:4::2
S   2001:DB8:ACAD:3::/64 [1/0]
     via 2001:DB8:ACAD:4::2
S   2001:DB8:ACAD:5::/64 [1/0]
     via 2001:DB8:ACAD:4::2
R1#
```

```
R1# show ipv6 route 2001:db8:acad:3::
Routing entry for 2001:DB8:ACAD:3::/64
  Known via "static", distance 1, metric 0
  Route count is 1/1, share count 0
  Routing paths:
    2001:DB8:ACAD:4::2
      Last updated 00:19:11 ago
R1#
```

```
R1# show running-config | section ipv6 route
ipv6 route 2001:DB8:ACAD:2::/64 2001:DB8:ACAD:4::2
ipv6 route 2001:DB8:ACAD:3::/64 2001:DB8:ACAD:4::2
ipv6 route 2001:DB8:ACAD:5::/64 2001:DB8:ACAD:4::2
R1#
```

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Default Static IPv6 Route

- Default static route matches all packets not specified in routing table

```
Router(config)# ipv6 route ::/0 {ipv6-address | exit-intf}
```

Parameter	Description
::/0	Matches any IPv6 prefix regardless of prefix length.
ipv6-address	• Commonly referred to as the next-hop router's IPv6 address. • Typically used when connecting to a broadcast media (i.e., Ethernet). • Commonly creates a recursive lookup.
exit-intf	• Use the outgoing interface to forward packets to the destination network. • Also referred to as a directly attached static route. • Typically used when connecting in a point-to-point configuration.

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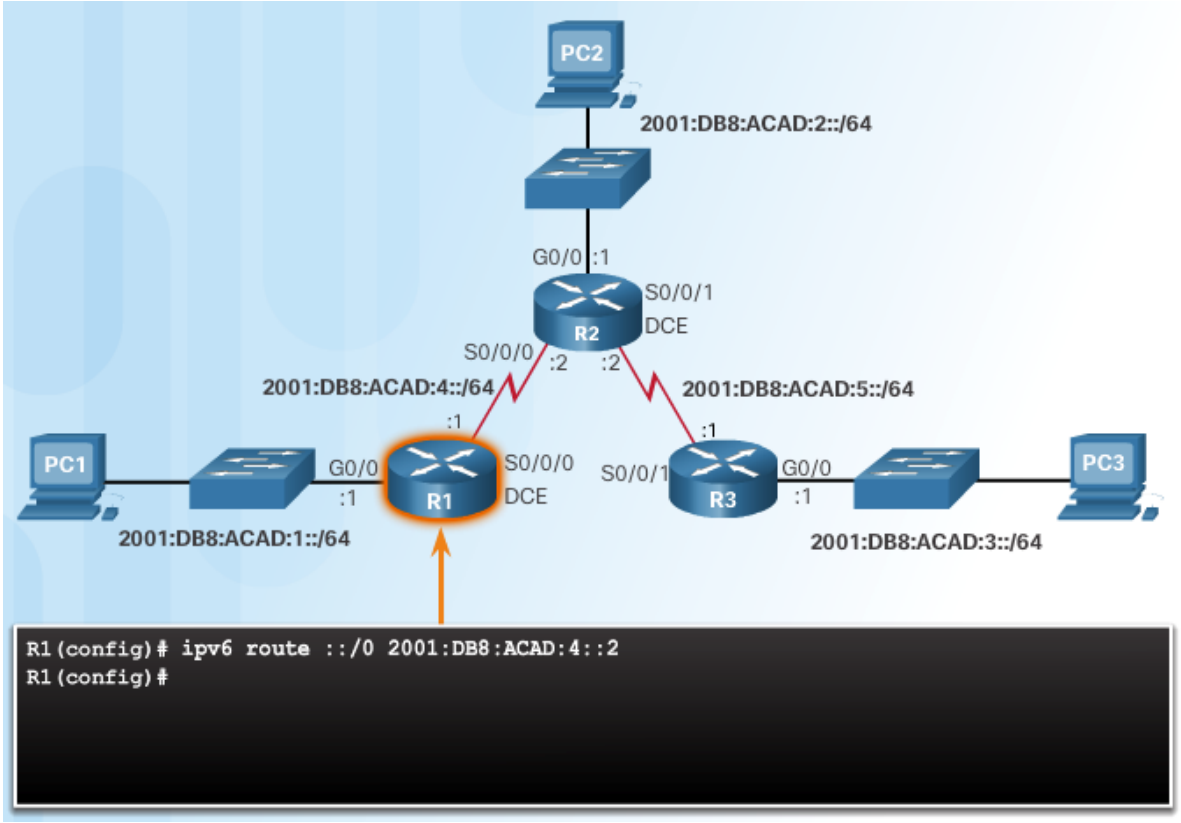
Configure a Default Static IPv6 Route



- R1 is a stub router because it is only connected to R2
- More efficient to configure a default static IPv6 route in this topology

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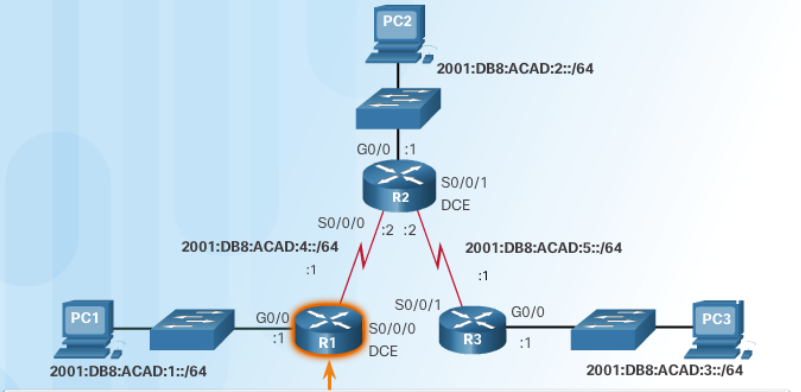
Verify a Default Static Route

- **::/0** mask indicates that none of the bits are required to match
- If a more specific match does not exist, the default static IPv6 route matches all packets.




```
R1# show ipv6 route static
IPv6 Routing Table - default - 6 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route,B - BGP,
       R - RIP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary,
       D - EIGRP, EX - EIGRP external, ND - ND Default, NDp - ND Prefix,
       DCE - Destination,  NDr - Redirect, O - OSPF Intra, OI - OSPF Inter,
       OE1 - OSPF ext 1, OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1,
       ON2 - OSPF NSSA ext 2
S   ::/0 [1/0]
          via 2001:DB8:ACAD:4::2
R1#
```

```
R1# ping 2001:0DB8:ACAD:3::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:3::1,
timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max
= 28/28/28 ms
R1#
```

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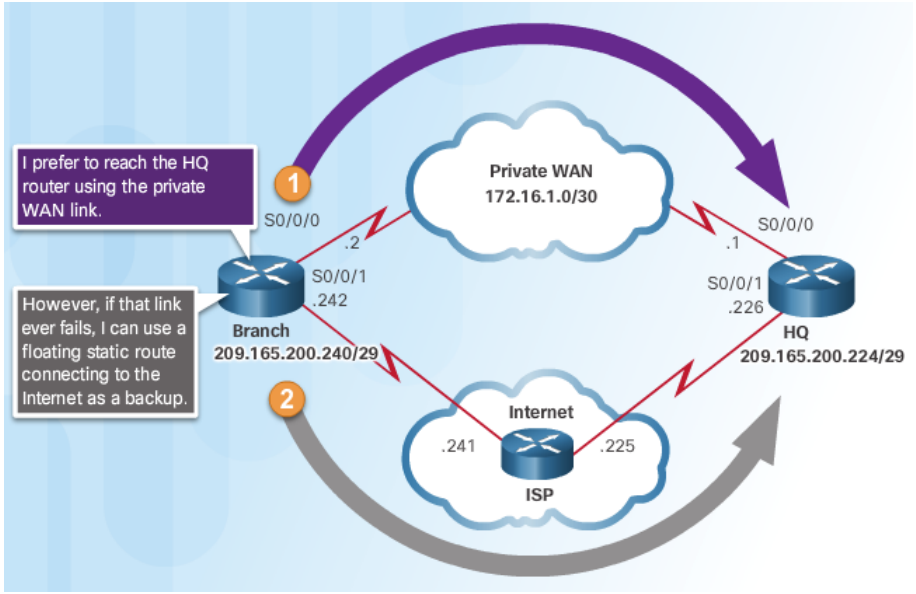
Floating Static Routes

Floating static routes have an administrative distance greater than the dynamic routing protocol or other static route

- Used as backup routes
- Administrative distance of common routing protocols
  - EIGRP = 90
  - IGRP = 100
  - OSPF = 110
  - IS-IS = 115
  - RIP = 120
- By default, AD of static route = 1
- Static route AD can be increased to make route less desirable until preferred route is lost



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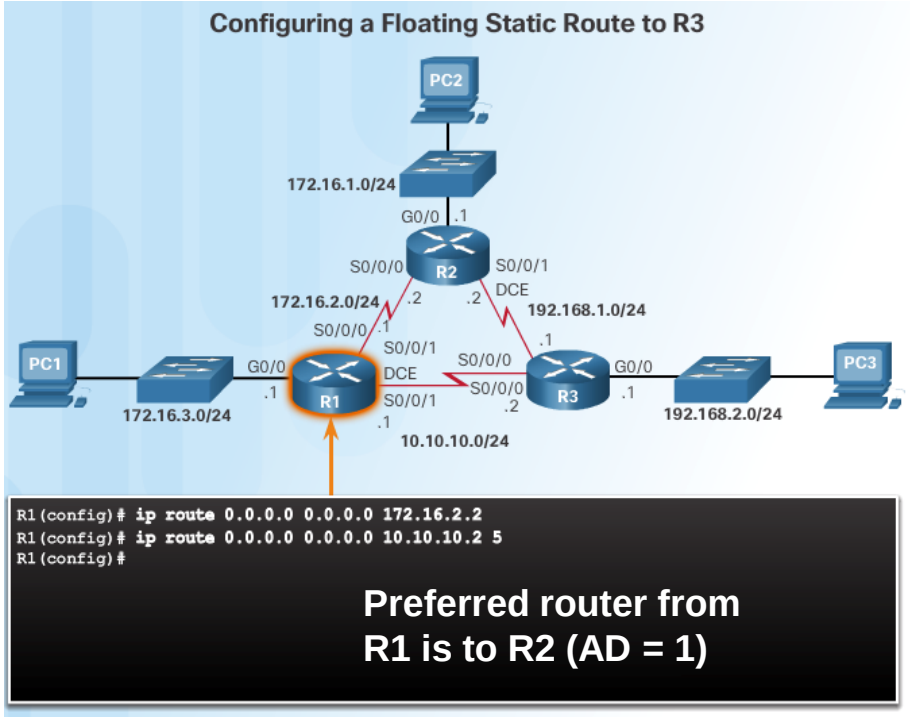
Configure a Floating Static Route




```
R1# show ip route static | begin Gateway
Gateway of last resort is 0.0.0.0 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 172.16.2.2`
R1#
```

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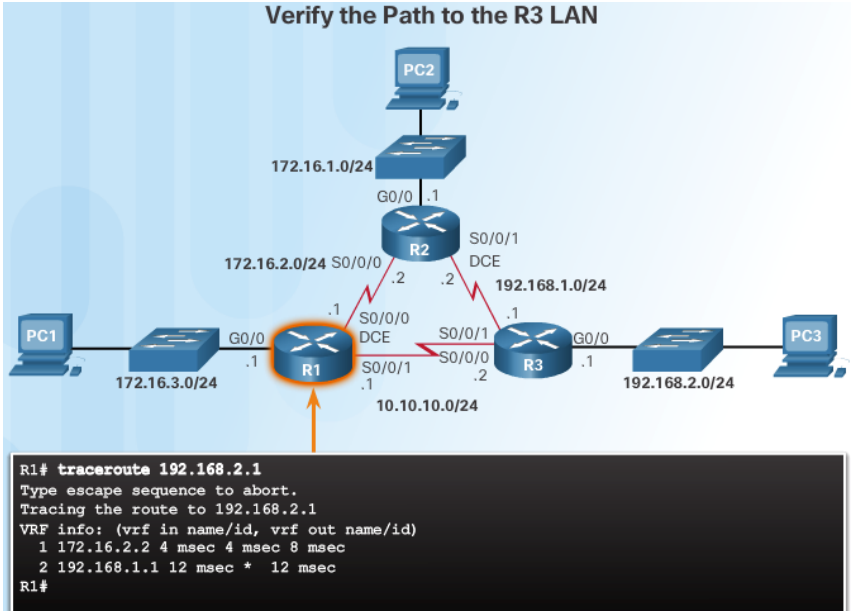
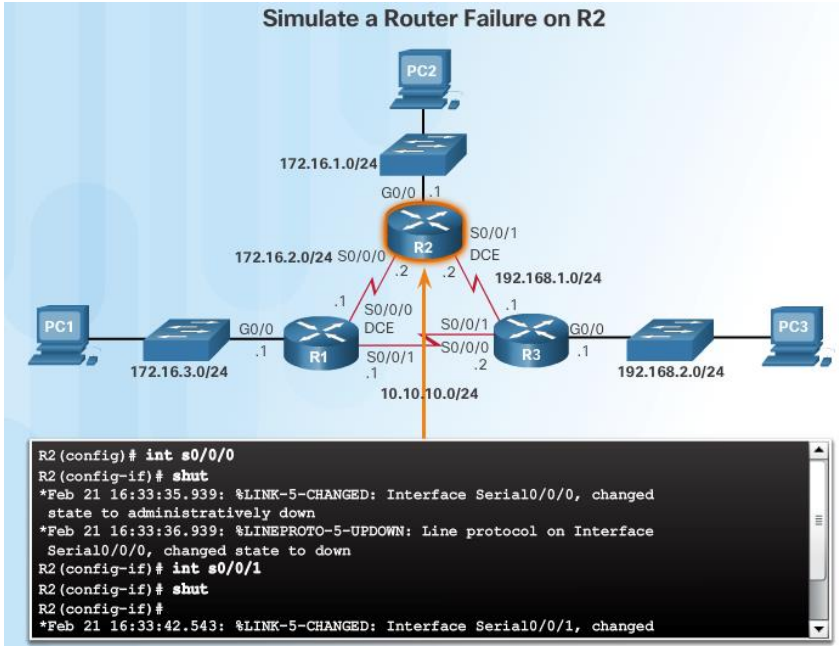
Test the IPv4 Floating Static Route





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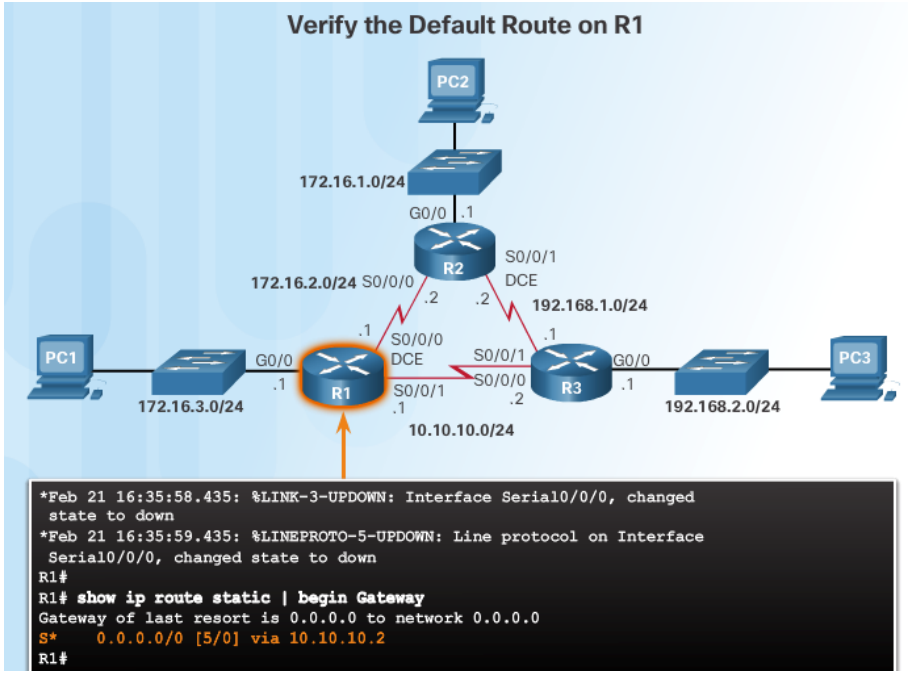
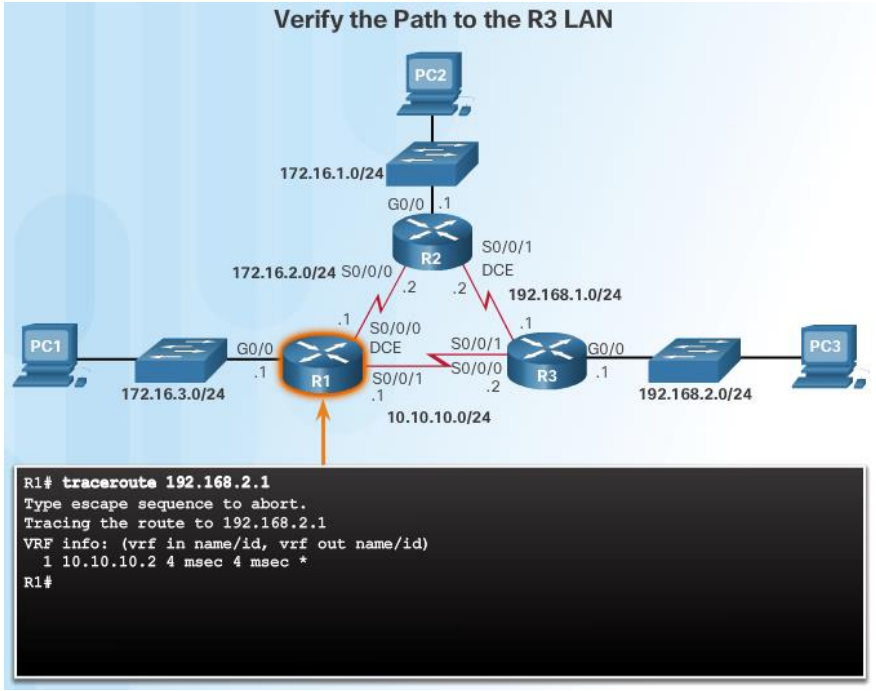
Test the IPv4 Floating Static Route (Cont.)





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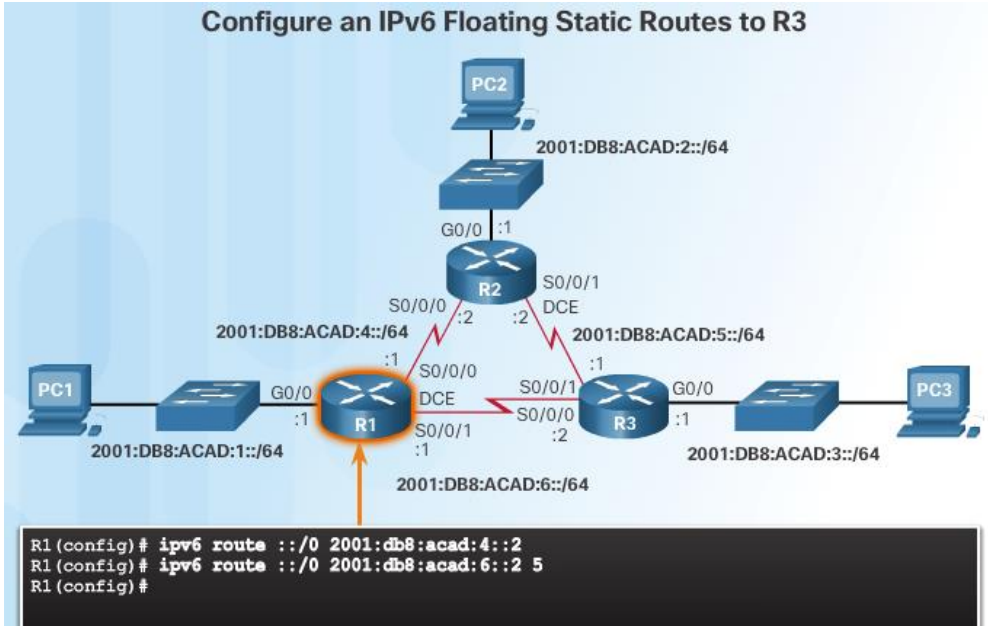
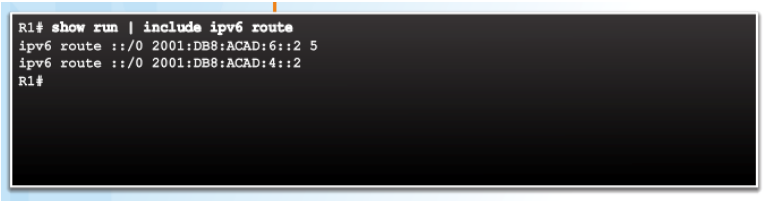
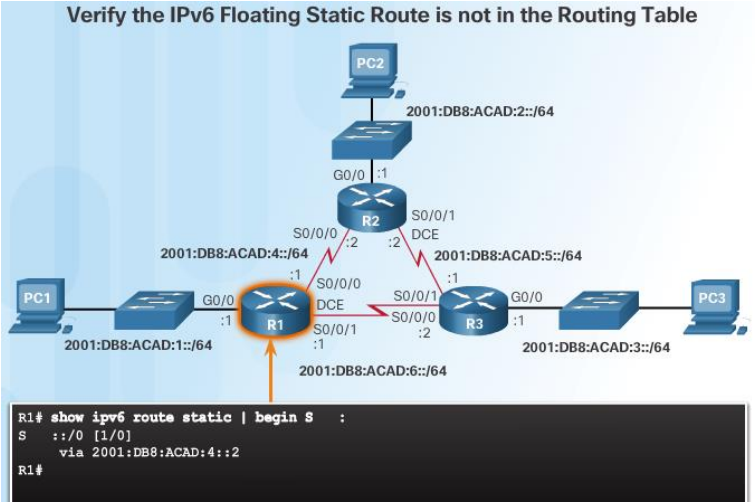
Configure an IPv6 Floating Static Route

- Similar to IPv4 floating static routes







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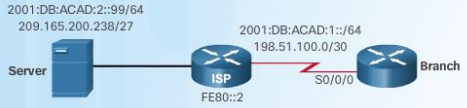
Automatically Installed Host Routes

Host route is an IPv4 address with a 32-bit mask or IPv6 address with a 128-bit mask.

- Automatically installed when IP address is configured
- Configured as a static host route
- Allows more efficiency for packets directed to the router
- Local route marked with “L” (introduced in IOS 15)

Branch IPv4 Routing Table




```
Branch# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override
Gateway of last resort is not set

      198.51.100.0/24 is variably subnetted, 2 subnets, 2 masks
C        198.51.100.0/30 is directly connected, Serial0/0/0
L        198.51.100.1/32 is directly connected, Serial0/0/0
Branch#
```

Branch IPv6 Routing Table

```
Branch# show ipv6 route
IPv6 Routing Table - default - 3 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, H - NHRP, I1 - ISIS L1
       I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary, D - EIGRP
       EX - EIGRP external, ND - ND Default, NDp - ND Prefix, DCE - Destination
       NDr - Redirect, O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1
       OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
       a - Application
C   2001:DB8:ACAD:1::/64 [0/0]
     via Serial0/0/0, directly connected
L   2001:DB8:ACAD:1::1/128 [0/0]
     via Serial0/0/0, receive
L   FF00::/8 [0/0]
     via Null0, receive
Branch#
```

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Configure IPv4 and IPv6 Static Host Routes

IPv4 and IPv6 Host Route Configuration and Verification

```
Branch(config)# ip route 209.165.200.238 255.255.255.255 198.51.100.2
Branch(config)# ipv6 route 2001:db8:acad:2::99/128 2001:db8:acad:1::2
Branch(config)# end
Branch# show ip route | begin Gateway
Gateway of last resort is not set

      198.51.100.0/24 is variably subnetted, 2 subnets, 2 masks
C        198.51.100.0/30 is directly connected, Serial0/0/0
L        198.51.100.1/32 is directly connected, Serial0/0/0
      209.165.200.0/32 is subnetted, 1 subnets
S        209.165.200.238 [1/0] via 198.51.100.2
Branch# show ipv6 route


C   2001:DB8:ACAD:1::/64 [0/0]
     via Serial0/0/0, directly connected
L   2001:DB8:ACAD:1::1/128 [0/0]
     via Serial0/0/0, receive
S   2001:DB8:ACAD:2::99/128 [1/0]
     via 2001:DB8:ACAD:1::2
L   FF00::/8 [0/0]
     via Null0, receive
Branch#
```

Fully Specified IPv6 Host Route with the Next-Hop Link-Local Address

```
Branch(config)# no ipv6 route 2001:db8:acad:2::99/128 2001:db8:acad:1::2
Branch(config)# ipv6 route 2001:db8:acad:2::99/128 serial 0/0/0 fe80::2
Branch(config)# end
Branch# show ipv6 route


S   ::/0 [1/0]
     via 2001:DB8:ACAD:1::2
C   2001:DB8:ACAD:1::/64 [0/0]
     via Serial0/0/0, directly connected
L   2001:DB8:ACAD:1::1/128 [0/0]
     via Serial0/0/0, receive
S   2001:DB8:ACAD:2::99/128 [1/0]
     via FE80::2, Serial0/0/0
L   FF00::/8 [0/0]
     via Null0, receive
Branch#
```

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