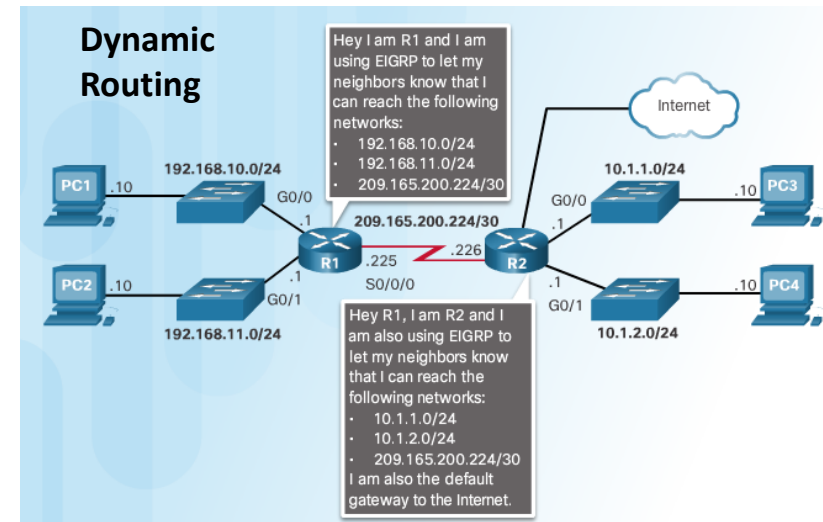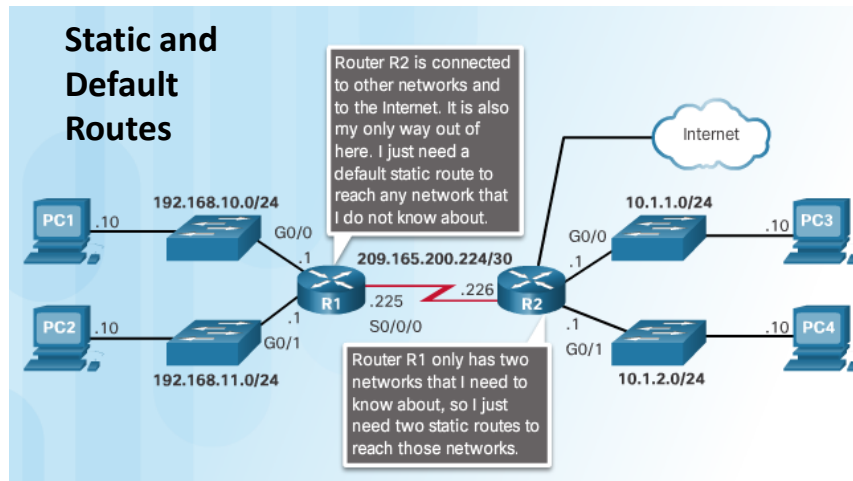# Static Routing

Faculty of Technology

University of Sri Jayewardenepura

2020

Routers Connecting to 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

Why use Static Routing versus Dynamic

	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

When to use 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 neighbour
  - 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
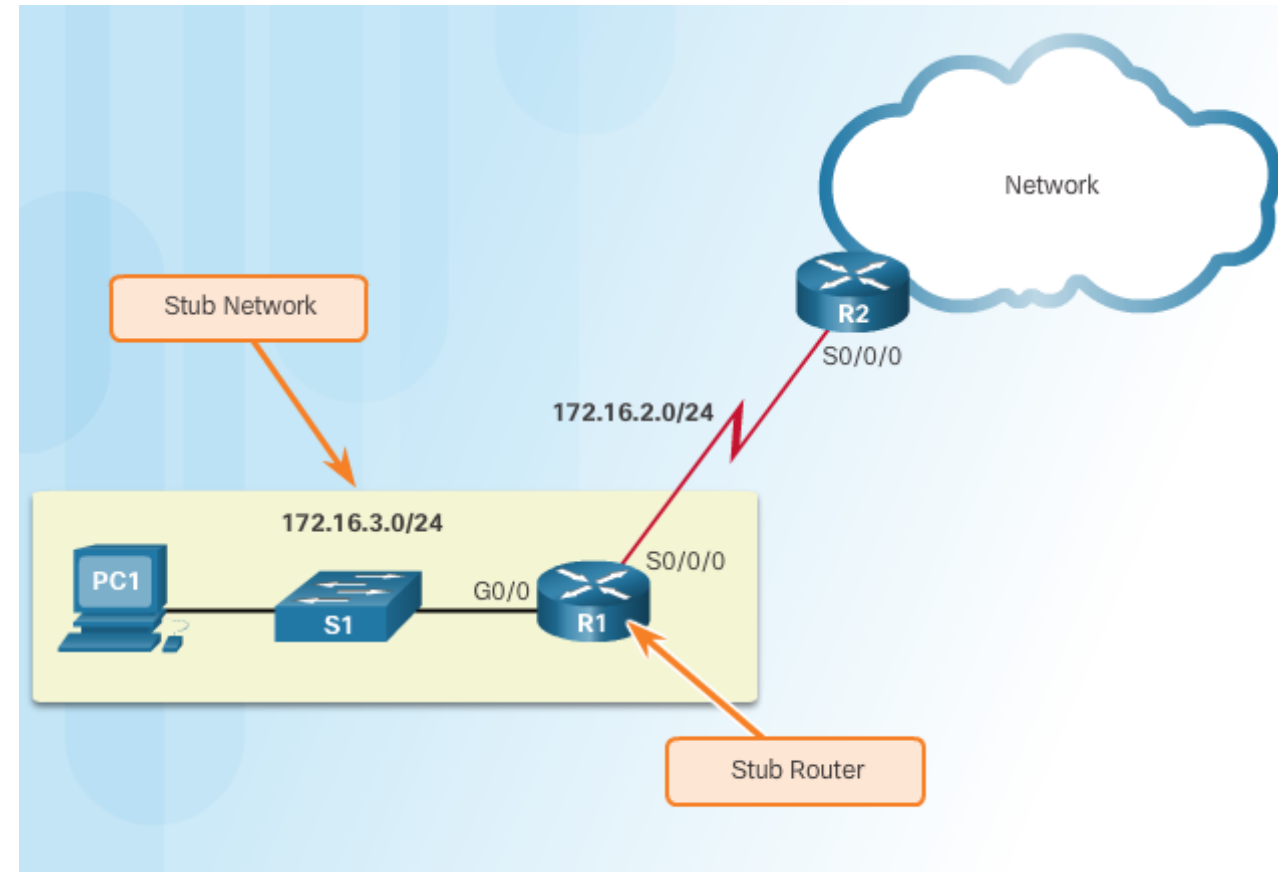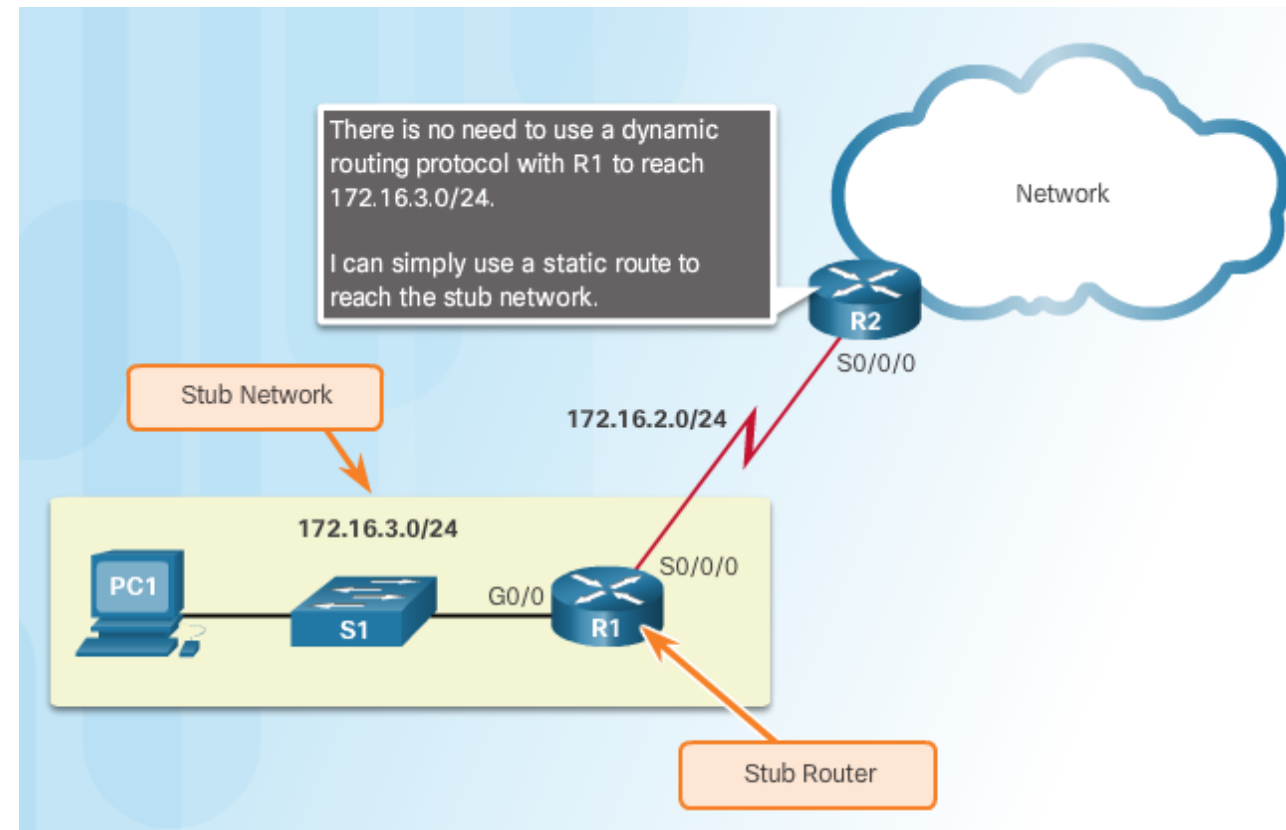
Static Route Applications

- 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

Standard Static Route

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

There is no need to use a dynamic routing protocol with R1 to reach 172.16.3.0/24.

I can simply use a static route to reach the stub network.

Network

R2
S0/0/0

Stub Network

172.16.2.0/24

172.16.3.0/24

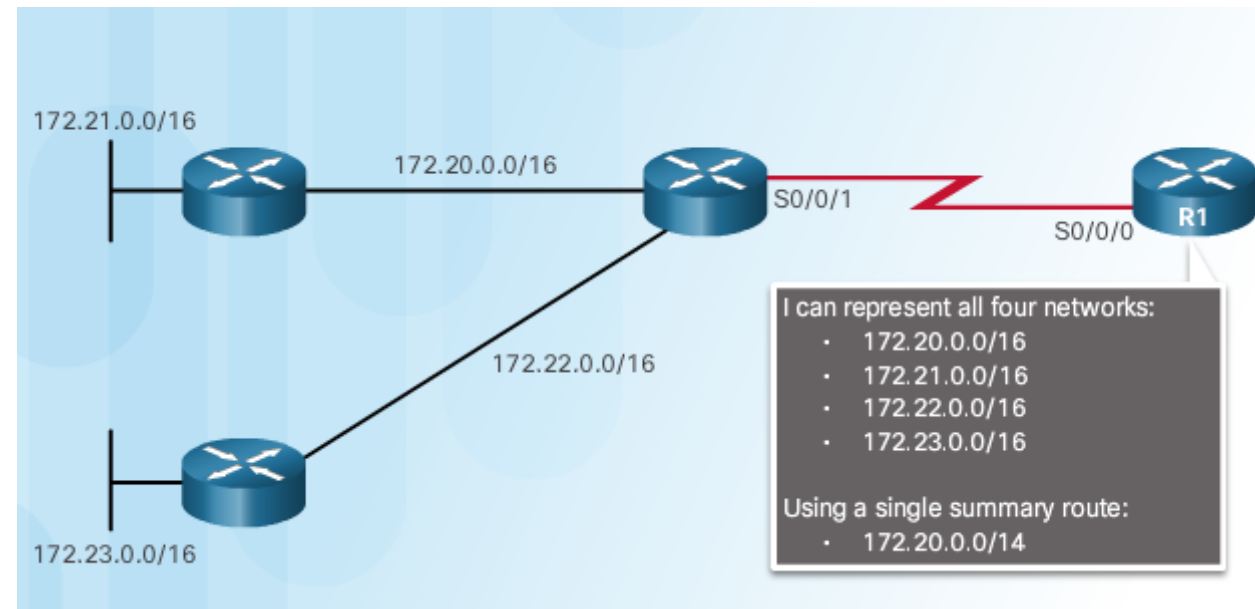PC1

S1

G0/0

S0/0/0

R1

Stub Router

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
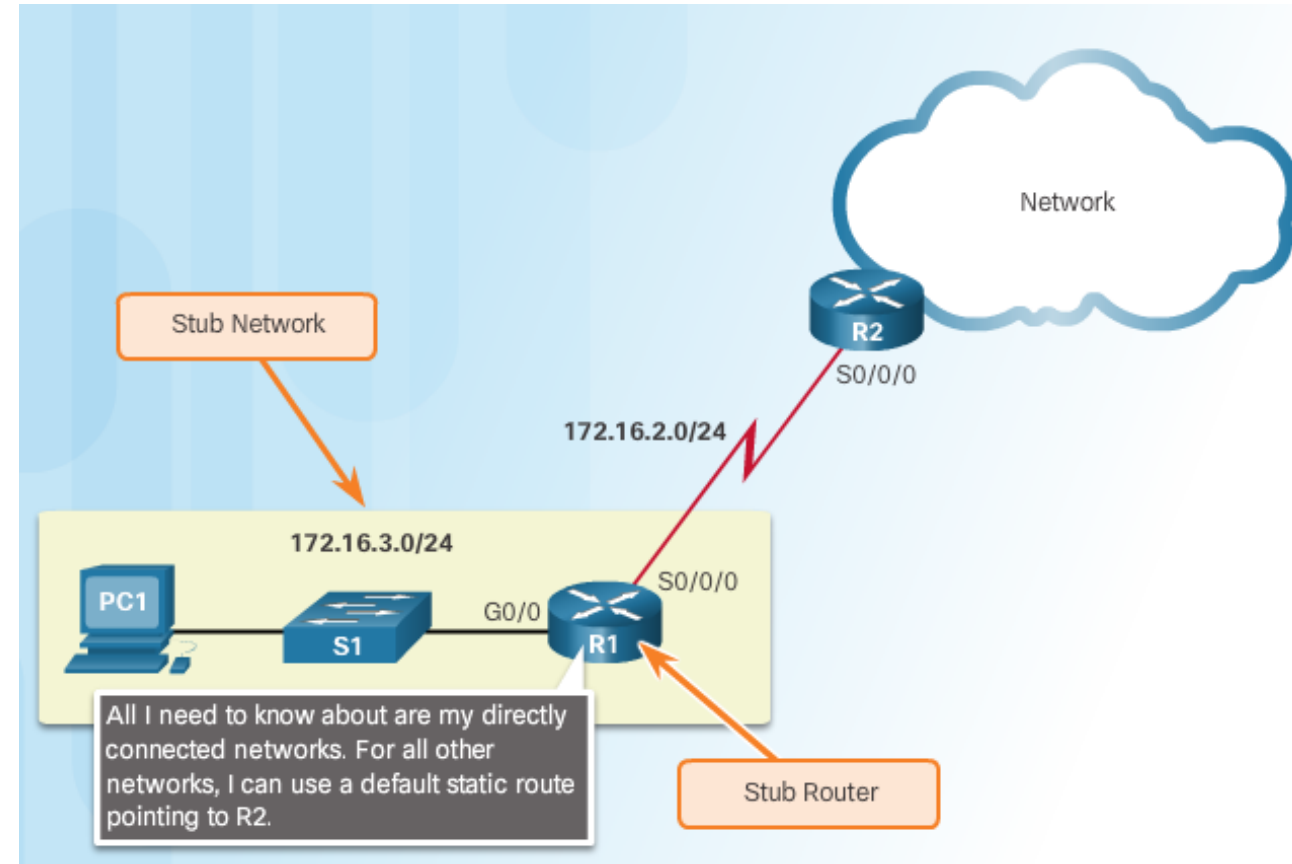
Summary Static Route

- 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

172.21.0.0/16

172.20.0.0/16

S0/0/1

S0/0/0 R1

172.22.0.0/16

172.23.0.0/16

I can represent all four networks:
- 172.20.0.0/16
- 172.21.0.0/16
- 172.22.0.0/16
- 172.23.0.0/16

Using a single summary route:
- 172.20.0.0/14

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.
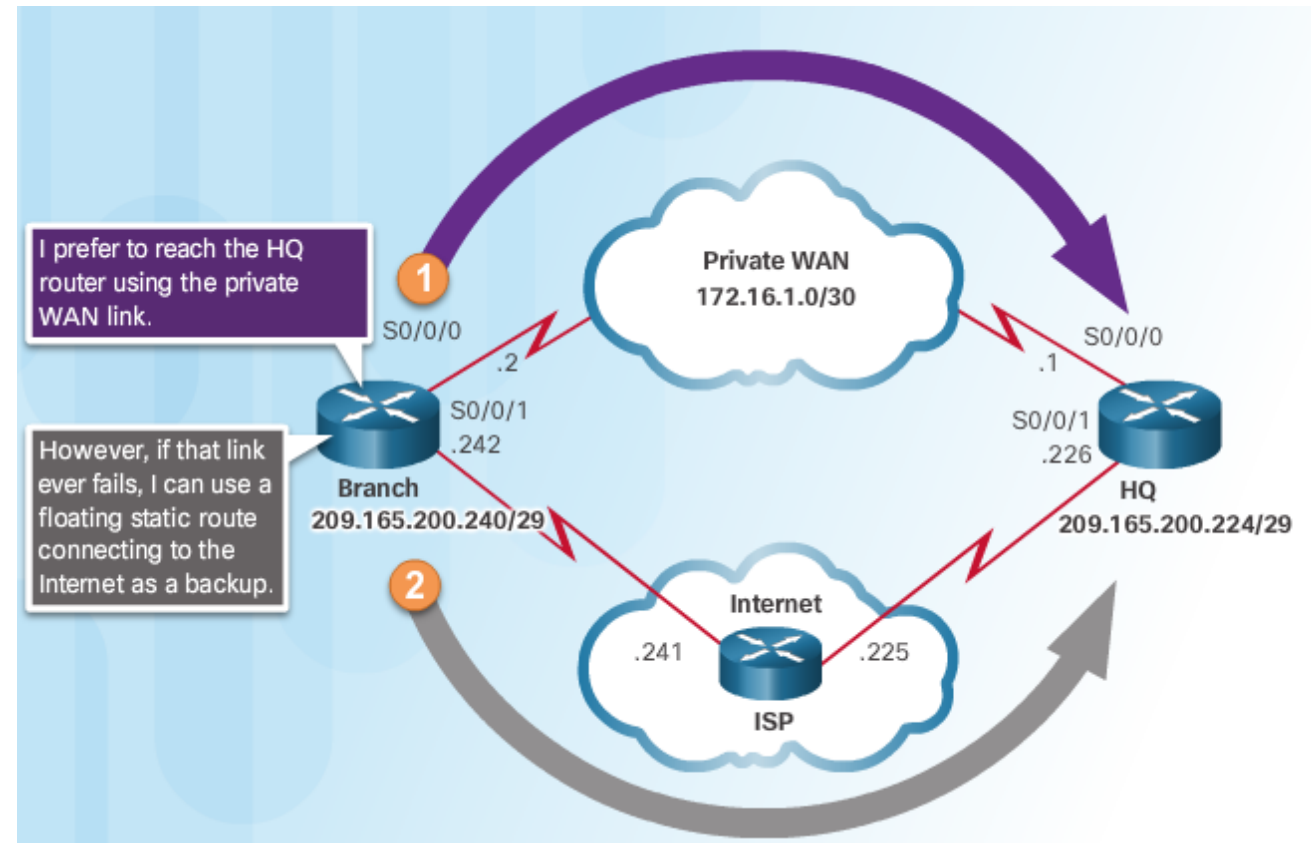
Configure IPv4 Static Routes

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.

Next-Hop Options

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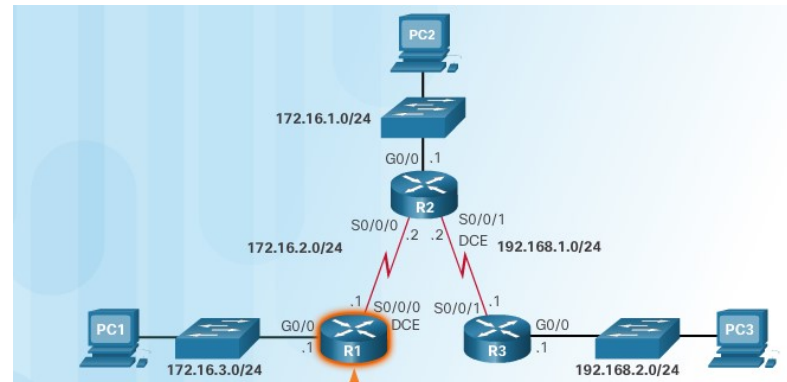

```
R1# show ip route | begin Gateway
Gateway of last resort is not set
      172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C        172.16.2.0/24 is directly connected, Serial0/0/0
L        172.16.2.1/32 is directly connected, Serial0/0/0
C        172.16.3.0/24 is directly connected, GigabitEthernet0/0
L        172.16.3.1/32 is directly connected, GigabitEthernet0/0
R1#
```
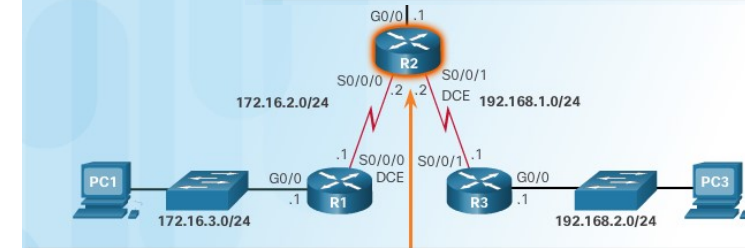
```
R2# show ip route | begin Gateway
Gateway of last resort is not set
      172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C        172.16.1.0/24 is directly connected, GigabitEthernet0/0
L        172.16.1.1/32 is directly connected, GigabitEthernet0/0
C        172.16.2.0/24 is directly connected, Serial0/0/0
L        172.16.2.2/32 is directly connected, Serial0/0/0
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, Serial0/0/1
L        192.168.1.2/32 is directly connected, Serial0/0/1
R2#
```
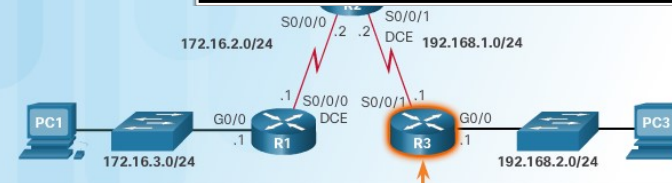
```
R3# show ip route | include C
Codes:L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
C        192.168.1.0/24 is directly connected, Serial0/0/1
C        192.168.2.0/24 is directly connected, GigabitEthernet0/0
R3#
```

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)

Configuring Next-Hop Static Routes on R1

```
R1(config)# ip route 172.16.1.0 255.255.255.0 172.16.2.2
R1(config)# ip route 192.168.1.0 255.255.255.0 172.16.2.2
R1(config)# ip route 192.168.2.0 255.255.255.0 172.16.2.2
R1(config)#
```
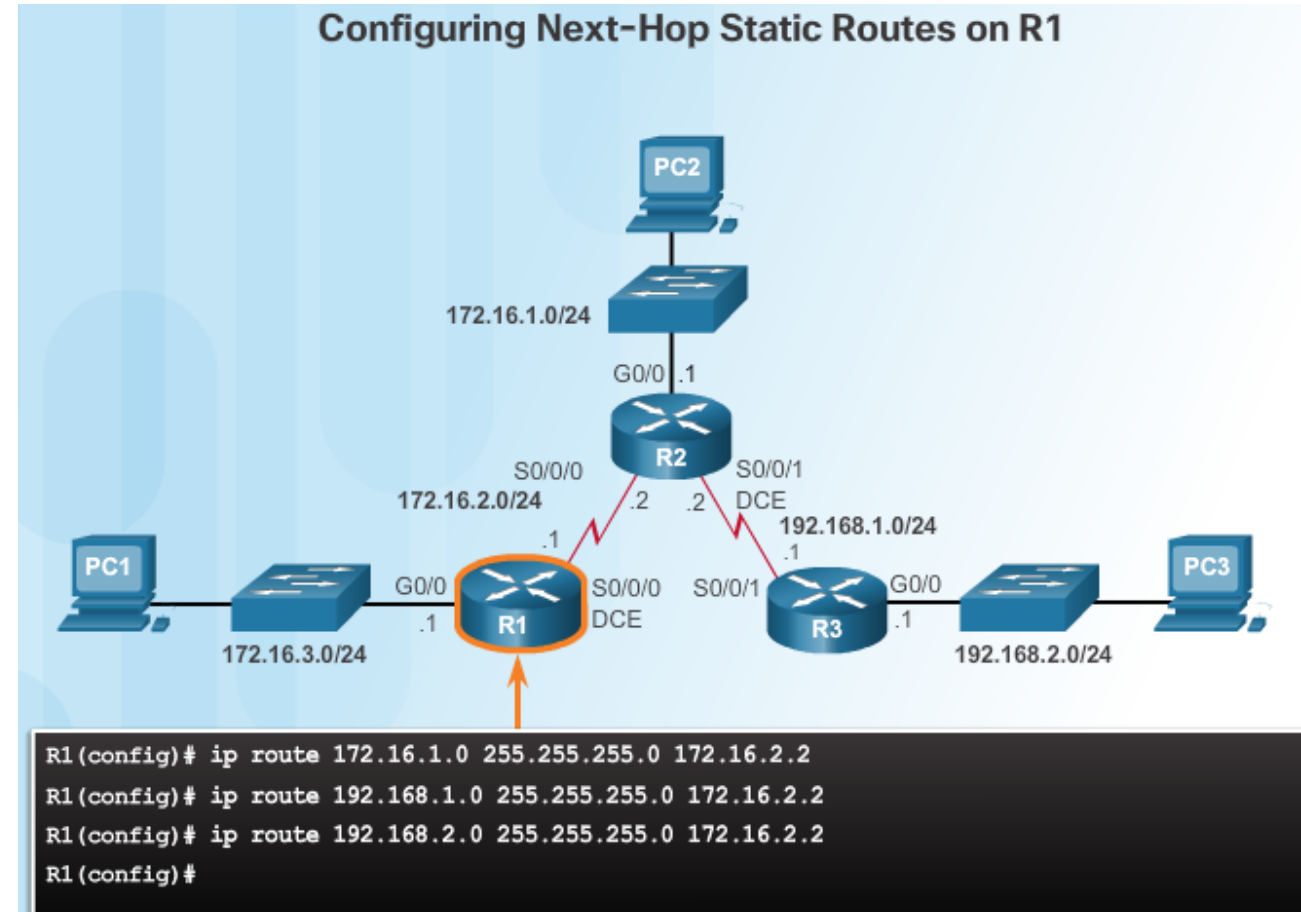
Configure a Directly Connected Static Route

- Use the exit interface to specify next-hop so no other lookups are required

- Administrative distance of static route is 1

Configure Directly Connected Static Routes on R1

```
R1(config)# ip route 172.16.1.0 255.255.255.0 s0/0/0
R1(config)# ip route 192.168.1.0 255.255.255.0 s0/0/0
R1(config)# ip route 192.168.2.0 255.255.255.0 s0/0/0
R1(config)#
```
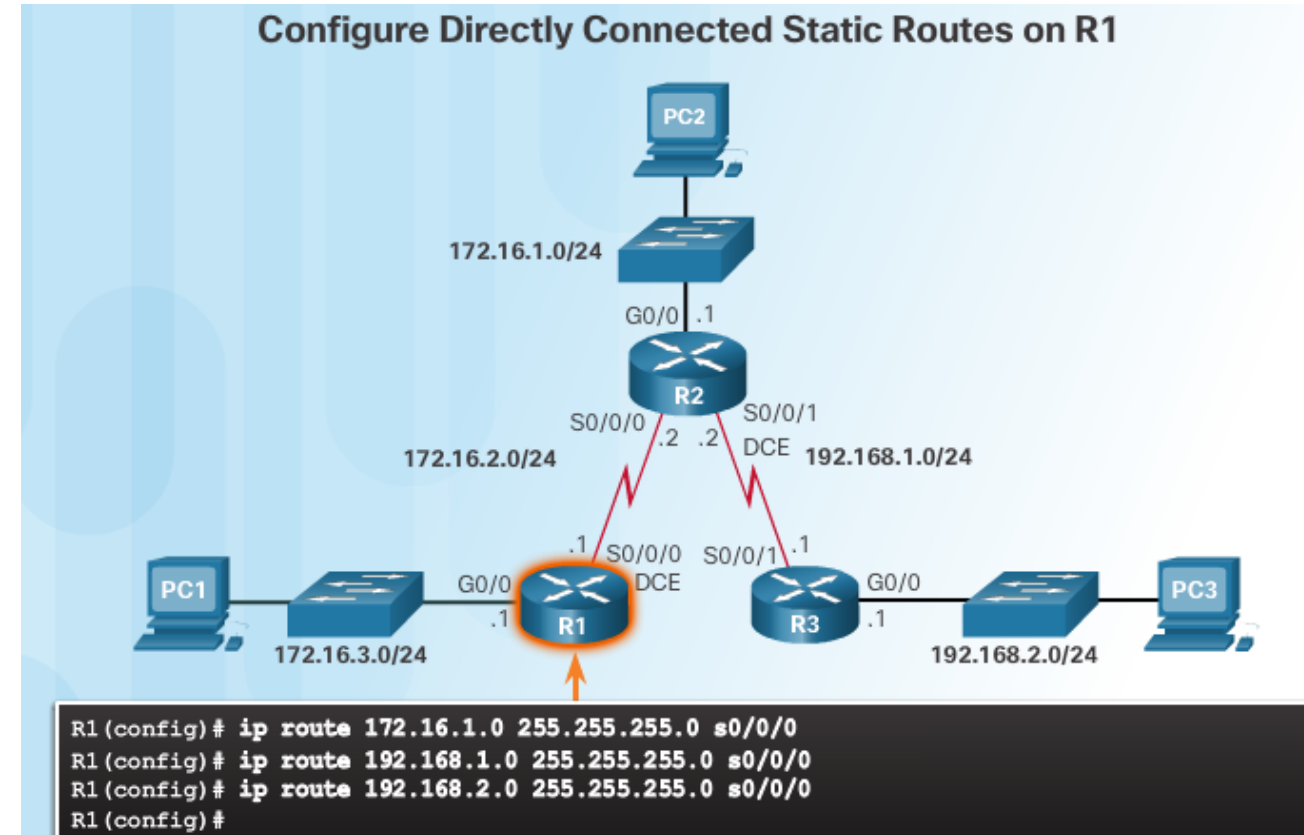
Configure a Fully Specified Static Route

- 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
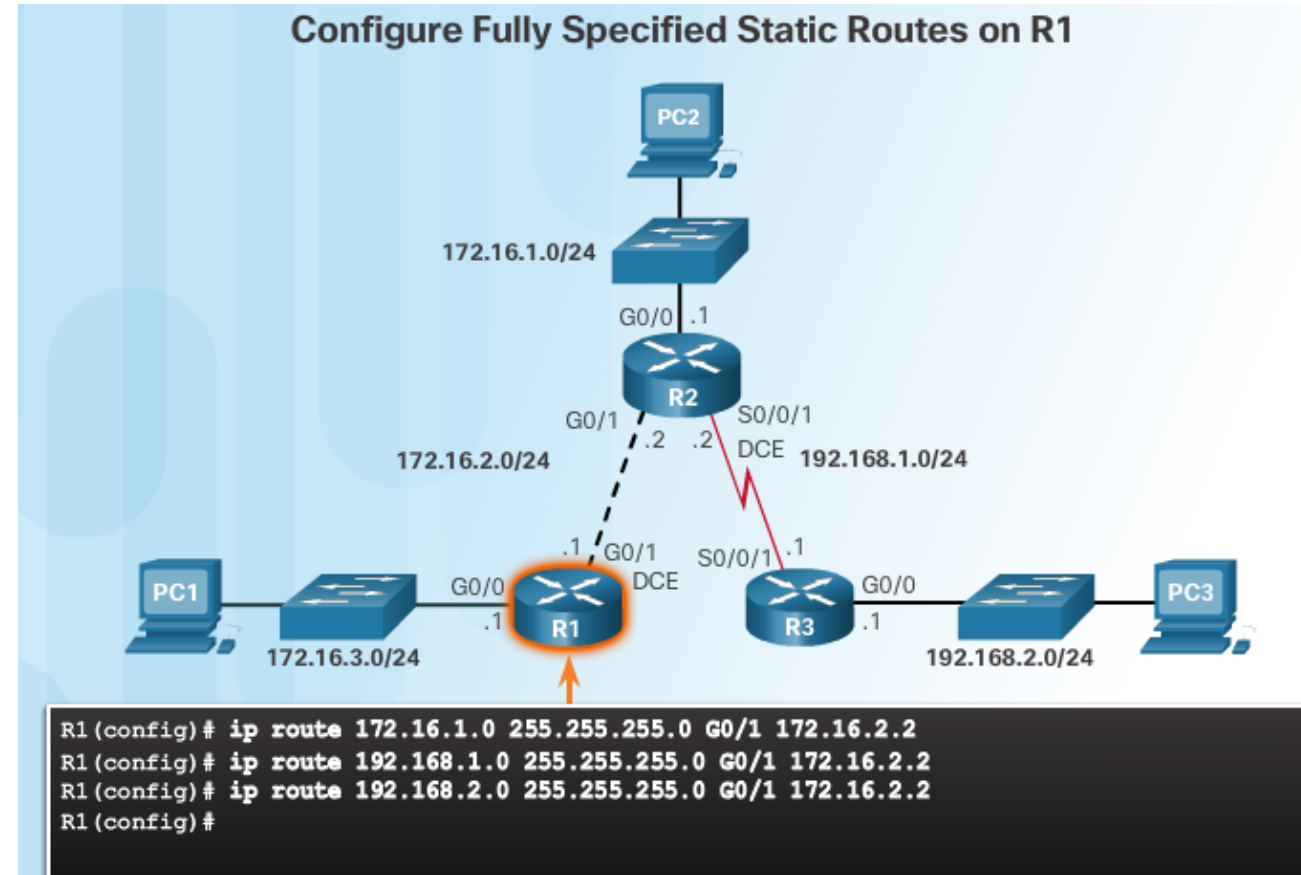
Default Static Route

- 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 neighbour 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.

Configure a Default Static Route


```
R1(config)# ip route 0.0.0.0 0.0.0.0 172.16.2.2
R1(config)#
```

Any packets not matching route entries are forwarded to 172.16.2.2
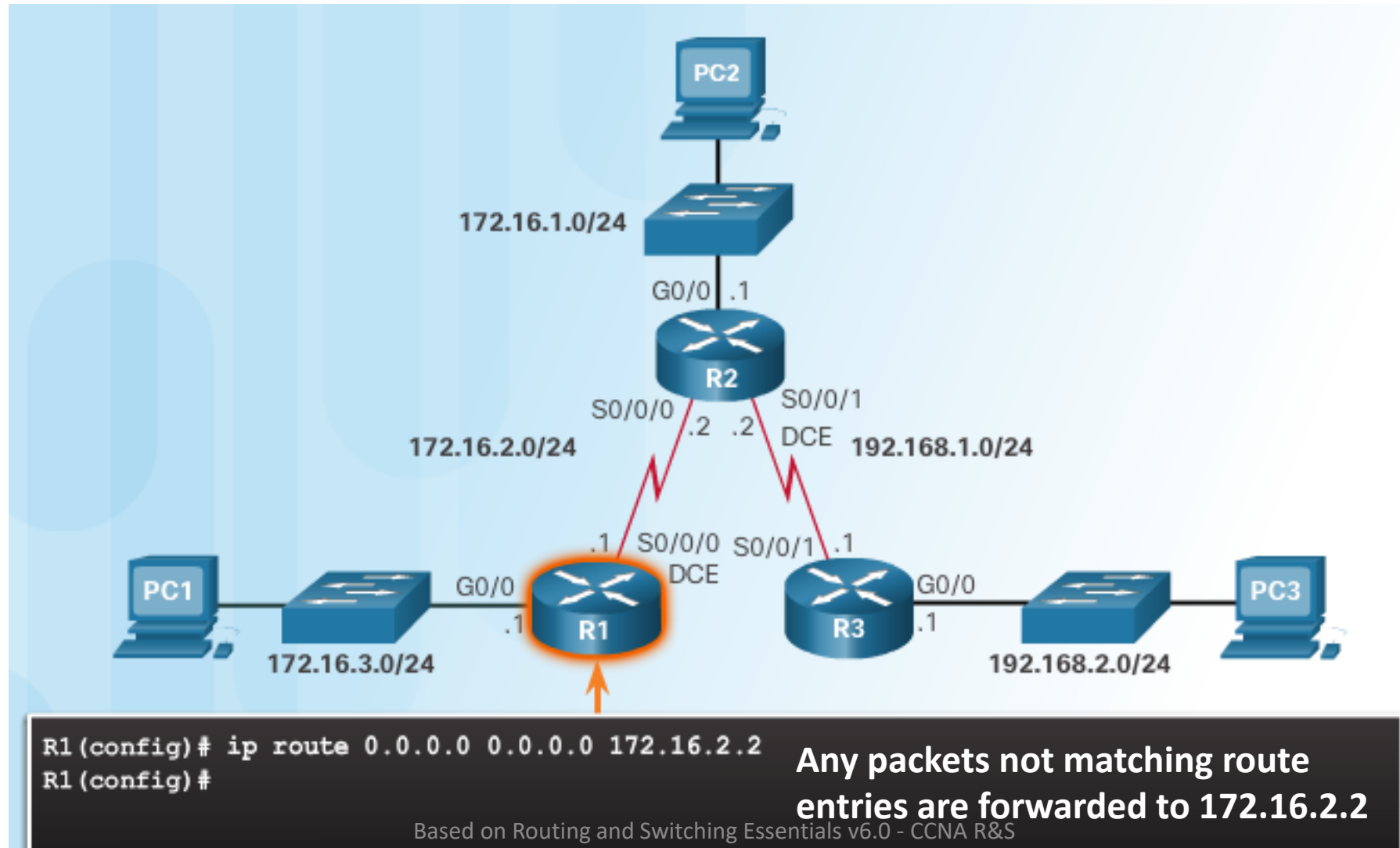
Configure IPv6 Static Routes

```
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.

The ipv6 route Command

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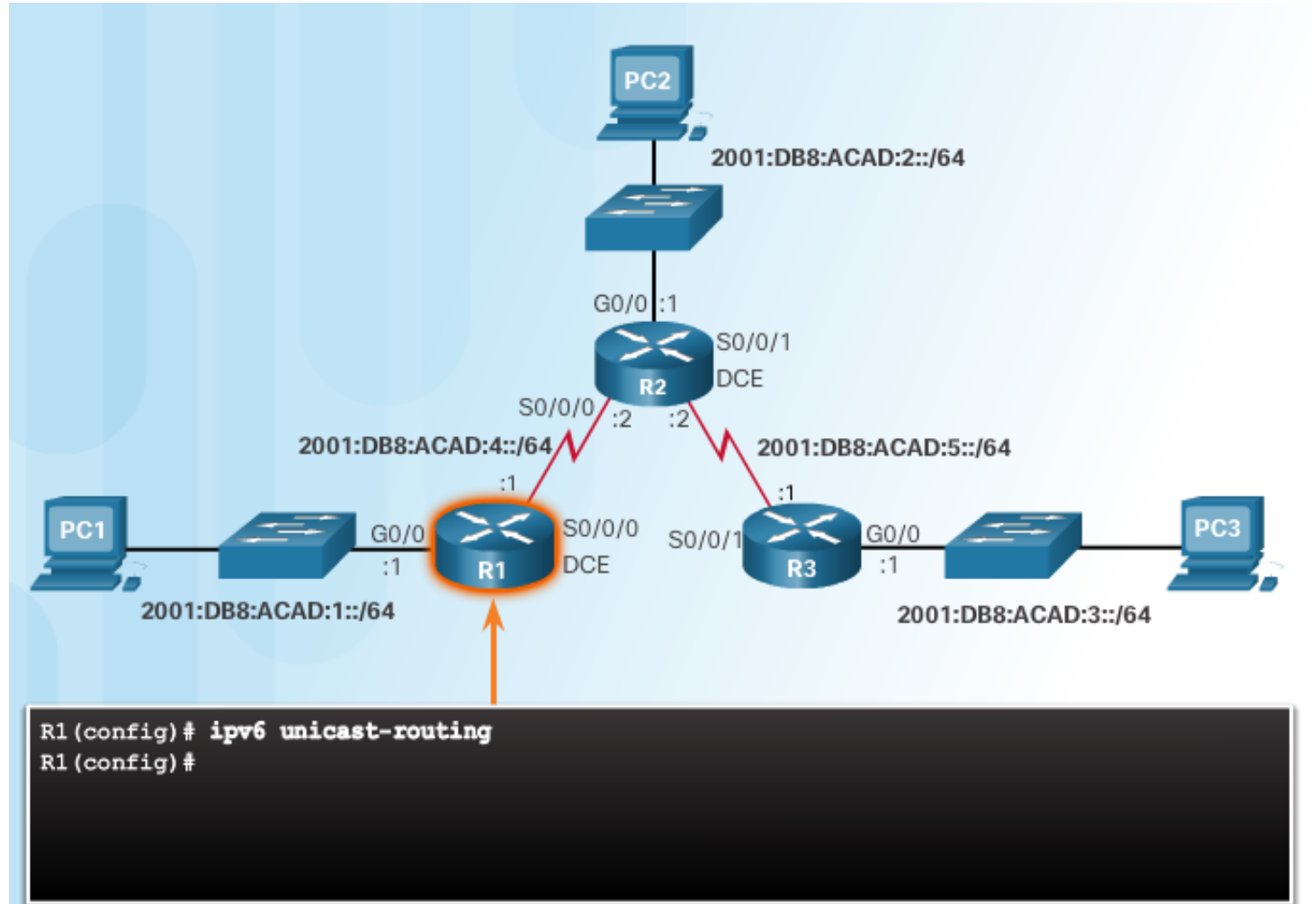
Next-Hop Options

- 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)
- Next hop can be identified by an IPv6 address, exit interface, or both.
- Destination is specified by one of three route types:
  - Next-hop static IPv6 route - Only the next-hop IPv6 address is specified
  - Directly connected static IPv6 route - Only the router exit interface is specified
  - Fully specified static IPv6 route - The next-hop IPv6 address and exit interface are specified


```
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#
```
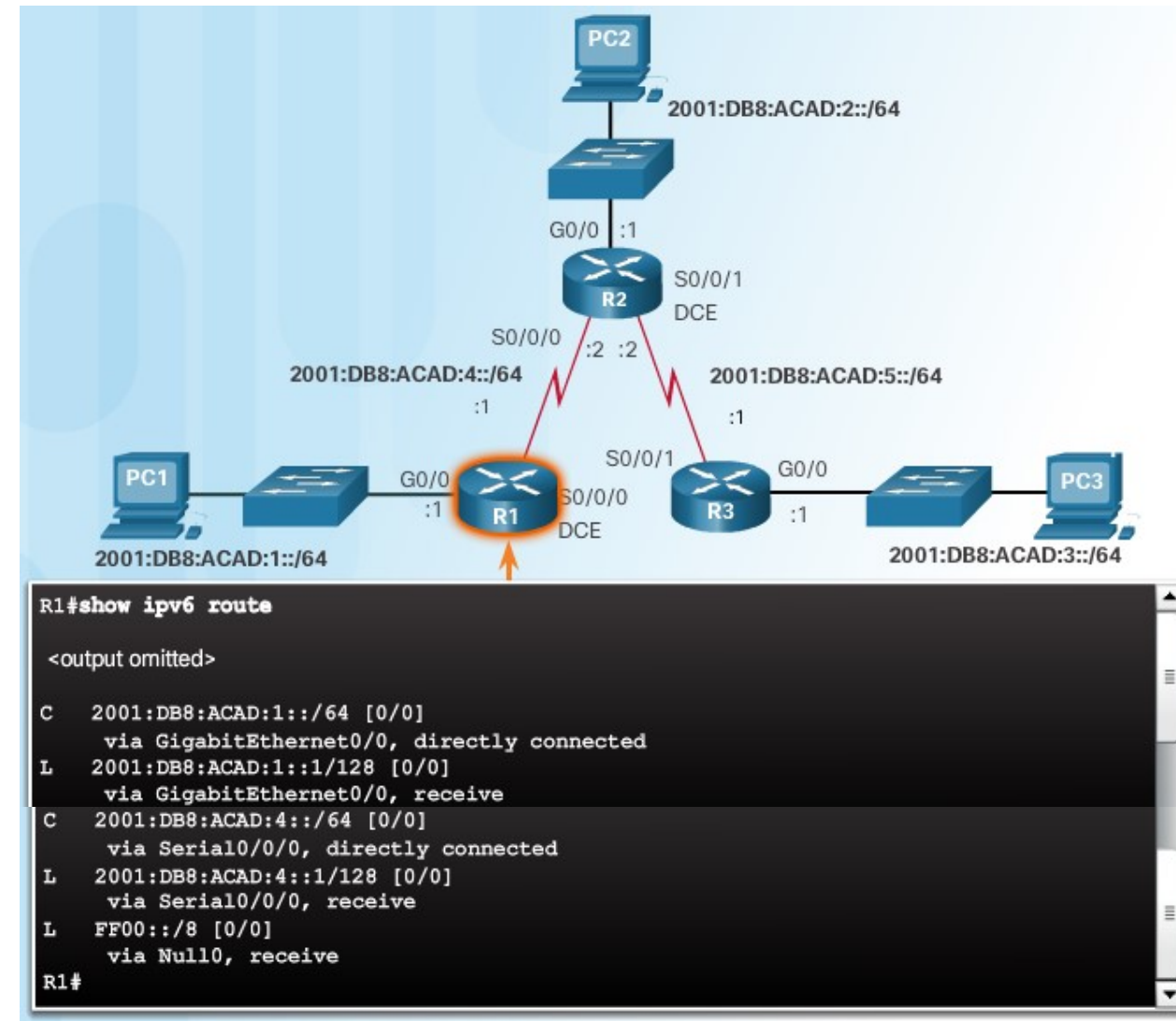
Configure a Next Hop Static IPv6 Route

- Three next-hop static routes are configured on 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.


```
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)#
```
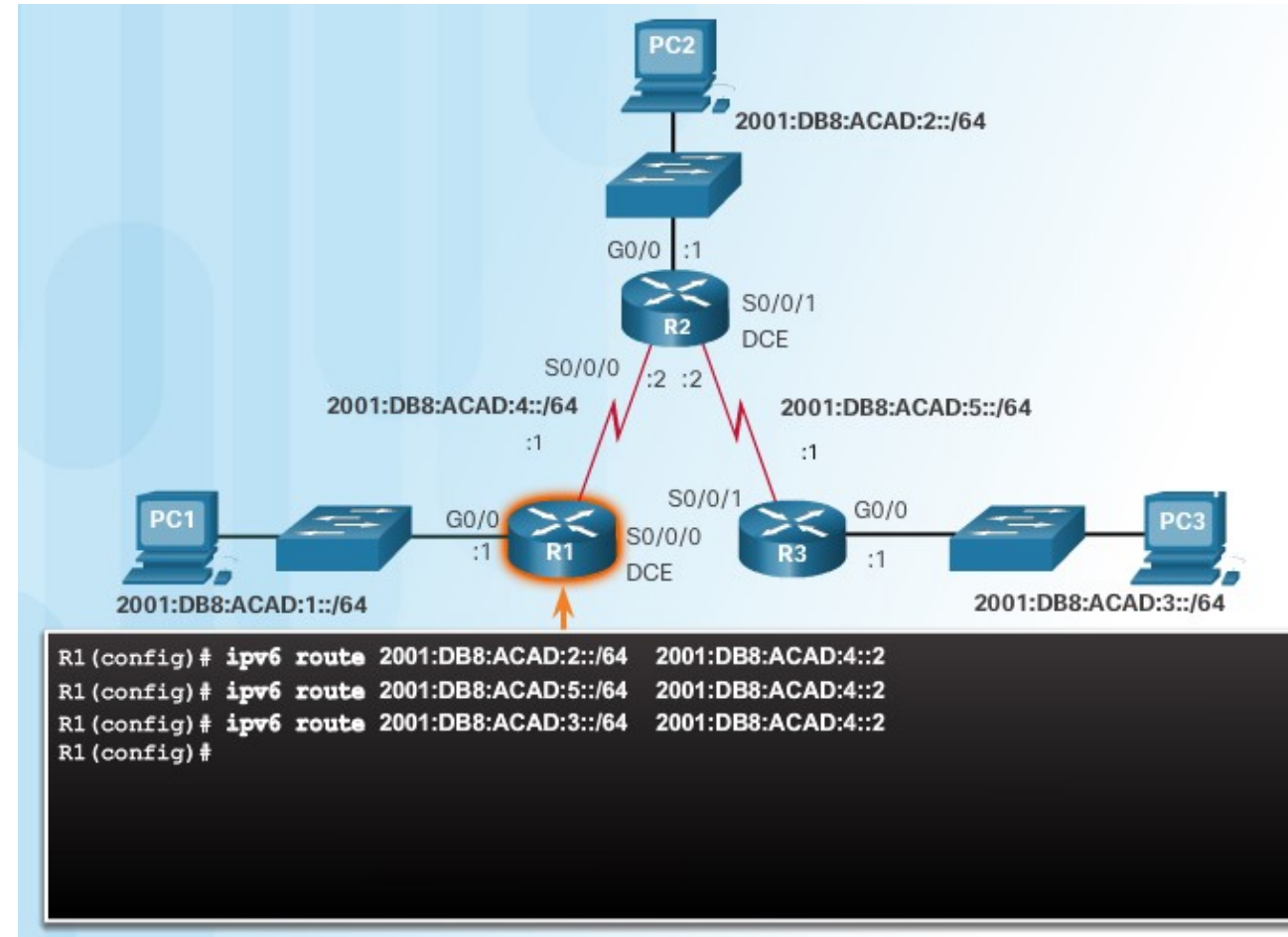
Configure a Directly Connected Static IPv6 Route

- 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(config)# ipv6 route 2001:DB8:ACAD:2::/64 s0/0/0
R1(config)# ipv6 route 2001:DB8:ACAD:5::/64 s0/0/0
R1(config)# ipv6 route 2001:DB8:ACAD:3::/64 s0/0/0
R1(config)#
R1#
```
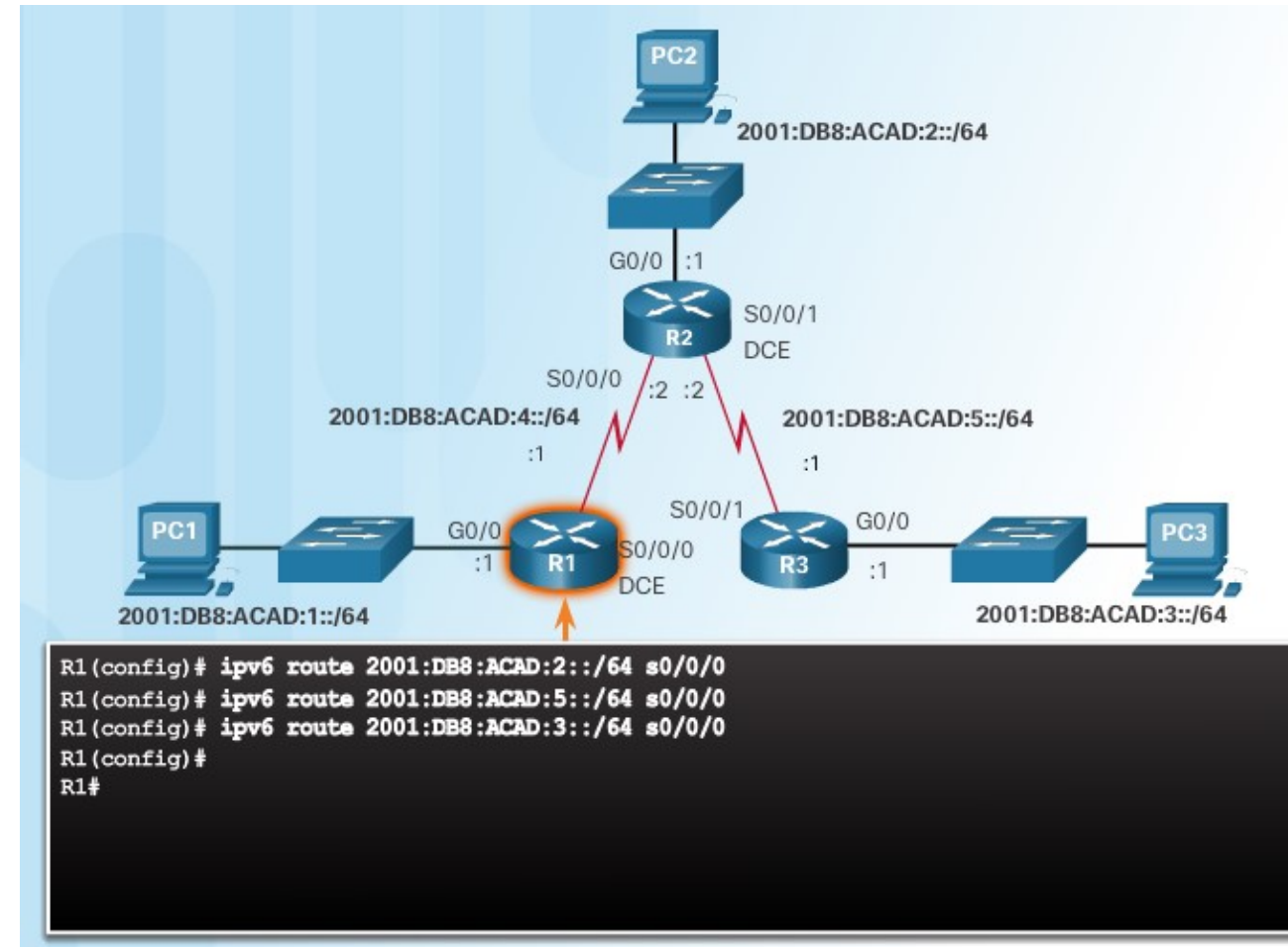
Configure a Fully Specified Static IPv6 Route

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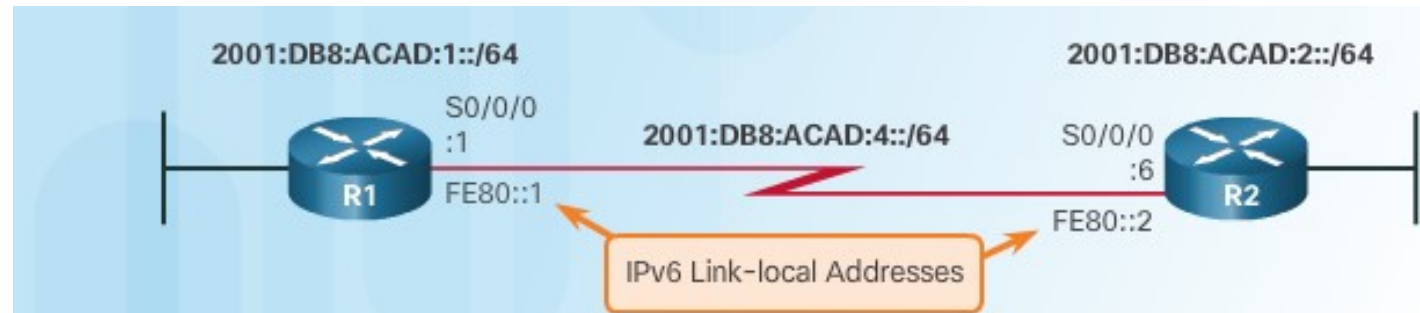


```
2001:DB8:ACAD:1::/64                                    2001:DB8:ACAD:2::/64
                    S0/0/0
                    :1          2001:DB8:ACAD:4::/64        S0/0/0
                                                            :6
         R1         FE80::1                                          R2
                                                FE80::2
                        IPv6 Link-local Addresses
```

```
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
```

# Configure a Default Static IPv6 Route

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

- R1 is a stub router because it is only connected to R2

- More efficient to configure a default static IPv6 route in this topology


```
R1(config)# ipv6 route ::/0 2001:DB8:ACAD:4::2
R1(config)#
```
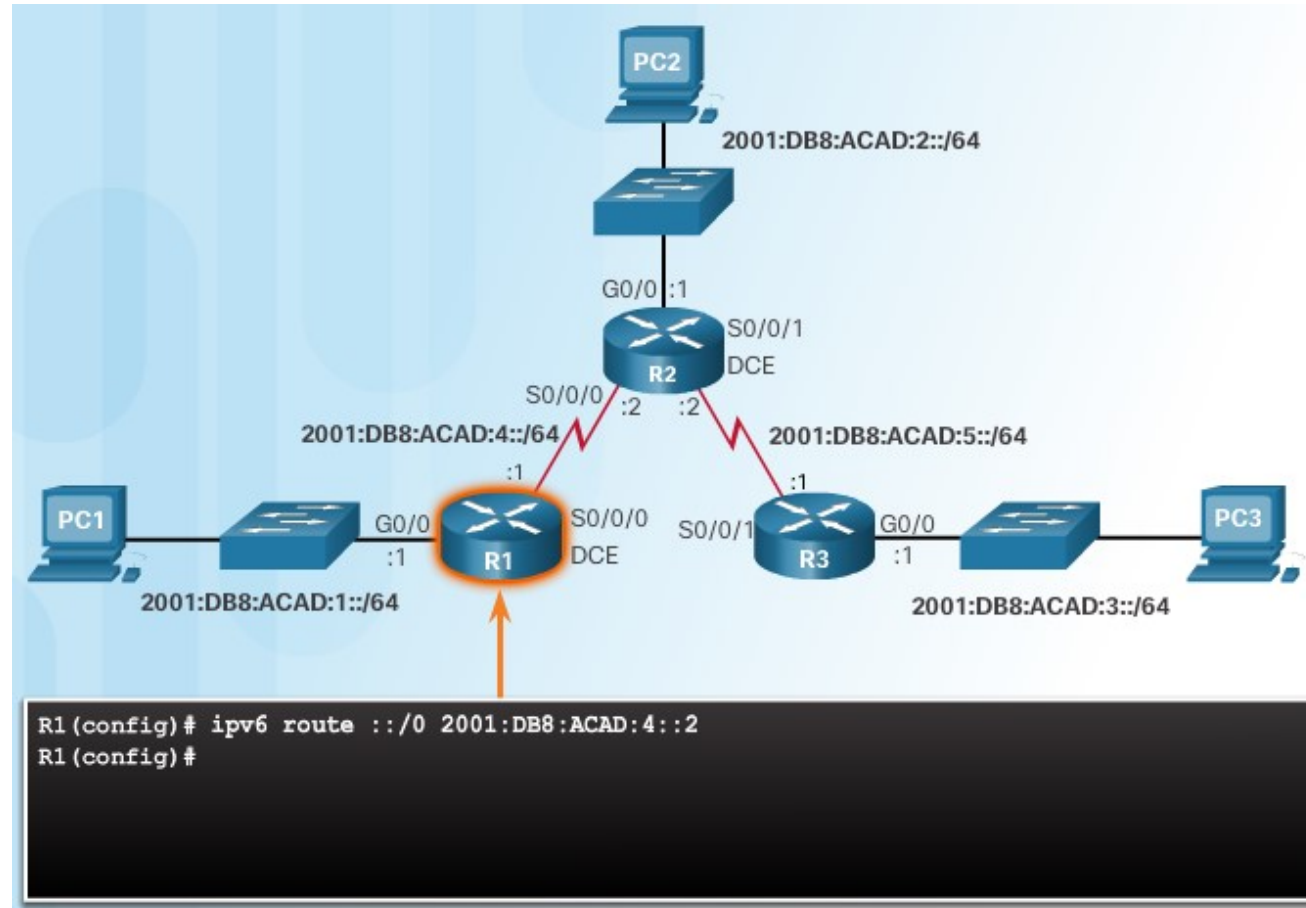
Floating Static Routes

- 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
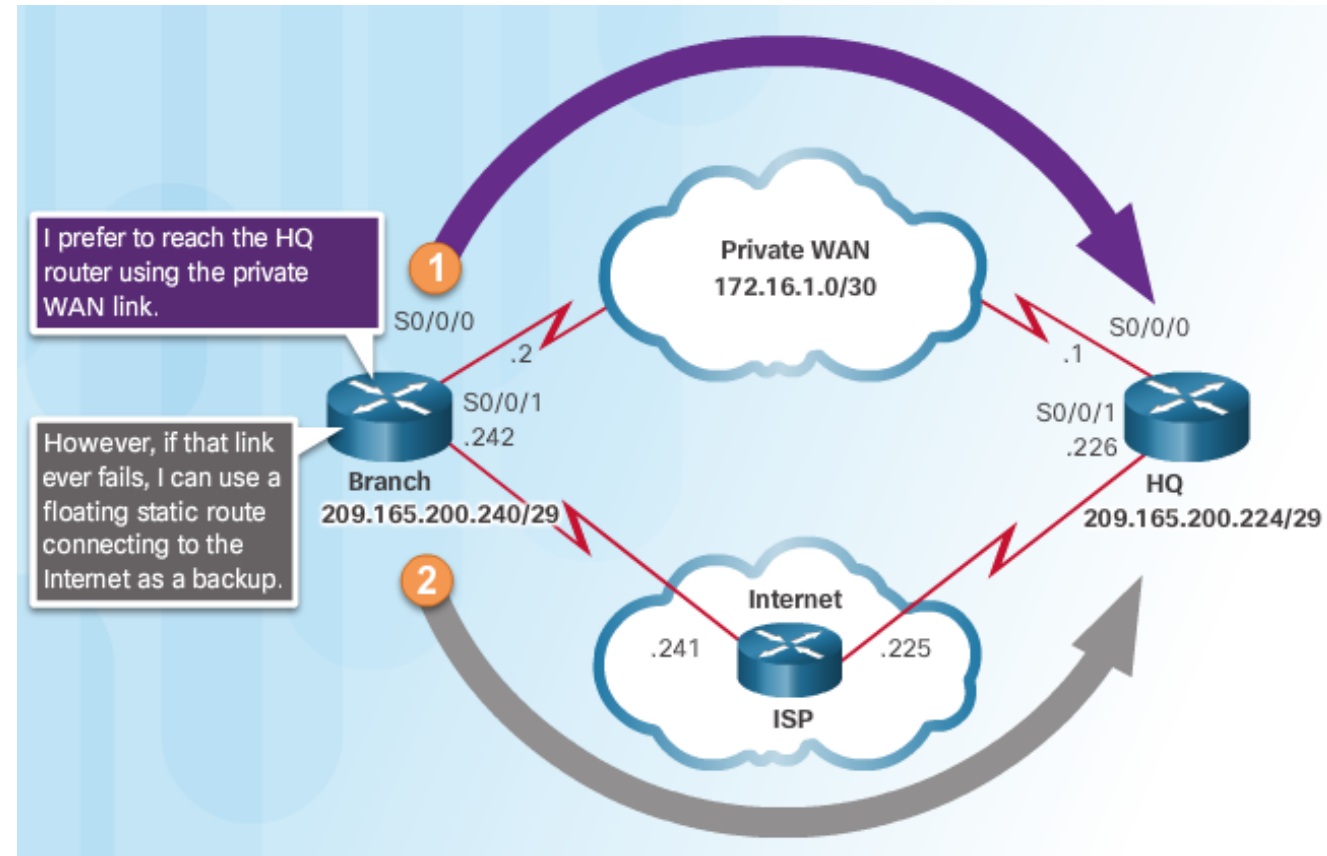
Configure a Floating Static Route

- Preferred router from R1 is to R2 (AD = 1)
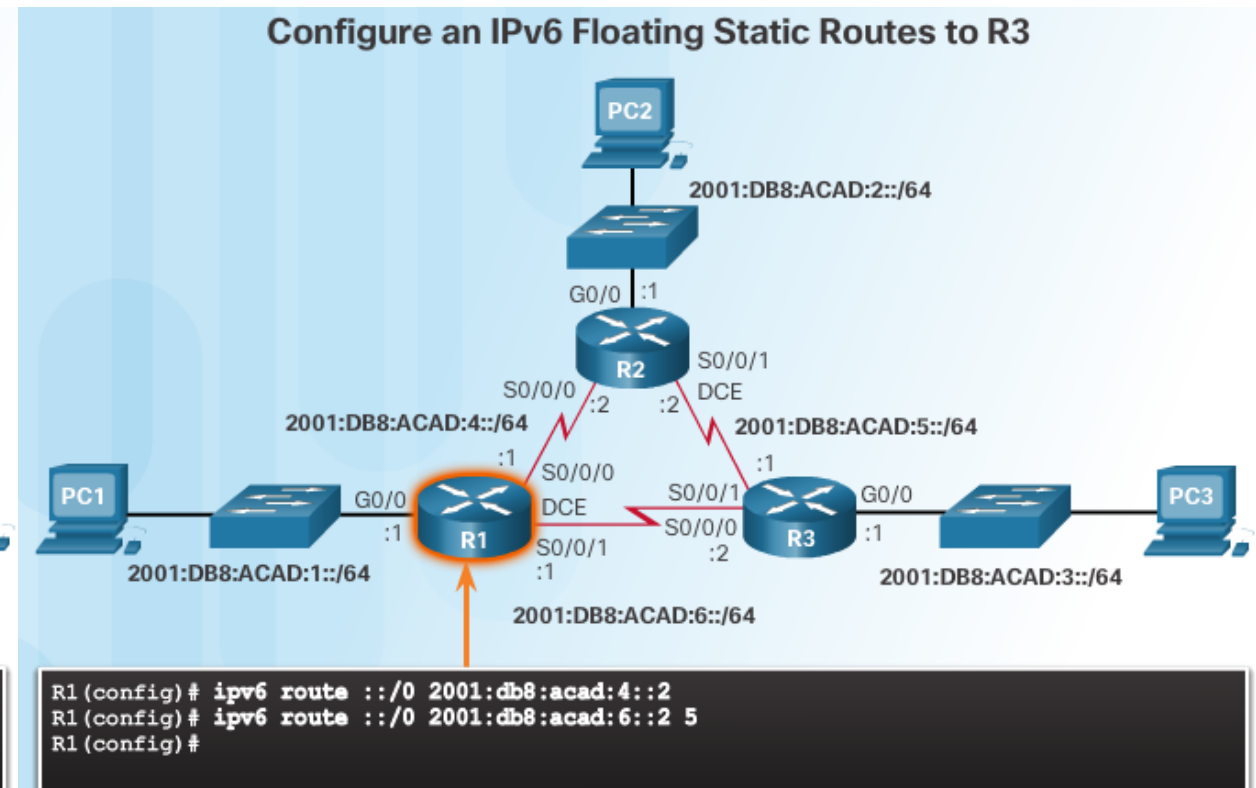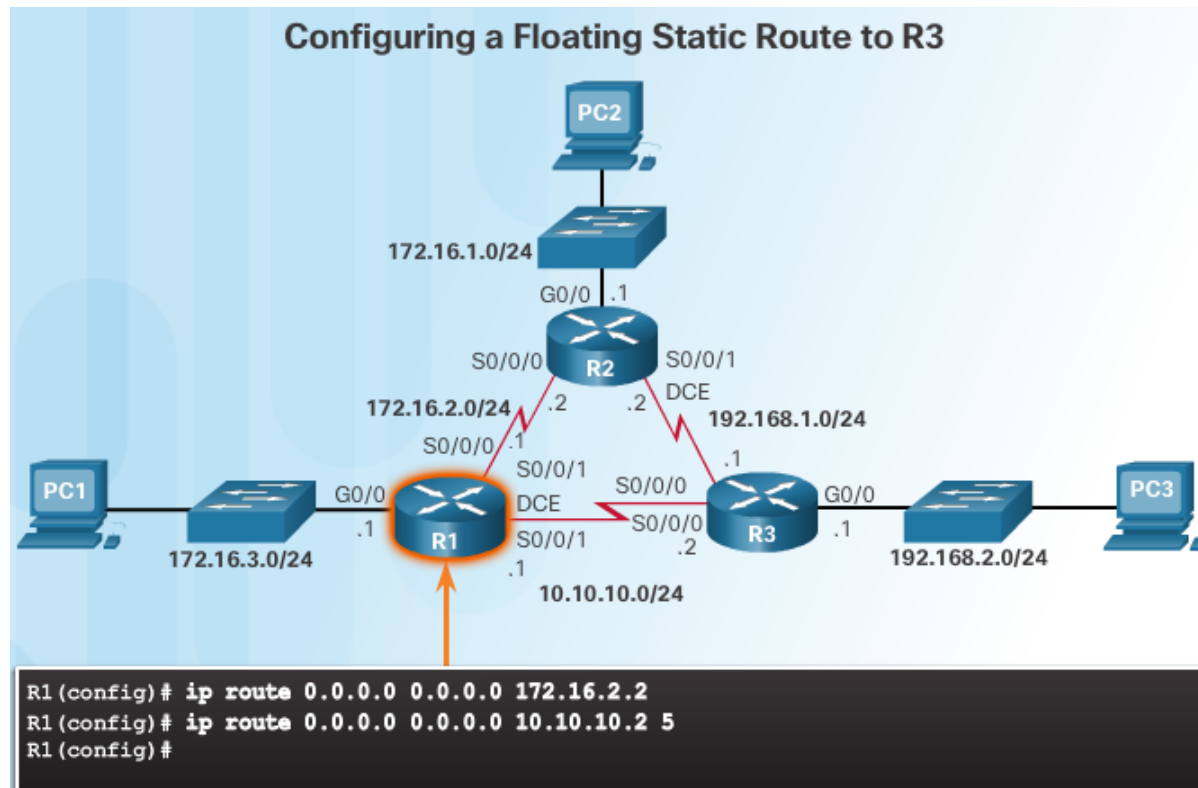
Configure Static Host Routes

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

- Configured as a static host route

- Allows more efficiency for packets directed to the router

- Static host routes are usually used when redundant paths exist.
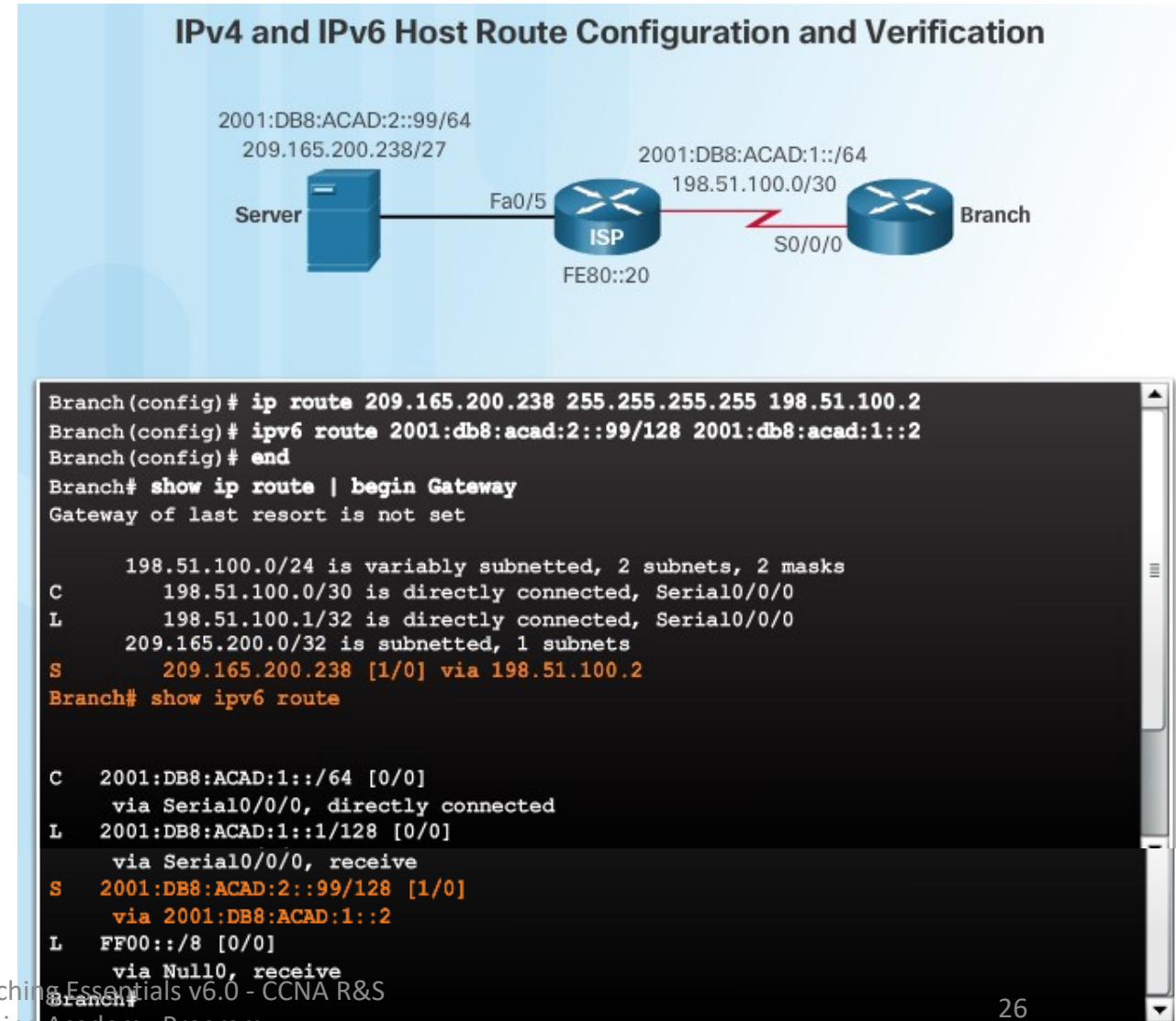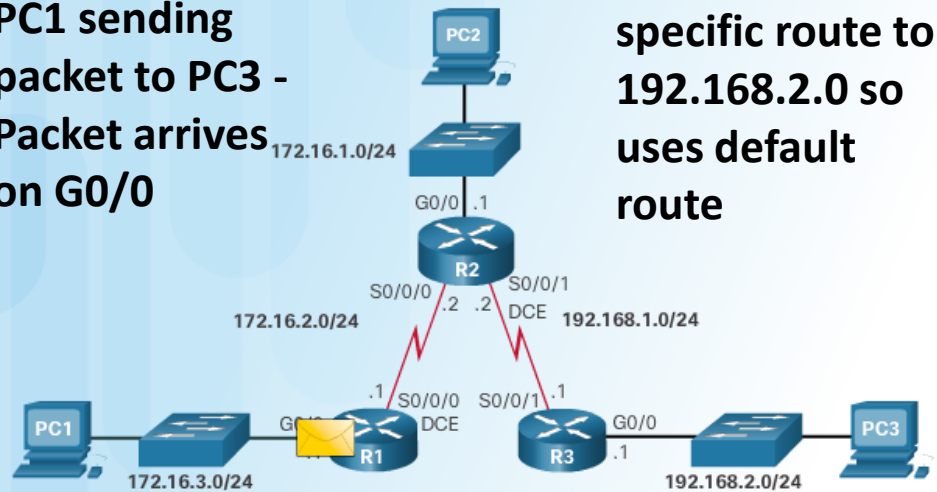

IPv4 and IPv6 Host Route Configuration and Verification

2001:DB8:ACAD:2::99/64
209.165.200.238/27

2001:DB8:ACAD:1::/64
198.51.100.0/30

Server — Fa0/5 — ISP — S0/0/0 — Branch

FE80::20

```
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#
```
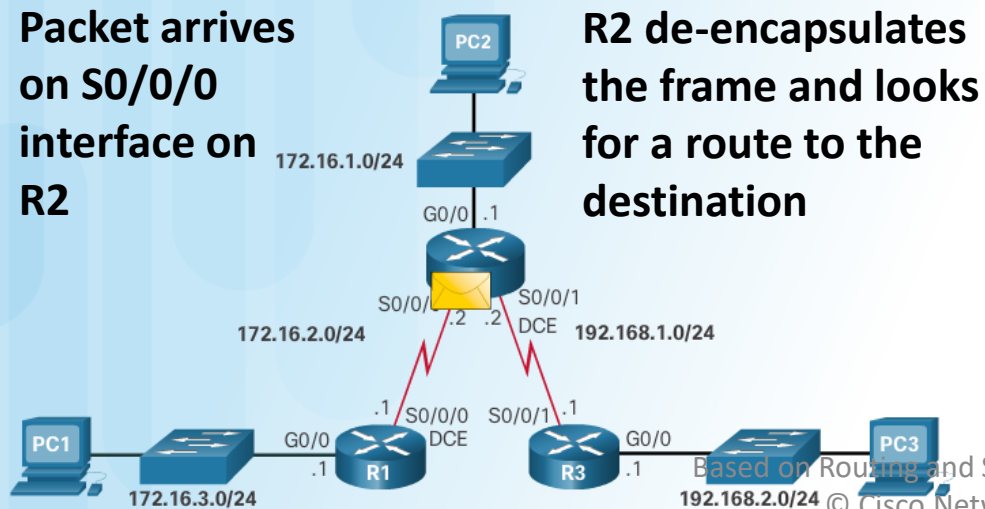
Packet Processing with Static Routes

PC1 sending packet to PC3 - Packet arrives on G0/0

R1 has no specific route to 192.168.2.0 so uses default route

R1 encapsulates packet in new frame

Frame forwarded out S0/0/0

Packet arrives on S0/0/0 interface on R2

R2 de-encapsulates the frame and looks for a route to the destination
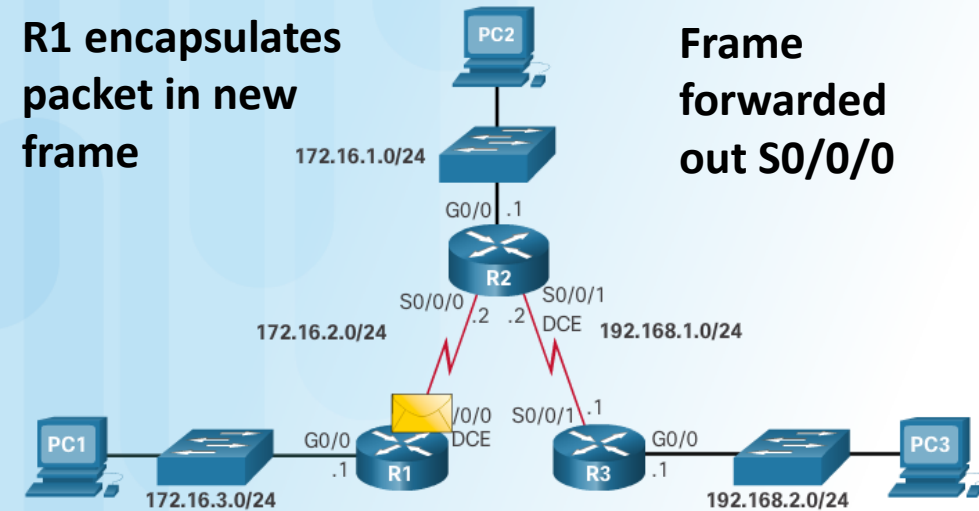
R2 has a static route to 192.168.2.0/24 out the Serial 0/0/1 interface

R2 encapsulates the packet in a new frame and forwards out S0/0/1

Packet Processing with Static Routes

R3 de-encapsulates the frame and sees a connected route to 192.168.2.0/24 out G0/0

R3 looks up the ARP table entry for 192.168.2.10 to find the Layer 2 MAC address for PC3 (ARP used if needed for PC3 MAC)

- **R3 encapsulates the packet in a new frame with the MAC address of the G0/0 interface as the source Layer 2 address and the MAC address of PC3 as the destination MAC address**
- **Frame is forwarded out of G0/0 interface and packet arrives on the NIC interface of PC3**
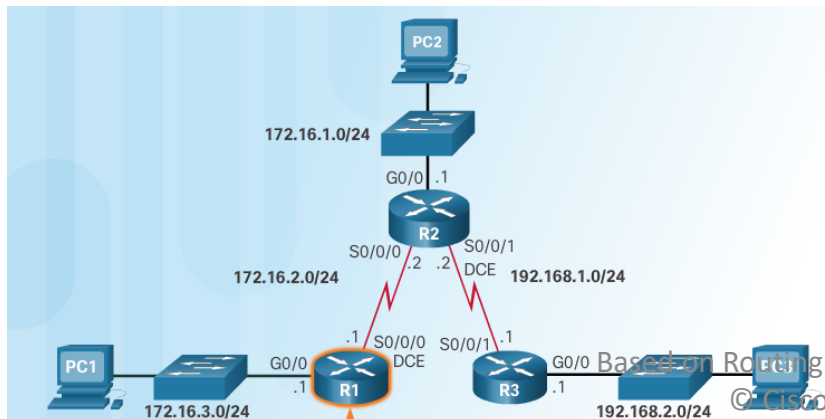
Troubleshoot a Missing Route

- Common IOS troubleshooting commands include:
  - ping
  - traceroute
  - show ip route
  - show ip interface brief
  - show cdp neighbors detail

```
R1# ping 192.168.2.1 source 172.16.3.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:
Packet sent with a source address of 172.16.3.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/28/28 ms
R1#
```

```
R1# traceroute 192.168.2.1
Type escape sequence to abort.
Tracing the route to 192.168.2.1
VRF info: (vrf in name/id, vrf out name/id)
  1 172.16.2.2 4 msec 4 msec 8 msec
  2 192.168.1.1 12 msec 12 msec *
R1#
```

```
R1# show ip route | begin Gateway
Gateway of last resort is not set

      172.16.0.0/16 is variably subnetted, 5 subnets, 2 masks
S        172.16.1.0/24 [1/0] via 172.16.2.2
C        172.16.2.0/24 is directly connected, Serial0/0/0
L        172.16.2.1/32 is directly connected, Serial0/0/0
C        172.16.3.0/24 is directly connected, GigabitEthernet0/0
L        172.16.3.1/32 is directly connected, GigabitEthernet0/0
L        172.16.3.1/32 is directly connected, GigabitEthernet0/0
S     192.168.1.0/24 [1/0] via 172.16.2.2
S     192.168.2.0/24 [1/0] via 172.16.2.2
R1#
```

```
R1# show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge,
                  B - Source Route Bridge, S - Switch, H - Host,
                  I - IGMP, r - Repeater, P - Phone, D - Remote,
                  C - CVTA, M - Two-port Mac Relay

Device ID    Local Intrfce   Holdtme   Capability   Platform    Port ID
netlab-cs5   Gig 0/0         156       S I          WS-C2960-   Fas 0/1
R2           Ser 0/0/0       153       R S I        CISCO1941   Ser 0/0/0
R1#
```

```
R1# show ip interface brief
Interface                      IP-Address      OK? Method Status                Protocol
Embedded-Service-Engine0/0     unassigned      YES unset  administratively down down
GigabitEthernet0/0             172.16.3.1      YES manual up                    up
GigabitEthernet0/1             unassigned      YES unset  administratively down down
Serial0/0/0                    172.16.2.1      YES manual up                    up
Serial0/0/1                    unassigned      YES unset  administratively down down
R1#
```

Practical Sessions

- Packet Tracer Activities:
  - https://www.youtube.com/playlist?list=PL8VT5seZ_GWjDSGR2d9agg4NxM5aniGJ8 ***
  - https://www.youtube.com/playlist?list=PLjQ5ns7ugQsnZ7JBL16c7_uKSLWmddsgw