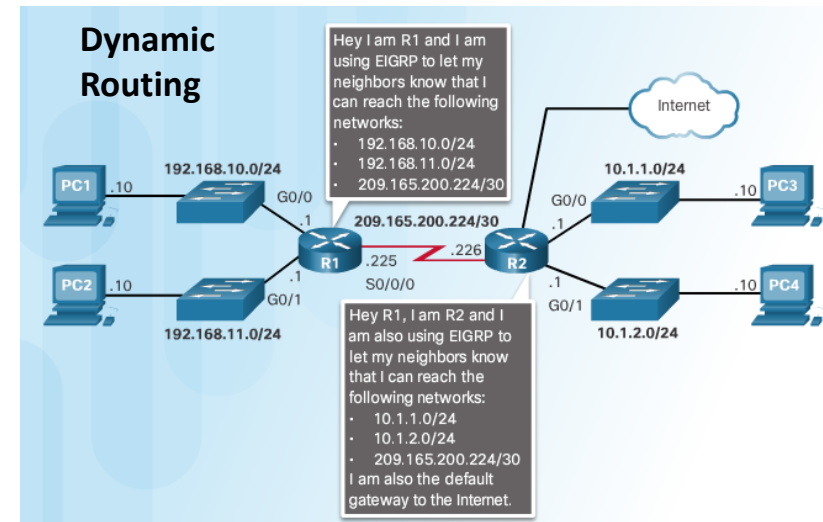
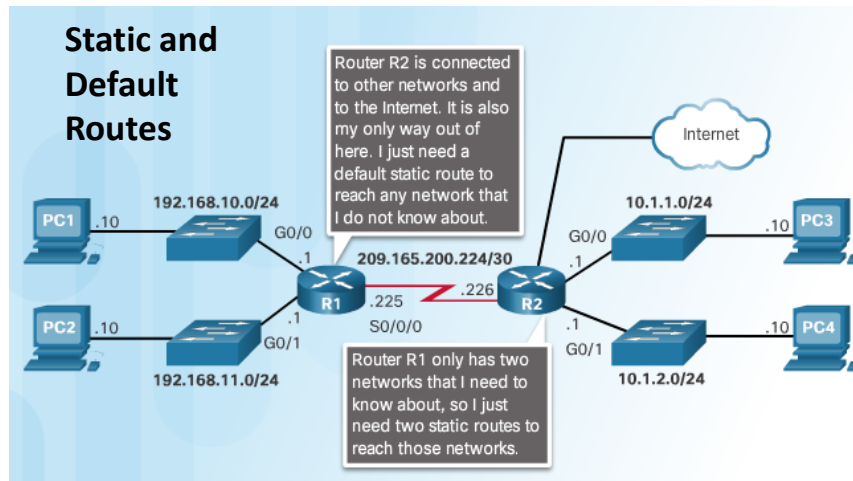


Static Routing

Faculty of Technology
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2019

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

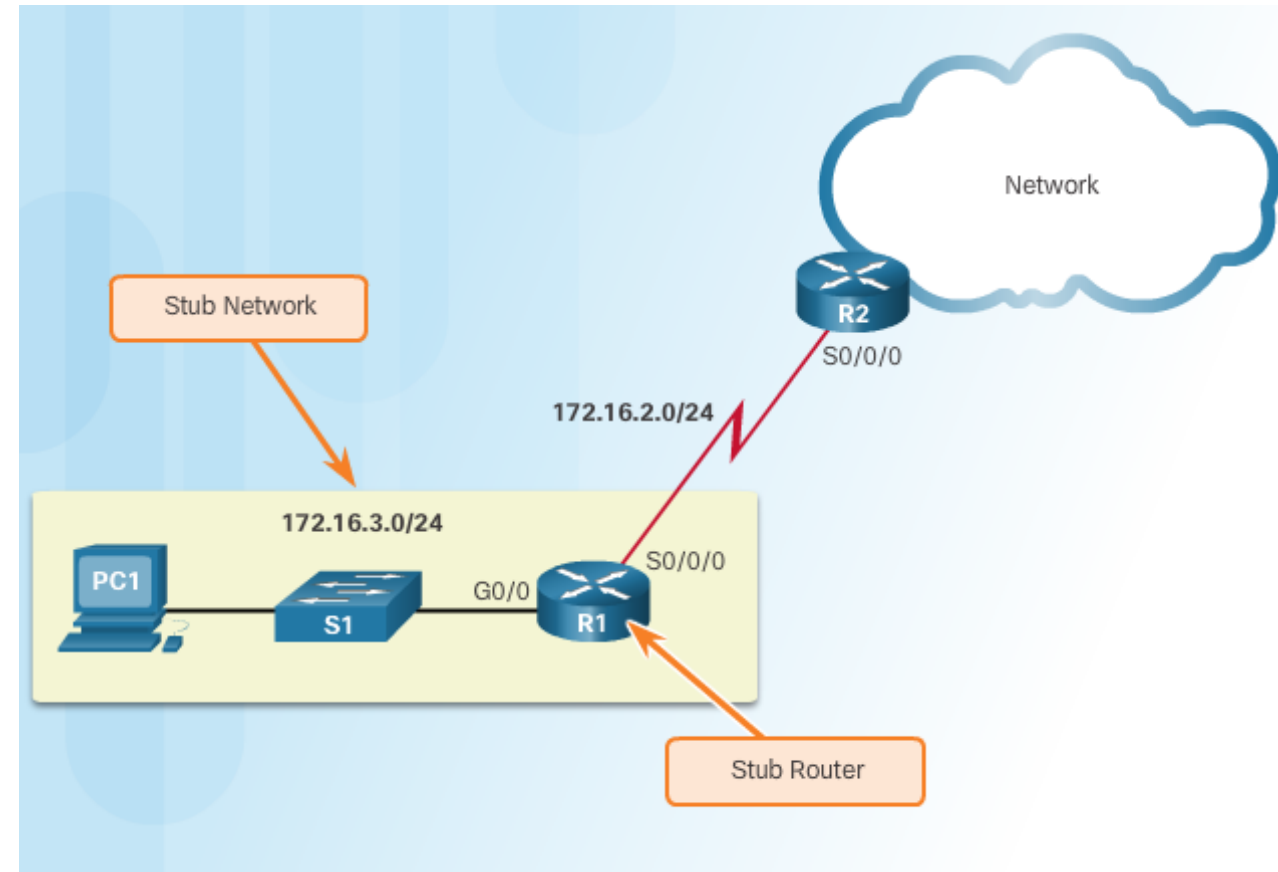


Why use Static Routing versus Dynamic

	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 bandwidth	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

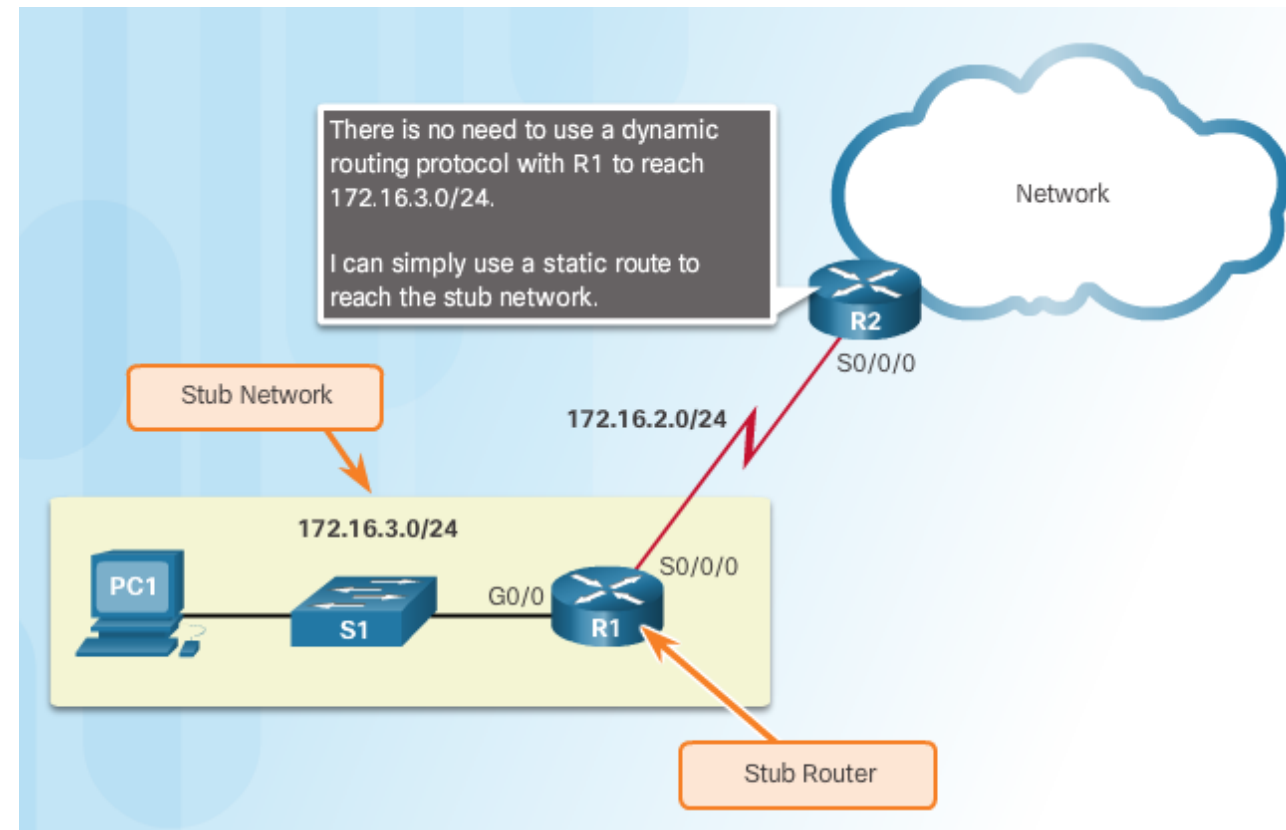


Static Route Applications

- 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

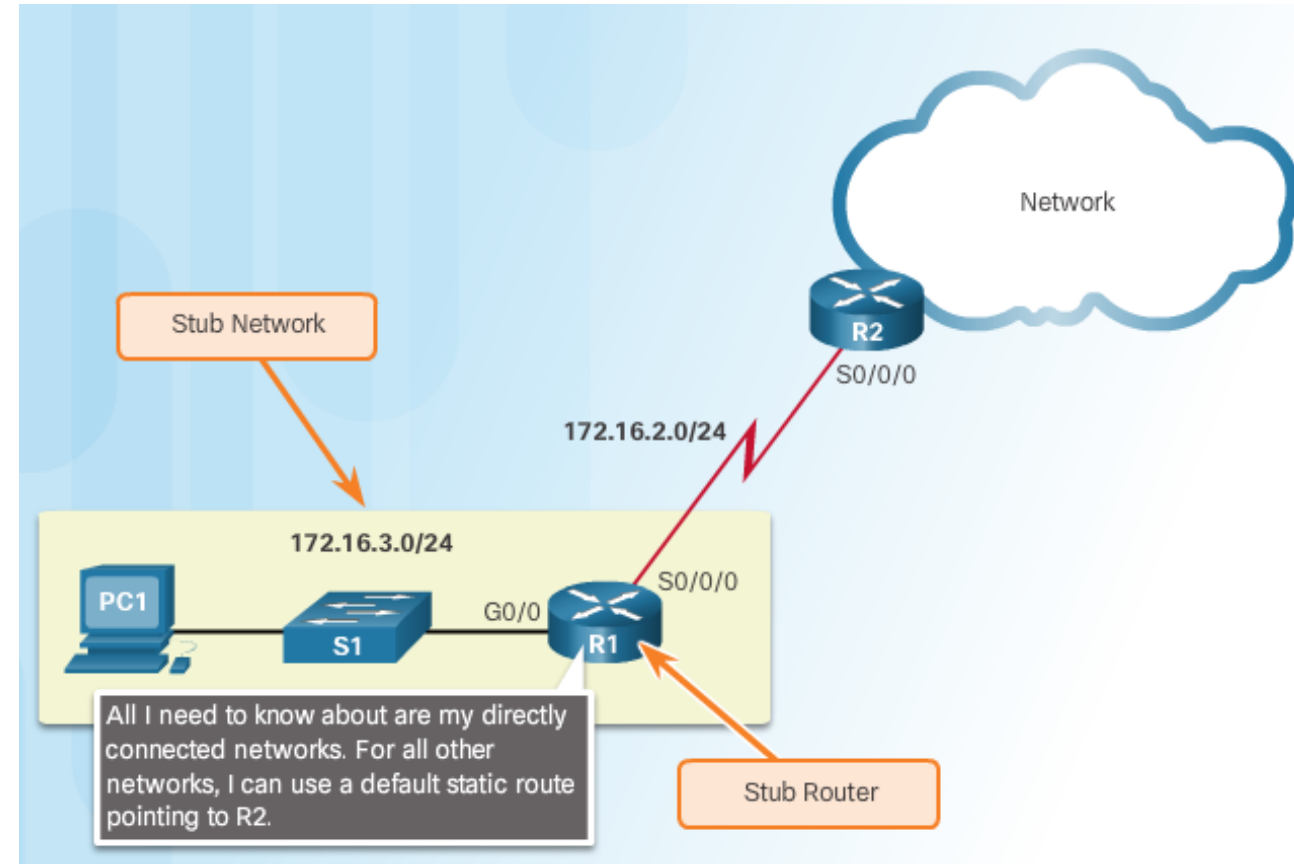
Standard Static Route

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



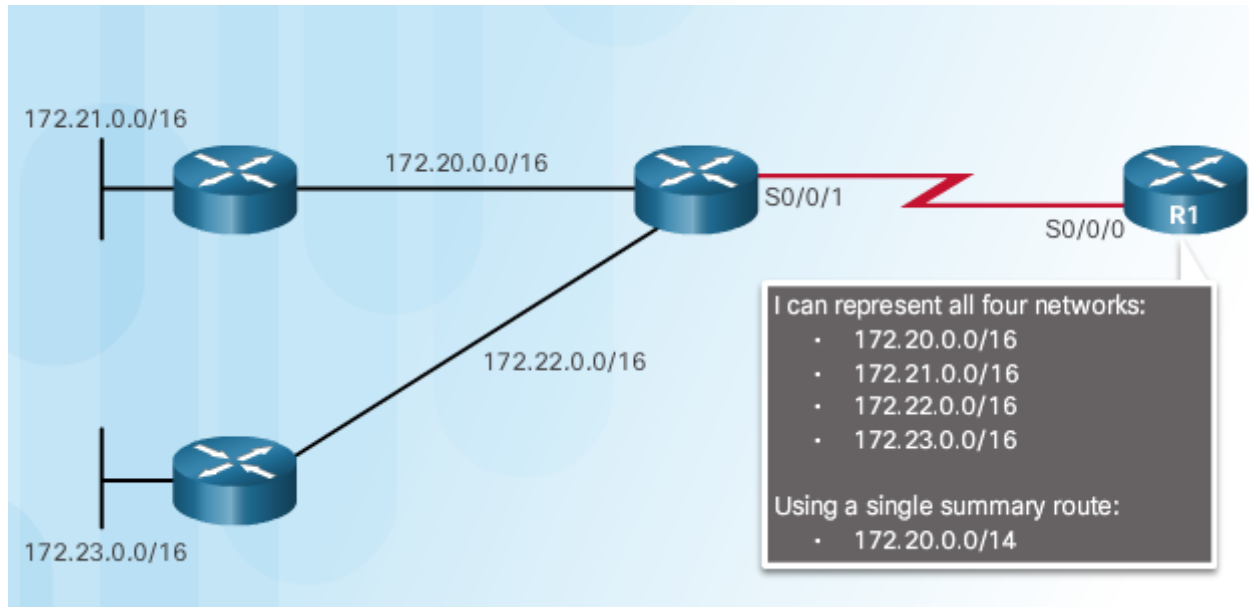
Default Static Route

- 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



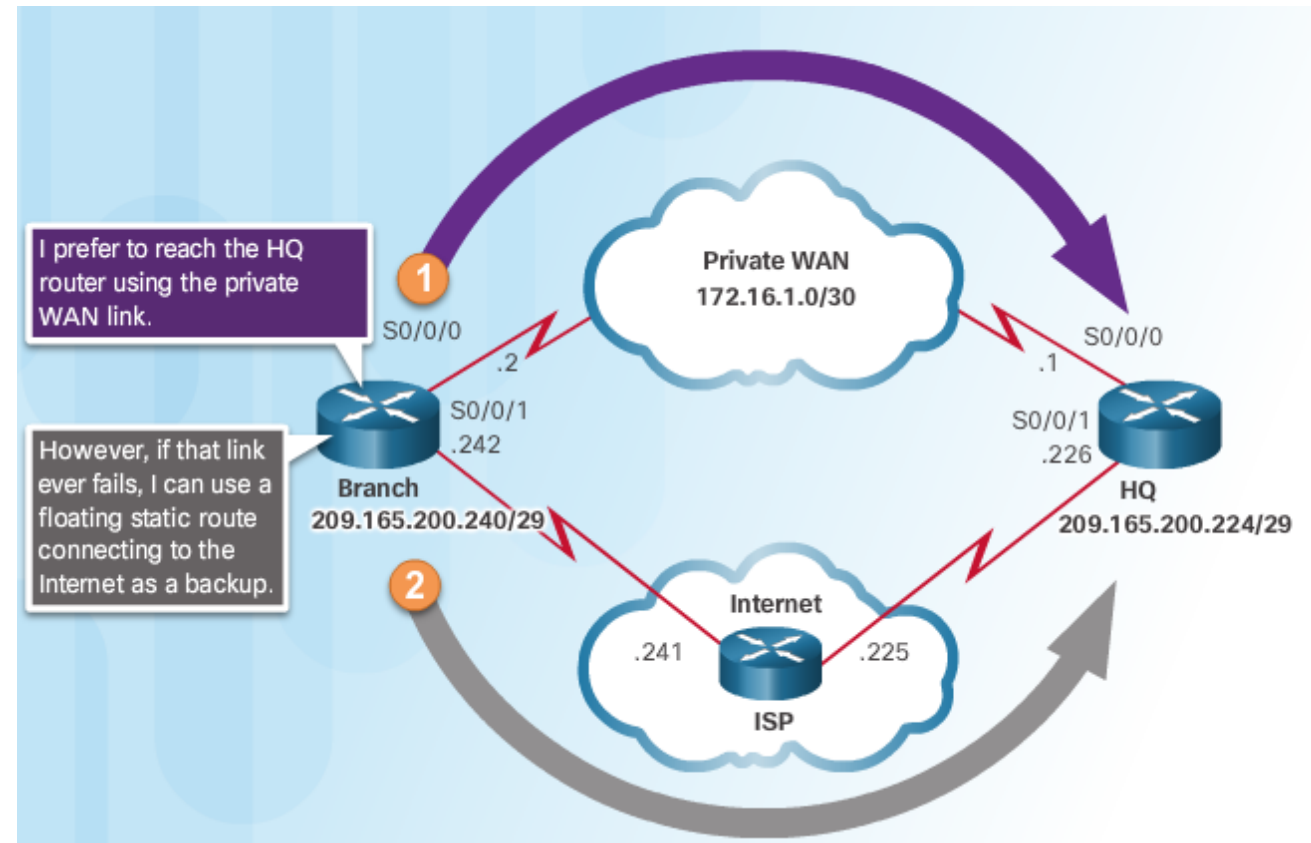
Summary Static Route

- 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



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

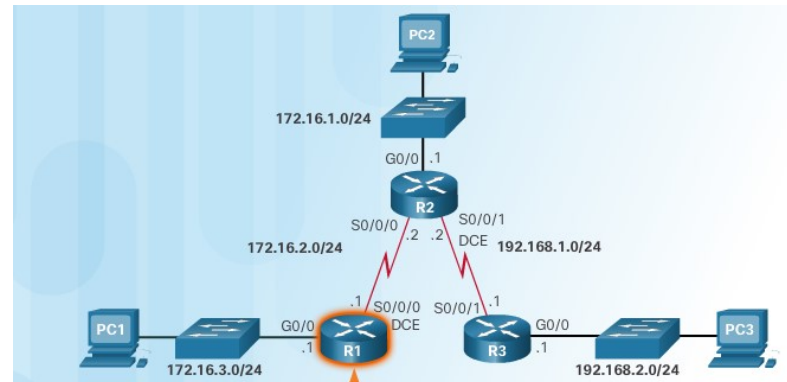
```
Router(config)# ip route network-address subnet-mask {ip-address | exit-intf}
```

Parameter	Description
network-address	Destination network address of the remote network to be added to the routing table
subnet-mask	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• (Optional) Configures an administrative distance.• Typically used to configure a floating static route.

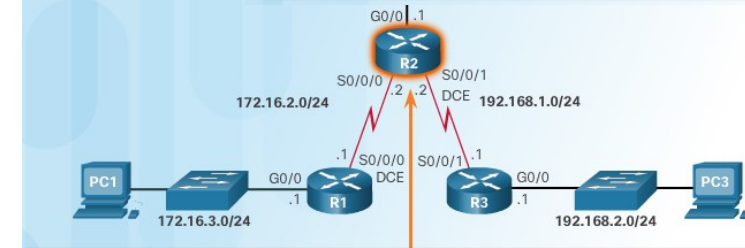
Based on Routing and Switching Essentials v6.0 - CCNA R&S

Next-Hop Options

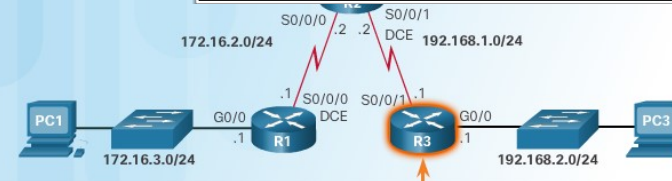
- In this example, each router only has entries for directly connected network
 - R1 does not have an entry in its routing table for the R3 LAN network
- In a static route next-hop can be identified by
 - Next-hop IP address
 - Router exit interface
 - Next-hop IP address and exit interface



```
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#
```



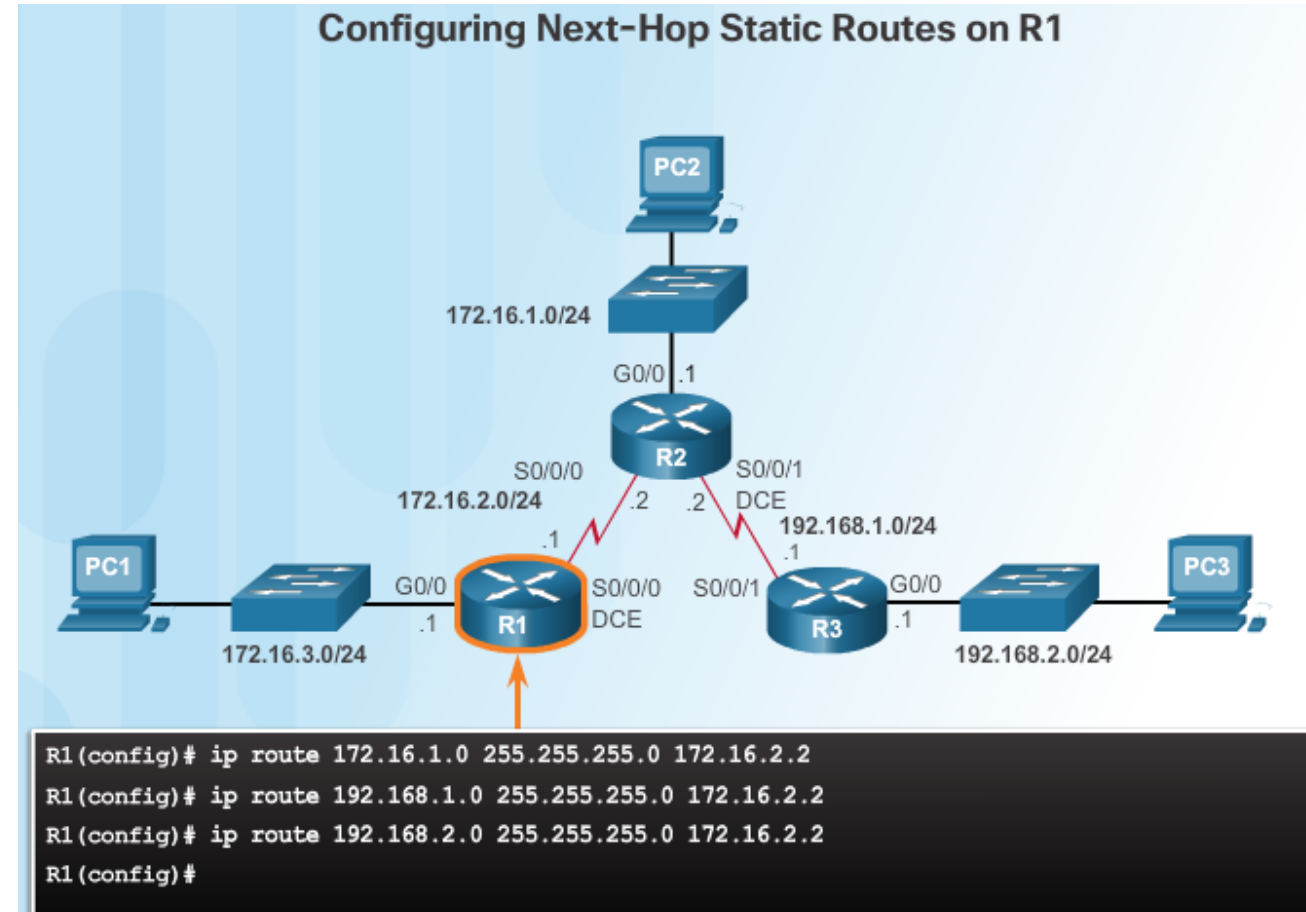
```
R2# show ip route | begin Gateway
Gateway of last resort is not set
172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C    172.16.1.0/24 is directly connected, GigabitEthernet0/0
L    172.16.1.1/32 is directly connected, GigabitEthernet0/0
L    172.16.2.0/24 is directly connected, Serial0/0/0
L    172.16.2.2/32 is directly connected, Serial0/0/0
192.168.0.0/16 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#
```

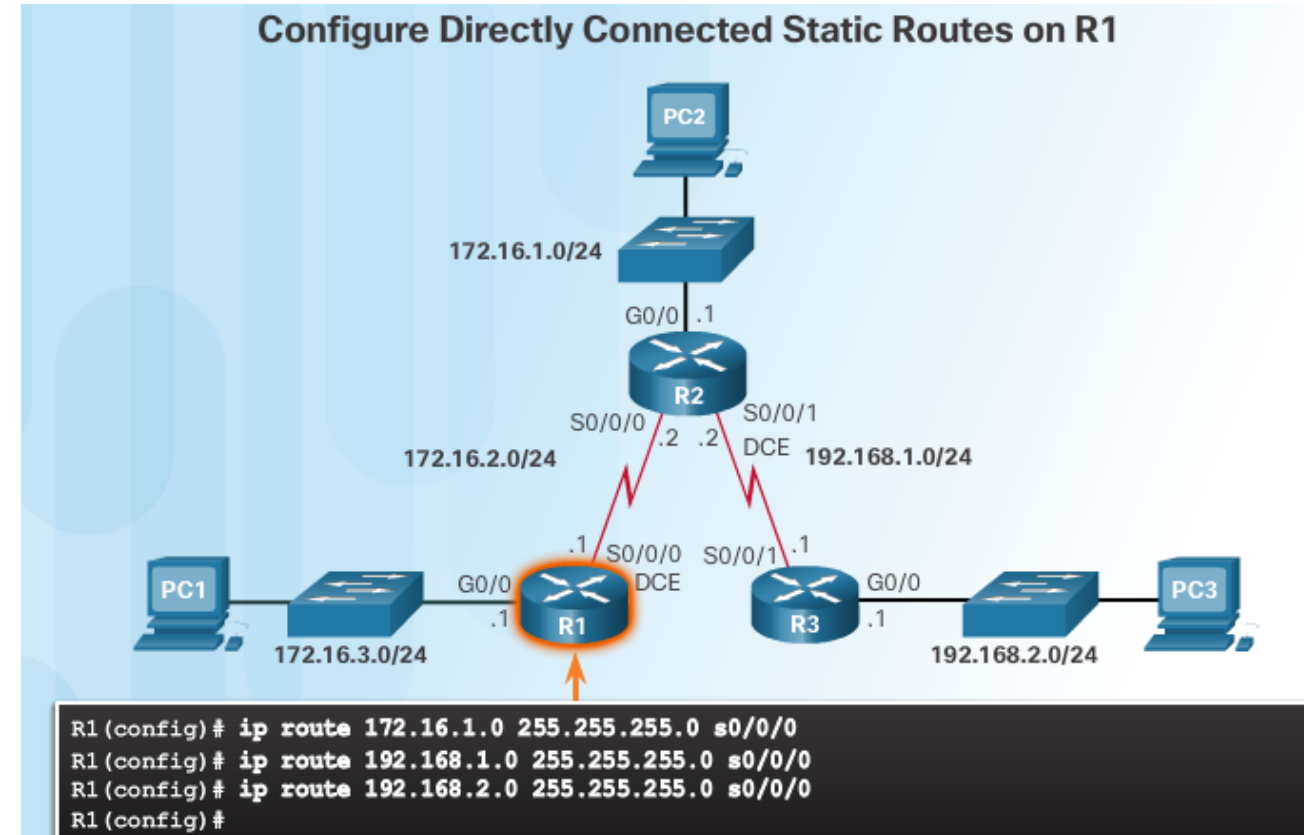
Configure a Next-Hop Static Route

- 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)



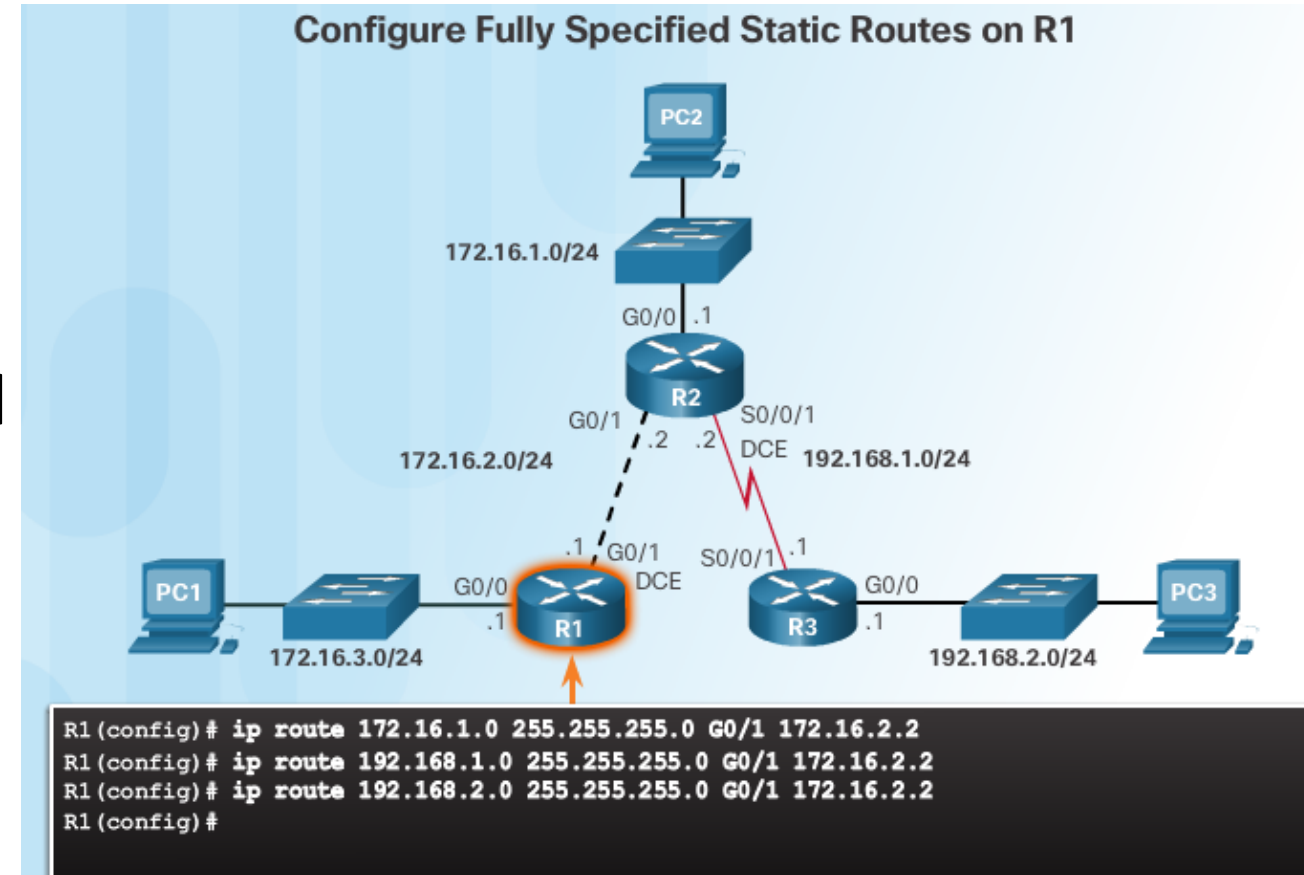
Configure a Directly Connected Static Route

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



Configure 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

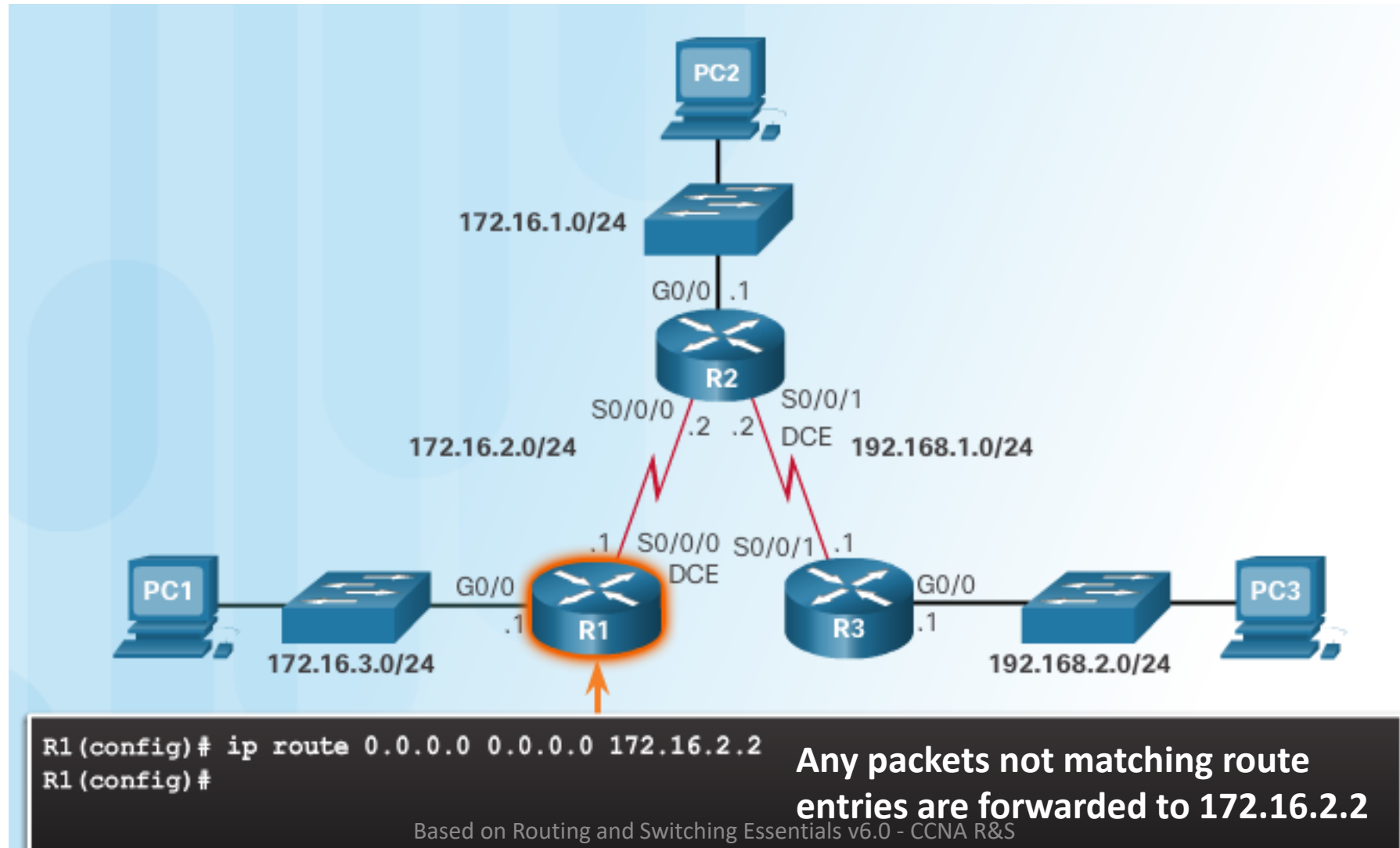
- Default static routes are commonly used when connecting:
 - An edge router to a service provider network
 - A stub router (a router with only one upstream neighbour router)
- Default route is used when no other routes in the routing table match the destination IP

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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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



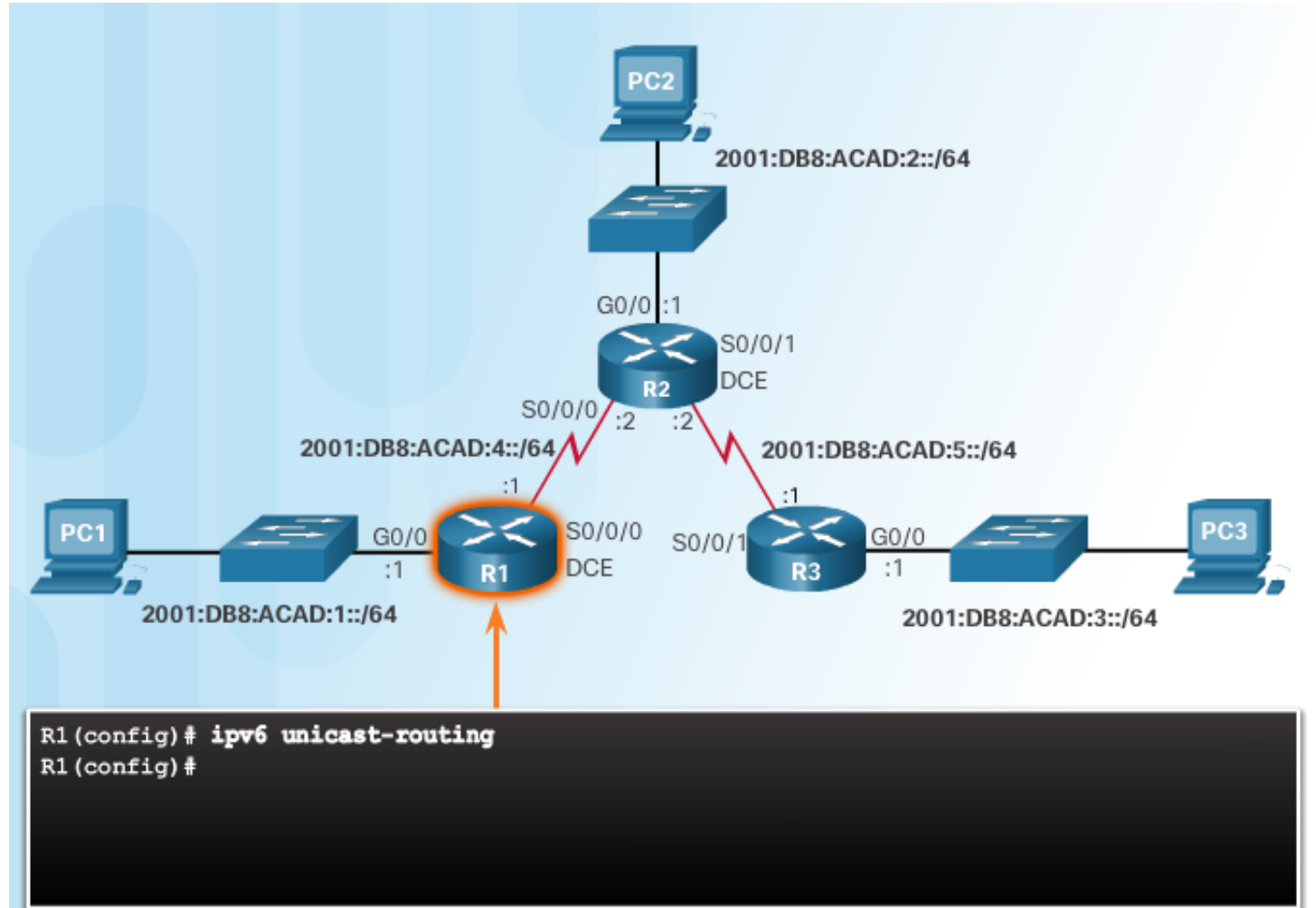
Configure IPv6 Static Routes

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

Parameter	Description
<code>ipv6-prefix</code>	Destination network address of the remote network to be added to the routing table.
<code>prefix-length</code>	Prefix length of the remote network to be added to the routing table.
<code>ipv6-address</code>	<ul style="list-style-type: none">• 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.
<code>exit-intf</code>	<ul style="list-style-type: none">• 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.

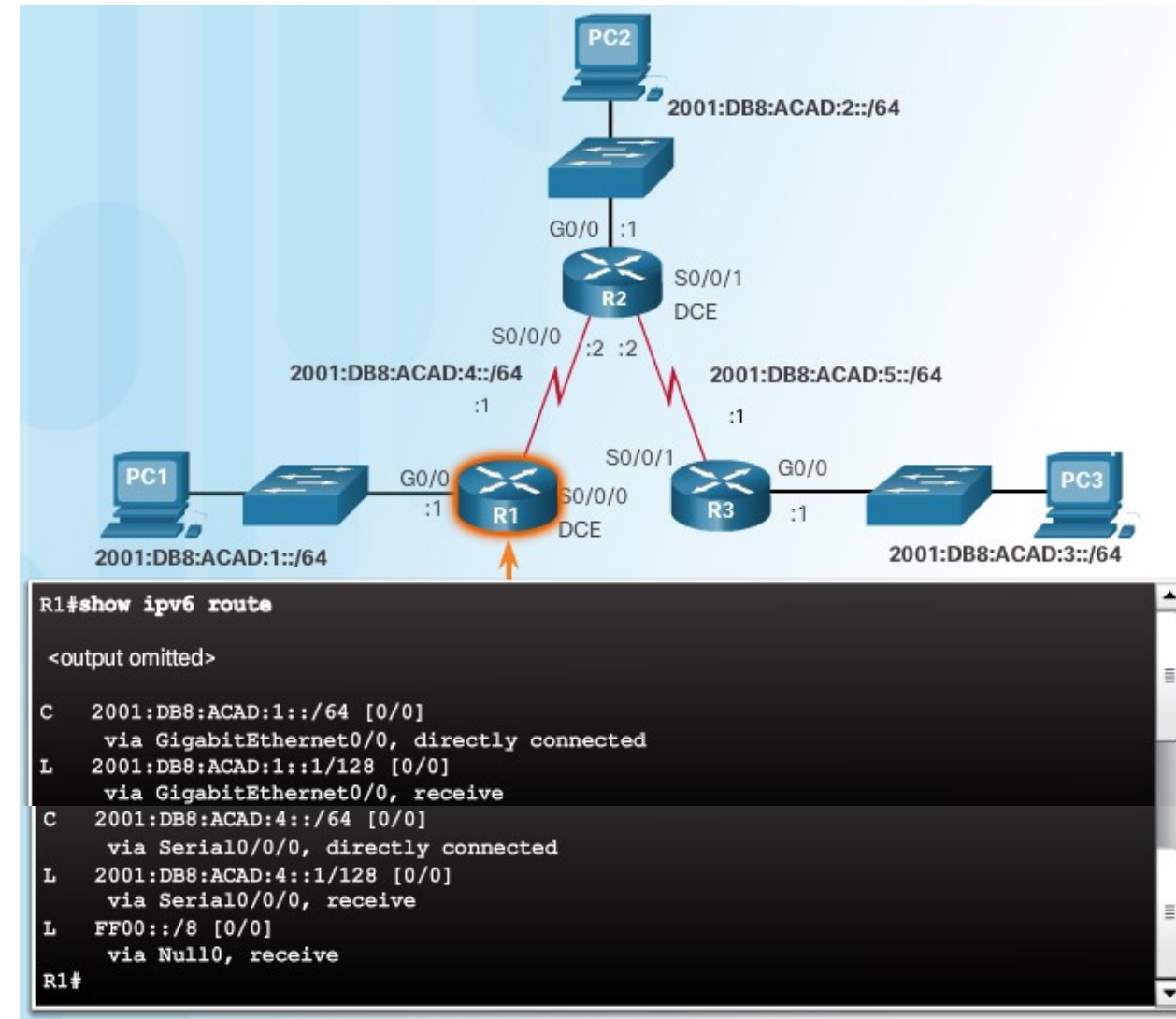
The ipv6 route Command

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



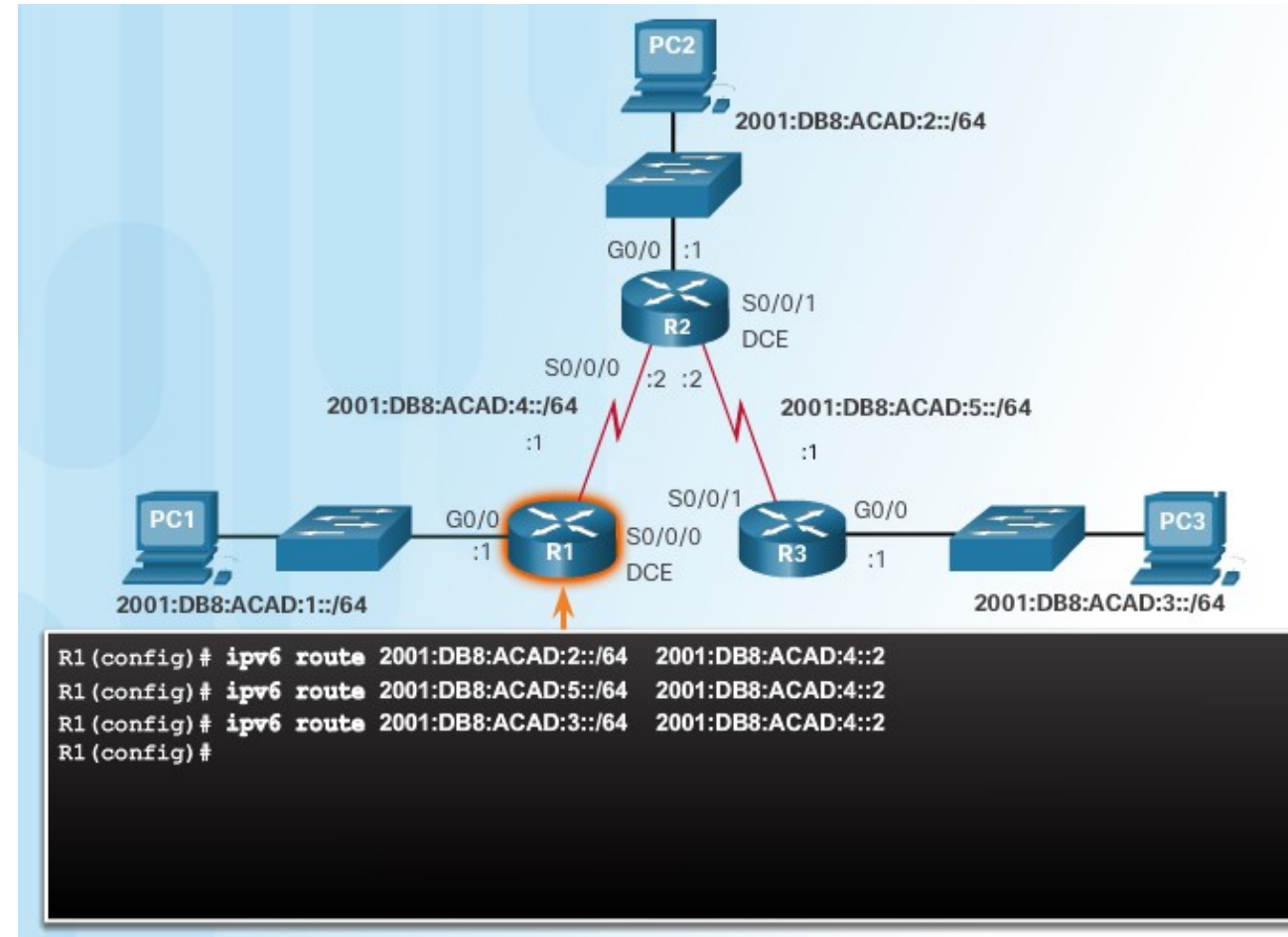
Next-Hop Options

- 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



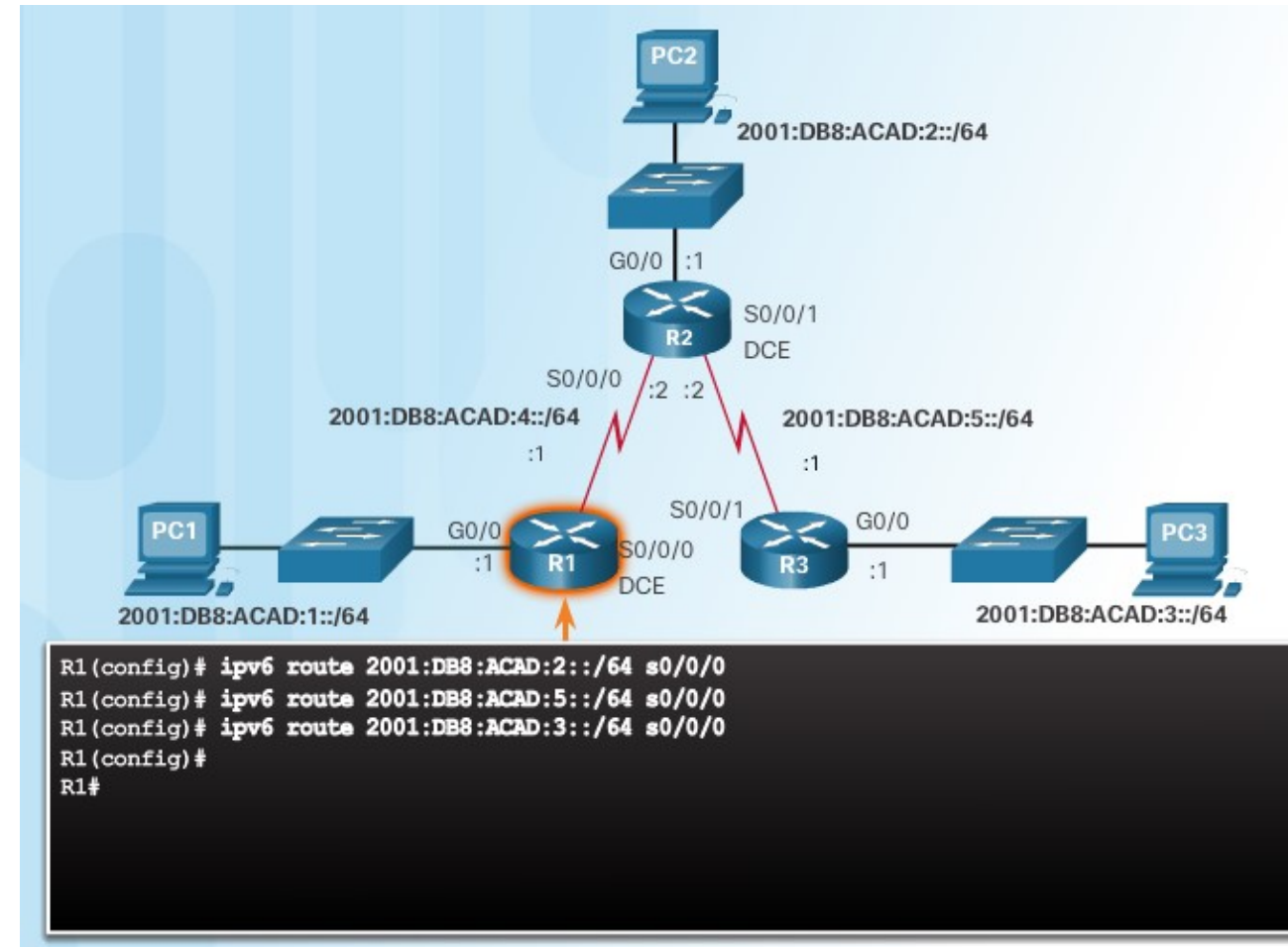
Configure a Next Hop Static IPv6 Route

- 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.



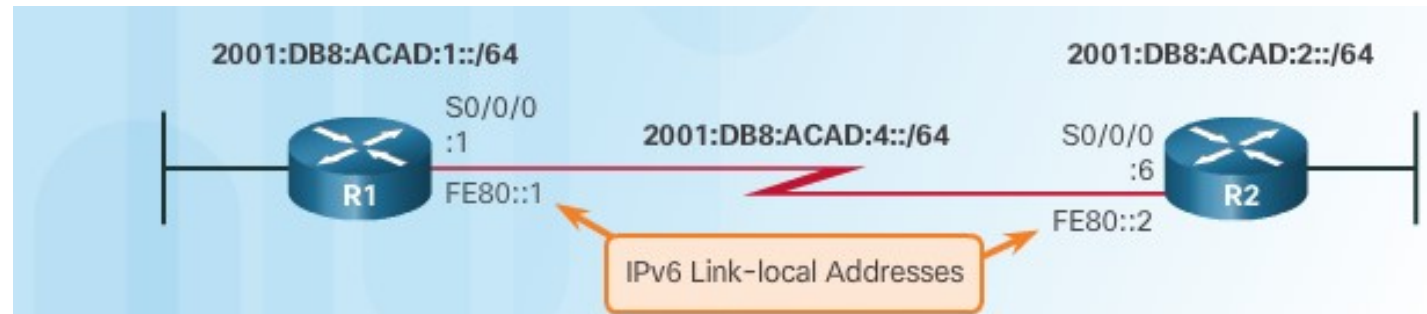
Configure a Directly Connected Static IPv6 Route

- 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



Configure a Fully Specified Static IPv6 Route

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

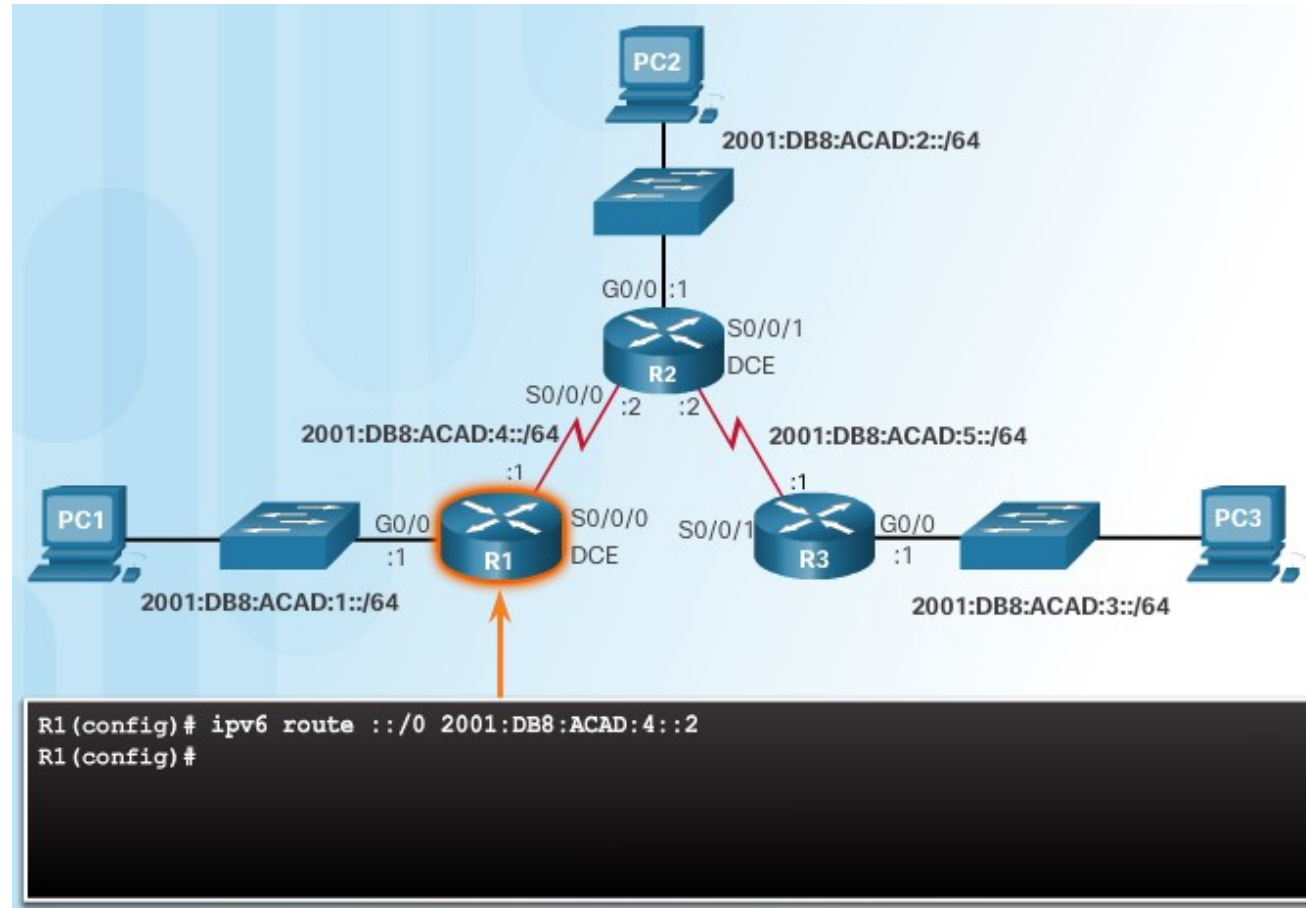


```
R1(config)# ipv6 route 2001:db8:acad:2::/64 fe80::2
% Interface has to be specified for a link-local nexthop
R1(config)# ipv6 route 2001:db8:acad:2::/64 s0/0/0 fe80::2
R1(config)#
```

```
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
```

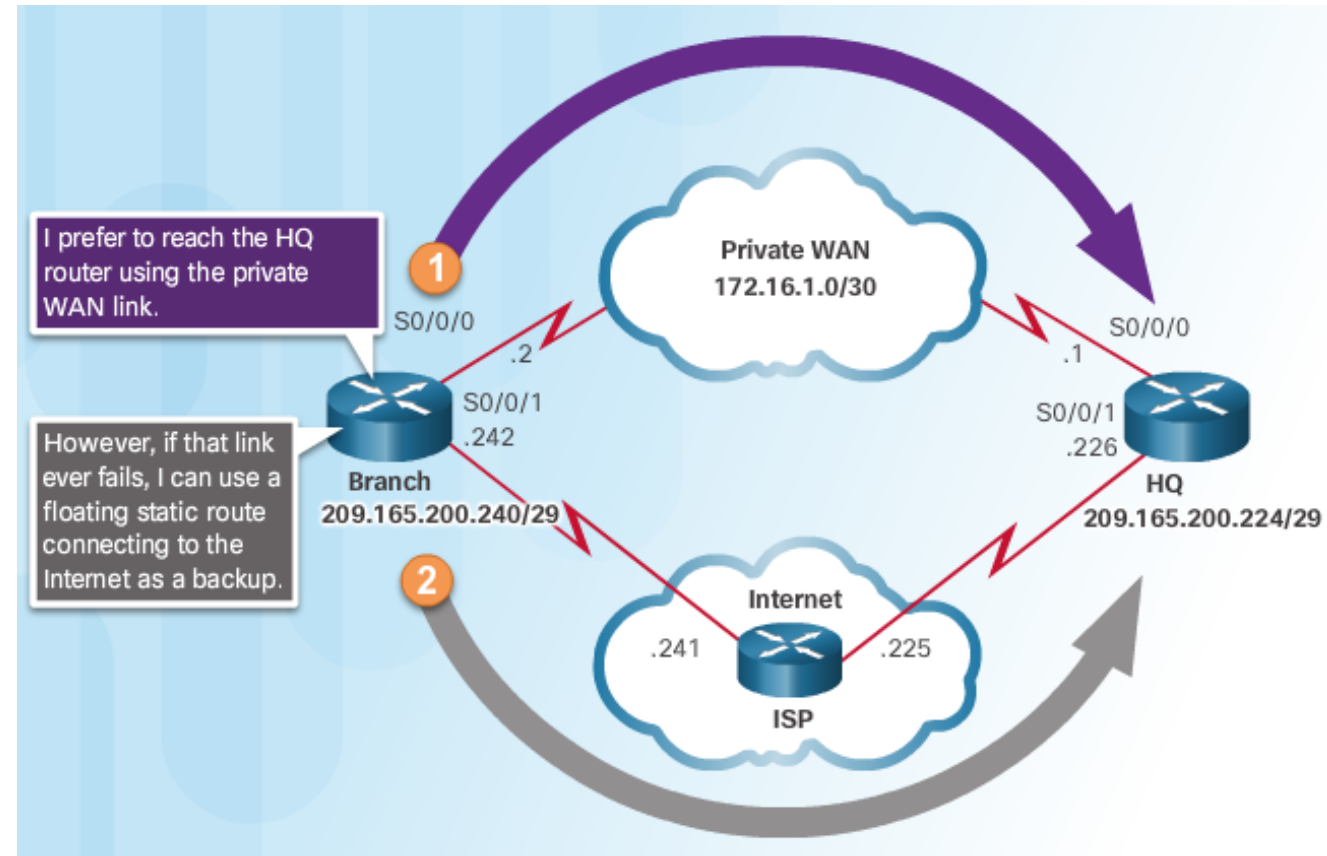
Configure a Default Static IPv6 Route

- 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



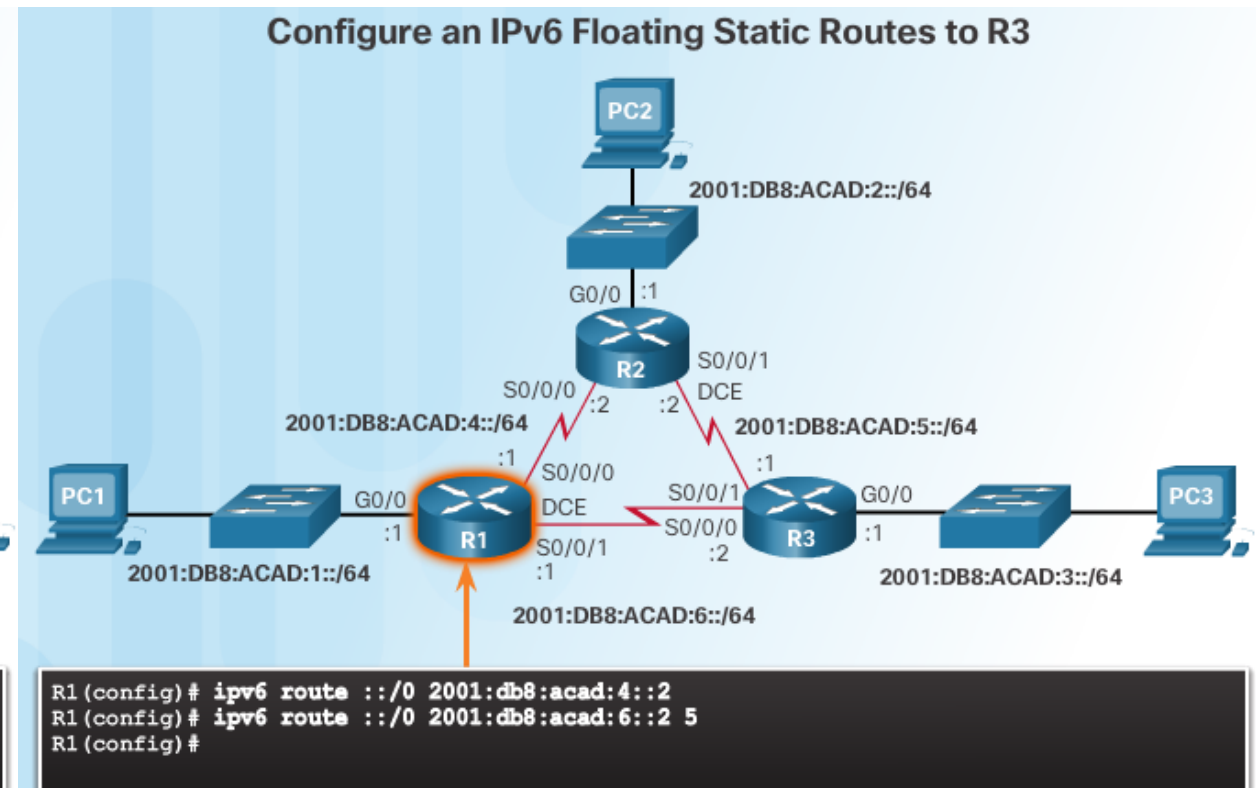
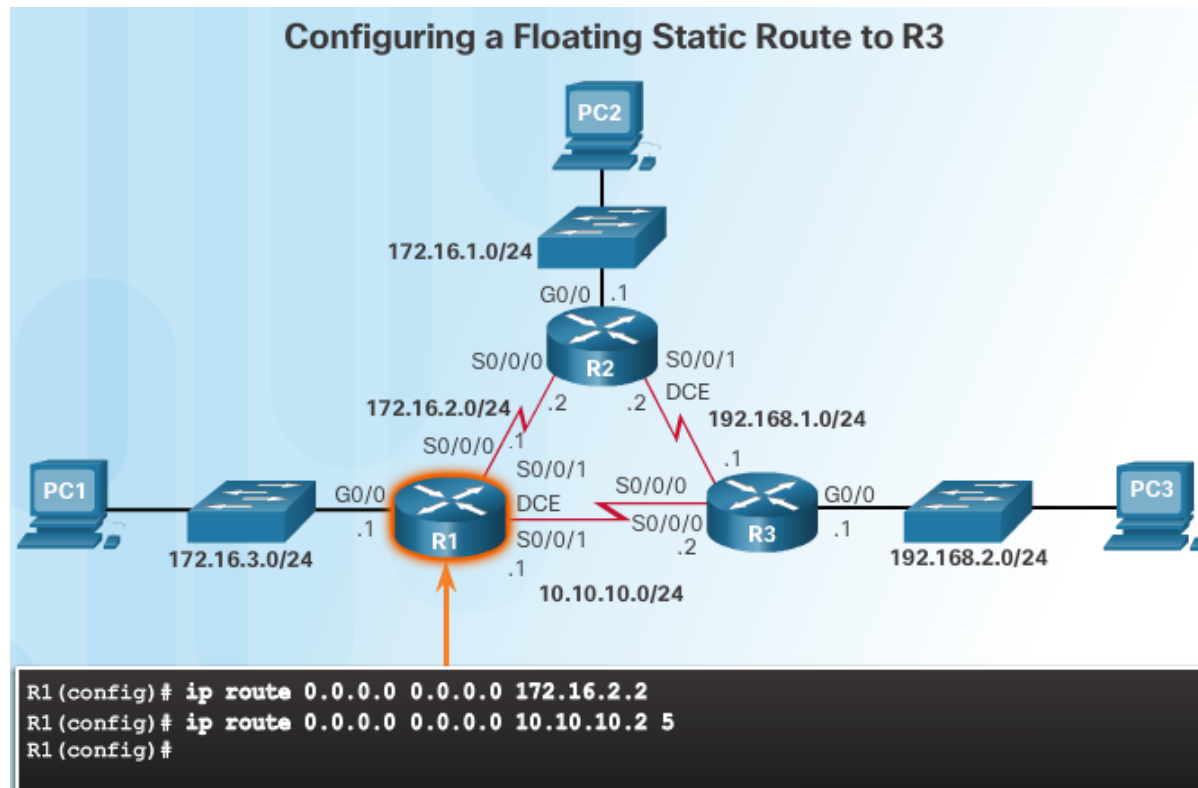
Floating Static Routes

- 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



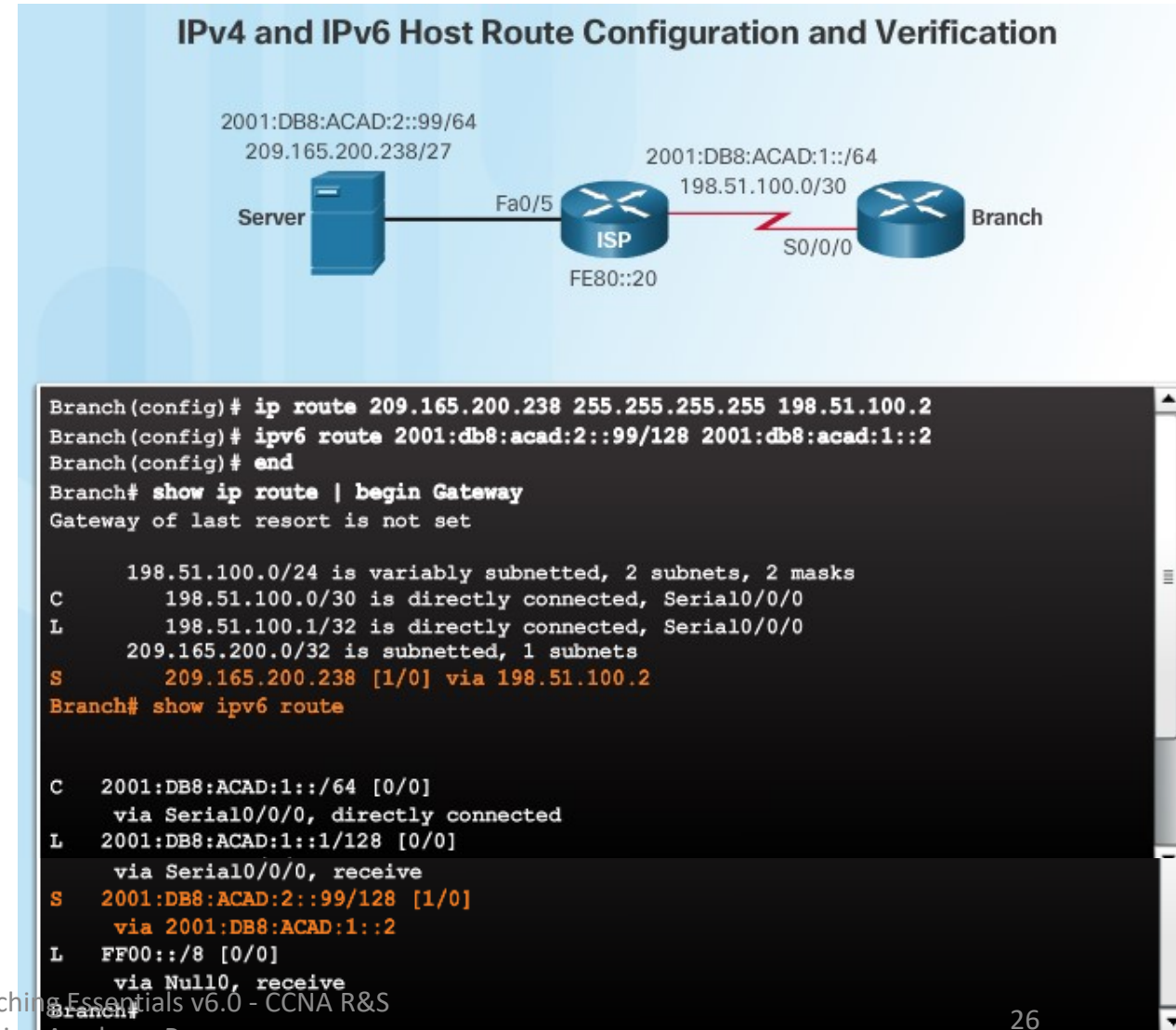
Configure a Floating Static Route

- Preferred router from R1 is to R2 (AD = 1)



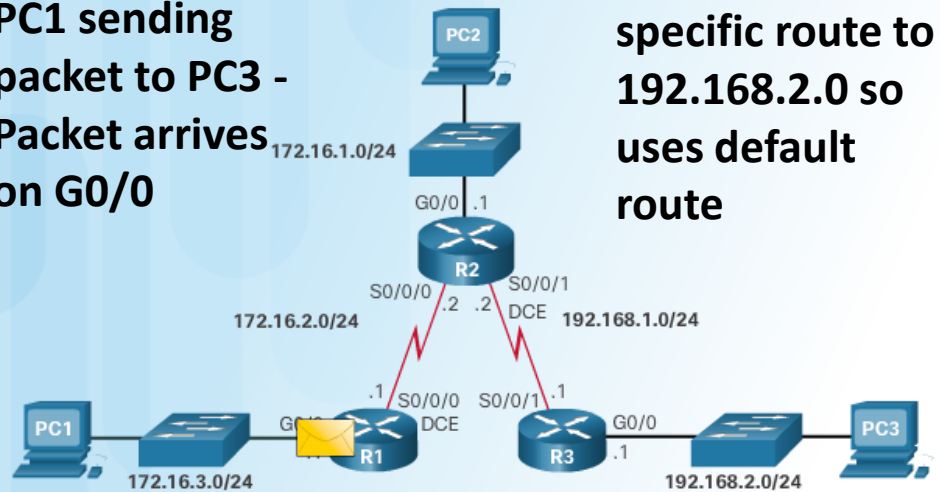
Configure Static Host Routes

- 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.



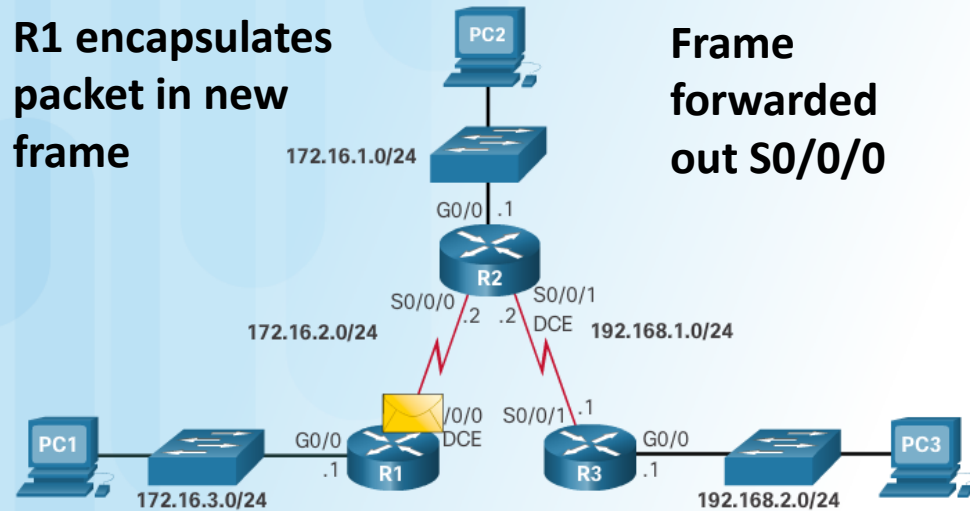
Packet Processing with Static Routes

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



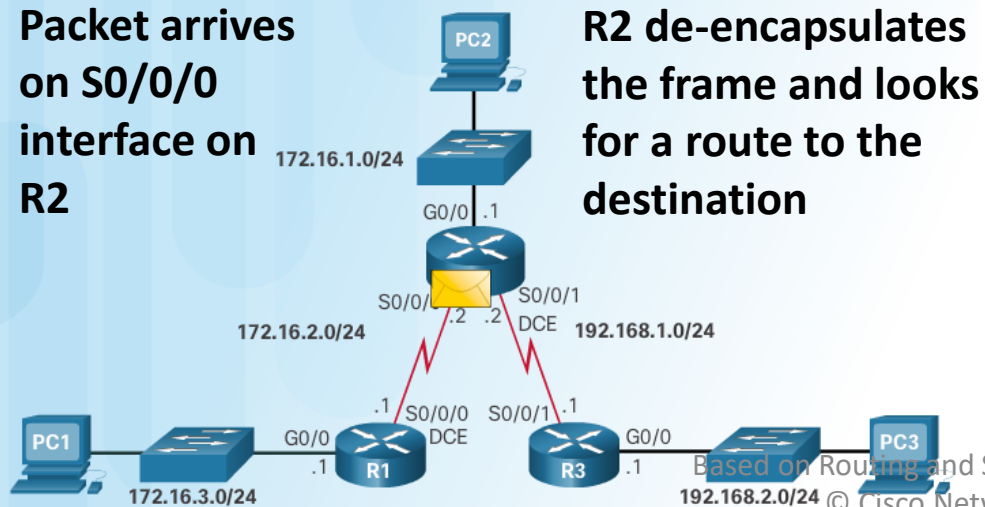
R1 has no specific route to 192.168.2.0 so uses default route

R1 encapsulates packet in new frame



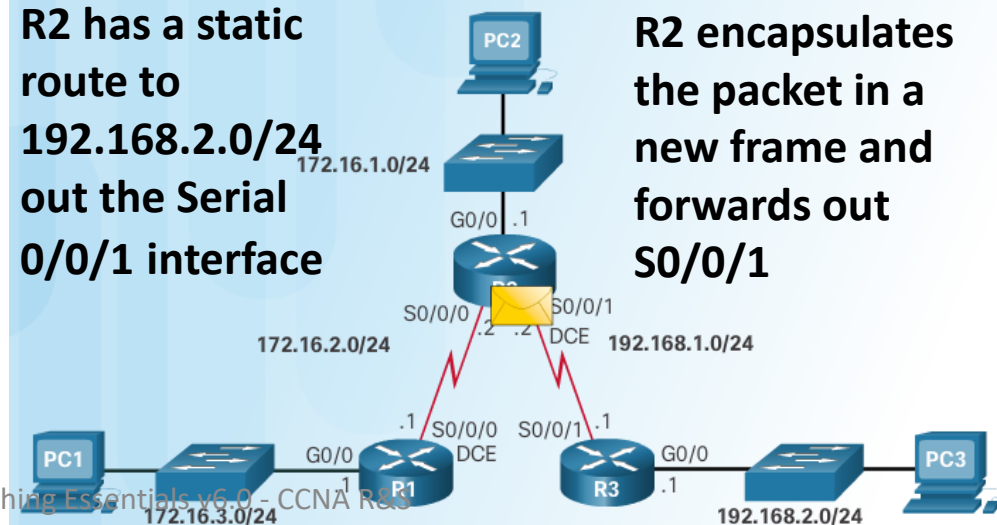
Frame forwarded out S0/0/0

Packet arrives on S0/0/0 interface on R2



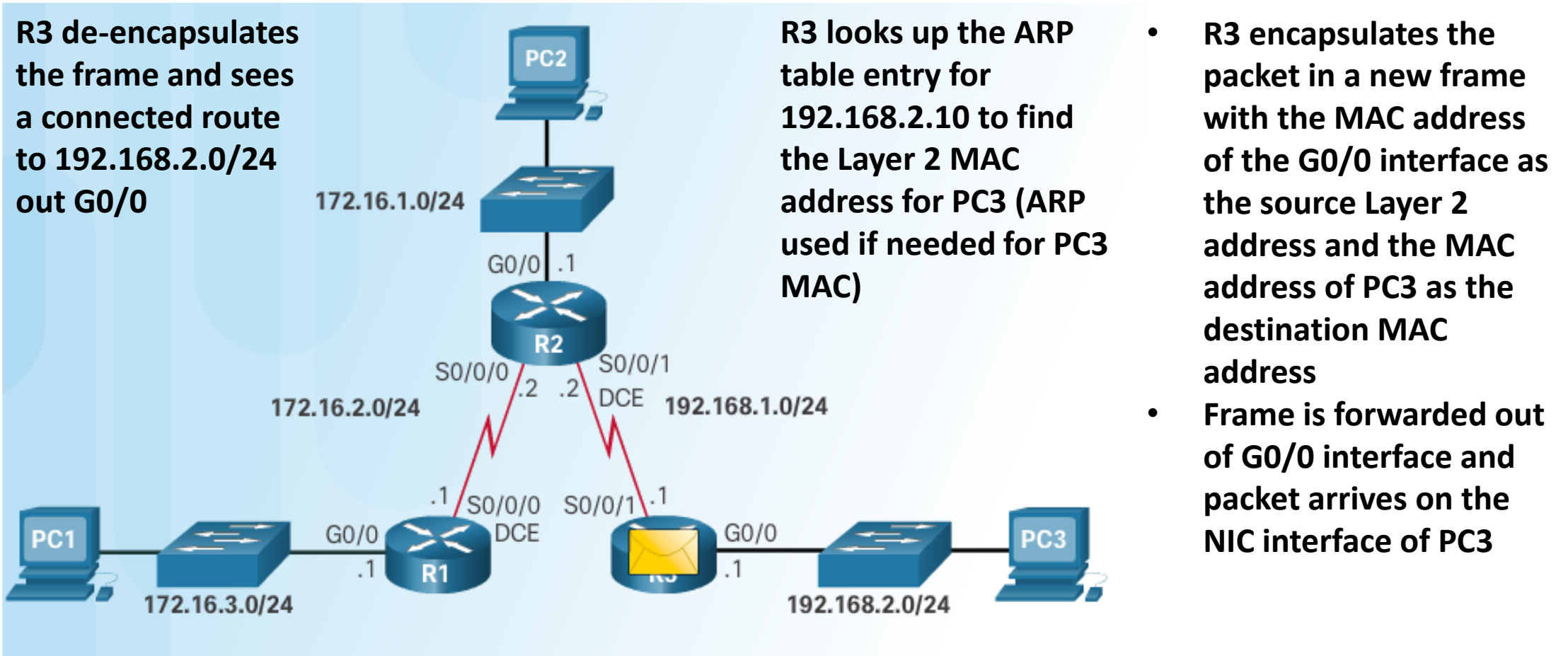
R2 de-encapsulates the frame and looks for a route to the destination

R2 has a static route to 192.168.2.0/24 out the Serial 0/0/1 interface



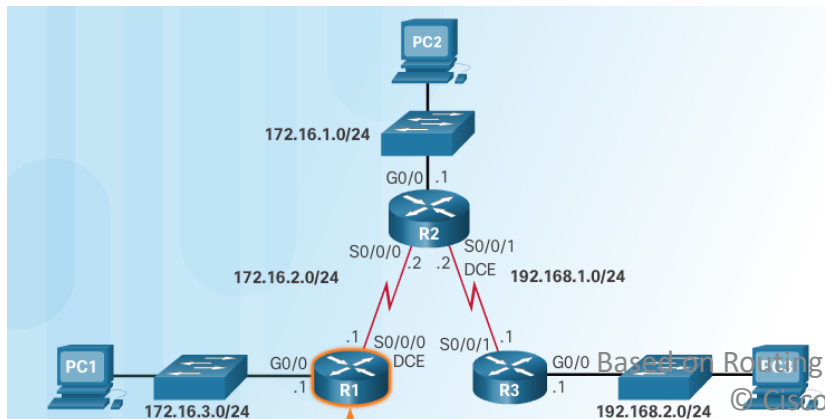
R2 encapsulates the packet in a new frame and forwards out S0/0/1

Packet Processing with Static Routes



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)
 0 172.16.2.2 4 msec 4 msec 8 msec
 1 192.168.1.1 12 msec 12 msec *
```

```
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#
```

Lab Practical Sessions

- Instructors:
 - Mr Anosh Ismail
 - Ms Kalani Ranasinghe
- Packet Tracer Activities:
 - https://www.youtube.com/playlist?list=PL8VT5seZ_GWjDSGR2d9agg4NxM5a_niGJ8 ***
 - https://www.youtube.com/playlist?list=PLjQ5ns7ugQsnZ7JBL16c7_uKSLWmd_dsgw