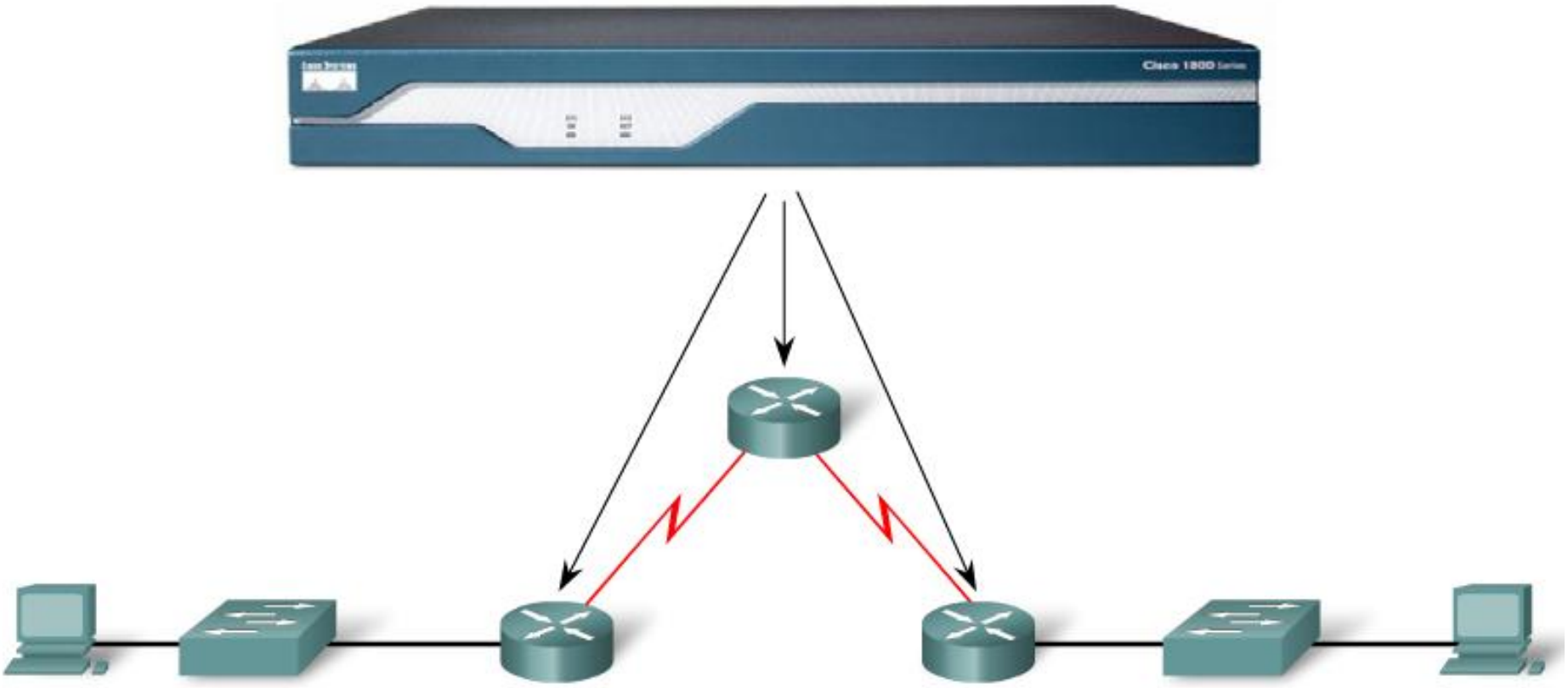
2.0.1 Chapter Introduction

In this chapter, you will learn to:

- Define the general role a router plays in networks.
- Describe the directly connected networks and the different router interfaces.
- Examine directly connected networks in the routing table and use the CDP protocol.
- Describe static routes with exit interfaces.
- Describe summary and default route.
- Examine how packets get forwarded when using static routes.
- Identify how to manage and troubleshoot static routes.

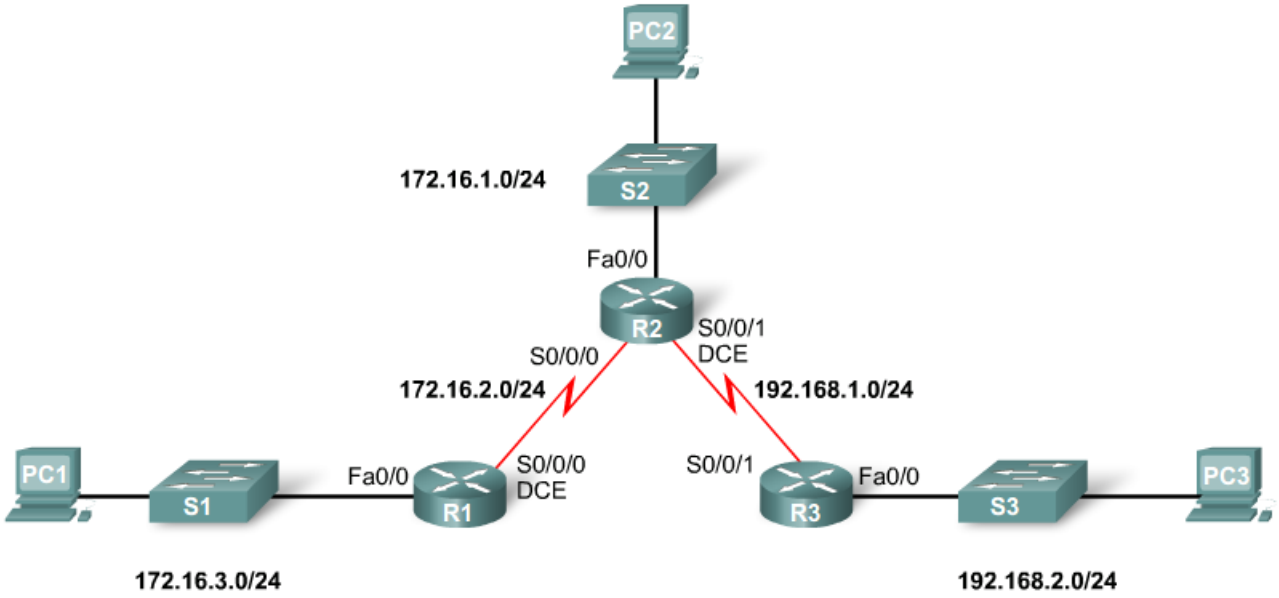
2.1.1 Role of the Router



The router is a special-purpose computer that plays a key role in the operation of any data network. Routers are primarily responsible for interconnecting networks by:

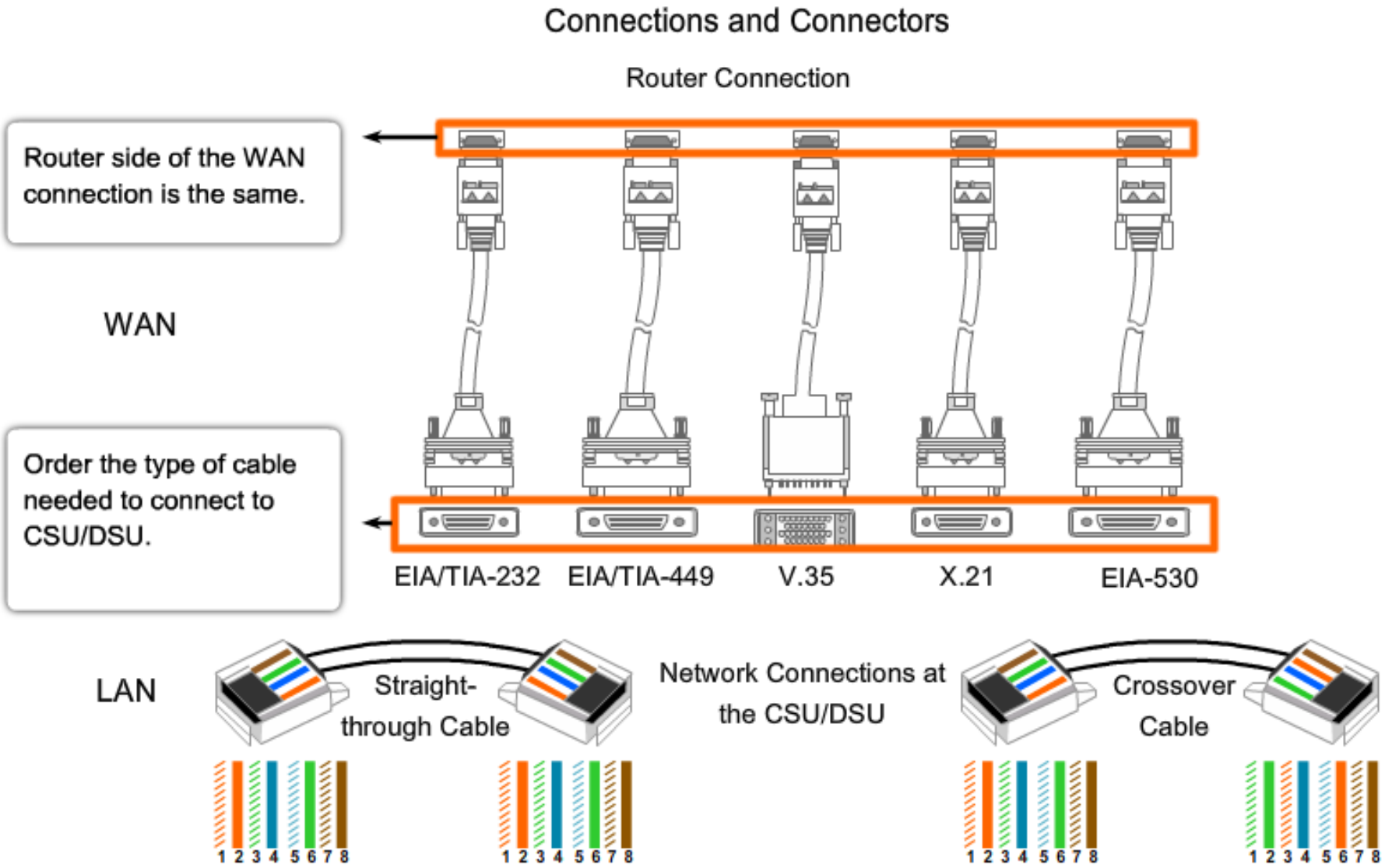
- Determining the best path to send packets
- Forwarding packets toward their destination

2.1.2 Introducing the Topology



Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	Fa0/0	172.16.3.1	255.255.255.0	N/A
	S0/0/0	172.16.2.1	255.255.255.0	N/A
R2	Fa0/0	172.16.1.1	255.255.255.0	N/A
	S0/0/0	172.16.2.2	255.255.255.0	N/A
	S0/0/1	192.168.1.2	255.255.255.0	N/A
R3	Fa0/0	192.168.2.1	255.255.255.0	N/A
	S0/0/1	192.168.1.1	255.255.255.0	N/A
PC1	NIC	172.16.3.10	255.255.255.0	172.16.3.1
PC2	NIC	172.16.1.10	255.255.255.0	172.16.1.1
PC3	NIC	192.168.2.10	255.255.255.0	192.168.2.1

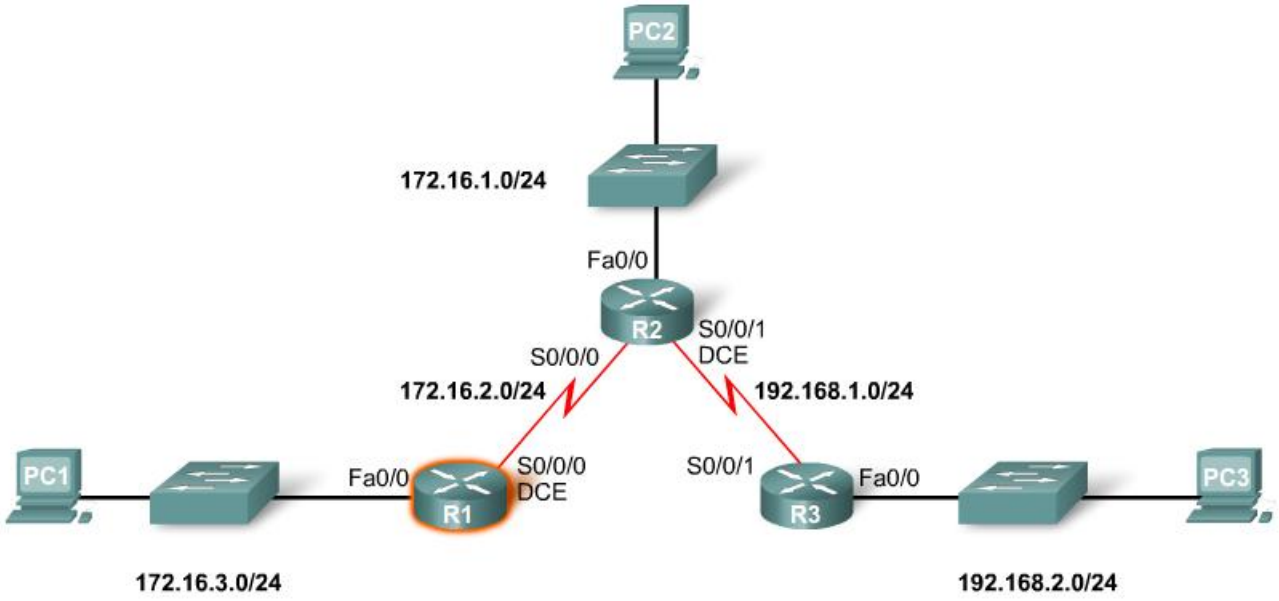
2.1.3 Examining the Connections to the Router



Packet Tracer Exploration:
Build the Chapter Topology

Use the Packet Tracer Activity to build the topology that you will use for the rest of this chapter. You will add all the necessary devices and connect them with the correct cabling.

2.2.1 Router Configuration Review



Summary of interface status with **show ip interface brief**

```
R1#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            unassigned      YES manual administratively down down
Serial0/0/0                unassigned      YES unset  administratively down down
FastEthernet0/1            unassigned      YES unset  administratively down down
Serial0/0/1                unassigned      YES unset  administratively down down
```

show ip route	show interfaces	show ip interface brief	show running-config

2.2.2 Configuring an Ethernet Interface

By default, all router interfaces are shutdown, or turned off. To enable this interface, use the no shutdown command, which changes the interface from administratively down to up.

```
R1(config)#interface fastethernet 0/0
R1(config-if)#ip address 172.16.3.1 255.255.255.0
R1(config-if)#no shutdown
```

The following message is returned from the IOS:

*Mar 1 01:16:08.212: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 01:16:09.214: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up

2.2.2 Configuring an Ethernet Interface (Unsolicited Messages)

```
R1(config)#int fa0/0
R1(config-if)#ip address 172.16.3.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#descri
*Mar  1 01:16:08.212: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar  1 01:16:09.214: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to upption
R1(config-if)#
```

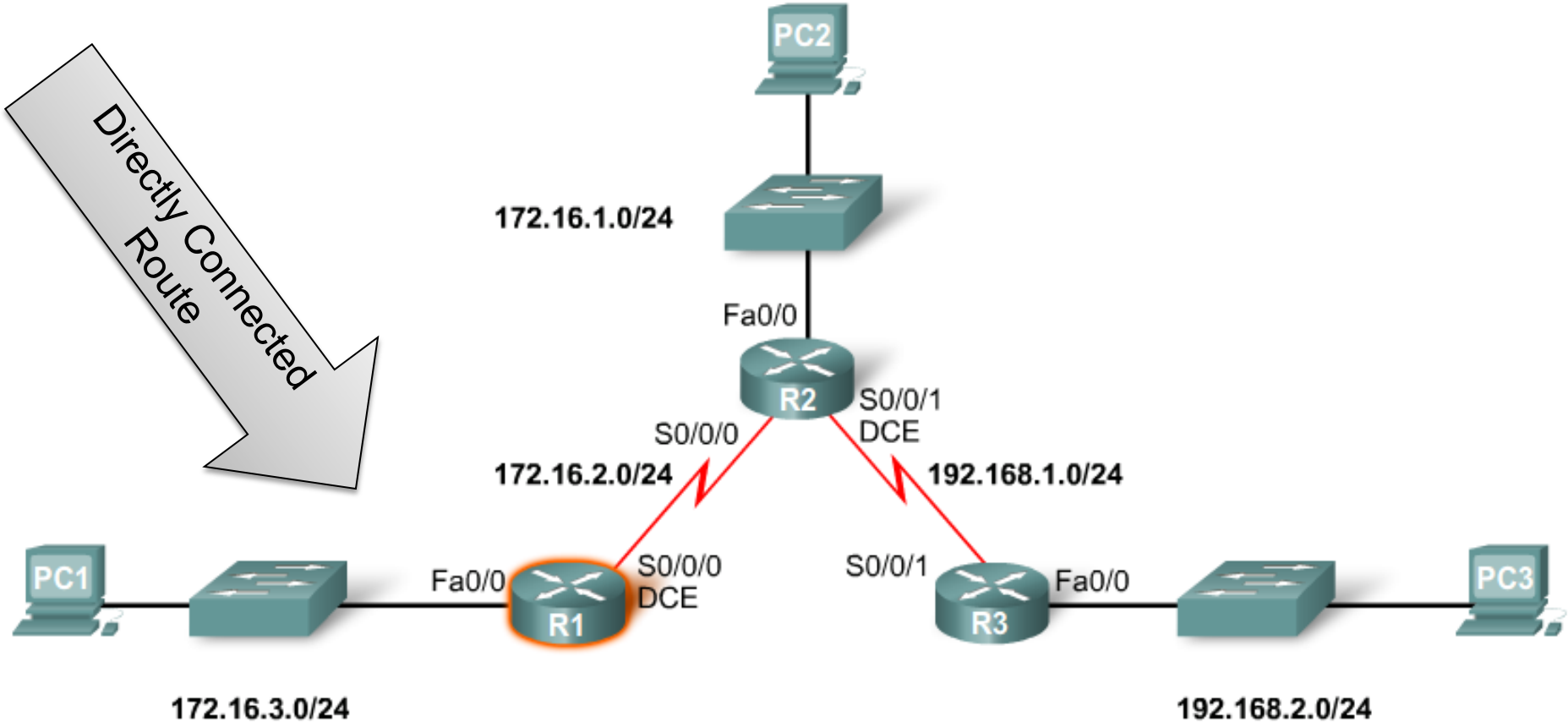
The description command was interrupted by unsolicited messa

Add the “logging synchronous” command stop unsolicited messages.

```
R1(config)#line console 0
R1(config-line)#logging synchronous
R1(config-if)#description
*Mar  1 01:28:04.242: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar  1 01:28:05.243: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to up
R1(config-if)#description
```

Keyboard input copied after message

2.2.2 Configuring Ethernet Interface



C 172.16.3.0 is directly connected, FastEthernet0/0
The /24 subnet mask for this route is displayed in the line above the actual route.
172.16.0.0/24 is subnetted, 1 subnets
C 172.16.3.0 is directly connected, FastEthernet0/0

2.2.2 Configuring Ethernet Interface

Directly Connected Route

```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.3.0 is directly connected, FastEthernet0/0
R1#
```

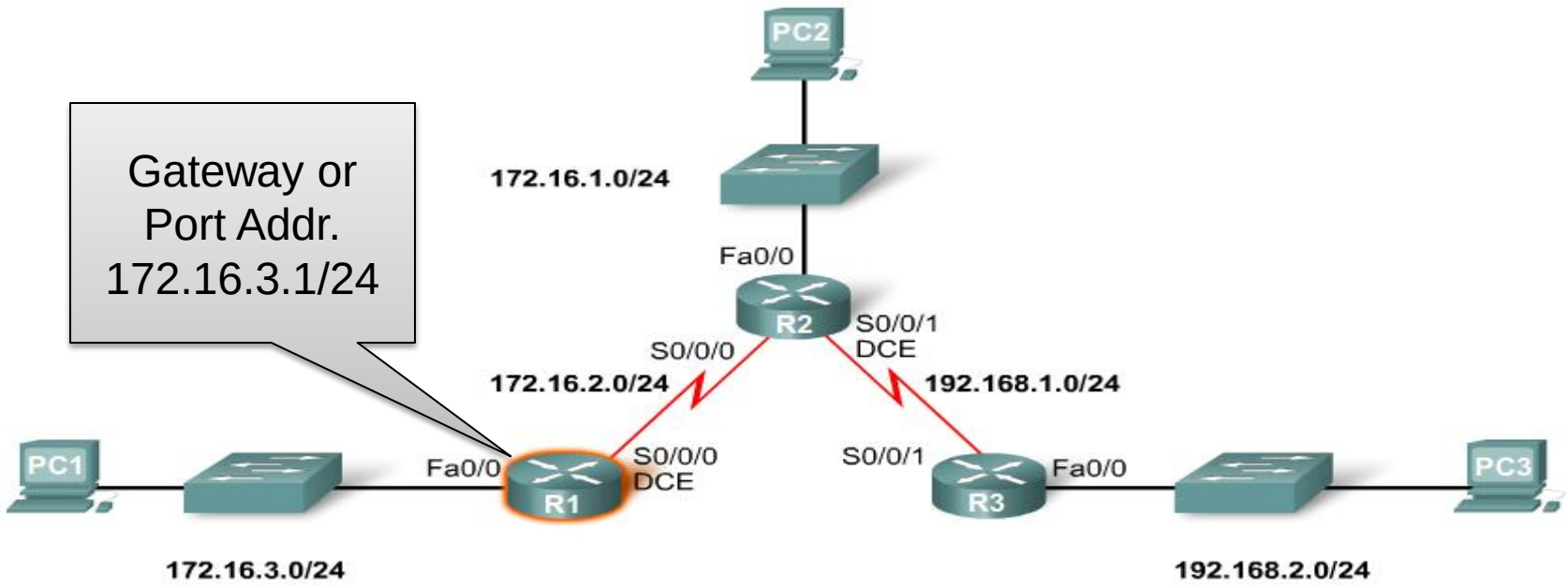
R1 now has a connected network.

2.2.3 Verifying Ethernet Interfaces

```
R1#show interfaces fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Hardware is AmdFE, address is 000c.3010.9260 (bia 000c.3010.9260)
  Internet address is 172.16.3.1/24
```

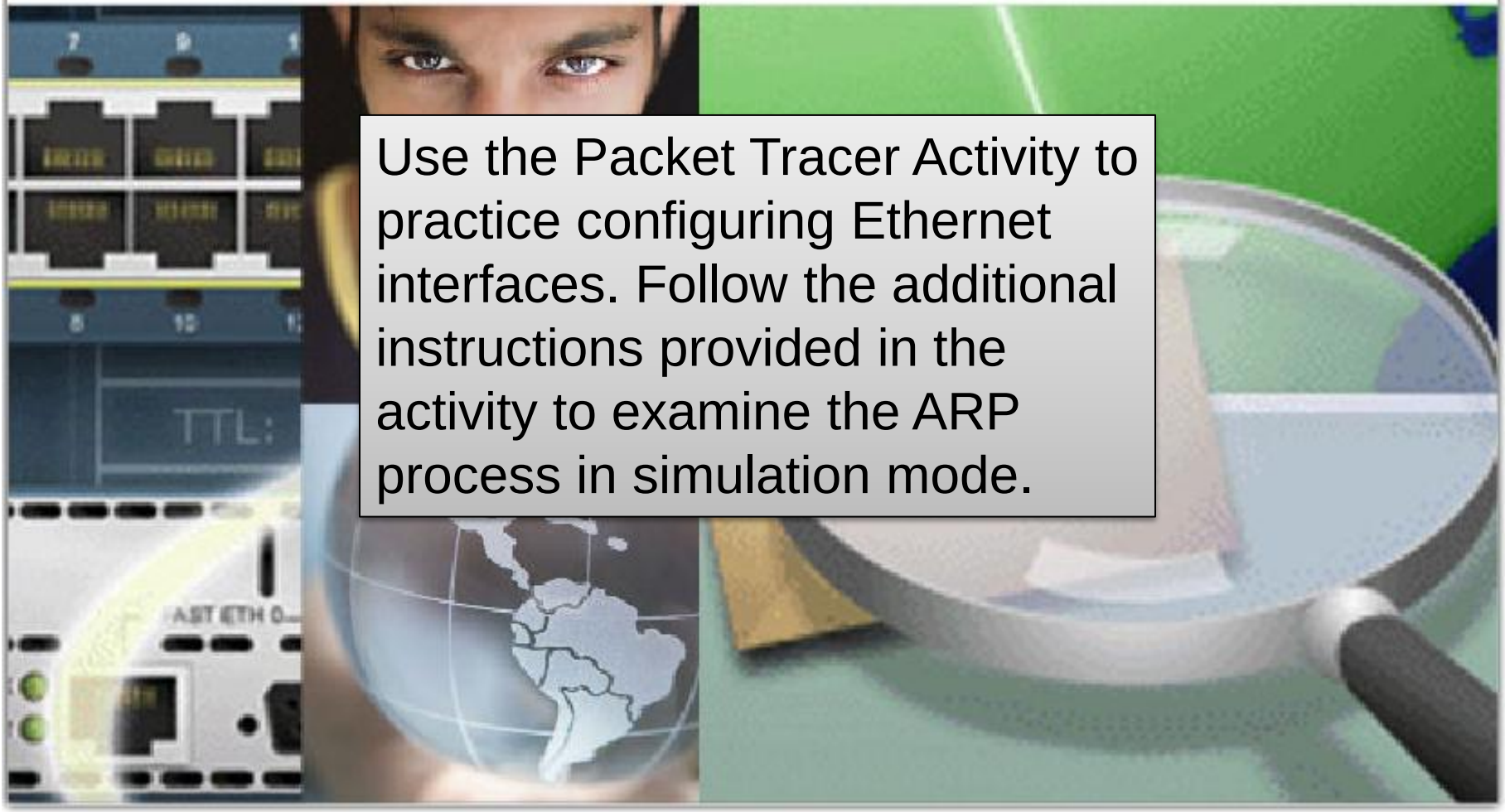
Physical Address

```
R1#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            172.16.3.1      YES manual up                    up
Serial0/0/0                unassigned      YES unset  administratively down down
FastEthernet0/1            unassigned      YES unset  administratively down down
Serial0/0/1                unassigned      YES unset  administratively down down
R1#
```



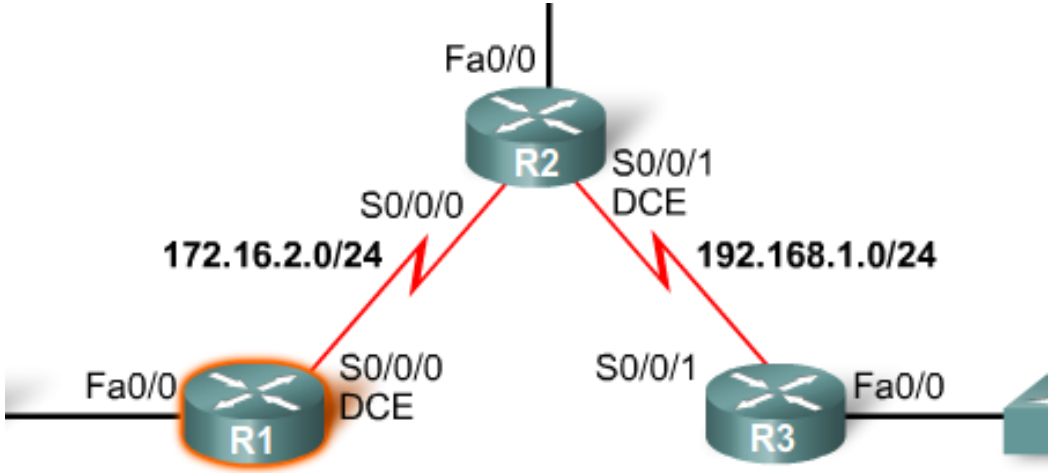
2.2.3 Verifying Ethernet Interfaces

Packet Tracer Exploration:
Configure Ethernet Interfaces for IP on Hosts and Routers



Use the Packet Tracer Activity to practice configuring Ethernet interfaces. Follow the additional instructions provided in the activity to examine the ARP process in simulation mode.

2.2.4 Configuring a Serial Interface



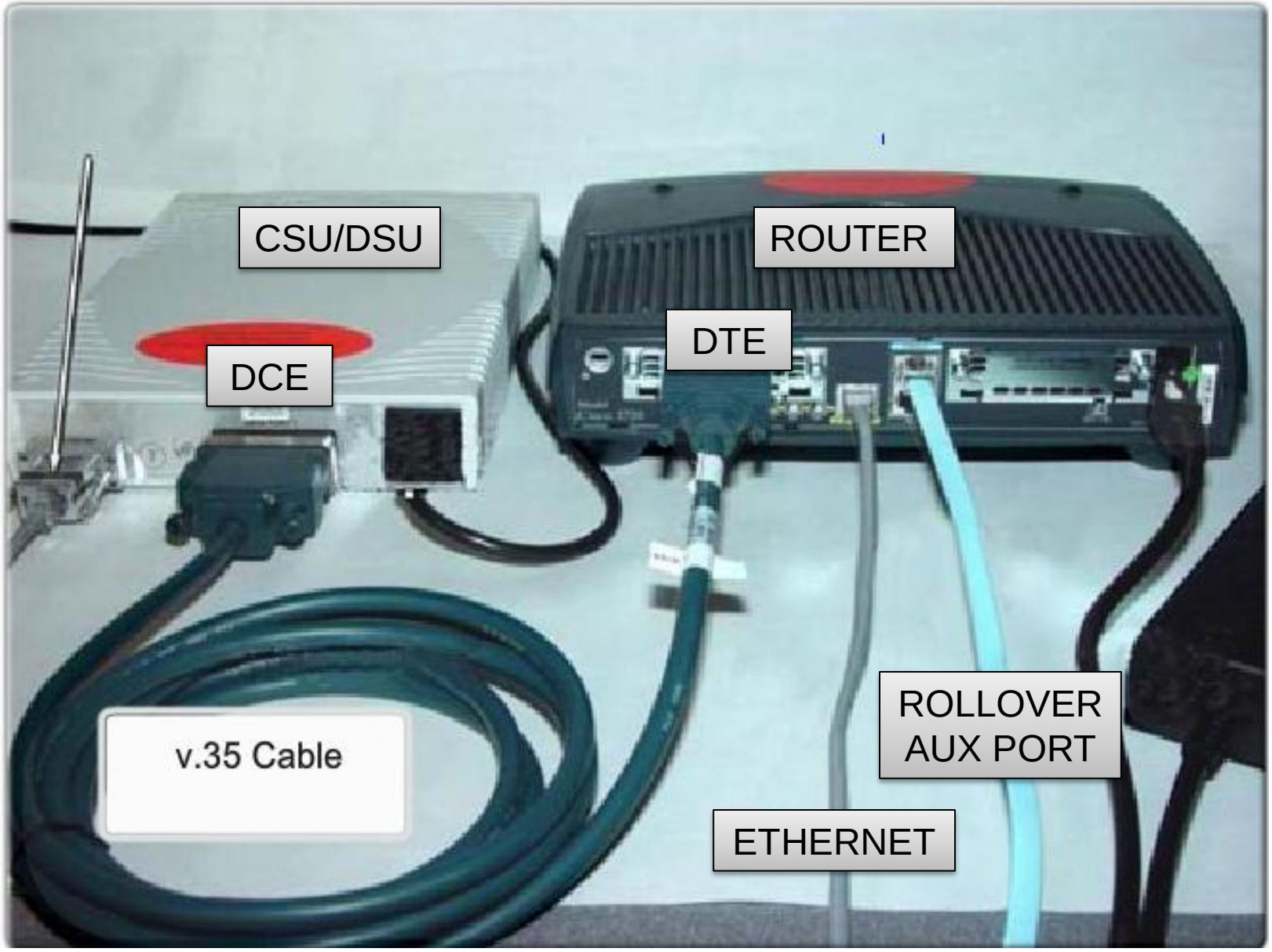
R1(config)#interface serial 0/0/0
R1(config-if)#ip address 172.16.2.1 255.255.255.0
R1(config-if)#no shutdown

R1#show interfaces serial 0/0/0
Serial0/0/0 is administratively down, line protocol is down

Line will remain down until other end of serial line is programmed.

2.2.5 Examining Router Interfaces

CSU/DSU connection using a DTE cable



```
R1#show controllers serial 0/0/0
Interface Serial0/0/0
Hardware is PowerQUICC MPC860
DCE V.35, no clock


R1#
```

R1 has a DCE cable connected. But no clock rate is set.

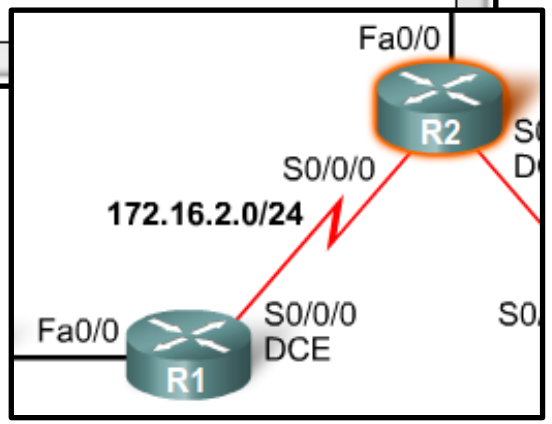
```
R1(config)#interface serial 0/0/0
R1(config-if)#clock rate 64000
01:10:28: %LINEPROTO-5-UPDOWN: Line protocol on
Interface Serial0/0/0, changed state to up
```

2.2.5 Examining Router Interfaces

```
R1#show interfaces serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 172.16.2.1/24
(**output omitted**)

R1#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            172.16.3.1      YES manual up                    up
Serial0/0/0                172.16.2.1      YES manual up                    up
(**output omitted**)
```

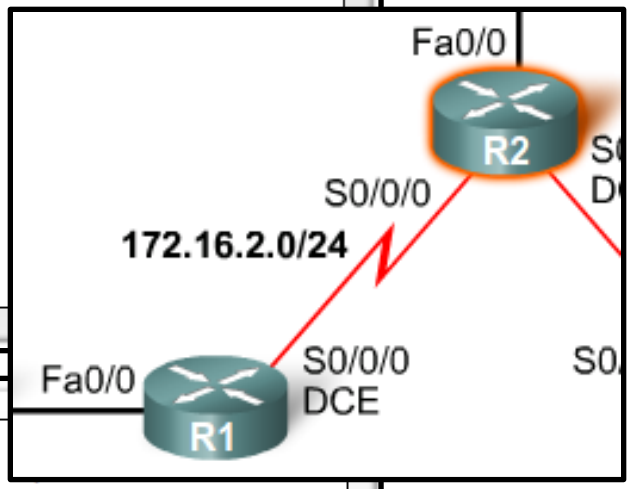
```
R1#ping 172.16.2.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/28/28 ms
R1#
```

R1 PINGS R2



2.3.1 Verifying Changes to the Routing Table

```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 2 subnets
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
R1#
```




```
R2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B -
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA e
       E1 - OSPF external type 1, E2 - OSPF external ty
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-
       * - candidate default, U - per-user static route
       P - periodic downloaded static route

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.2.0 is directly connected, Serial0/0/0

R2#
```

R1 and R2 only have routes for directly connected networks.
Could also list static and dynamic networks

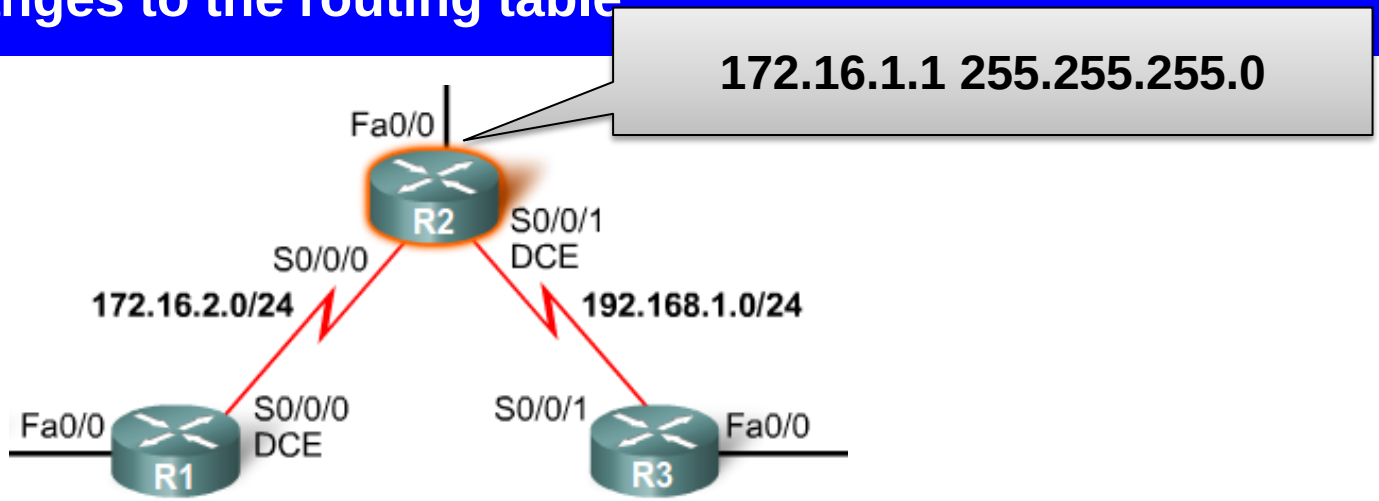
2.3.1 Verifying changes to the routing table

```
R2#debug ip routing
IP routing debugging is on

R2(config)#int fa0/0
R2(config-if)#ip address 172.16.1.1 255.255.255.0
R2(config-if)#no shutdown

%LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up

RT: add 172.16.1.0/24 via 0.0.0.0, connected metric [0/0]
RT: interface FastEthernet0/0 added to routing table
```

```
R2#undebug all
All possible debugging has been turned off
!

!
R2#undebug ip routing
IP routing debugging is off
R2#
```

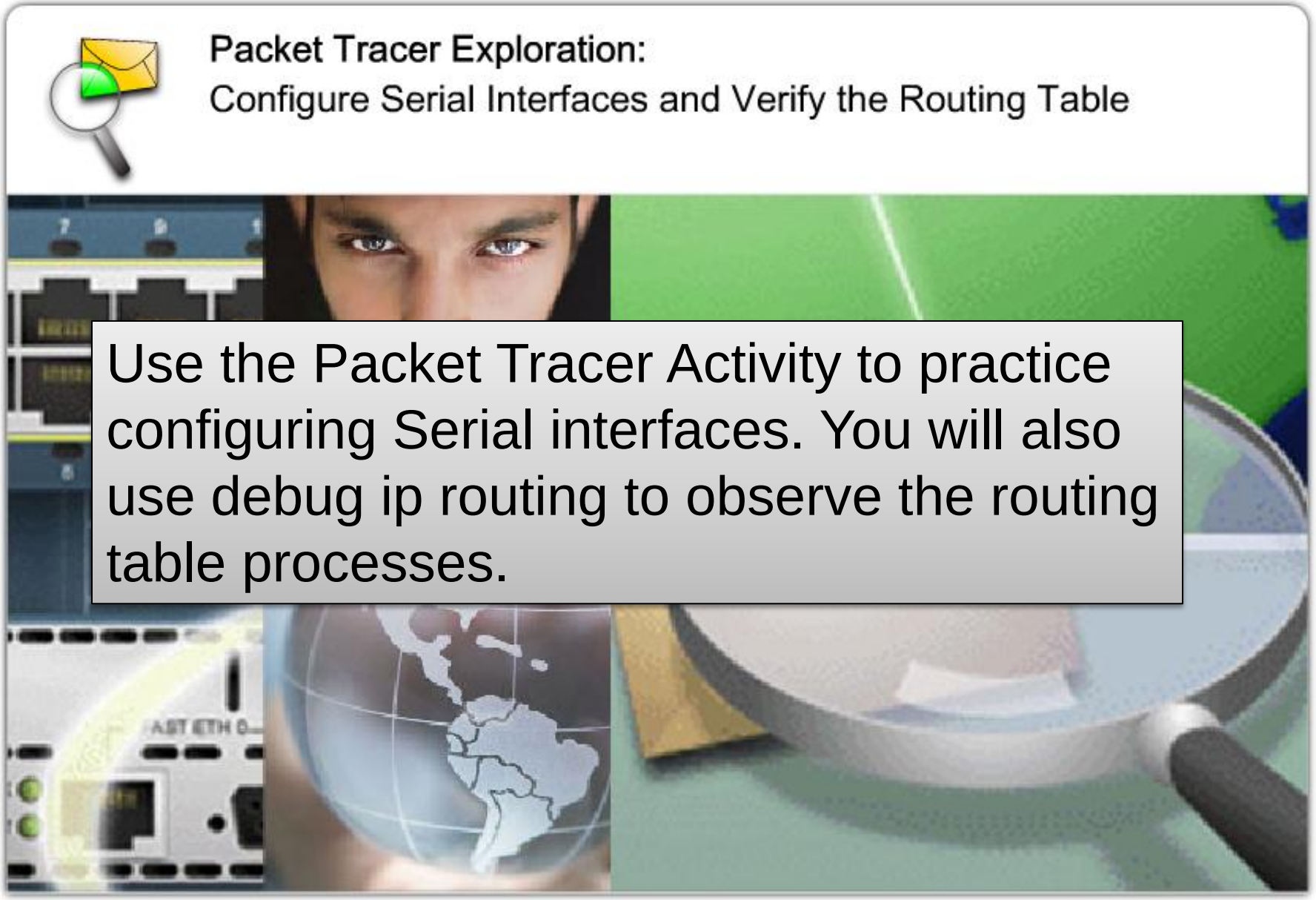
Debug commands can be used to monitor router operations in real time.

2.3.1 Verifying changes to the routing table




```
R2(config)#interface fastethernet 0/0
R2(config-if)#ip address 172.16.1.1 255.255.255.0
R2(config-if)#no shutdown

The following message will be returned from the IOS:

02:35:30: %LINK-3-UPDOWN: Interface FastEthernet0/0,
changed state to up
02:35:31: %LINEPROTO-5-UPDOWN: Line protocol on
Interface FastEthernet0/0, changed state to up
```

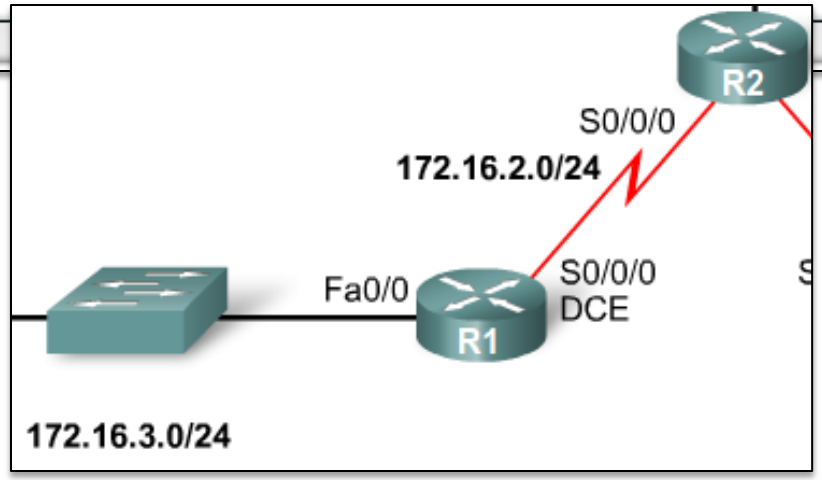
2.3.1 Verifying changes to the routing table



2.3.2 Devices on Directly Connected Networks

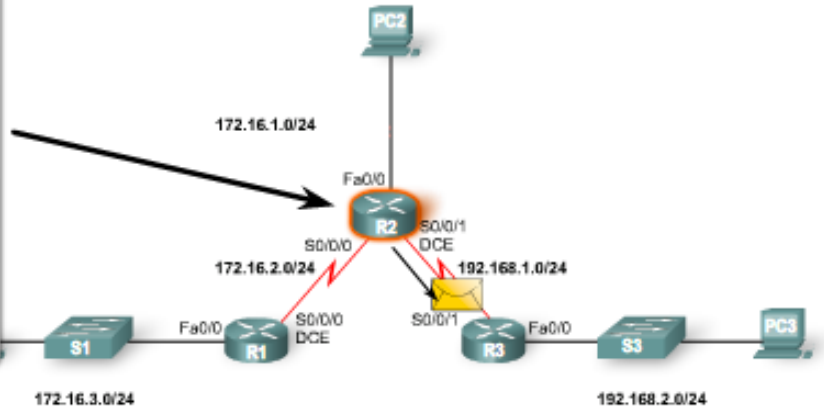
```
R1#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            172.16.3.1      YES manual up                    up
Serial0/0/0                172.16.2.1      YES manual up                    up
FastEthernet0/1            unassigned      YES manual administratively down down
Serial0/0/1                unassigned      YES manual administratively down down
R1#
```

```
R1#show ip route
 (**output omitted**)
     172.16.0.0/24 is subnetted, 2 subnets
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
```



2.3.2 Devices on Directly Connected Networks

```
R2#ping 192.168.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1,
timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5)
R2#
```




```
R2#show ip route
***ouput omitted***

     172.16.0.0/24 is subnetted, 2 subnets
C       172.16.1.0 is directly connected, FastEthernet0/0
C       172.16.2.0 is directly connected, Serial0/0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
R2#
```

Destination IP Address	192.168.1.1	**11000000.10101000.00000001**.00000001	
First route in routing table	172.16.1.0	**10101100.00010000.00000001**.00000000	No Match
Destination IP Address	192.168.1.1	**11000000.10101000.00000001**.00000001	
Second route in routing table	172.16.2.0	**10101100.00010000.00000010**.00000000	No Match
Destination IP Address	192.168.1.1	**11000000.10101000.00000001**.00000001	
Third route in routing table	192.168.1.0	**11000000.10101000.00000001**.00000000	Match!!

2.3.2 Devices on Directly Connected Networks

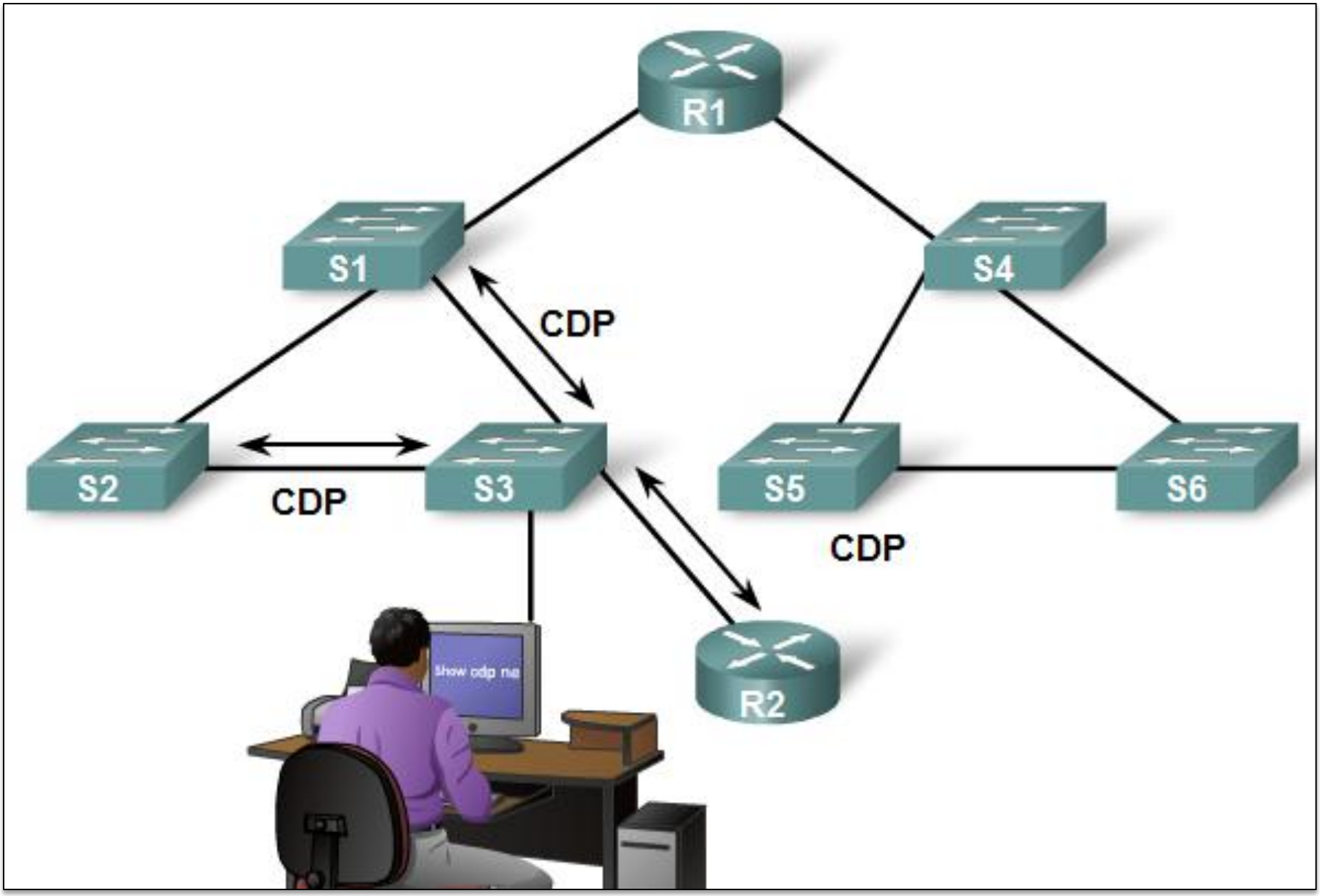
Packet Tracer Exploration:
Verify Connectivity of Directly Connected Devices

Use the Packet Tracer Activity to test connectivity between directly connected devices.

Network discovery with CDP

- CDP is an information-gathering tool used by network administrators to get information about directly connected Cisco devices.
- CDP is a proprietary tool that enables you to access a summary of protocol and address information about Cisco devices that are directly connected.
- By default, each Cisco device sends periodic messages, which are known as CDP advertisements, to directly connected Cisco devices.
- These advertisements contain information such as the types of devices that are connected, the router interfaces they are connected to, the interfaces used to make the connections, and the model numbers of the devices.

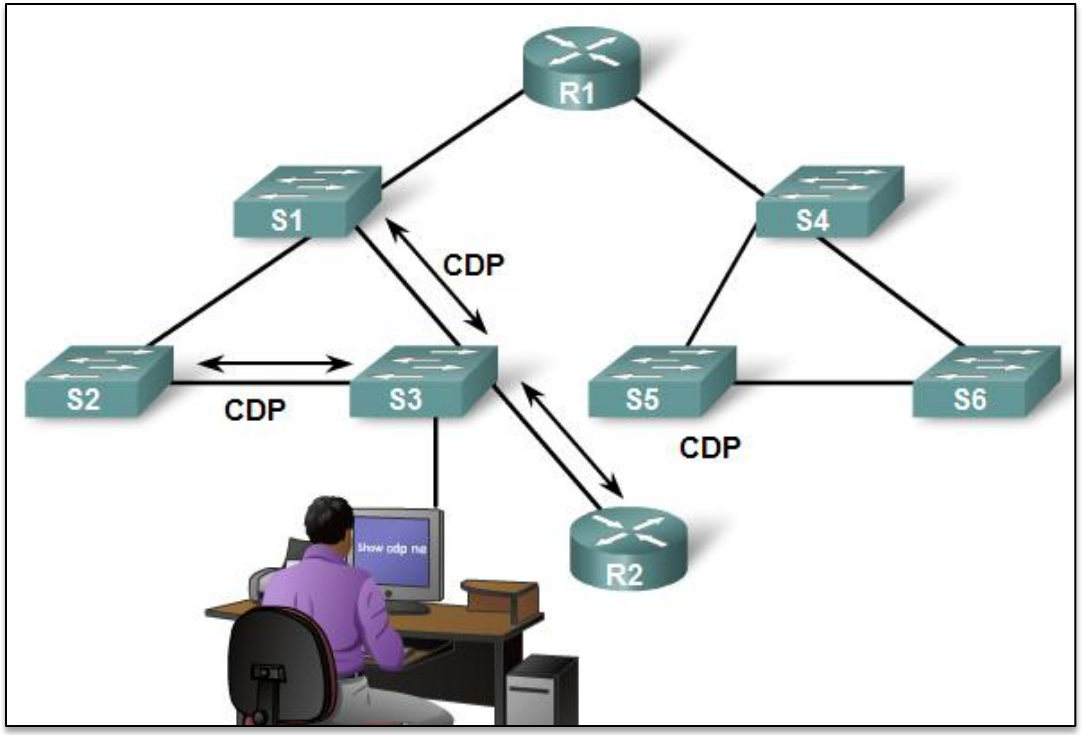
2.3.3 Cisco Discovery Protocol



2.3.3 Cisco Discovery Protocol

Layer 3 Neighbors

At Layer 3, routing protocols consider neighbors to be devices that share the same network address space.

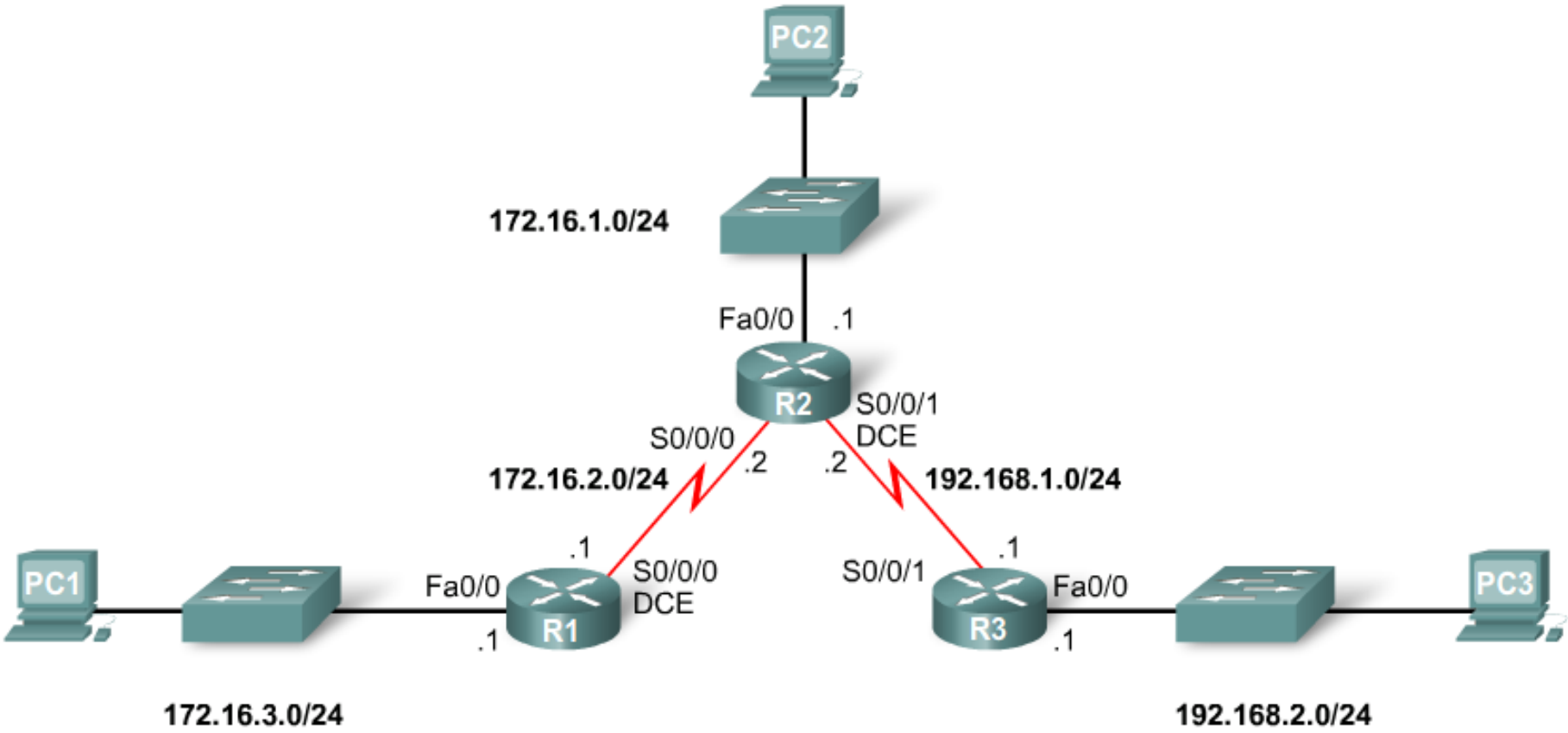


Layer 2 Neighbors

CDP neighbors are Cisco devices that are directly connected physically and share the same data linkS3 will receive CDP advertisements from S1, S2, and R2 only.

2.3.3 Cisco Discovery Protocol

R1 and S1 are CDP neighbors.
R1 and R2 are CDP neighbors.
R2 and S2 are CDP neighbors.
R2 and R3 are CDP neighbors.
R3 and S3 are CDP neighbors.



2.3.3 Cisco Discovery Protocol

```
R3#show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
S3               Fas 0/0            151         S I       WS-C2950  Fas 0/6
R2               Ser 0/0/1          125          R        1841      Ser 0/0/1

R3#show cdp neighbors detail

Device ID: R2
Entry address(es):
  IP address : 192.168.1.2
Platform: Cisco 1841,  Capabilities: Router Switch IGMP
Interface: Serial0/0/1,  Port ID (outgoing port): Serial0/0/1
Holdtime : 161 sec

Version :
```

CDP provides the following information about each CDP neighbor device:

- Device identifiers - For example, the configured host name of a switch
- Address list - Up to one Network layer address for each protocol supported
- Port identifier - The name of the local and remote port-in the form of an ASCII character string such as ethernet0
- Capabilities list - For example, whether this device is a router or a switch
- Platform - The hardware platform of the device; for example, a Cisco 7200 series router

2.3.3 Cisco Discovery Protocol

Packet Tracer Exploration:
Cisco Discovery Protocol (CDP)

Use the Packet Tracer Activity to explore the features of the Cisco Discovery Protocol (CDP). Practice enabling and disabling CDP - globally and on a per-interface basis. Investigate the power of using CDP to discover the topology of a network.

2.3.4 Using CDP for Network Discovery

```
R3#show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
Switch           Fas 0/0             133         S I       WS-C2950-2Fas 0/11
R2               Ser 0/0/            149        R S I      Cisco 1841Ser 0/0/1
```

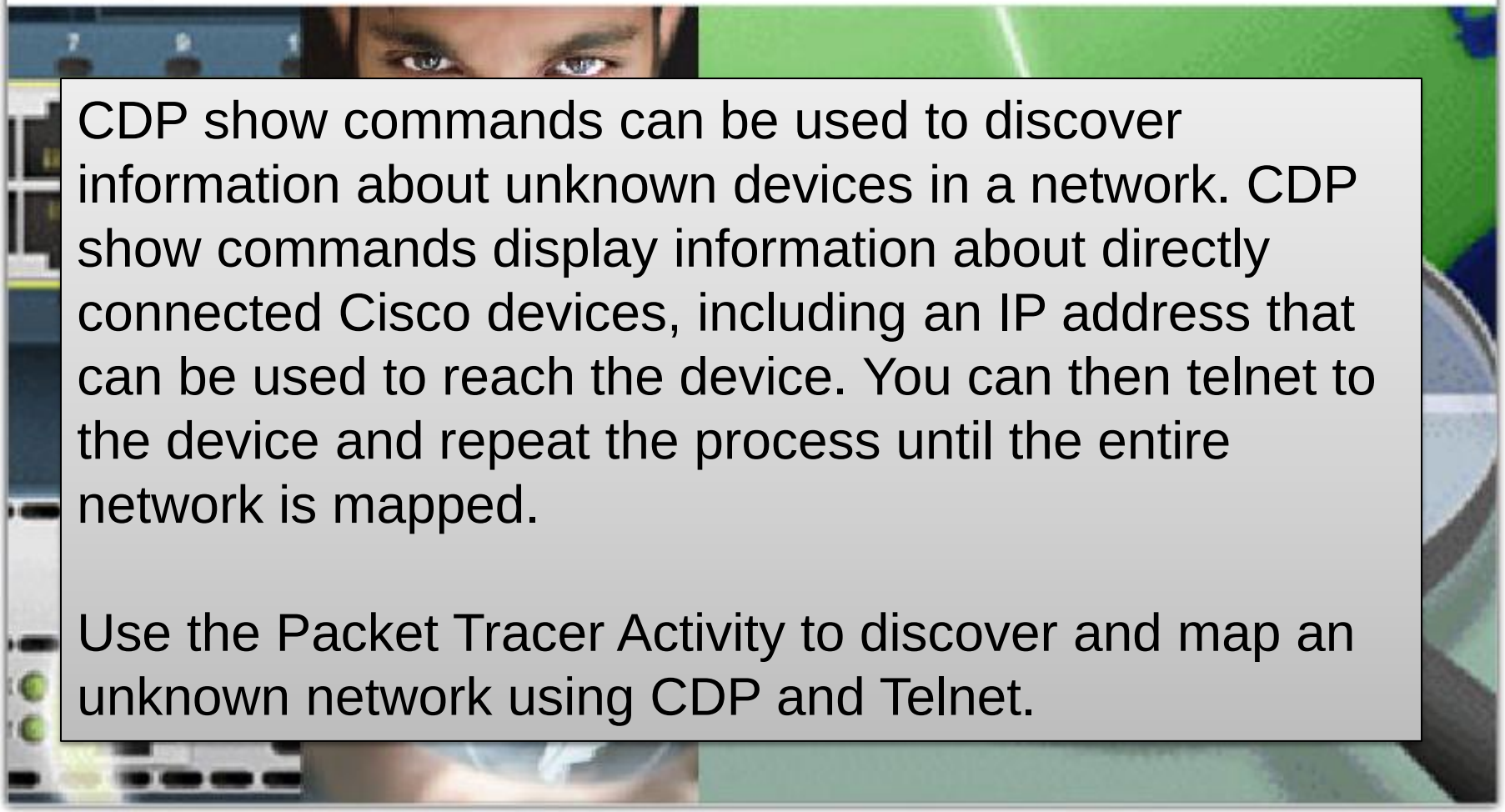
```
R3#show cdp neighbors detail
-------------------------
Device ID: R2
Entry address(es):
  IP address: 192.168.1.2
Platform: Cisco 1841,  Capabilities: Router Switch IGMP
Interface: Serial0/0/1,  Port ID (outgoing port): Serial0/0/1
Holdtime : 161 sec
```

- Neighbor device ID
- Local interface
- Holdtime value, in seconds
- Neighbor device capability code
- Neighbor hardware platform
- Neighbor remote port ID

```
!To disable CDP globally use...
R3(config)#no cdp run
!
!or, to disable CDP on only an interface...
R3(config-if)#no cdp enable
```

2.3.4 Using CDP for Network Discovery

Packet Tracer Exploration:
Mapping a Network with CDP and Telnet



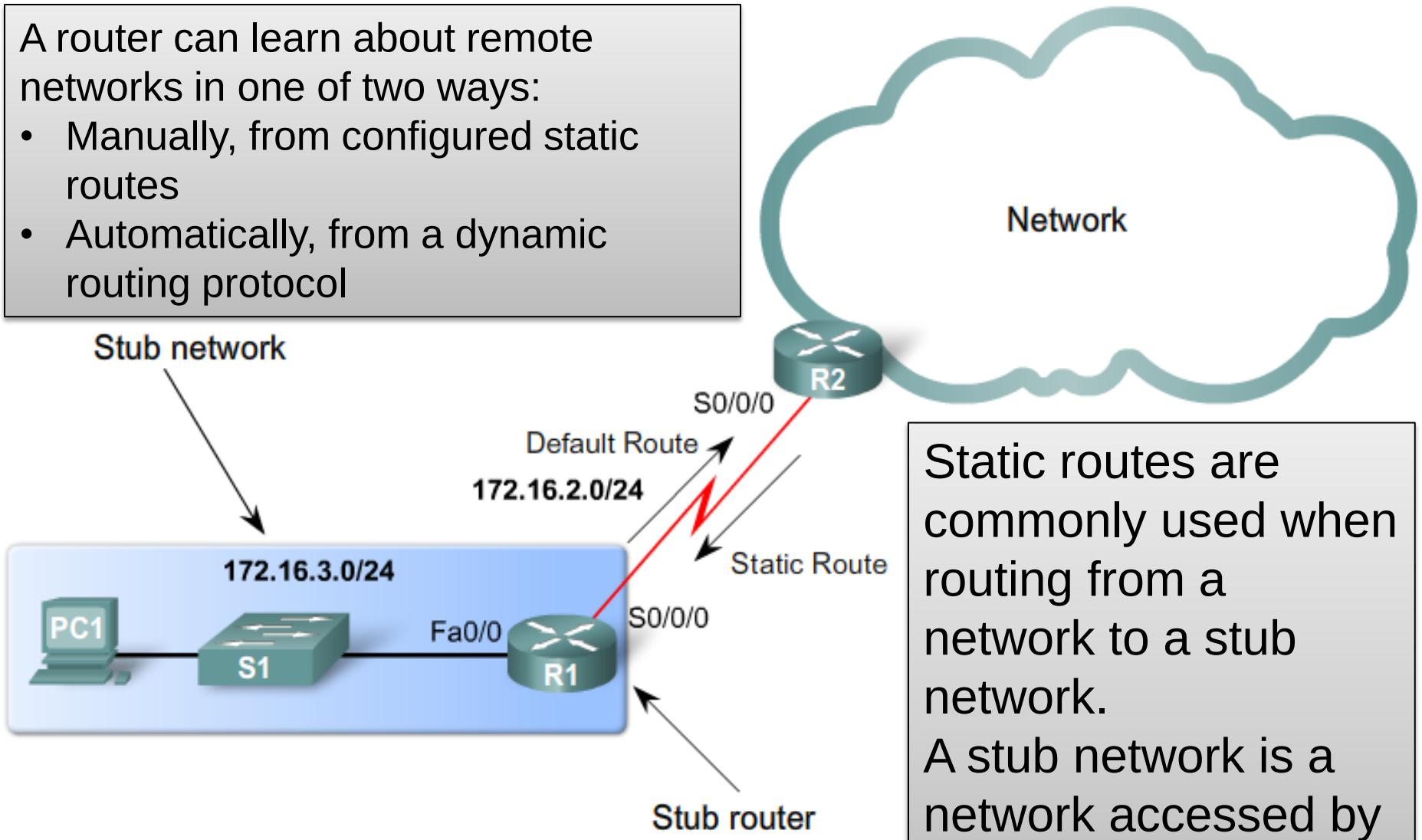
CDP show commands can be used to discover information about unknown devices in a network. CDP show commands display information about directly connected Cisco devices, including an IP address that can be used to reach the device. You can then telnet to the device and repeat the process until the entire network is mapped.

Use the Packet Tracer Activity to discover and map an unknown network using CDP and Telnet.

2.4.1 The Purpose and Command Syntax of IP Route

A router can learn about remote networks in one of two ways:

- Manually, from configured static routes
- Automatically, from a dynamic routing protocol



Static routes are commonly used when routing from a network to a stub network.

A stub network is a network accessed by a single route.

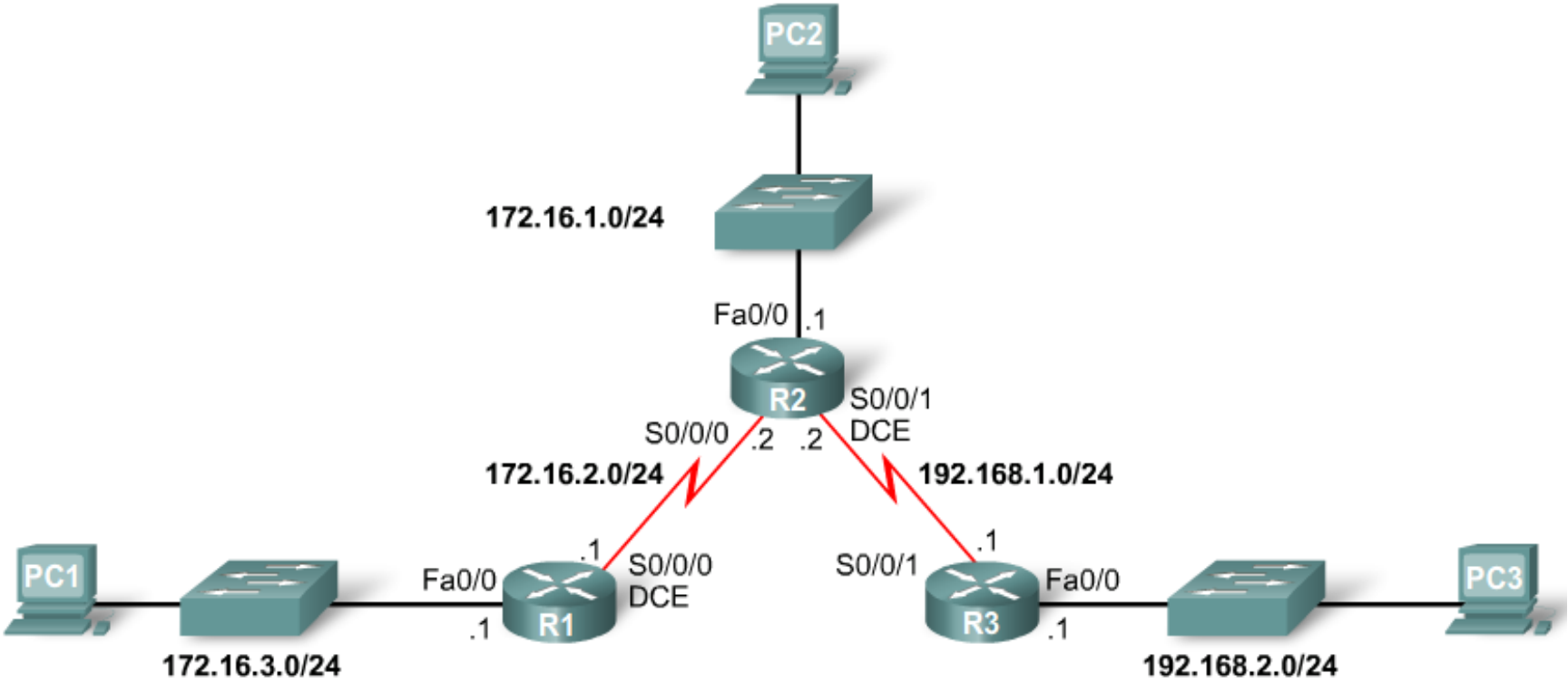
2.4.1 Purpose and Command Syntax for ip route

The command for configuring a static route is ip route.

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

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.
exit-interface	Outgoing interface that is used to forward packets to the destination network.

2.4.2 Configuring Static Routes



The remote networks that R1 does not know about are:
172.16.1.0/124 - The LAN on R2
192.168.1.0/24 - The serial network between R2 and R3
192.168.2.0/24 - The LAN on R3

2.4.2 Configuring Static Routes

```
R1#debug ip routing
(**output omitted**)

R1#conf t
R1(config)#ip route 172.16.1.0 255.255.255.0 172.16.2.2

00:20:15: RT: add 172.16.1.0/24 via 172.16.2.2, static metric [1/0]

R1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 3 subnets
S       172.16.1.0 [1/0] via 172.16.2.2
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
R1#
```

ip route - Static route command
172.16.1.0 - Network address of remote network
255.255.255.0 - Subnet mask of remote network
172.16.2.2 - Serial 0/0/0 interface IP address on R2, which is the "next-hop" to this network

2.4.2 Configuring Static Routes

Configuring remaining R1 static routes

```
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)#end
R1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 3 subnets
S       172.16.1.0 [1/0] via 172.16.2.2
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
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
```

All three static routes configured on R1 have the same next-hop IP address: 172.16.2.2. Using the topology diagram as a reference, we can see that this is true because packets for all of the remote networks must be forwarded to router R2, the next-hop router.

2.4.3 Routing Table Principles and Static Routes

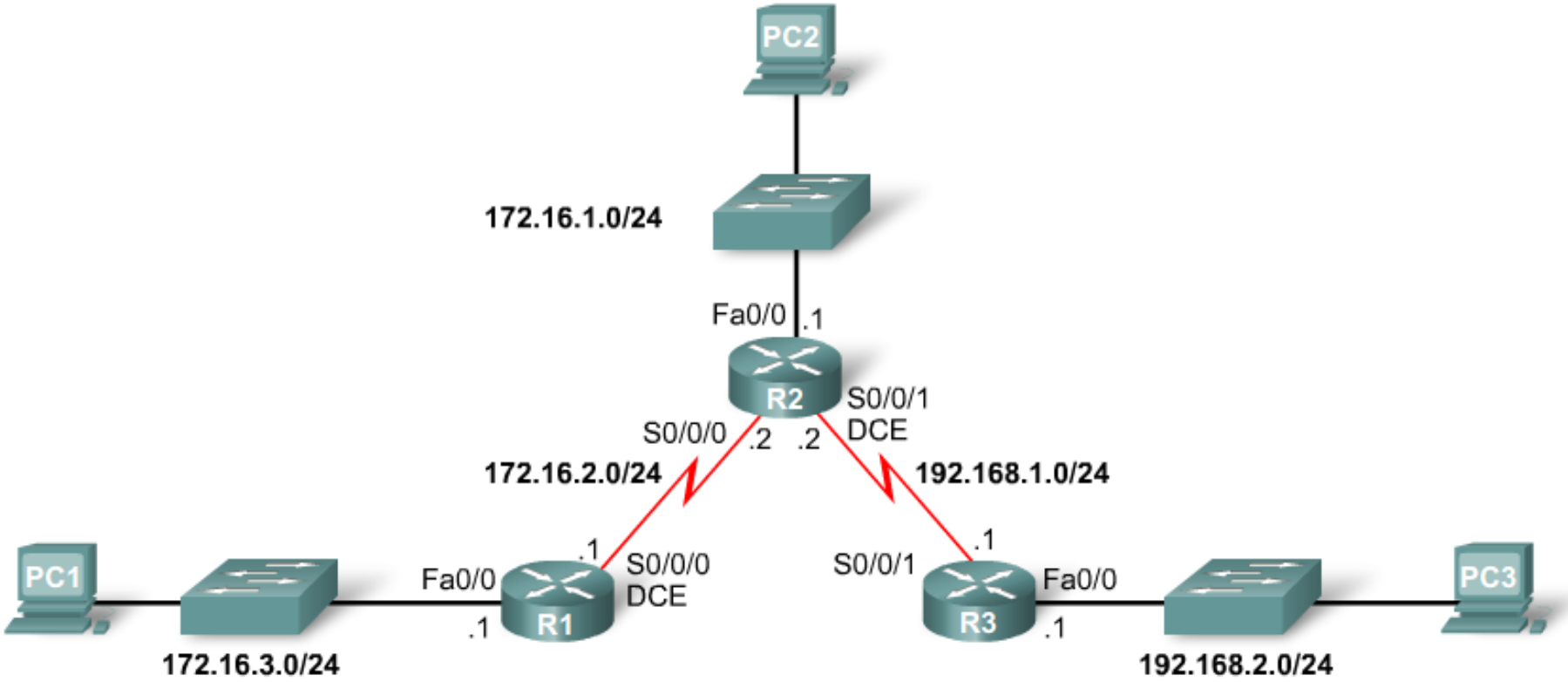
Alex Zinin's Routing Principles

Principle 1:
"Every router makes its decision alone, based on the information it has in its own routing table."

Principle 2:
"The fact that one router has certain information in its routing table does not mean that other routers have the same information."

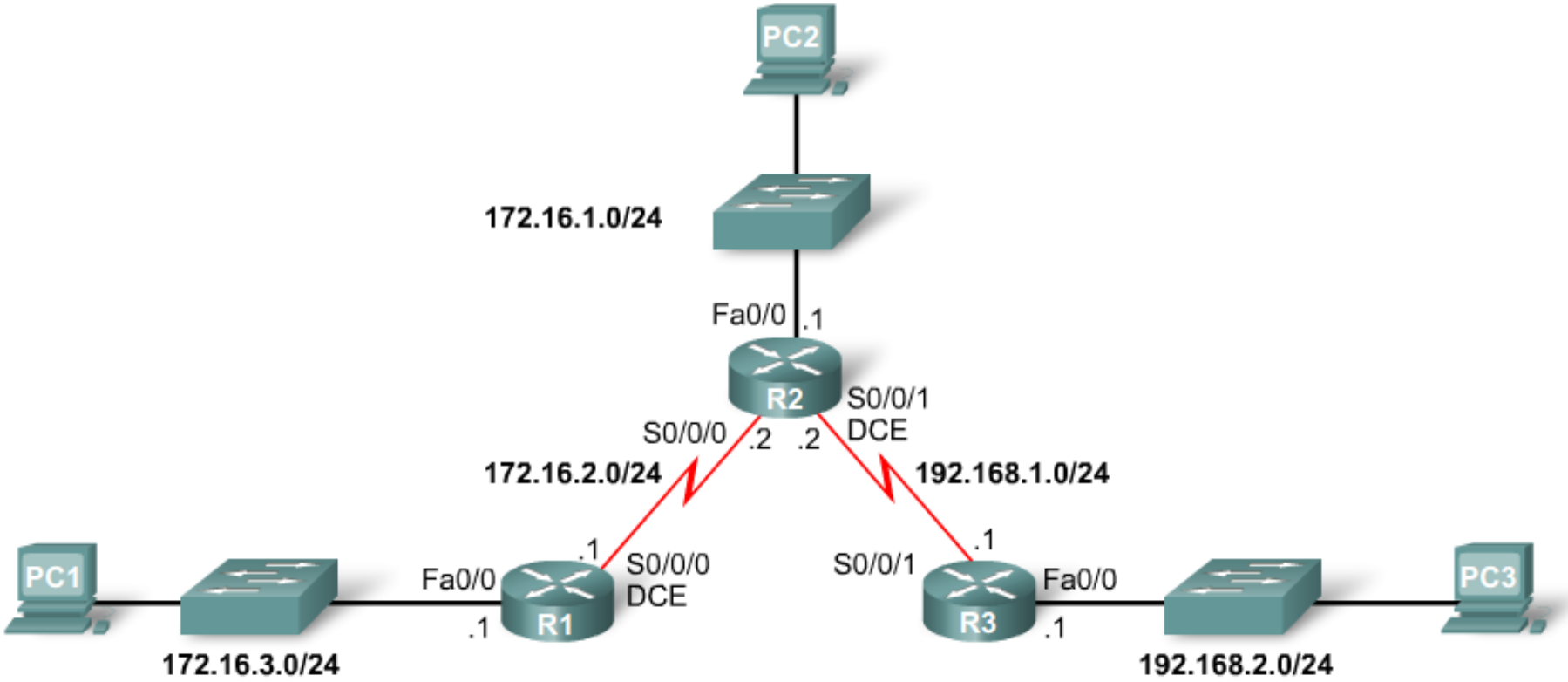
Principle 3:
"Routing information about a path from one network to another does not provide routing information about the reverse, or return path."

2.4.3 Routing Table Principles and Static Routes



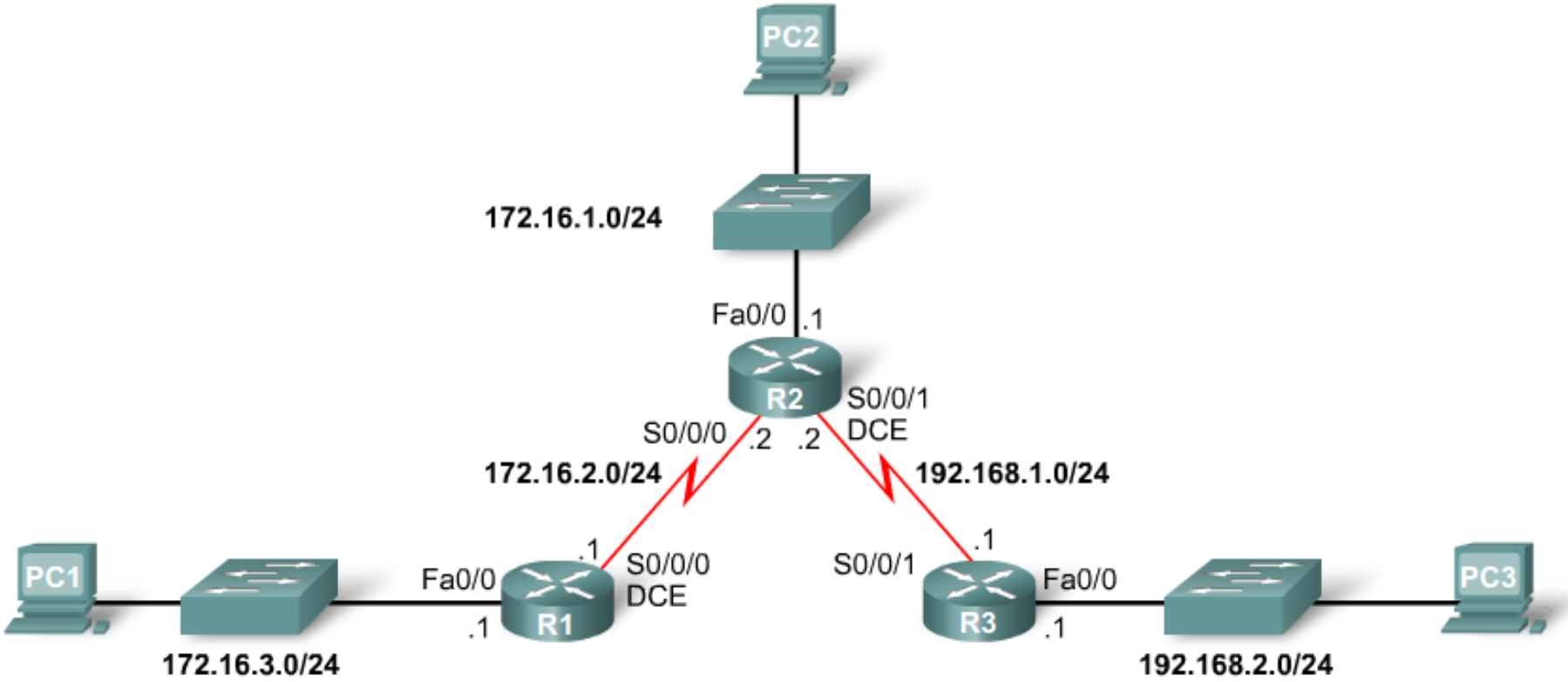
Packets destined for 172.16.1.0/24 and 192.168.1.0/24 networks would reach their destination. This is because router R1 has a route to these networks through R2. When packets reach router R2, these networks are directly connected on R2 and are routed using its routing table.

2.4.3 Routing Table Principles and Static Routes



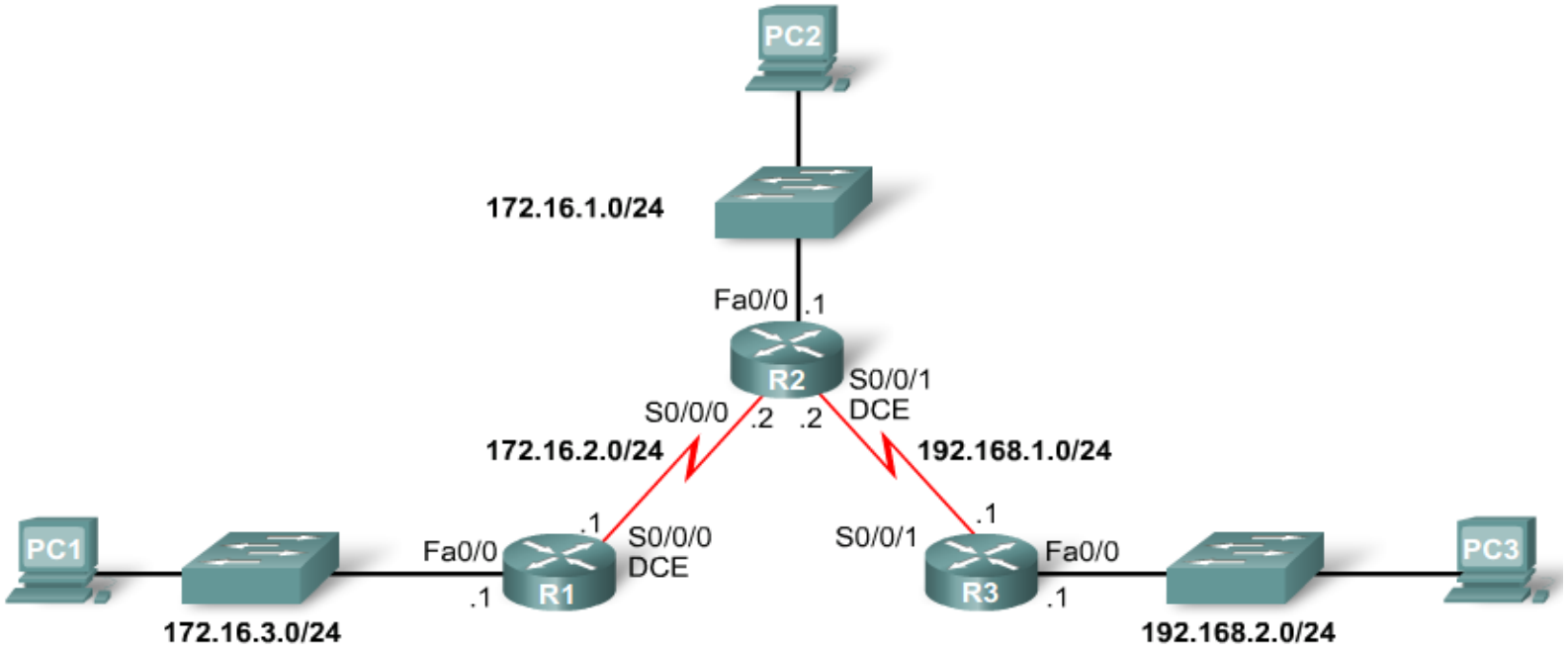
Packets destined for 192.168.2.0/24 network would not reach their destination. R1 has a static route to this network through R2. However, when R2 receives a packet, it will drop it because R2 does not yet contain a route for this network in its routing table.

2.4.3 Routing Table Principles and Static Routes



If R2 or R3 receives a packet destined for 172.16.3.0/24, the packet will not reach its destination, because neither router has a route to the 172.16.3.0/24 network.

2.4.3 Routing Table Principles and Static Routes




```
R2(config)#ip route 172.16.3.0 255.255.255.0 172.16.2.1
R2(config)#ip route 192.168.2.0 255.255.255.0 192.168.1.1
```

Static Routes for R2

```
R3(config)#ip route 172.16.1.0 255.255.255.0 192.168.1.2
R3(config)#ip route 172.16.2.0 255.255.255.0 192.168.1.2
R3(config)#ip route 172.16.3.0 255.255.255.0 192.168.1.2
```

Static Routes for R3

2.4.4 Resolving the Exit Interface (recursive lookup)

```
R1#show ip route
(**output omitted**)
     172.16.0.0/24 is subnetted, 3 subnets
S       172.16.1.0 [1/0] via 172.16.2.2
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
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
```

172.16.2.2, is matched to the directly connected network 172.16.2.0/24 with the exit interface of Serial 0/0/0

When the router has to perform multiple lookups in the routing table before forwarding a packet, it is performing a process known as a **recursive lookup**

Step 1: Find a route.
Step 2: Find an exit interface.

Before any packet is forwarded by a router, the routing table process must determine the exit interface to use to forward the packet. This is known as route **resolvability**

2.4.4 Resolving the Exit Interface

```
R1#debug ip routing
IP routing debugging is on
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int s0/0/0
R1(config-if)#shutdown
R1(config-if)#end

is_up: 0 state: 6 sub state: 1 line: 0
RT: interface Serial0/0/0 removed from routing table
RT: del 172.16.2.0/24 via 0.0.0.0, connected metric [0/0]
RT: delete subnet route to 172.16.2.0/24
RT: del 192.168.1.0 via 172.16.2.2, static metric [1/0]
RT: delete network route to 192.168.1.0
RT: del 172.16.1.0/24 via 172.16.2.2, static metric [1/0]
RT: delete subnet route to 172.16.1.0/24

R1#show ip route
***output omitted***
```

If Serial 0/0/0 interface goes down the static route cannot be resolved to an exit interface, in this case Serial 0/0/0, the static route is removed from the routing table.

Four routes are removed.

Only one route is left in the table.

The static routes are still in the R1's running configuration. If the interface comes back up (is enabled again with no shutdown), the IOS routing table process will reinstall these static routes back into the routing table.

2.5.1 Configuring a Static Route with an Exit Interface

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

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.
exit-interface	Outgoing interface that is used to forward packets to the destination network.

Most static routes can be configured with an exit interface, which allows the routing table to resolve the exit interface in a single search instead of two searches.

2.5.1 Configuring a Static Route with an Exit Interface

```
R1(config)#no ip route 192.168.2.0 255.255.255.0 172.16.2.2
R1(config)#ip route 192.168.2.0 255.255.255.0 serial 0/0/0
R1(config)#end
R1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 3 subnets
S       172.16.1.0 [1/0] via 172.16.2.2
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
S    192.168.1.0/24 [1/0] via 172.16.2.2
S    192.168.2.0/24 is directly connected, Serial0/0/0
```

Exit interface now specified in the static route. No need for a recursive lookup.

Reconfigure this static route to use an exit interface instead of a next-hop IP address

2.5.2 Modifying Static Routes

```
R1(config)#no ip route 172.16.1.0 255.255.255.0 172.16.2.2
R1(config)#ip route 172.16.1.0 255.255.255.0 serial 0/0/0
R1(config)#no ip route 192.168.1.0 255.255.255.0 172.16.2.2
R1(config)#ip route 192.168.1.0 255.255.255.0 serial 0/0/0
```

Using exit interface rather than next hop ip address

```
R2(config)#no ip route 172.16.3.0 255.255.255.0 172.16.2.1
R2(config)#ip route 172.16.3.0 255.255.255.0 serial 0/0/0
R2(config)#no ip route 192.168.2.0 255.255.255.0 192.168.1.1
R2(config)#ip route 192.168.2.0 255.255.255.0 serial 0/0/1
```

```
R3(config)#no ip route 172.16.1.0 255.255.255.0 192.168.1.2
R3(config)#ip route 172.16.1.0 255.255.255.0 serial 0/0/1
R3(config)#no ip route 172.16.2.0 255.255.255.0 192.168.1.2
R3(config)#ip route 172.16.2.0 255.255.255.0 serial 0/0/1
R3(config)#no ip route 172.16.3.0 255.255.255.0 192.168.1.2
R3(config)#ip route 172.16.3.0 255.255.255.0 serial 0/0/1
```

There are times when a previously configured static route needs to be modified

There is no way to modify an existing static route. The static route must be deleted and a new one configured.

2.5.3 Verifying Static Route Configuration

```
R1#show running-config

ip route 172.16.1.0 255.255.255.0 Serial0/0/0
ip route 192.168.1.0 255.255.255.0 Serial0/0/0
ip route 192.168.2.0 255.255.255.0 Serial0/0/0
```

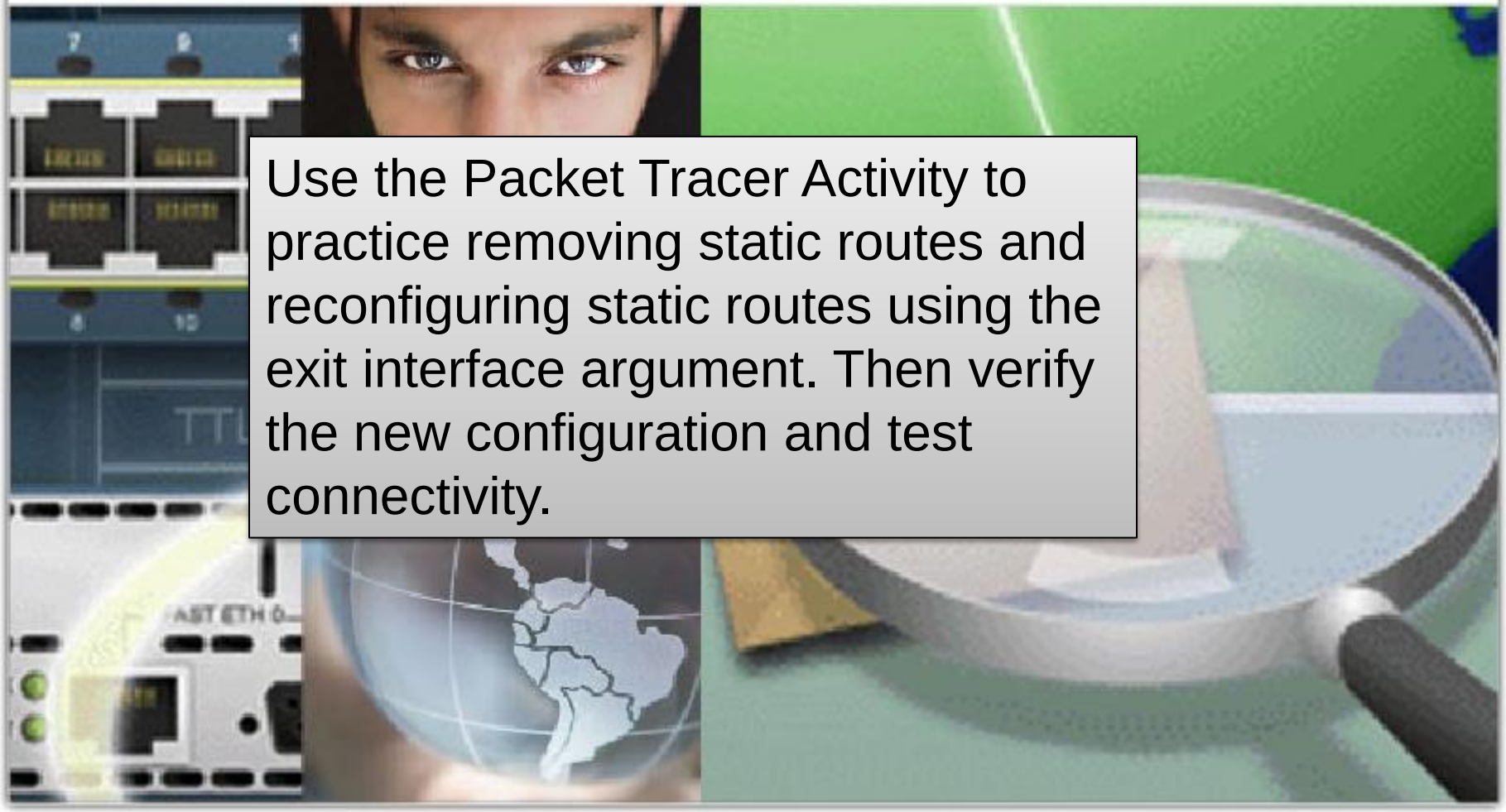
```
R2#show running-config

ip route 172.16.3.0 255.255.255.0 Serial0/0/0
ip route 192.168.2.0 255.255.255.0 Serial0/0/1
```

```
R3#show running-config

ip route 172.16.1.0 255.255.255.0 Serial0/0/1
ip route 172.16.2.0 255.255.255.0 Serial0/0/1
ip route 172.16.3.0 255.255.255.0 Serial0/0/1
```

show running-config show ip route ping

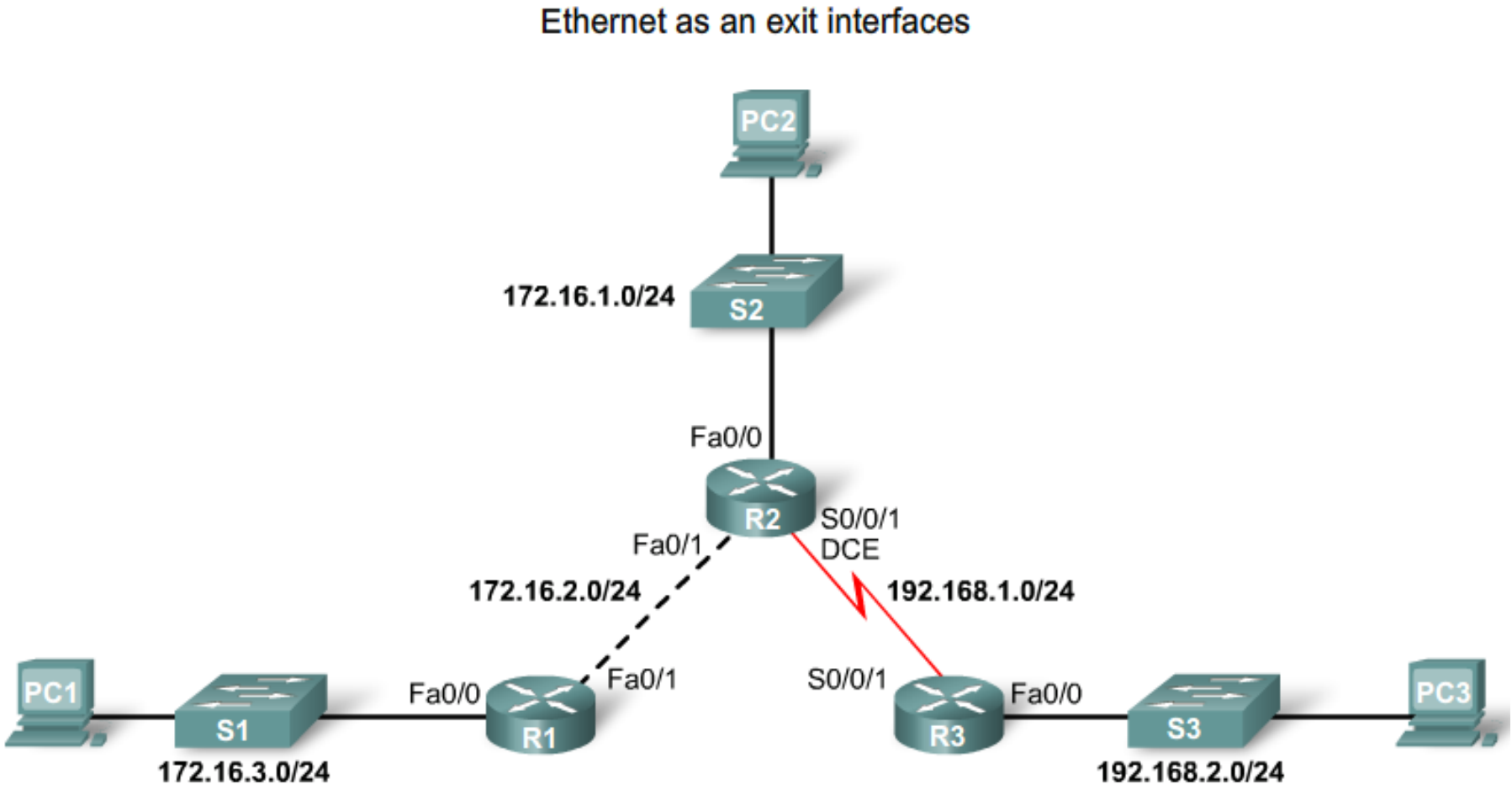
2.5.3 Verifying Static Route Configuration

Packet Tracer Exploration:
Removing and Configuring Static Routes



Use the Packet Tracer Activity to practice removing static routes and reconfiguring static routes using the exit interface argument. Then verify the new configuration and test connectivity.

2.5.4 Static Routes with Ethernet Interfaces



Sometimes the exit interface is an Ethernet network.

R1(config)#ip route 192.168.2.0 255.255.255.0 172.16.2.2

IP packet must be encapsulated into an Ethernet frame with an Ethernet destination MAC address.

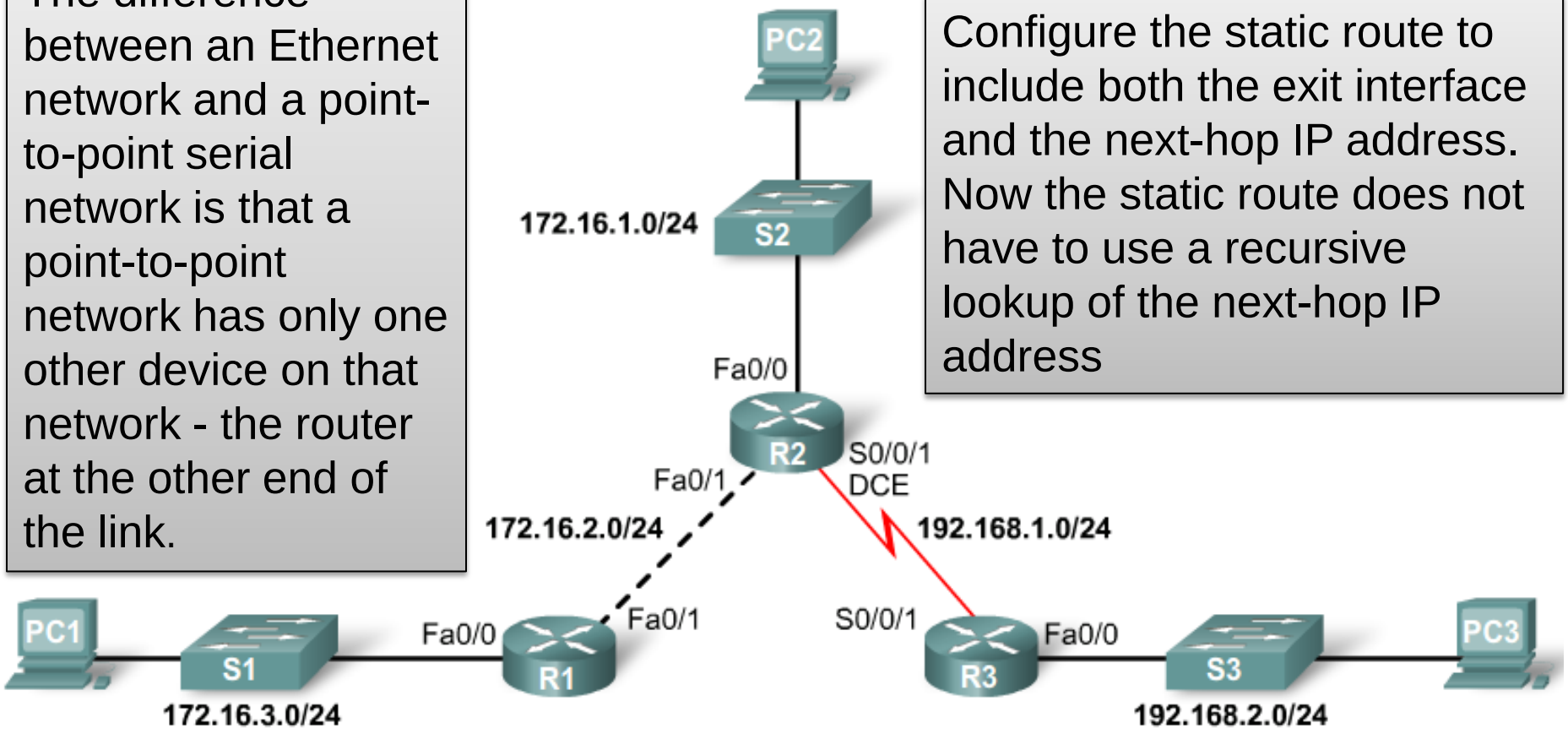
2.5.4 Static Routes with Ethernet Interfaces

```
R1(config)#ip route 192.168.2.0 255.255.255.0 FastEthernet 0/1 172.16.2.2
```

Exit interface and next-hop address

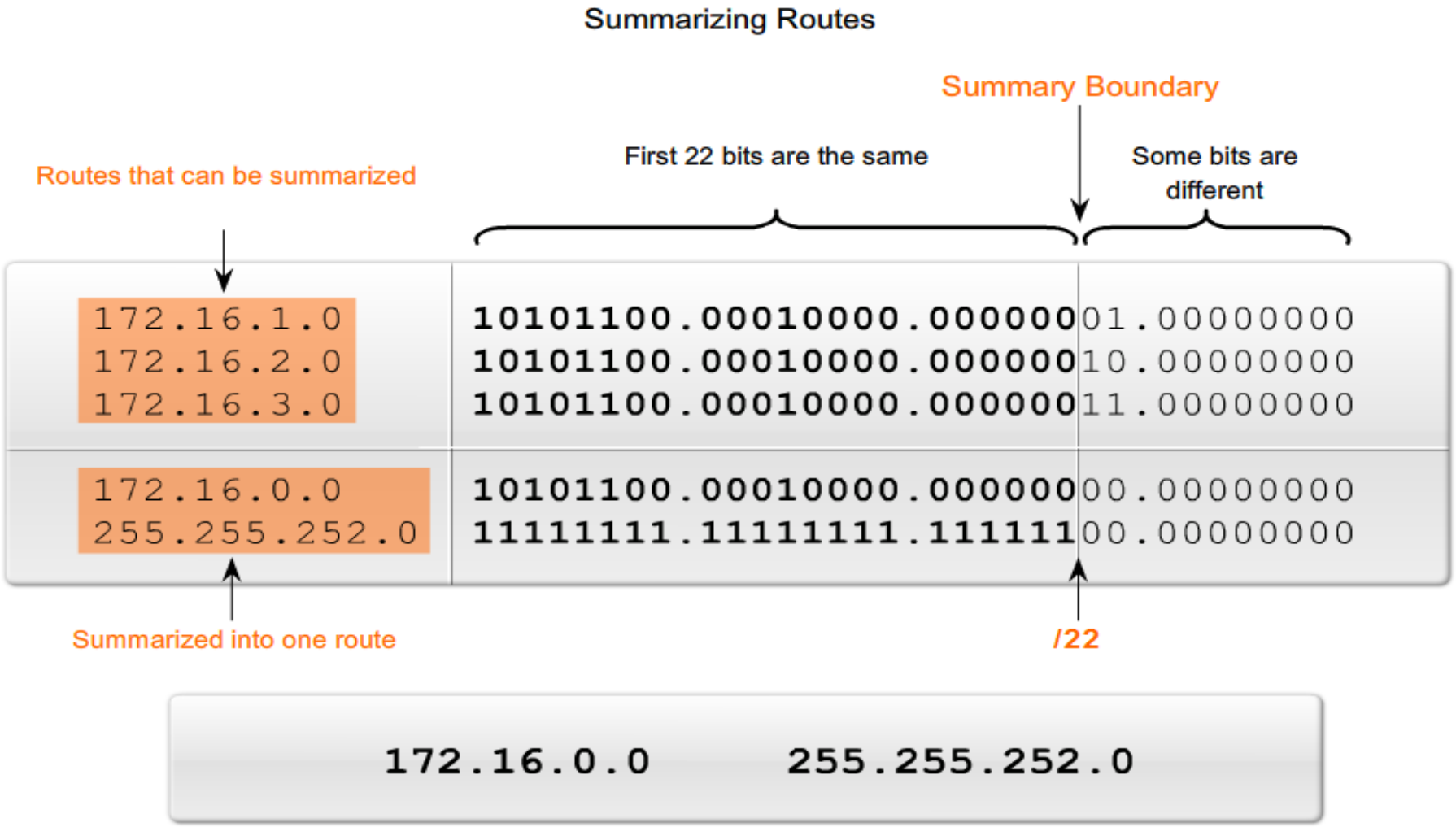
The difference between an Ethernet network and a point-to-point serial network is that a point-to-point network has only one other device on that network - the router at the other end of the link.

Configure the static route to include both the exit interface and the next-hop IP address. Now the static route does not have to use a recursive lookup of the next-hop IP address



The routing table process will only need to perform a single lookup to get both the exit interface and the next-hop IP address.

2.6.1 Summary Static Routes



Multiple static routes can be summarized into a single static route if:

- The destination networks can be summarized into a single network address, and
- The multiple static routes all use the same exit-interface or next-hop IP addres

2.6.1 Summary Static Routes

```
R3#show ip route
***output omitted***
Gateway of last resort is not set

 172.16.0.0/24 is subnetted, 3 subnets
S       172.16.1.0 is directly connected, Serial0/0/1
S       172.16.2.0 is directly connected, Serial0/0/1
S       172.16.3.0 is directly connected, Serial0/0/1
C    192.168.1.0/24 is directly connected, Serial0/0/1
C    192.168.2.0/24 is directly connected, FastEthernet0/0
```

no ip route
for each route

```
R3#show ip route
***output omitted***
Gateway of last resort is not set

     172.16.0.0/22 is subnetted, 1 subnets
S       172.16.0.0 is directly connected, Serial0/0/1
C    192.168.1.0/24 is directly connected, Serial0/1
C    192.168.2.0/24 is directly connected, FastEthernet0/0
```

Substitute
Summary Route

The destination IP address only needs to match the left-most 22 bits of the 172.16.0.0 network. Any packet with a destination IP address belonging to the 172.16.1.0/24, 172.16.2.0/24, or 172.16.3.0/24 network matches this summarized route.

Most Specific Match

It is possible that the destination IP address of a packet will match multiple routes in the routing table.

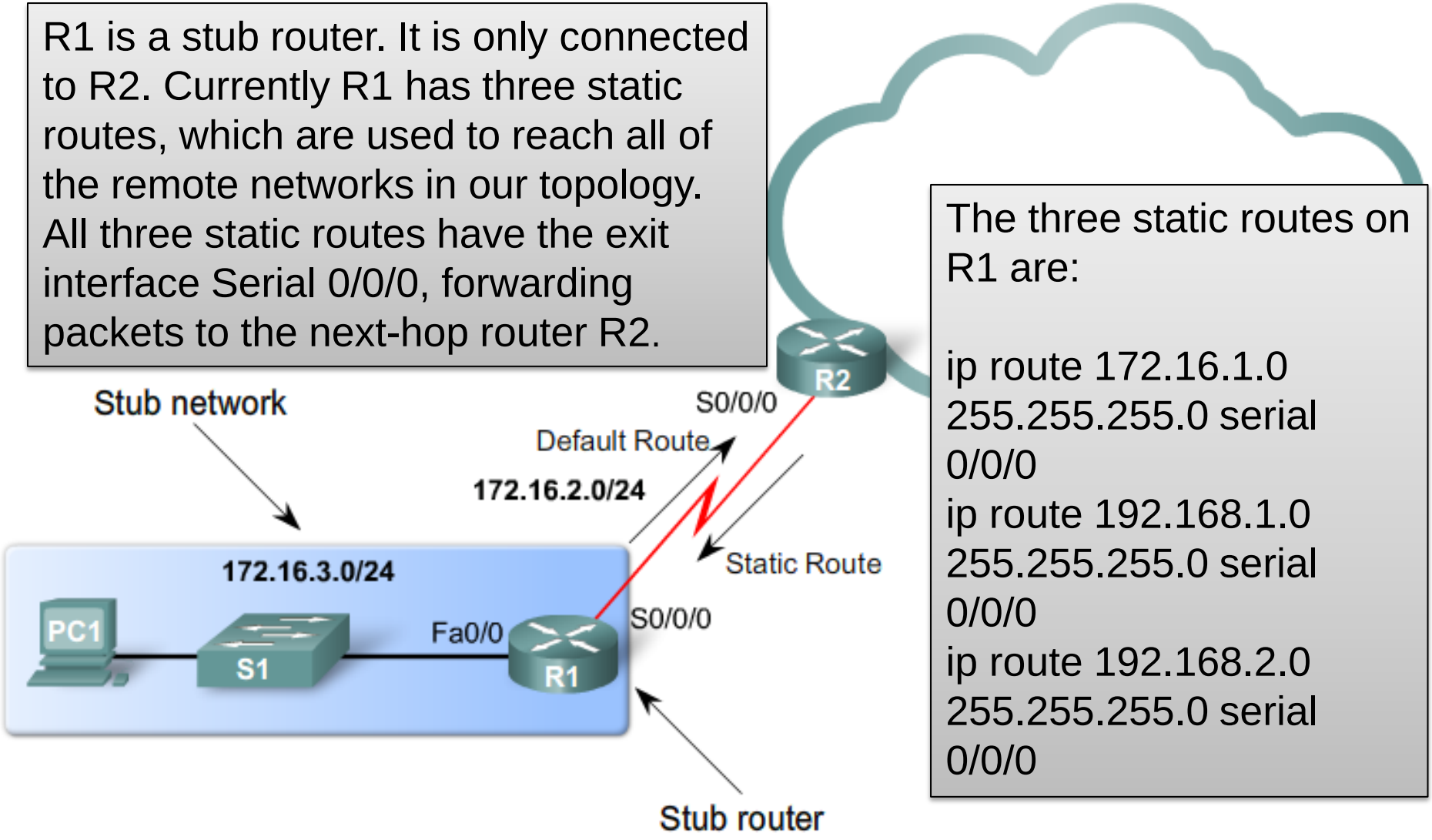
172.16.0.0/24 is subnetted, 3 subnets
S 172.16.1.0 is directly connected, Serial0/0/0 and
S 172.16.0.0/16 is directly connected, Serial0/0/1

A packet with the destination IP address 172.16.1.10. matches both routes.

The routing table lookup process will use the most-specific match. Because 24 bits match the 172.16.1.0/24 route, and only 16 bits of the 172.16.0.0/16 route match, the static route with the 24 bit match will be used. This is the longest match.

2.6.2 Default Static Route

R1 is a stub router. It is only connected to R2. Currently R1 has three static routes, which are used to reach all of the remote networks in our topology. All three static routes have the exit interface Serial 0/0/0, forwarding packets to the next-hop router R2.



The three static routes on R1 are:

ip route 172.16.1.0 255.255.255.0 serial 0/0/0
ip route 192.168.1.0 255.255.255.0 serial 0/0/0
ip route 192.168.2.0 255.255.255.0 serial 0/0/0

R1 is an ideal candidate to have all of its static routes replaced by a single default route. First, delete the three static routes:

2.6.2 Default Static Route

Configuring a Default Static Route

The syntax for a default static route is similar to any other static route, except that the network address is 0.0.0.0 and the subnet mask is 0.0.0.0:

Router(config)#ip route 0.0.0.0 0.0.0.0 [exit-interface | ip-address]

The 0.0.0.0 0.0.0.0 network address and mask is called a "quad-zero" route.

First, delete the three static routes:
R1(config)#no ip route 172.16.1.0 255.255.255.0 serial 0/0/0
R1(config)#no ip route 192.168.1.0 255.255.255.0 serial 0/0/0
R1(config)#no ip route 192.168.2.0 255.255.255.0 serial 0/0/0

Next, configure the single default static route using the same Serial 0/0/0 exit interface as the three previous static routes:

R1(config)#ip route 0.0.0.0 0.0.0.0 serial 0/0/0

2.6.2 Default Static Route

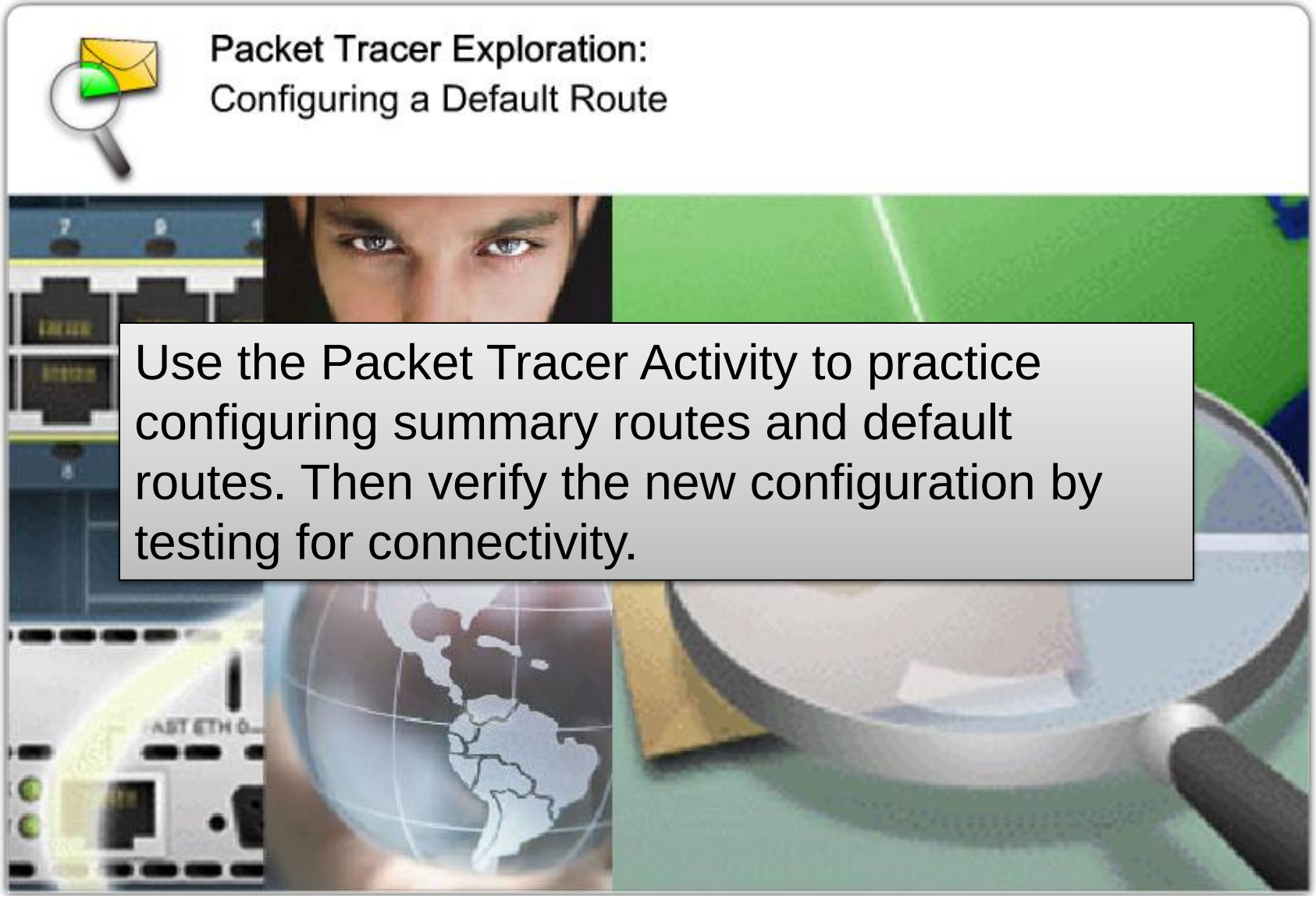
```
R1#show ip route
***output omitted***

Gateway of last resort is not set

 172.16.0.0/24 is subnetted, 3 subnets
S       172.16.1.0 is directly connected, Serial0/0/0
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
S    192.168.1.0/24 is directly connected, Serial0/0/0
S    192.168.2.0/24 is directly connected, Serial0/0/0
R1#
```

Before Summarizing Routes

```
R1#show ip route

       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

     172.16.0.0/24 is subnetted, 2 subnets
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
S*   0.0.0.0/0 is directly connected, Serial0/0/0
R1#
```

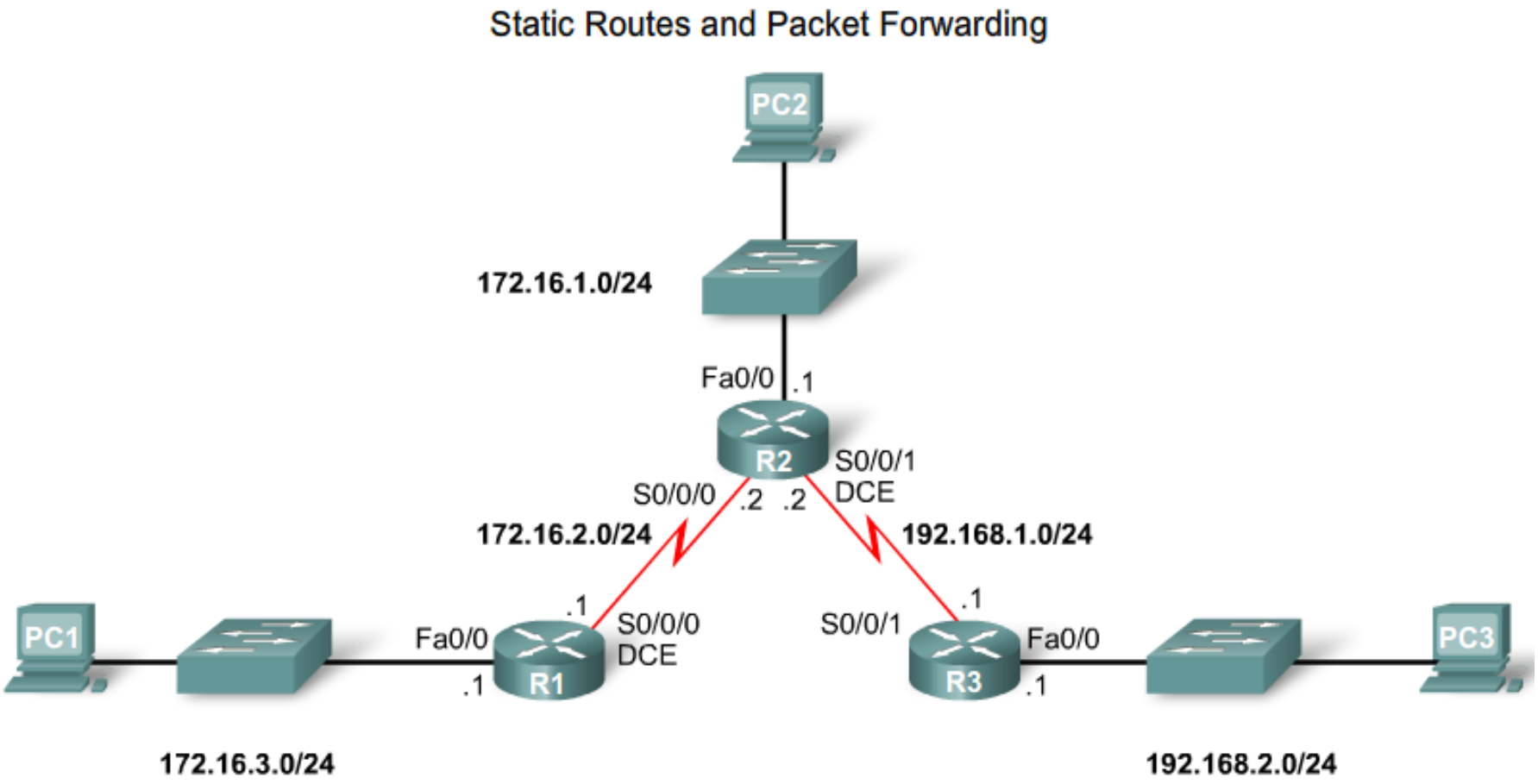
After Summarizing Routes

2.6.2 Default Static Route



2.7.1 Static Routes and Packet Forwarding

Follow the step by step 11 step sequence of events in the curriculum



2.7.2 Troubleshooting a Missing Route

Connectivity Troubleshooting Tools

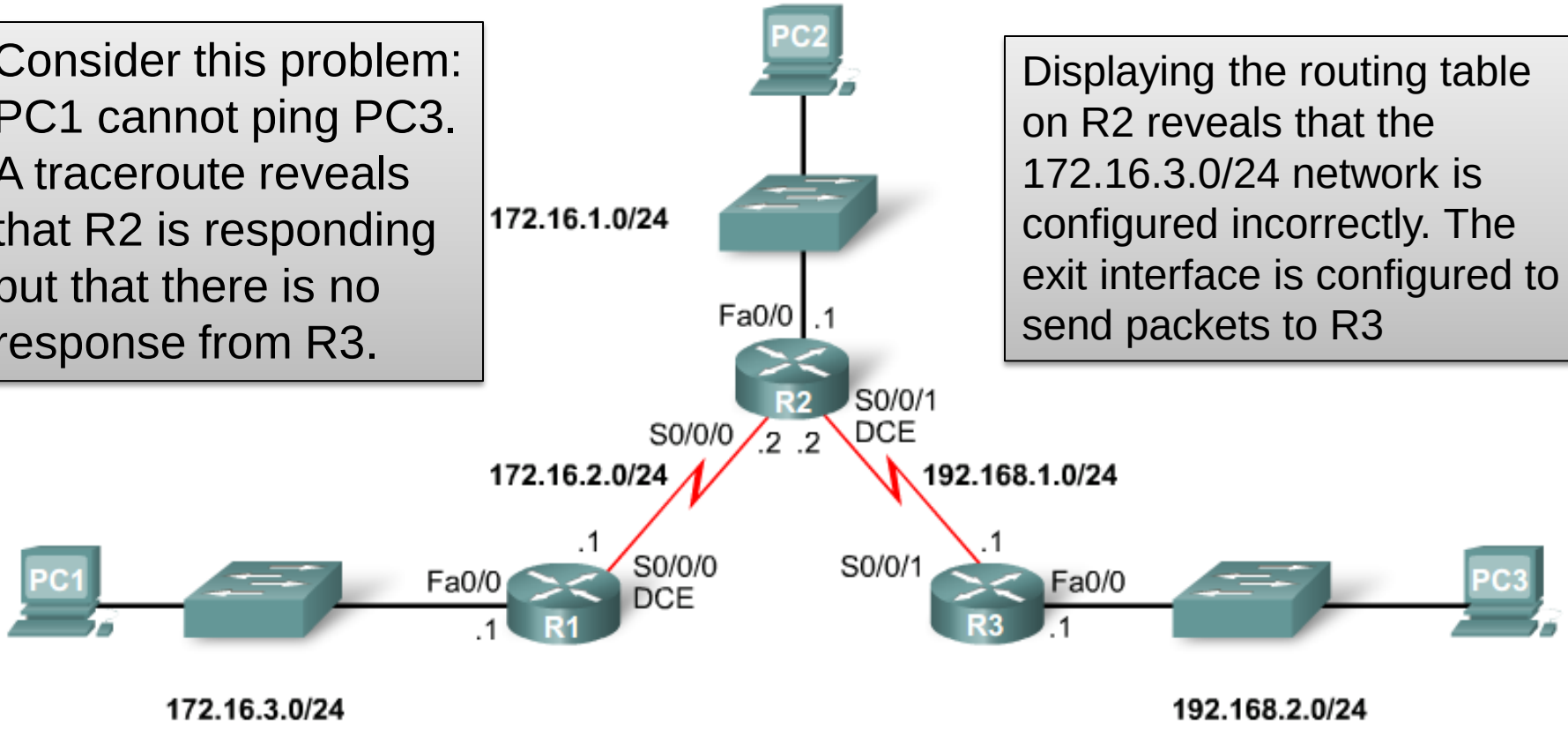
- **ping**
- **traceroute**
- **show ip route**
- **show ip interface brief**
- **show cdp neighbors detail**

```
R2#show ip route


Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 3 subnets
C       172.16.1.0 is directly connected, FastEthernet0/0
C       172.16.2.0 is directly connected, Serial0/0/0
S       172.16.3.0 is directly connected, Serial0/0/1
C    192.168.1.0/24 is directly connected, Serial0/0/1
S*   0.0.0.0/0 is directly connected, Serial0/0/1
```

Misconfigured route to 172.16.3.0/24

2.7.3 Solving the Missing Route

Consider this problem: PC1 cannot ping PC3. A traceroute reveals that R2 is responding but that there is no response from R3.



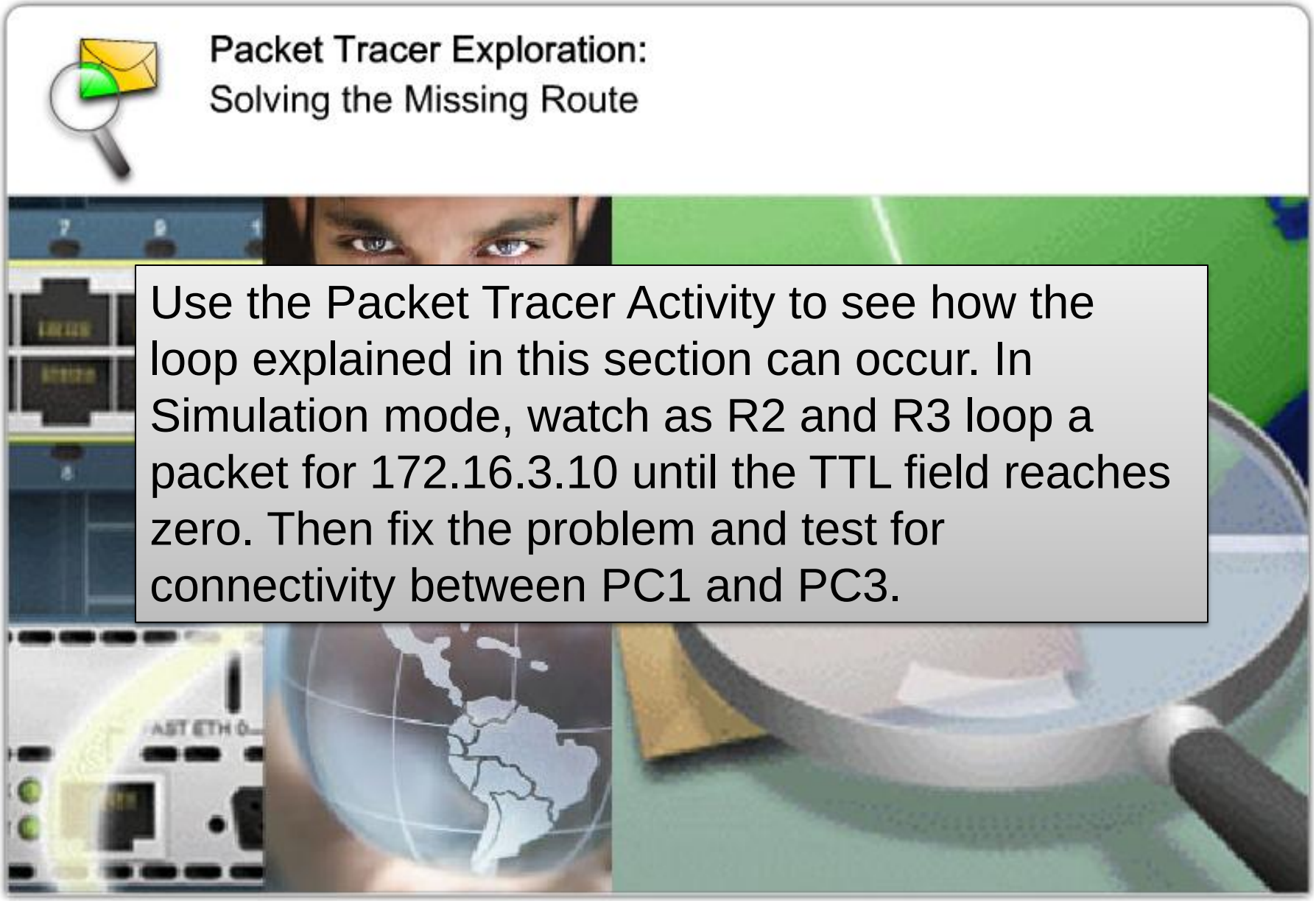
Displaying the routing table on R2 reveals that the 172.16.3.0/24 network is configured incorrectly. The exit interface is configured to send packets to R3

Obviously, from the topology, we can see that R1 has the 172.16.3.0/24 network. Therefore, R2 must use Serial 0/0/0 as the exit interface - not Serial0/0/1

To remedy the situation, remove the incorrect route and add the route for network 172.16.3.0/24 with the Serial 0/0/0 specified as the exit interface.

```
R2(config)#no ip route 172.16.3.0 255.255.255.0 serial0/0/1
R2(config)#ip route 172.16.3.0 255.255.255.0 serial 0/0/0
```

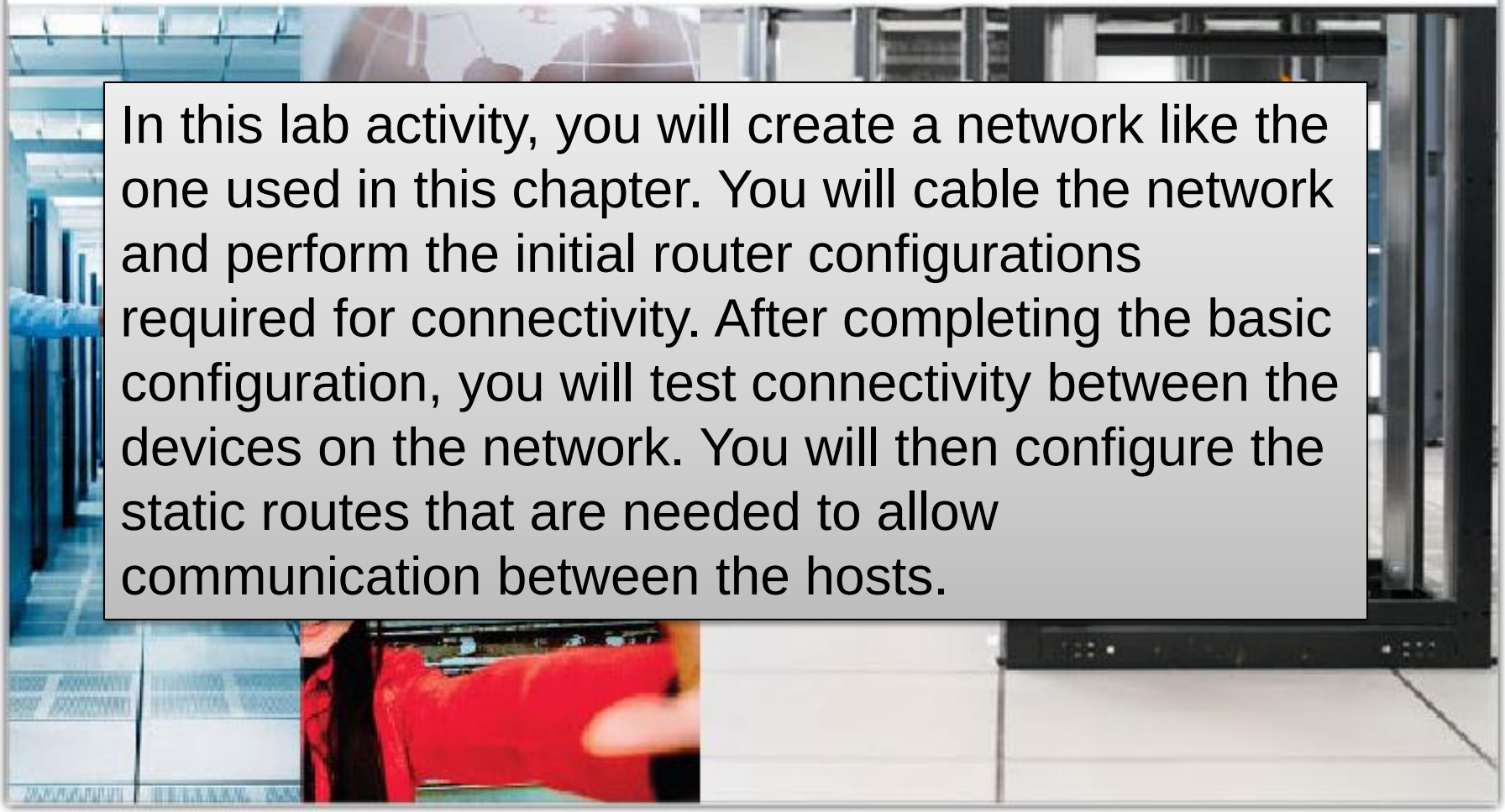
2.7.3 Solving the Missing Route



2.8.1 Basic Static Route Configuration

Hands-on Lab:

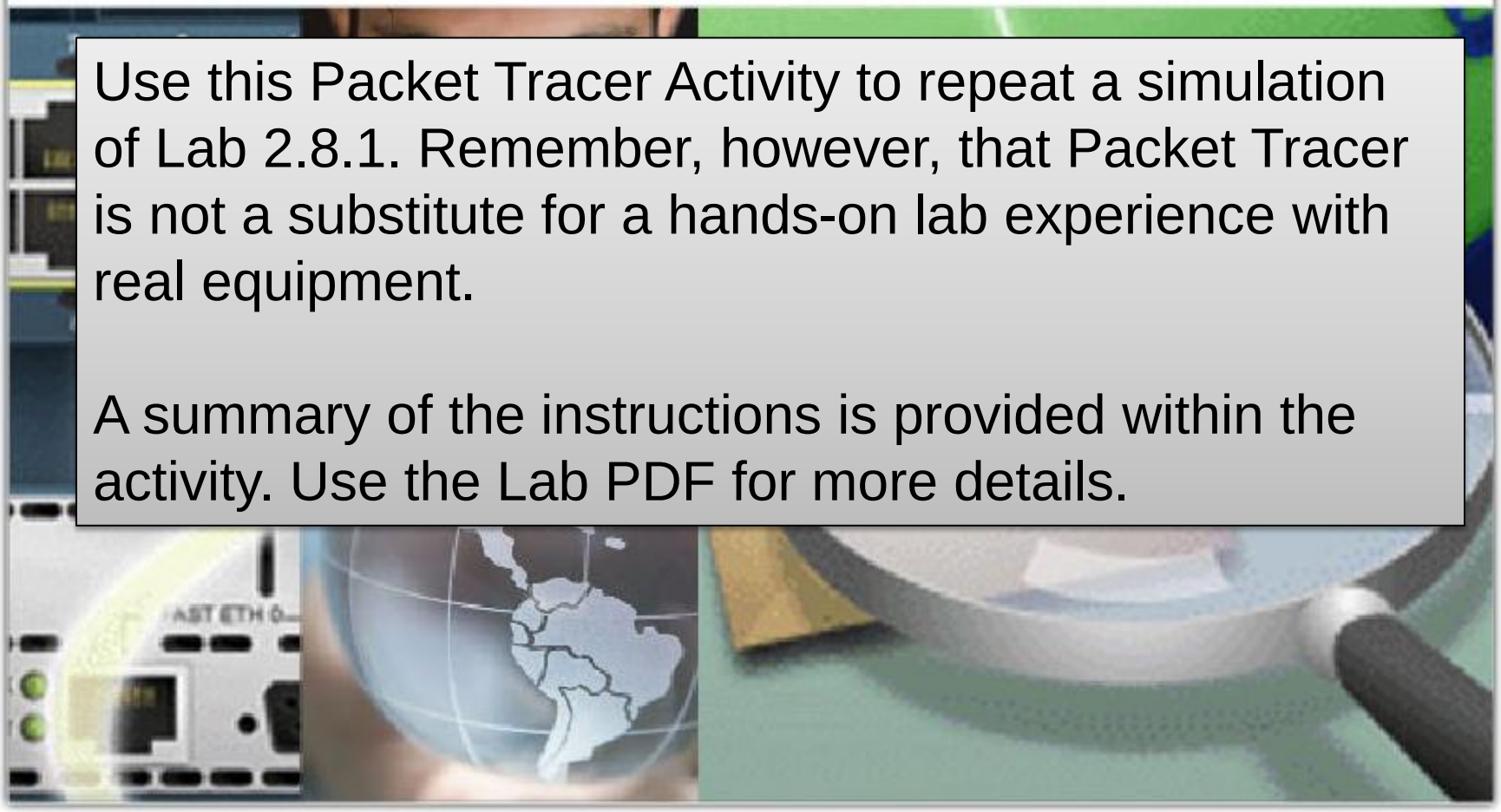
Basic Static Route Configuration



In this lab activity, you will create a network like the one used in this chapter. You will cable the network and perform the initial router configurations required for connectivity. After completing the basic configuration, you will test connectivity between the devices on the network. You will then configure the static routes that are needed to allow communication between the hosts.

2.8.1 Basic Static Route Configuration

Packet Tracer Exploration:
Basic Static Route Configuration

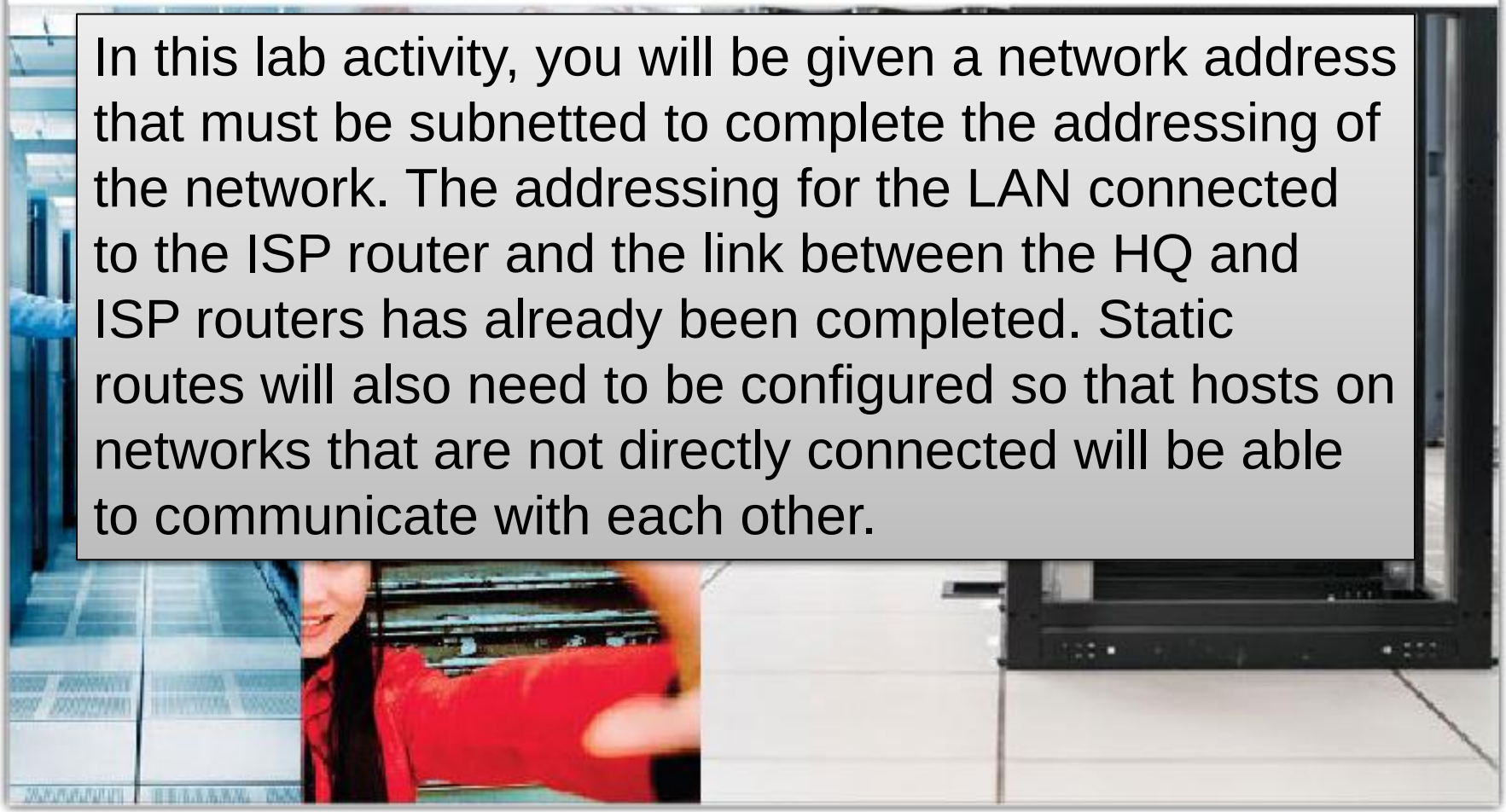


Use this Packet Tracer Activity to repeat a simulation of Lab 2.8.1. Remember, however, that Packet Tracer is not a substitute for a hands-on lab experience with real equipment.

A summary of the instructions is provided within the activity. Use the Lab PDF for more details.

2.8.2 Challenge Static Route Configuration

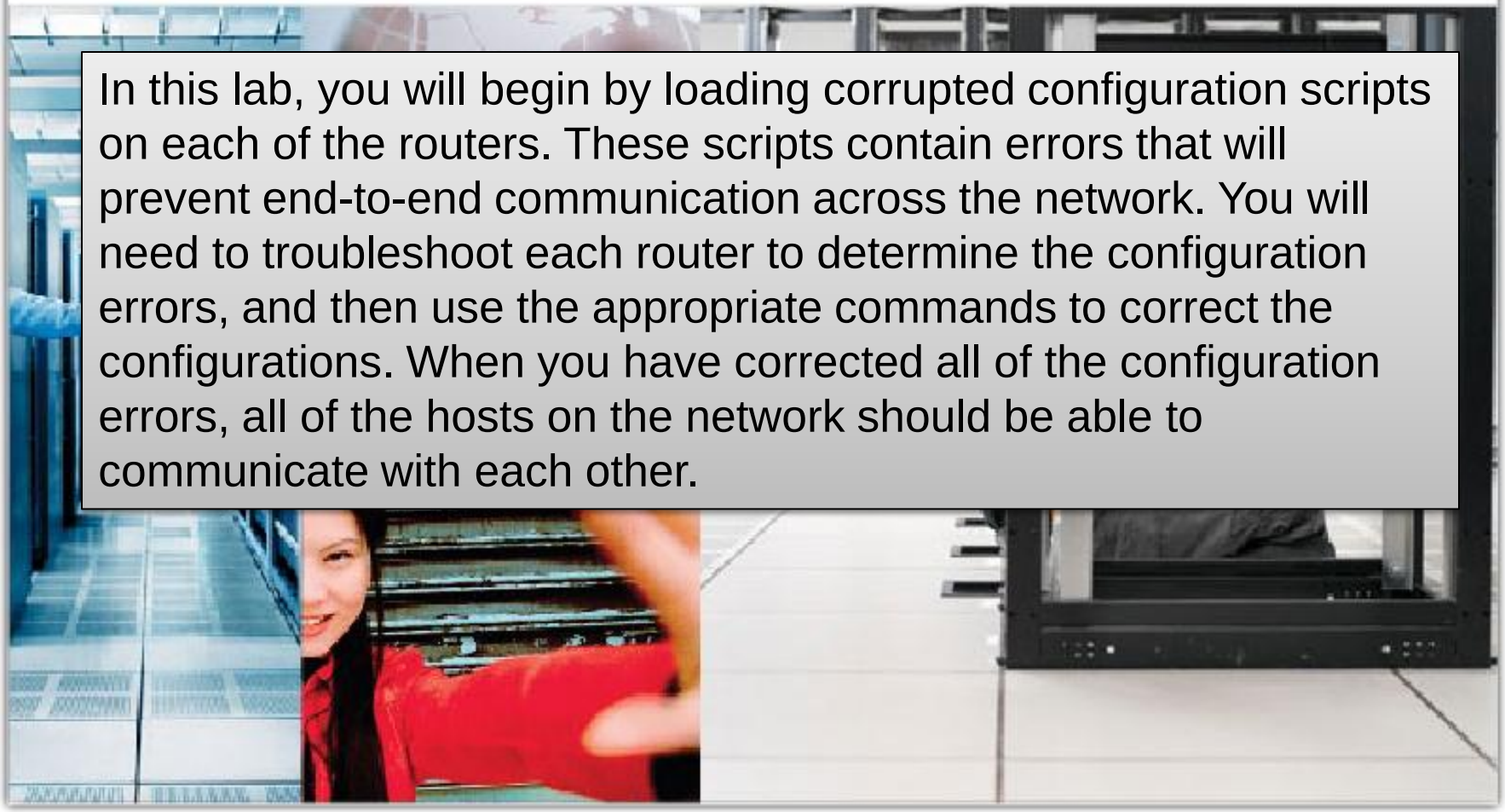
Hands-on Lab:
Challenge Static Route Configuration



In this lab activity, you will be given a network address that must be subnetted to complete the addressing of the network. The addressing for the LAN connected to the ISP router and the link between the HQ and ISP routers has already been completed. Static routes will also need to be configured so that hosts on networks that are not directly connected will be able to communicate with each other.

2.8.3 Troubleshooting Static Routes

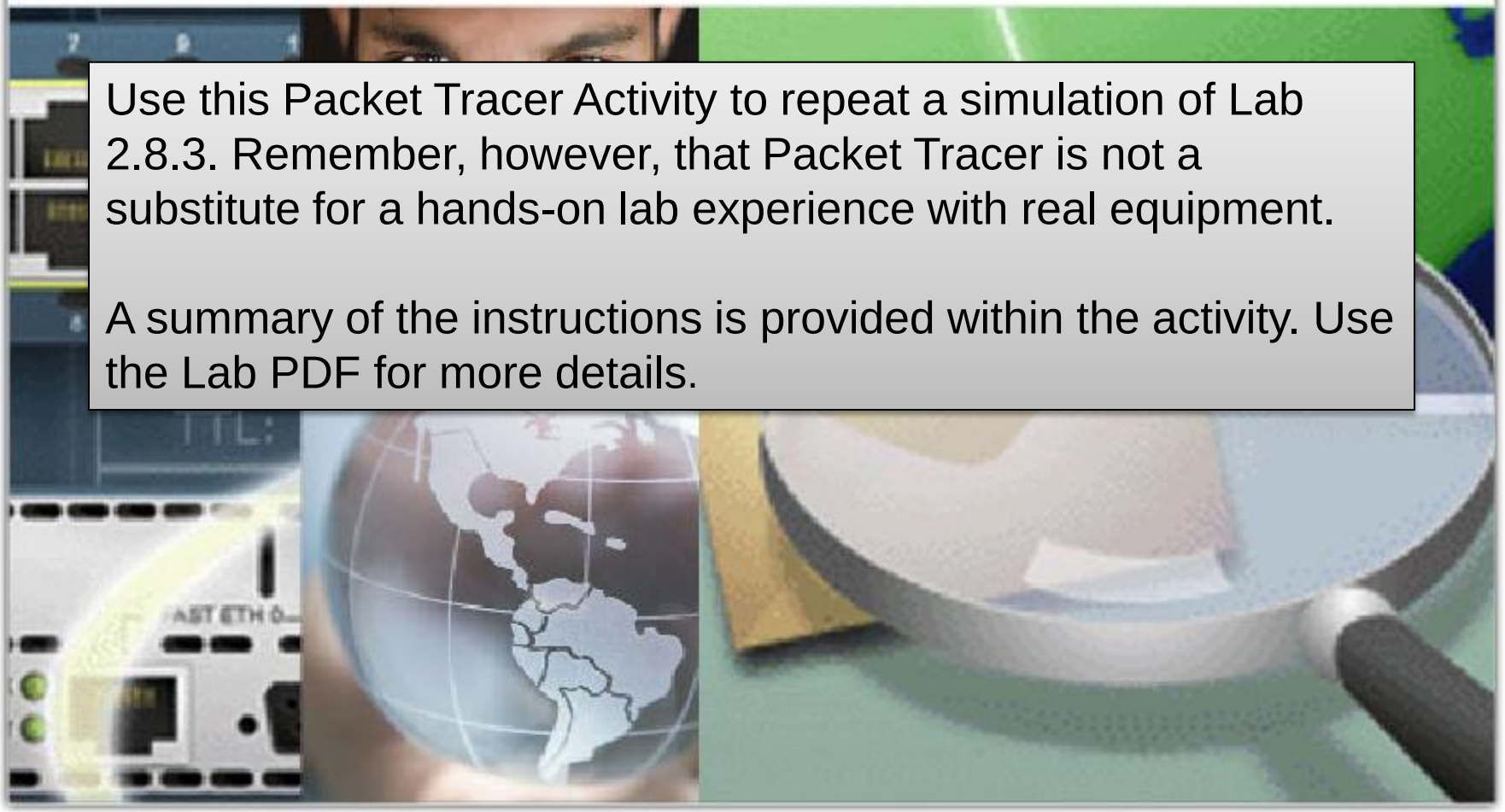
Hands-on Lab:
Troubleshooting Static Routes



In this lab, you will begin by loading corrupted configuration scripts on each of the routers. These scripts contain errors that will prevent end-to-end communication across the network. You will need to troubleshoot each router to determine the configuration errors, and then use the appropriate commands to correct the configurations. When you have corrected all of the configuration errors, all of the hosts on the network should be able to communicate with each other.

2.8.3 Troubleshooting Static Routes

Packet Tracer Exploration:
Troubleshooting Static Routes



Use this Packet Tracer Activity to repeat a simulation of Lab 2.8.3. Remember, however, that Packet Tracer is not a substitute for a hands-on lab experience with real equipment.

A summary of the instructions is provided within the activity. Use the Lab PDF for more details.

2.9.1 summary

In this chapter, you have learned to:

- Define the general role a router plays in networks.
- Describe the directly connected networks and the different router interfaces.
- Examine directly connected networks in the routing table and use the CDP protocol.
- Describe static routes with exit interfaces.
- Describe summary and default route.
- Examine how packets get forwarded when using static routes.
- Identify how to manage and troubleshoot static routes.