1.0.1 CHAPTER INTRODUCTION

1841 Integrated Services Router

In this chapter, you will learn to:

- Identify a router as a computer with an operating system (OS) and hardware designed for the routing process.
- Demonstrate the ability to configure devices and apply addresses.
- Describe the structure of a routing table.
- Describe how a router determines a path and switches packets.

1.1.1 ROUTERS ARE COMPUTERS

Sample Router Output

```
R1# show ip route
Codes: C - connected, S - static, I - IGR
       D - EIGRP, EX - EIGRP external, O
       N1 - OSPF NSSA external type 1, N2
       E1 - OSPF external type 1, E2 - OS
       i - IS-IS, L1 - IS-IS level-1, L2
       * - candidate default, U - per-use
       R - periodic downloaded static rou
```

Routers have many of the same hardware and software components that are found in other computers including:

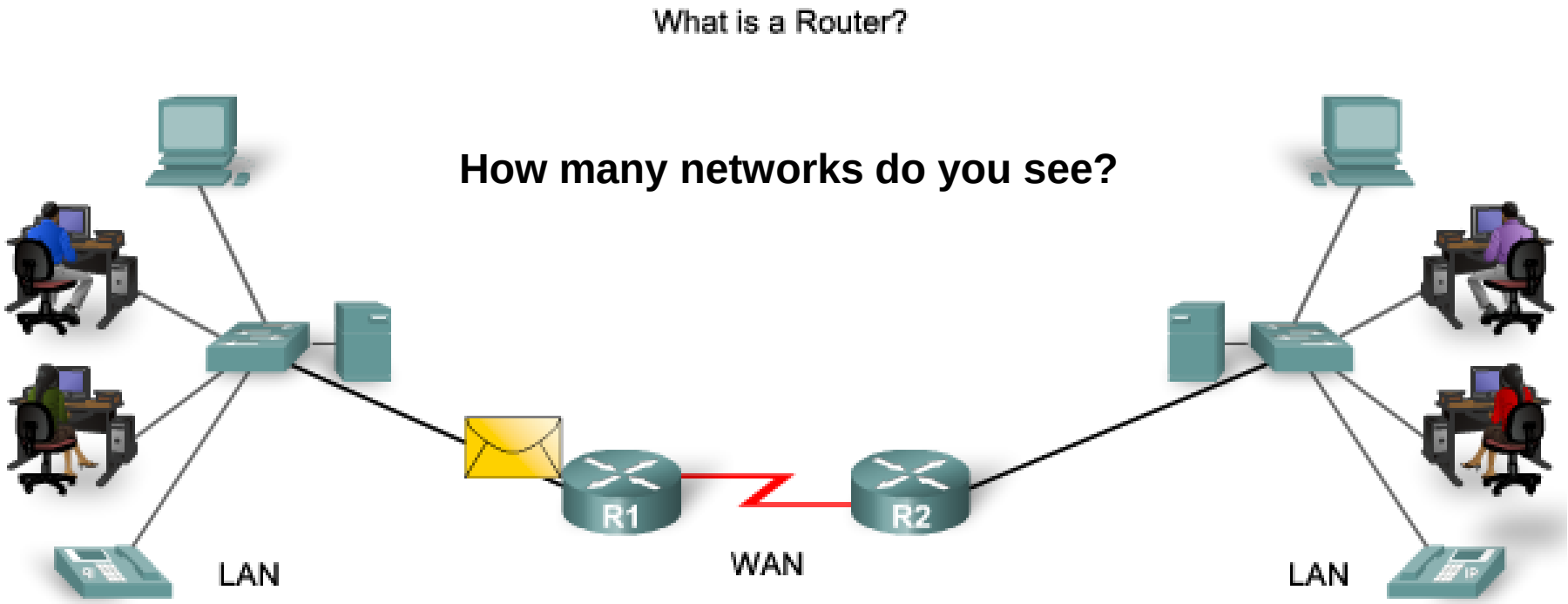
CPU

RAM

ROM

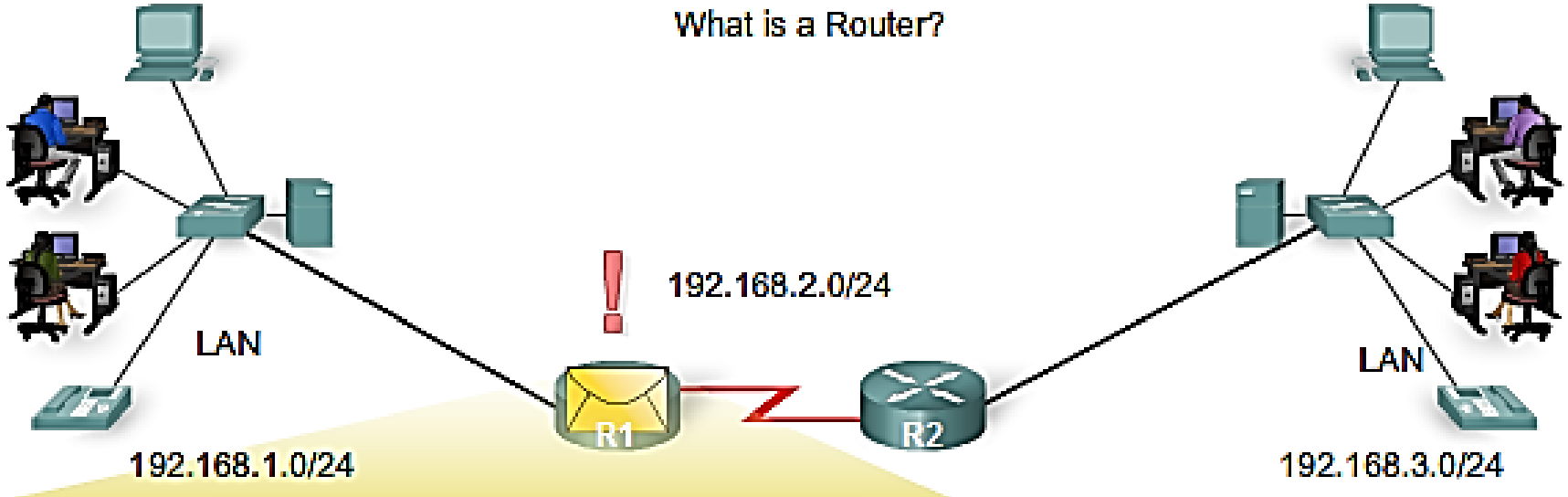
Operating System

1.1.1 ROUTERS ARE COMPUTERS



- ROUTERS CONNECT NETWORKS
- EACH PORT ON A ROUTER REQUIRES ITS OWN IP ADDRESS

1.1.1 ROUTERS ARE COMPUTERS



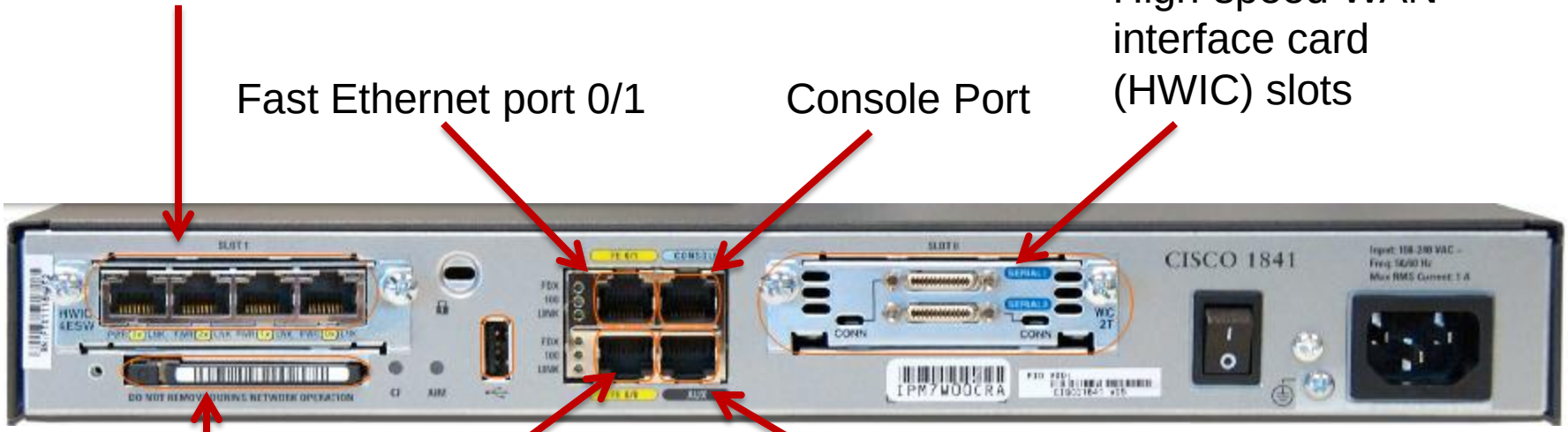

```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       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

C    192.168.1.0/24 is directly connected, FastEthernet0/0
C    192.168.2.0/24 is directly connected, Serial0/0/0
S    192.168.3.0/24 is directly connected, Serial0/0/0
```

Routers use the routing table like a map to discover the best path for a given address.

1.1.1 ROUTERS ARE COMPUTERS



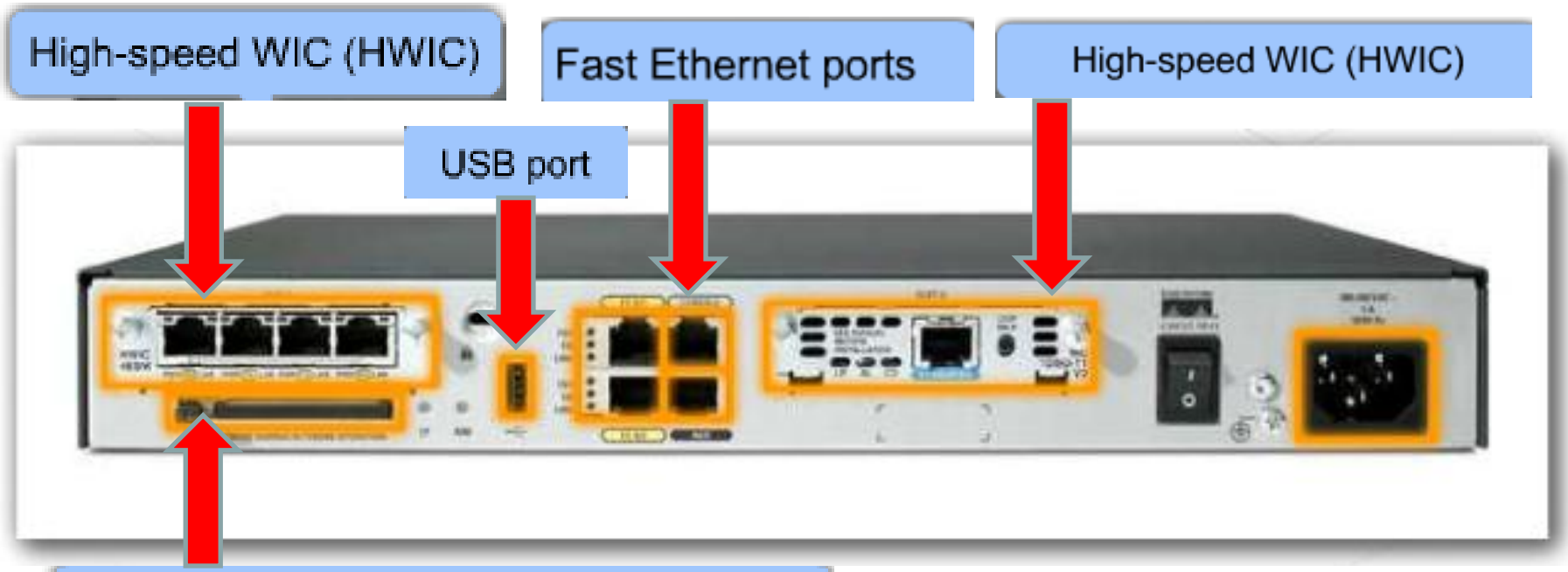
1.1.1 ROUTERS ARE COMPUTERS

Packet Tracer Exploration:
Corporate Network Simulation

This Packet Tracer Activity shows a complex network of routers with many different technologies. Be sure to view the activity in Simulation Mode so that you can see the traffic traveling from multiple sources to multiple destinations over various types of media. Please be patient as this complex topology may take some time to load.

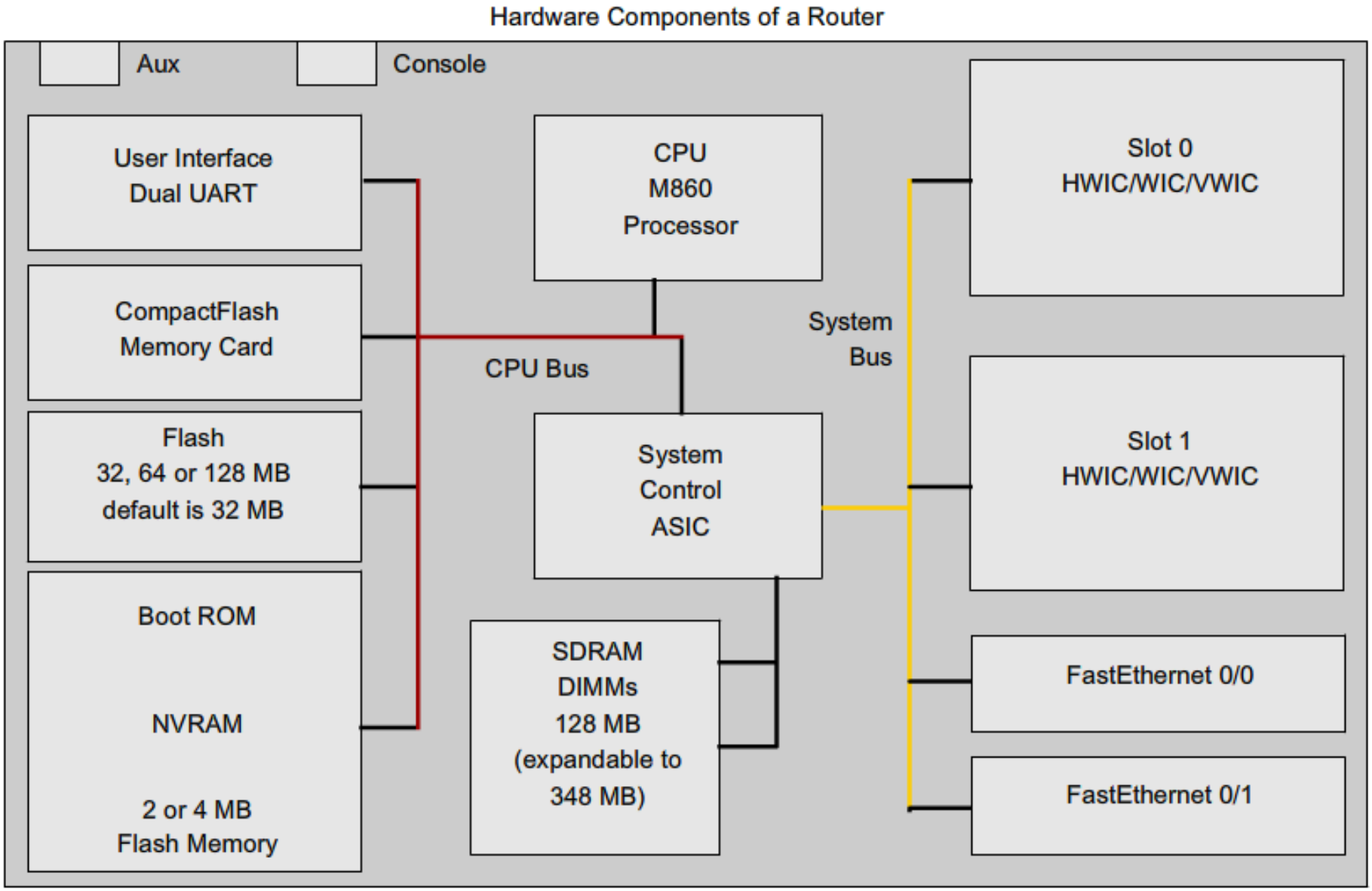
1.1.2 ROUTER CPU AND MEMORY

WAN interface cards (WIC)



Flash memory used for storing the software image, configuration files, and log files. Flash memory for the 1841 is implemented in an external CompactFlash memory card.

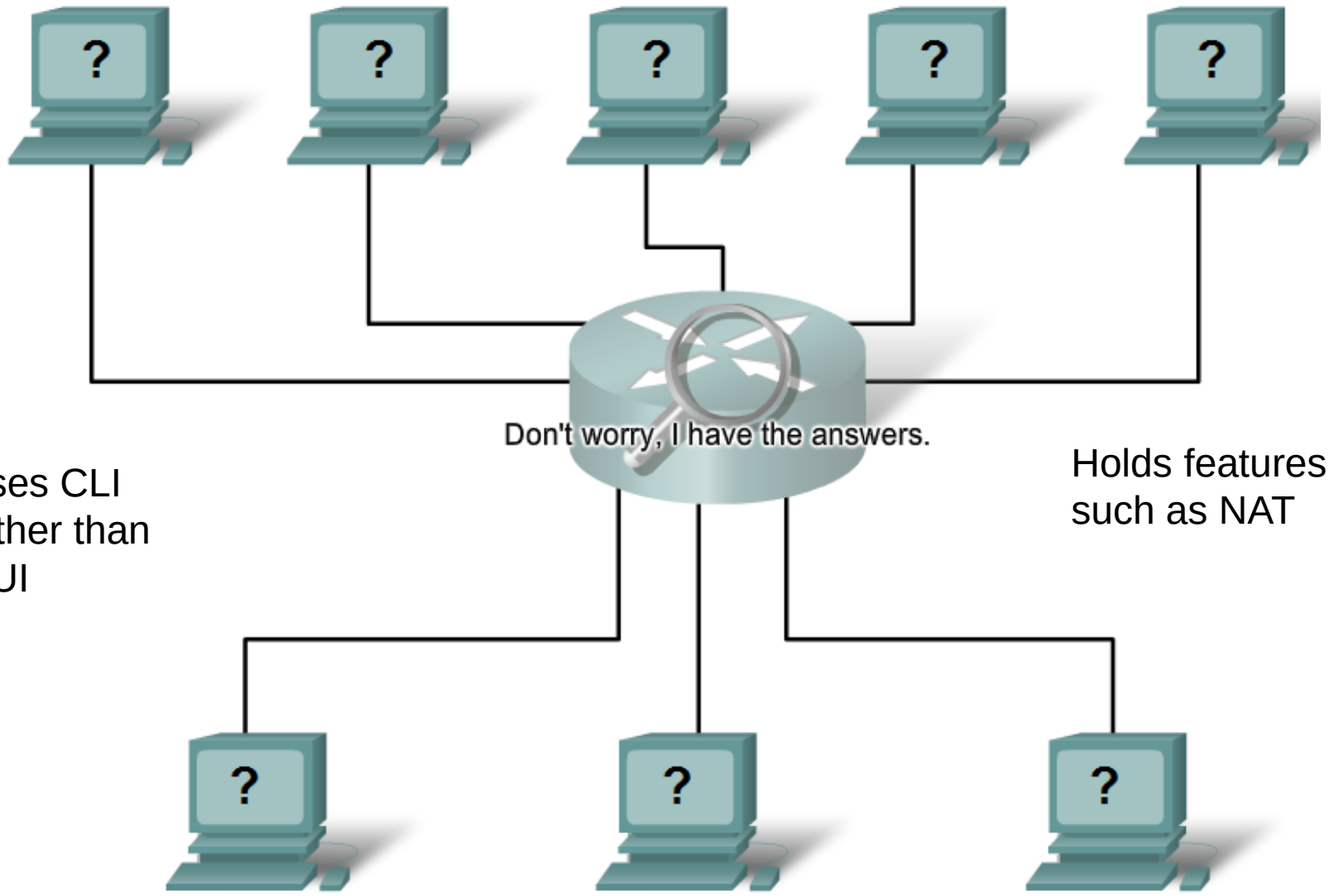
1.1.2 ROUTER CPU AND MEMORY



Logical diagram of the Internal Components of a Cisco 1841 router

Roll over the components to see a brief description.

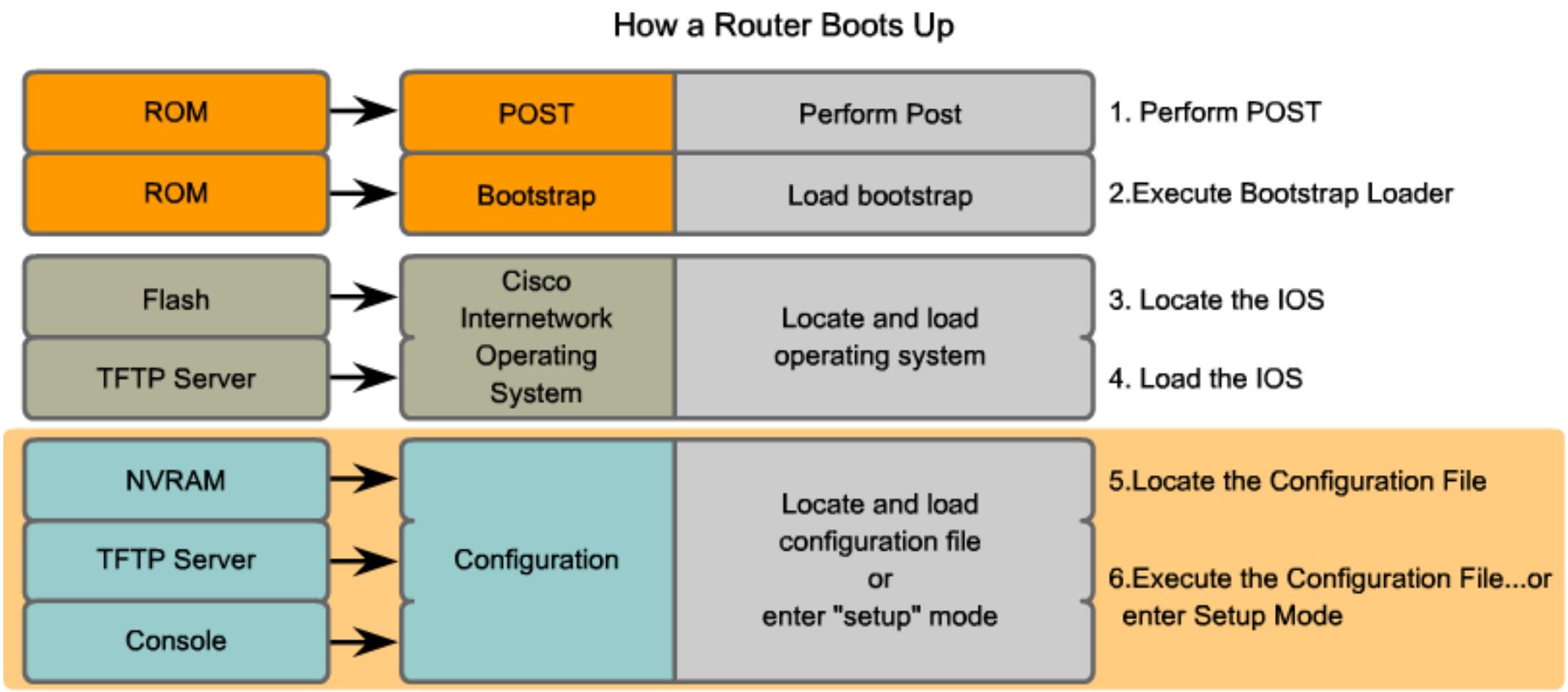
1.1.3 Internetwork Operating System



Uses CLI rather than GUI

Holds features such as NAT

1.1.4 Router Boot-Up Process

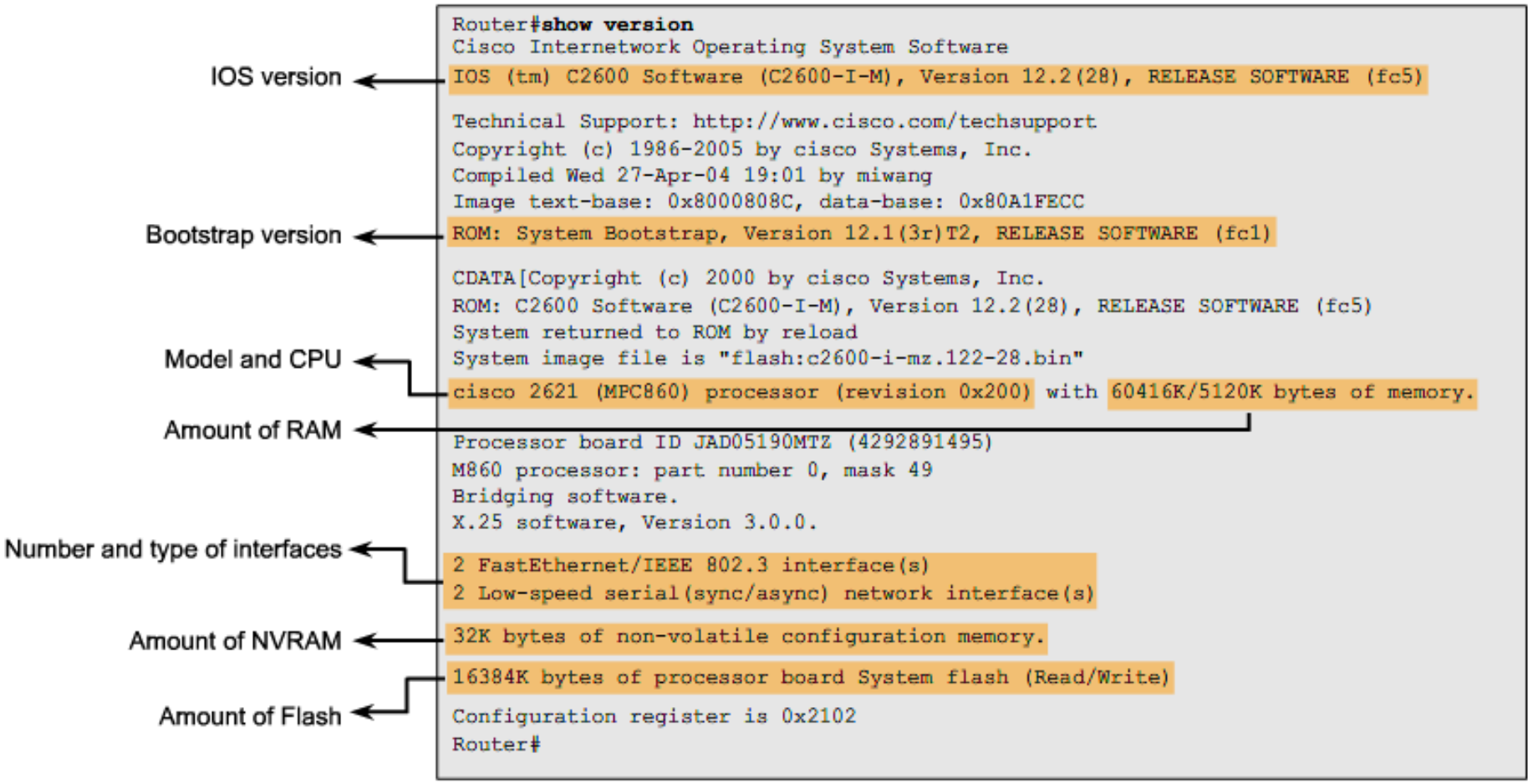


Note: A TFTP server is usually used as a backup server for IOS but it can also be used as a central point for storing and loading the IOS. IOS management and using the TFTP server is discussed in a later course.

Loading the IOS. Some of the older Cisco routers ran the IOS directly from flash, but current models copy the IOS into RAM for execution by the CPU.

1.1.4 Router Boot-Up Process

How a Router Boots Up



1.1.4 Router Boot-Up Process

Packet Tracer Exploration:
Using Setup Mode

Use this Packet Tracer Activity to experience setup mode and investigate the show running-configuration command.

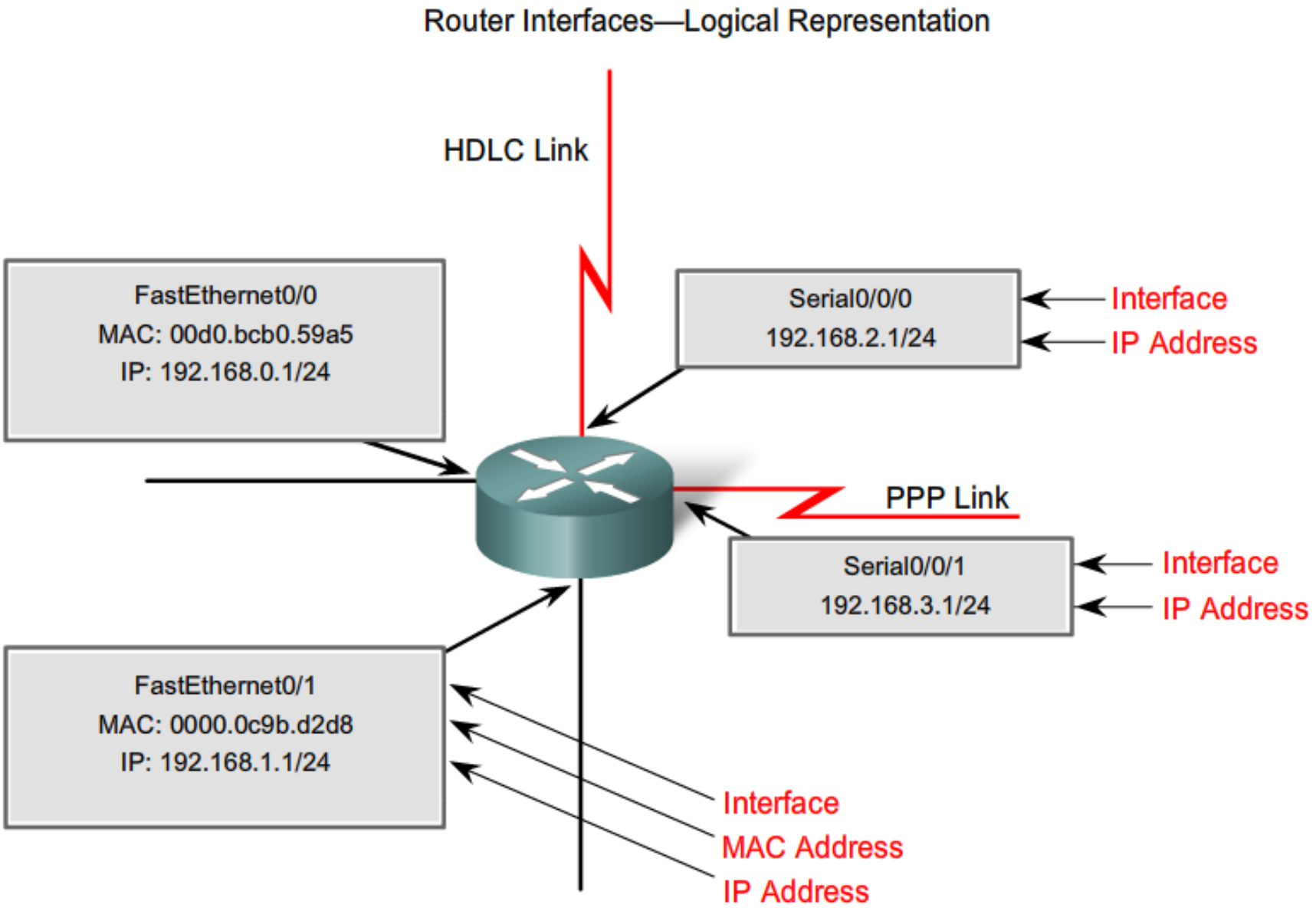
1.1.5 Router Interfaces

Router Interfaces - Physical Representation

Each individual interface connects to a different network. Thus each interface has an IP address/mask from that network.

Each individual LAN and WAN interface connects to a different network and has an IP address and subnet mask

1.1.5 Router Interfaces



1.1.5 Router Interfaces

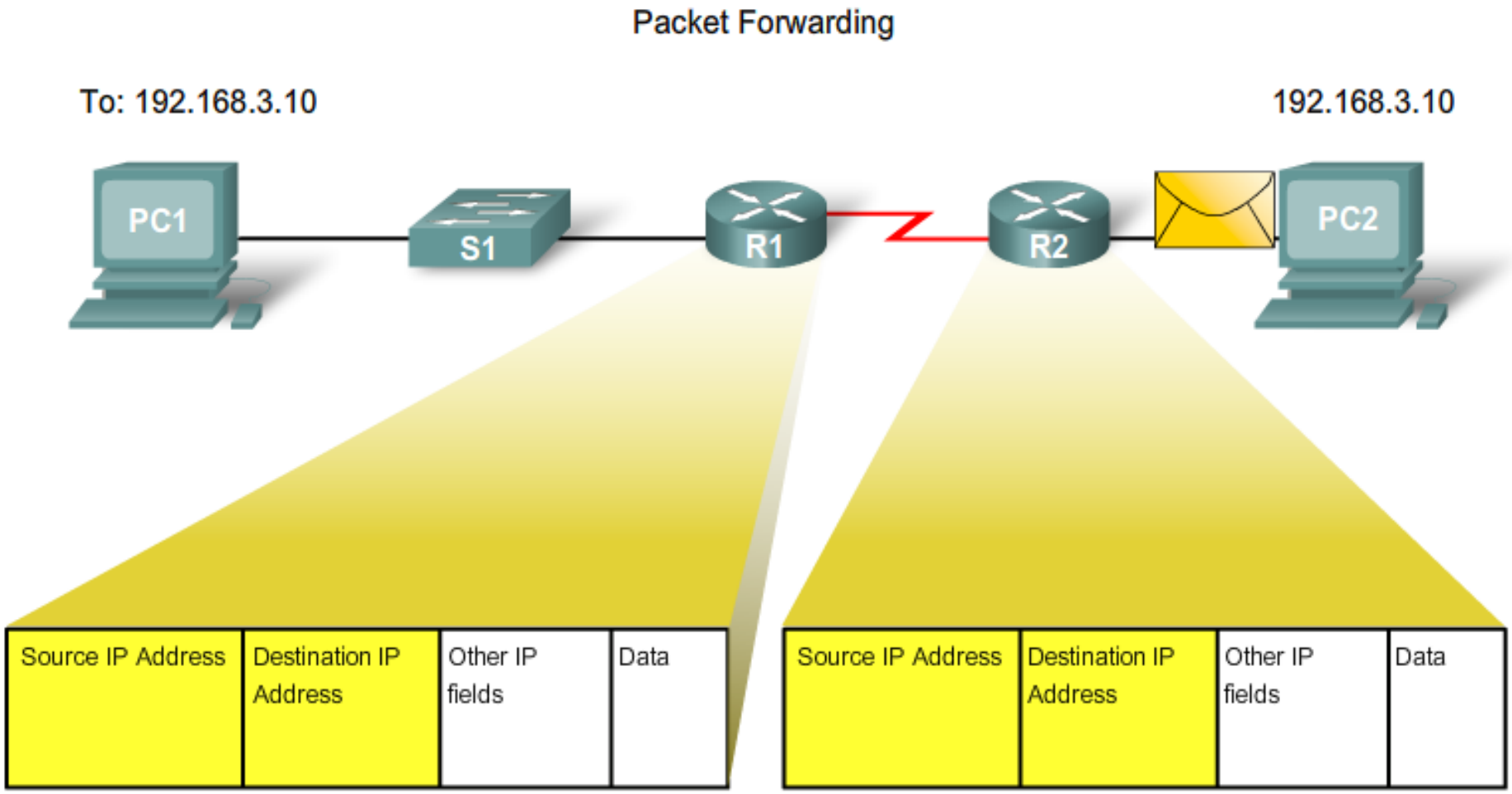
Packet Tracer Exploration:
Cabling Devices

Use the Packet Tracer Activity to practice selecting the correct cable to connect devices

Packet Tracer Exploration:
Using Packet Tracer Device Tabs

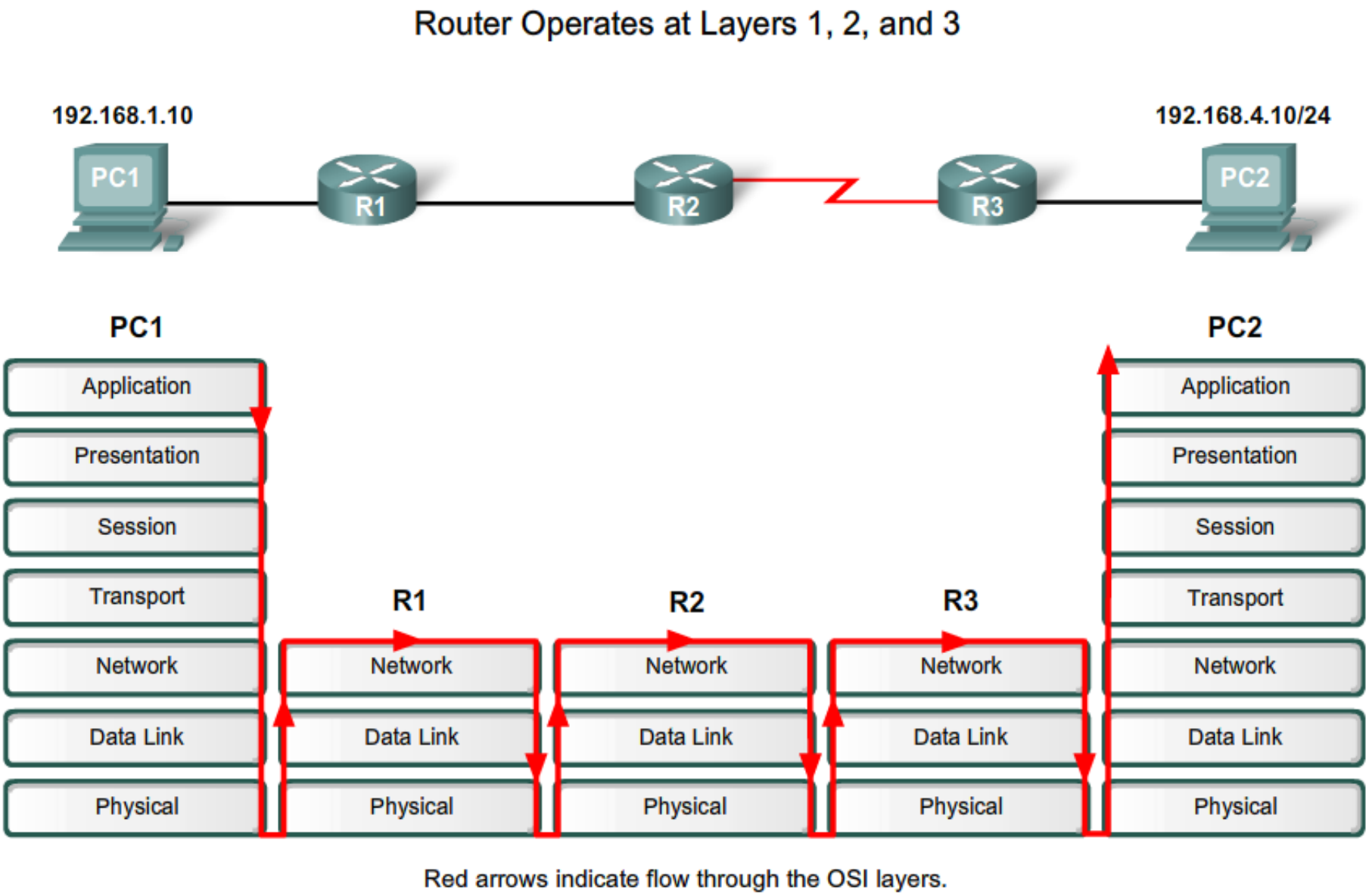
Use the Packet Tracer Activity to explore using the Physical, Config, and CLI tabs for a router.

1.1.6 Routers and the Network Layer



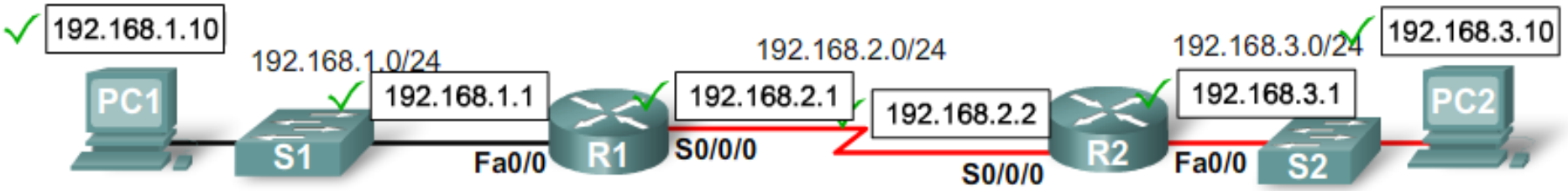
Each router examines the destination IP address to correctly forward the packet.

1.1.6 Routers and the Network Layer



1.2.1 Implementing Basic Addressing Schemes

Documenting an Addressing Scheme



Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	Fa0/0	192.168.1.1	255.255.255.0	N/A
	S0/0/0	192.168.2.1	255.255.255.0	N/A
R2	Fa0/0	192.168.3.1	255.255.255.0	N/A
	S0/0/0	192.168.2.2	255.255.255.0	N/A
PC1	N/A	192.168.1.10	255.255.255.0	192.168.1.1
PC2	N/A	192.168.3.10	255.255.255.0	192.168.3.1

Packet Tracer Exploration:
Connecting and Identifying Devices

Use the Packet Tracer Activity to connect the devices. Configure the device names to match the figure and use the Place Note feature to add network address labels.

1.2.2 Basic Router Configuration

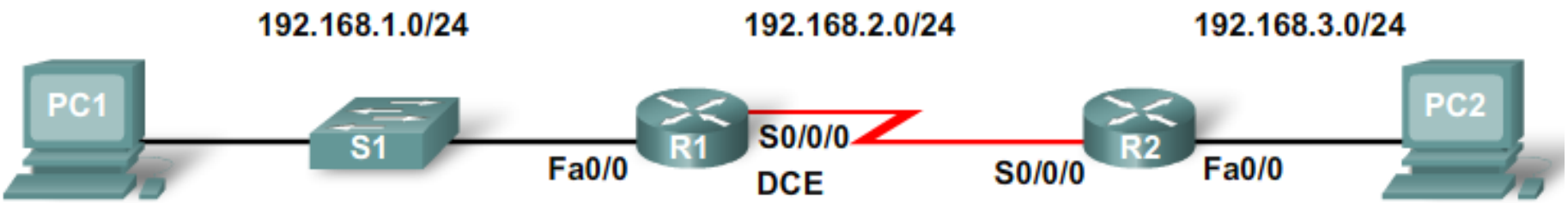
Configuring Basic Router Parameters

Basic Router Configuration Command Syntax	
Naming the router	`Router(config)#hostname name`
Setting Passwords	`Router(config)#enable secret password`
	`Router(config)#line console 0`
	`Router(config-line)#password password`
	`Router(config-line)#login`
	`Router(config)#line vty 0 4`
	`Router(config-line)#password password`
	`Router(config-line)#login`
Configuring a message-of-the-day banner	`Router(config)#banner motd # message #`

1.2.2 Basic Router Configuration

Basic Router Configuration Command Syntax	
Configuring an interface	`Router(config)#interface type number`
	`Router(config-if)#ip address address mask`
	`Router(config-if)#description description`
	`Router(config-if)#no shutdown`
Saving changes on a router	`Router#copy running-config startup-config`
Examining the output of **show** commands	`Router#show running-config`
	`Router#show ip route`
	`Router#show ip interface brief`
	`Router#show interfaces`

1.2.2 Basic Router Configuration




```
R1#show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/0        192.168.1.1     YES manual up                    up
FastEthernet0/1        unassigned      YES manual administratively down down
Serial0/0/0            192.168.2.1     YES manual up                    up
Serial0/0/1            unassigned      YES manual administratively down down
Vlan1                  unassigned      YES manual administratively down down
```

show running-config | show interfaces | show ip route

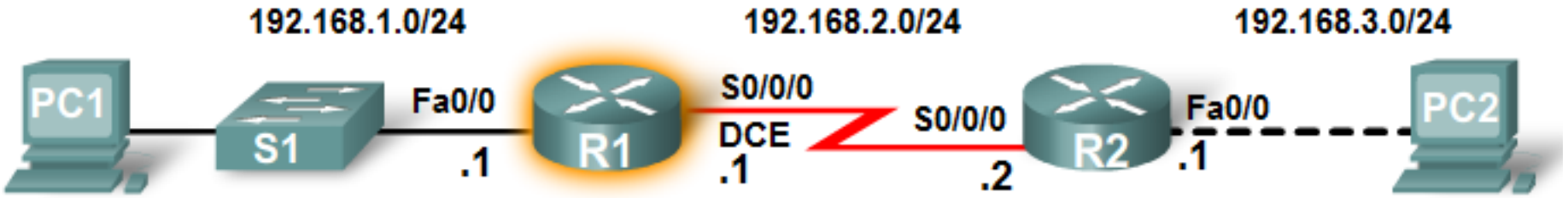
show startup-config | **show ip interface brief**

1.2.2 Basic Router Configuration

Packet Tracer Exploration:
Configure and Verify R1

Use the Packet Tracer Activity to practice basic router configuration and verification commands.

1.3.1 Introducing the Routing Table



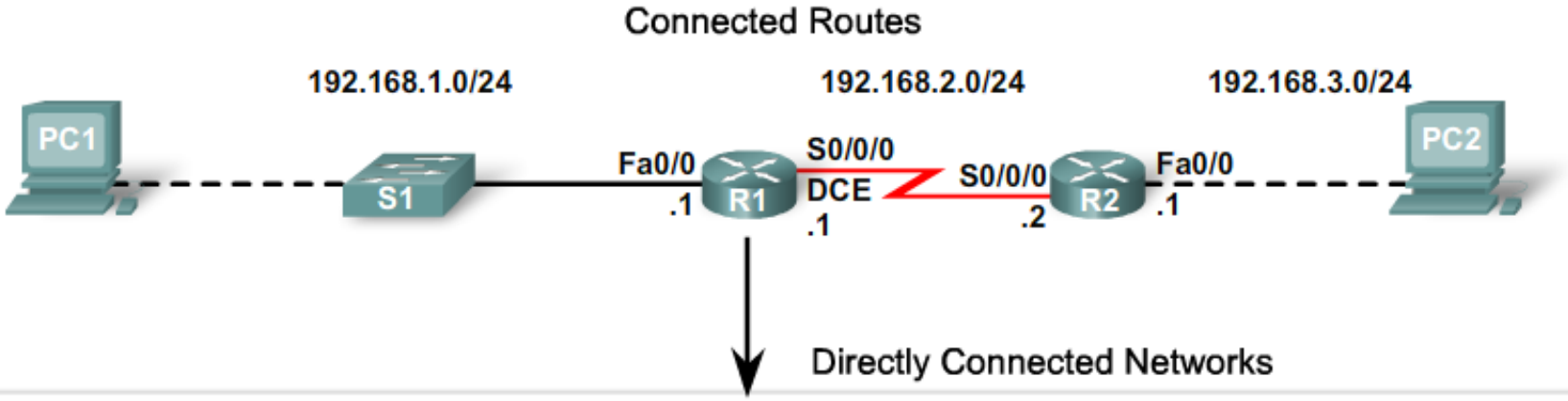

```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       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

C    192.168.1.0/24 is directly connected, FastEthernet0/0
C    192.168.2.0/24 is directly connected, Serial0/0/0
```

Source: Connected Routes

1.3.2 Directly Connected Networks

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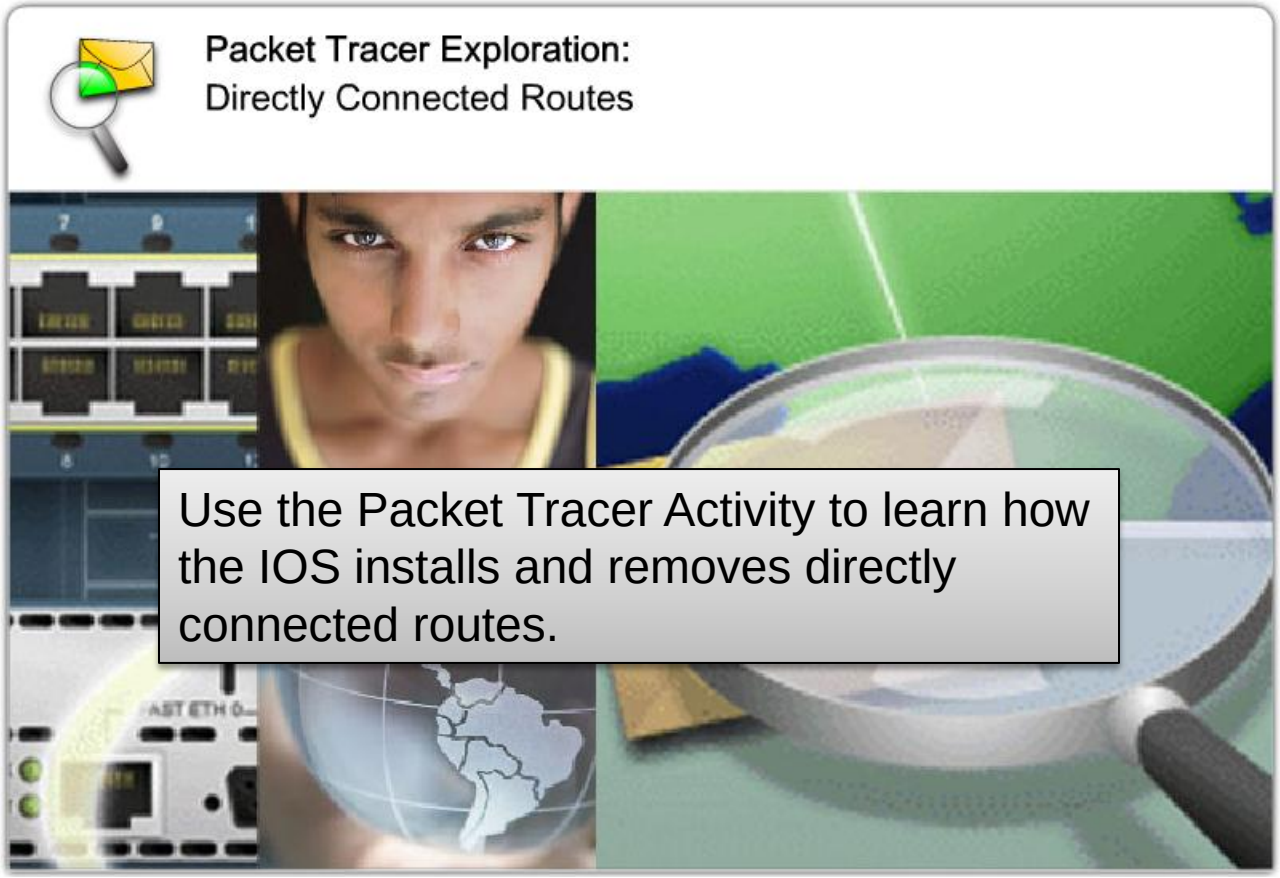
```

1.3.2 Directly Connected Networks



1.3.3 Static Routing

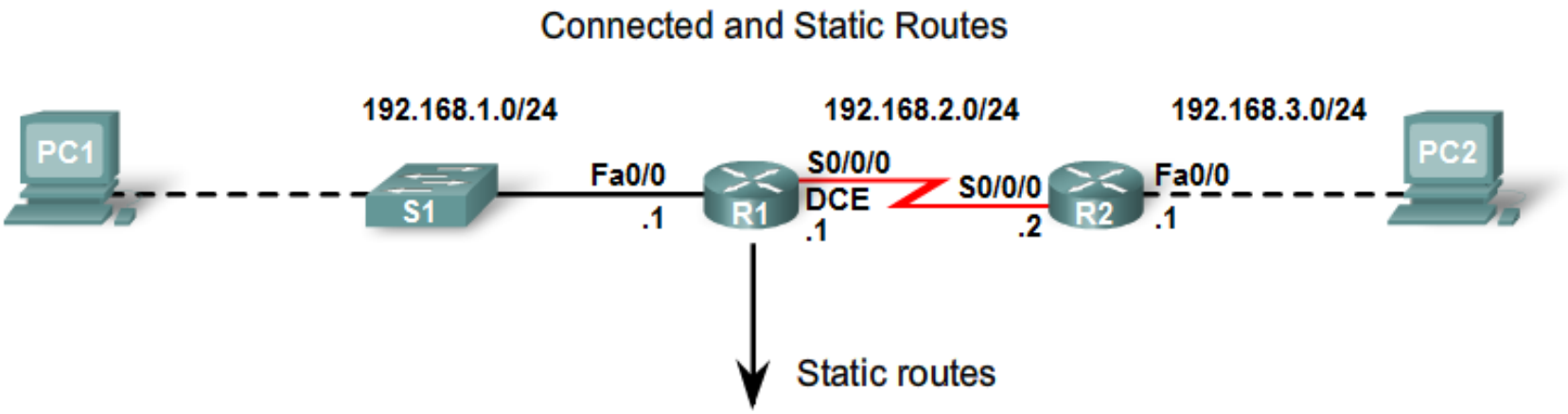
A static route includes the network address and subnet mask of the remote network, along with the IP address of the next-hop router or exit interface.

When to Use Static Routes

Static routes should be used in the following cases:

- A network consists of only a few routers.
- A network is connected to the Internet only through a single ISP.
- A large network is configured in a hub-and-spoke topology.

1.3.3 Static Routing

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       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

C    192.168.1.0/24 is directly connected, FastEthernet0/0
C    192.168.2.0/24 is directly connected, Serial0/0/0
S    192.168.3.0/24 [1/0] via 192.168.2.2
```
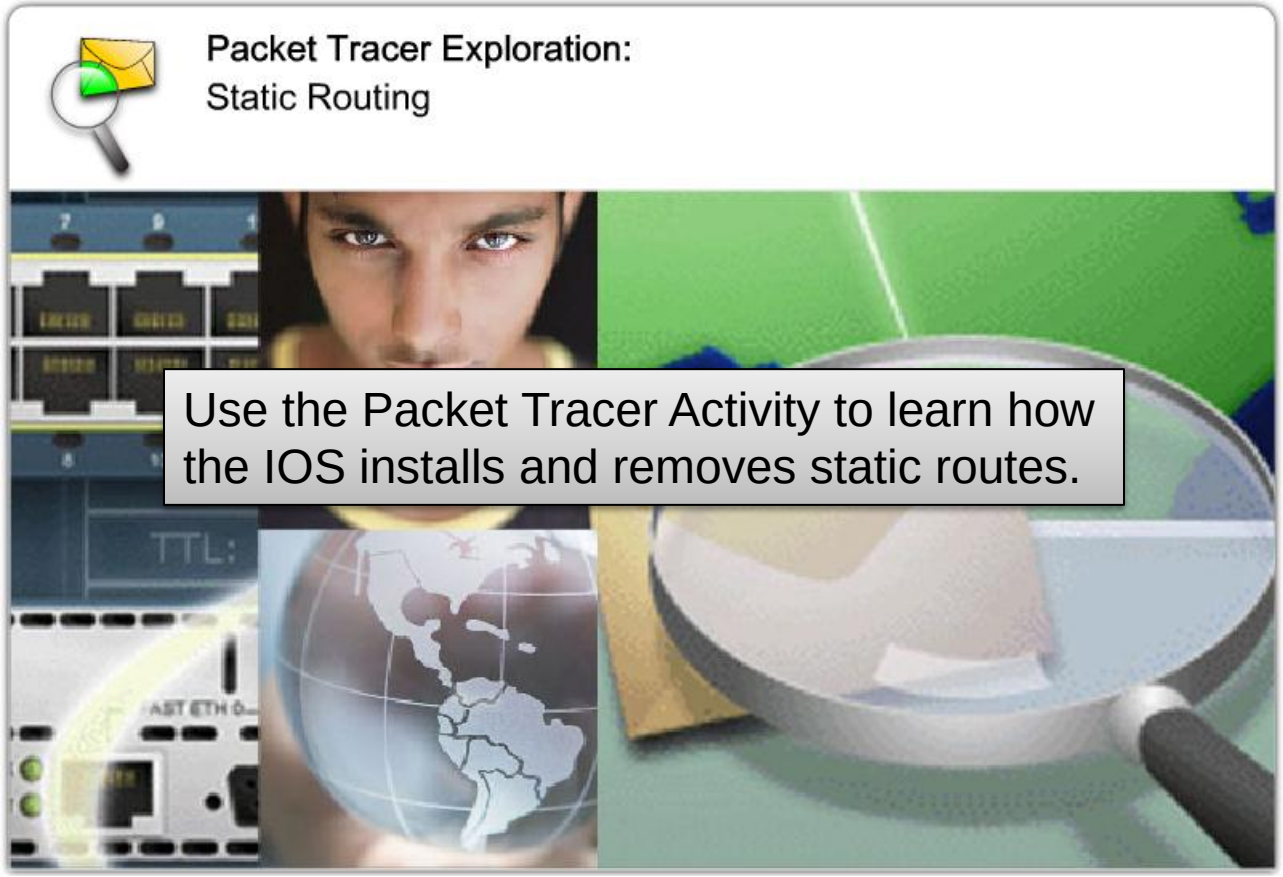
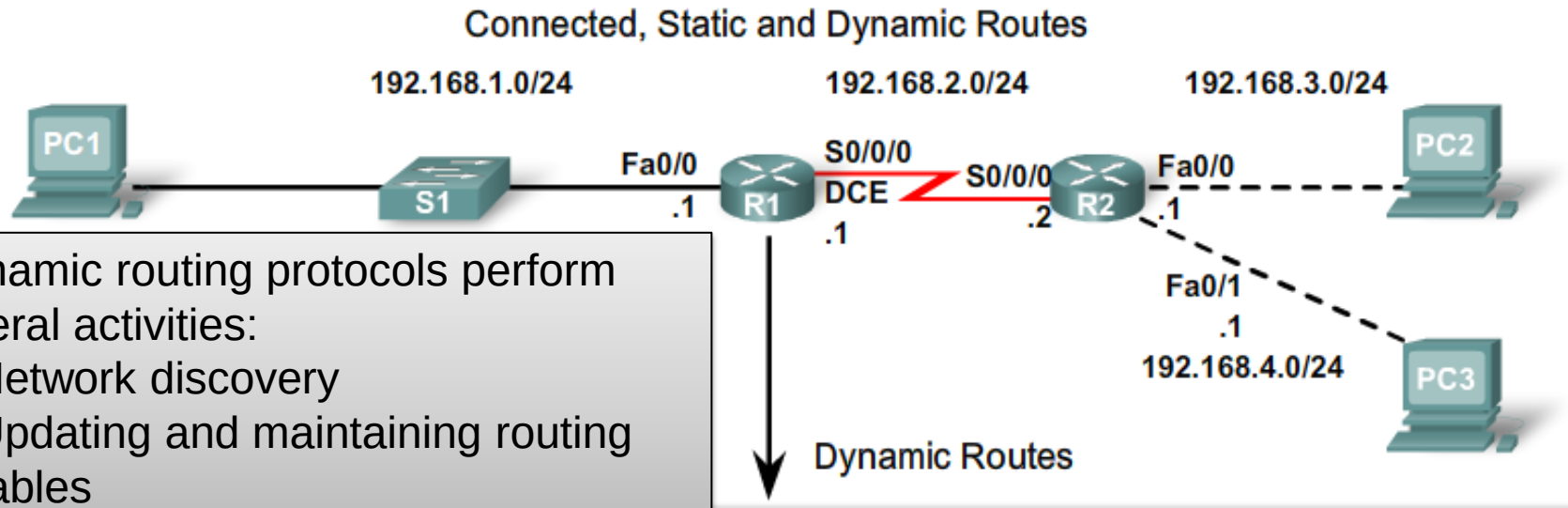

1.3.3 Static Routing



1.3.4 Dynamic Routing

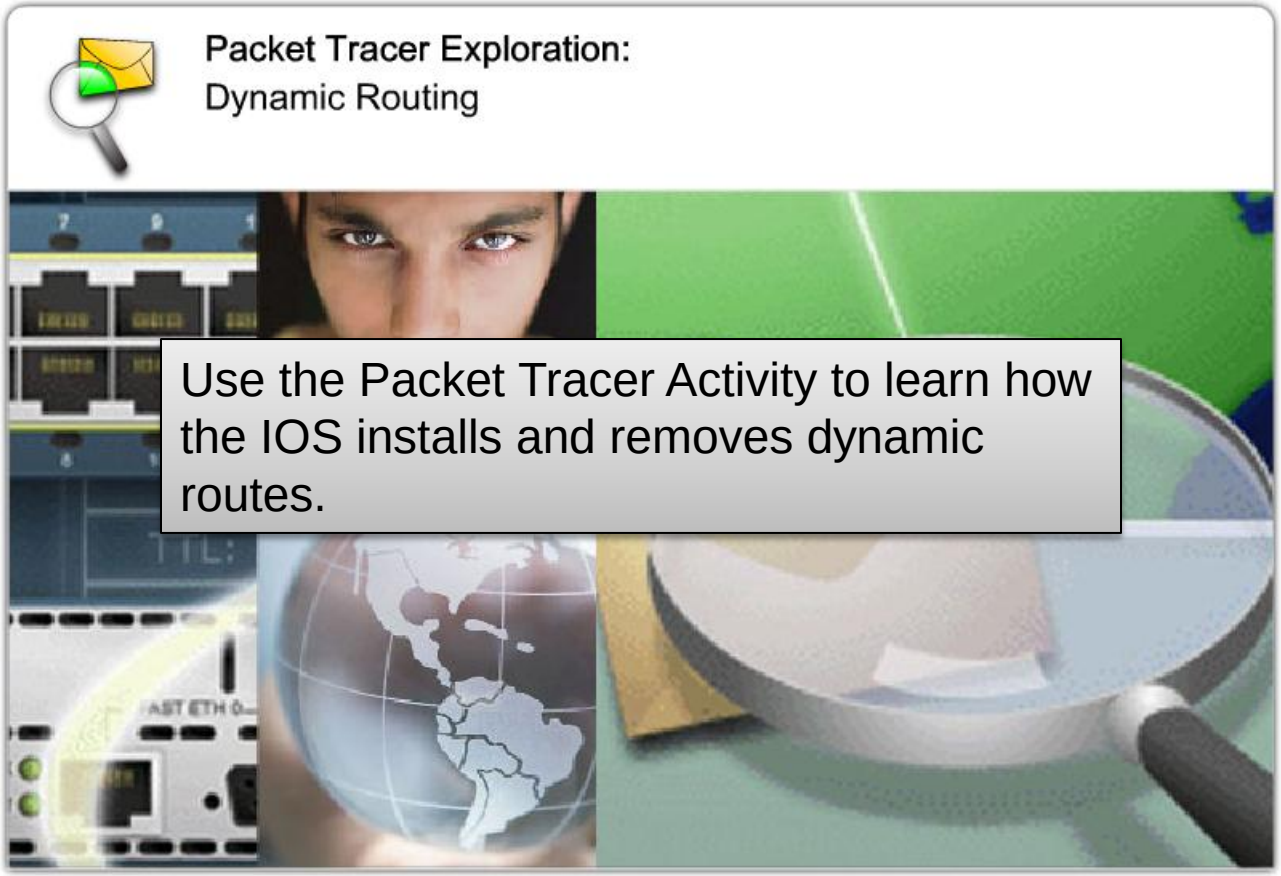


Dynamic routing protocols perform several activities:

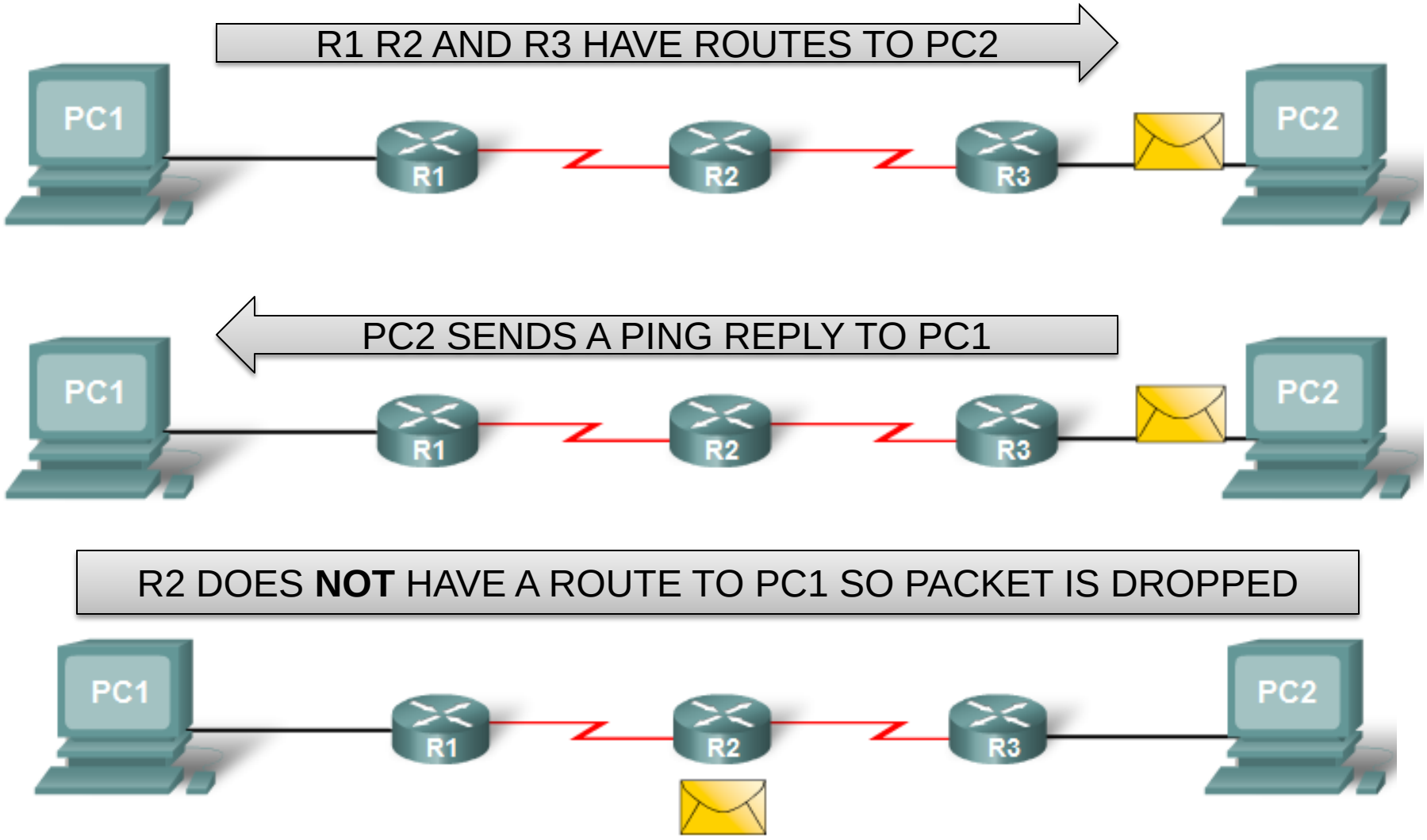
- Network discovery
- Updating and maintaining routing tables

```
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
C    192.168.1.0/24 is directly connected, FastEthernet0/0
C    192.168.2.0/24 is directly connected, Serial0/0/0
S    192.168.3.0/24 [1/0] via 192.168.2.2
R    192.168.4.0/24 [120/1] via 192.168.2.2, 00:00:20, Serial0/0/0
```

1.3.4 Dynamic Routing

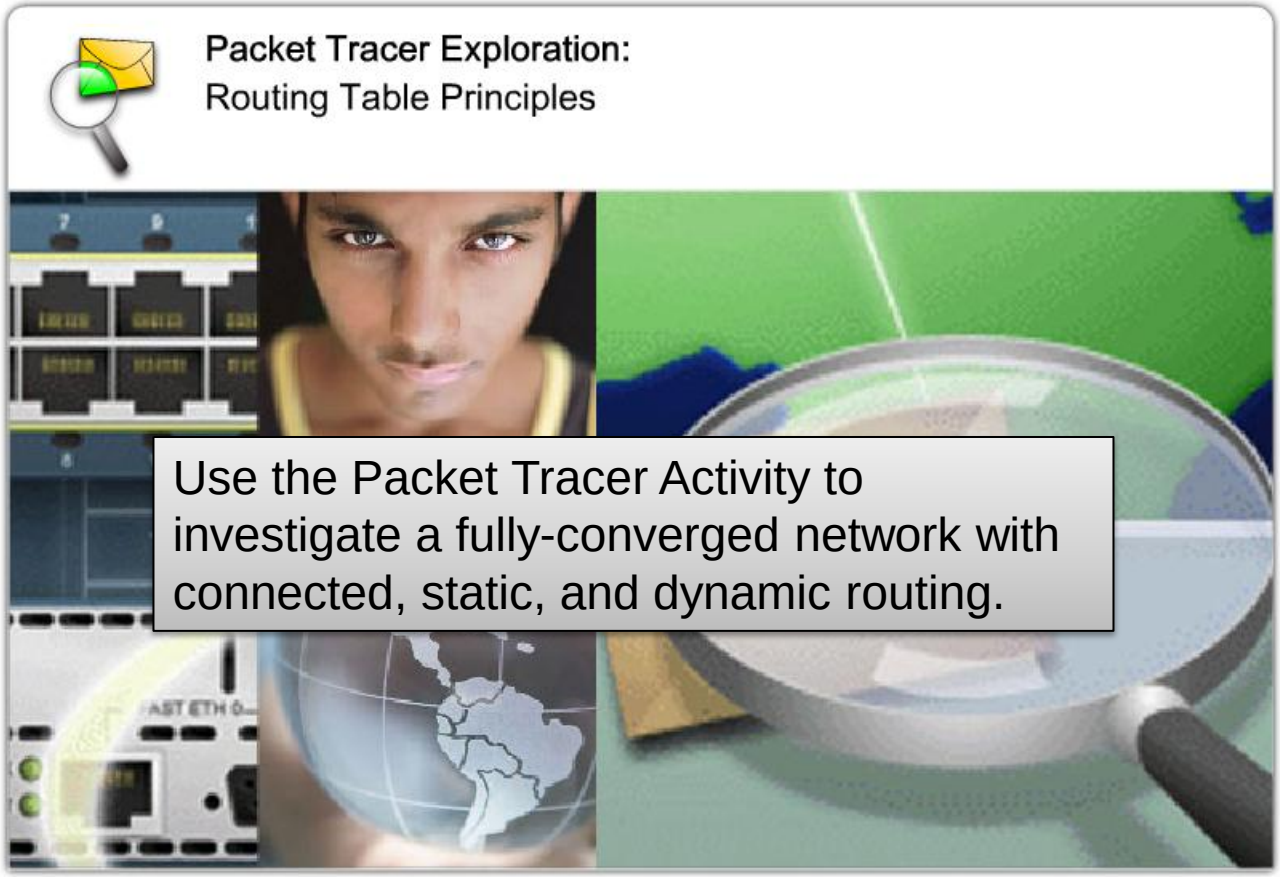


1.3.5 Routing Table Principles



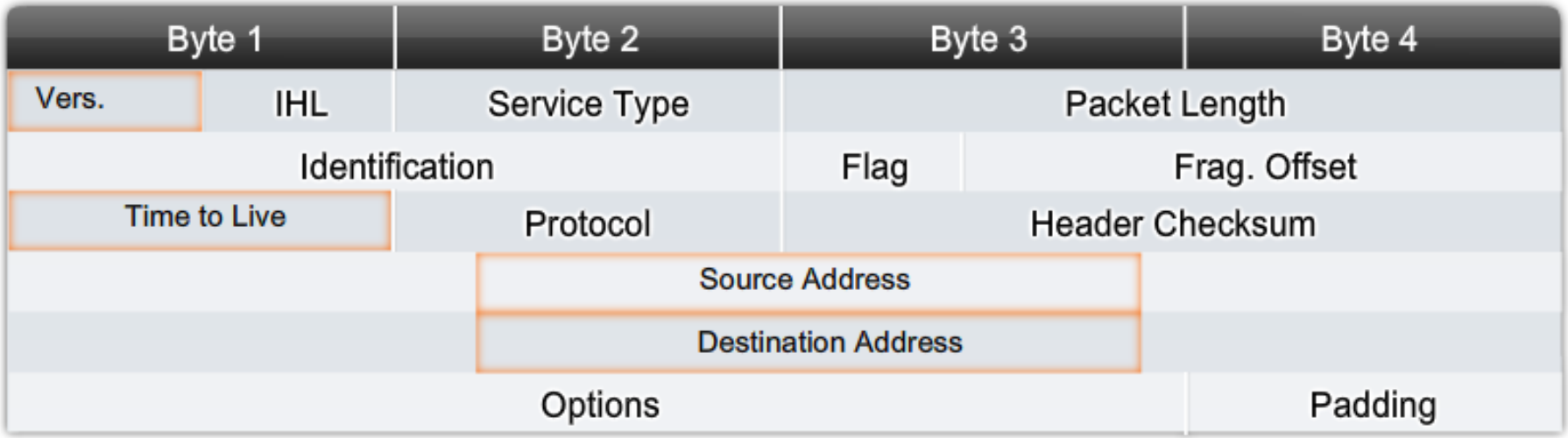
Because routers do not necessarily have the same information in their routing tables, packets can traverse the network in one direction, using one path, and return via another path. This is called ***asymmetric routing***.

1.3.5 Routing Table Principles



1.4.1 Packet Fields and Frame Fields

IP Packet Fields



The IP packet header has specific fields that contain information about the packet and about the sending and receiving hosts.

1.4.1 Packet Fields and Frame Fields

Ethernet Frame Fields

Ethernet

Field Length in Bytes

8	6	6	2	46-1500	4
Preamble	Destination Address	Source Address	Type	Data	FCS

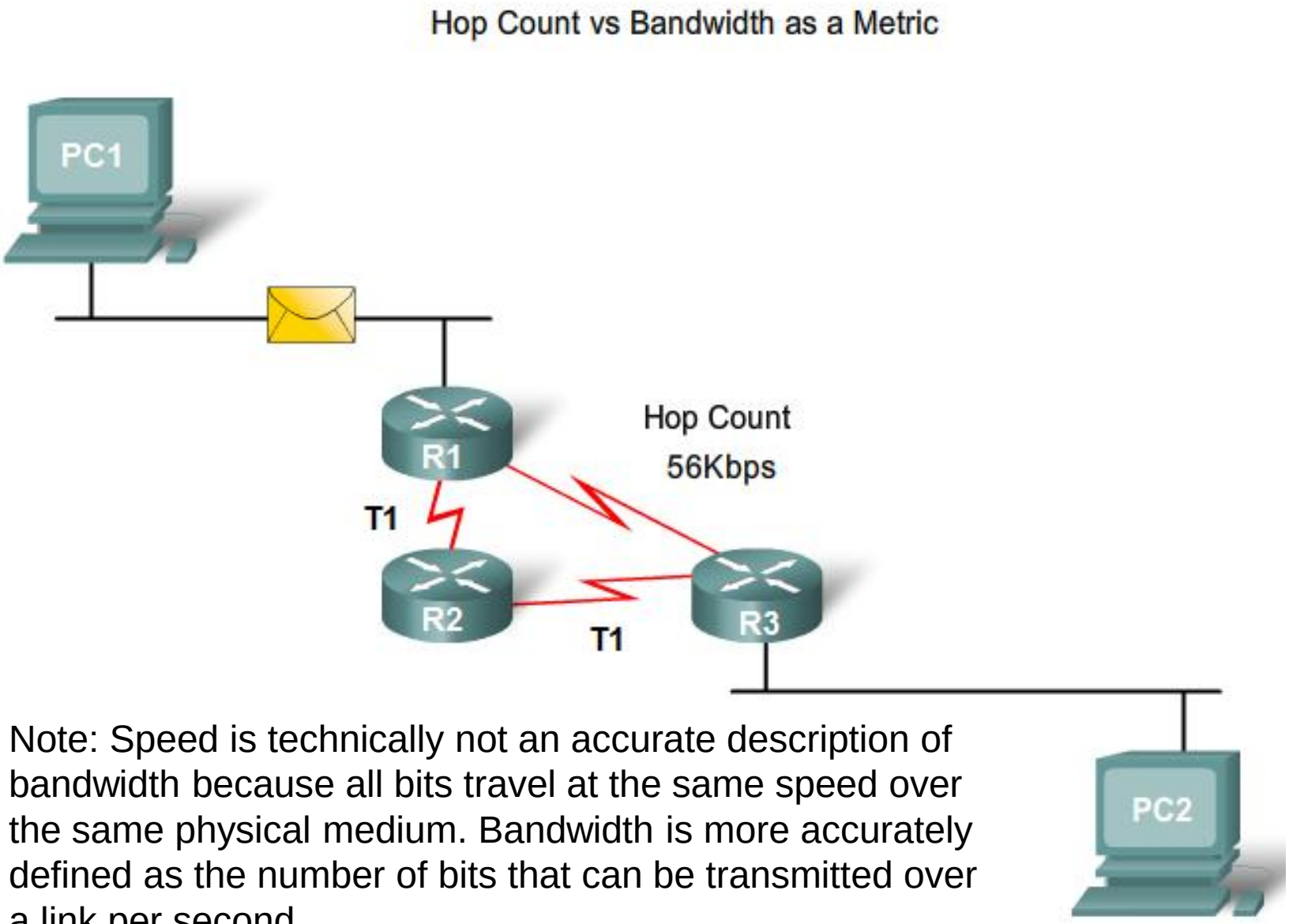
IEEE 802.3

Field Length in Bytes

7	1	6	6	2	46-1500	4
Preamble	SOF	Destination Address	Source Address	Length	802.2 Header and Data	FCS

The Layer 2 data link frame usually contains header information with a data link source and destination address, trailer information, and the actual transmitted data. The data link source address is the Layer 2 address of the interface that sent the data link frame.

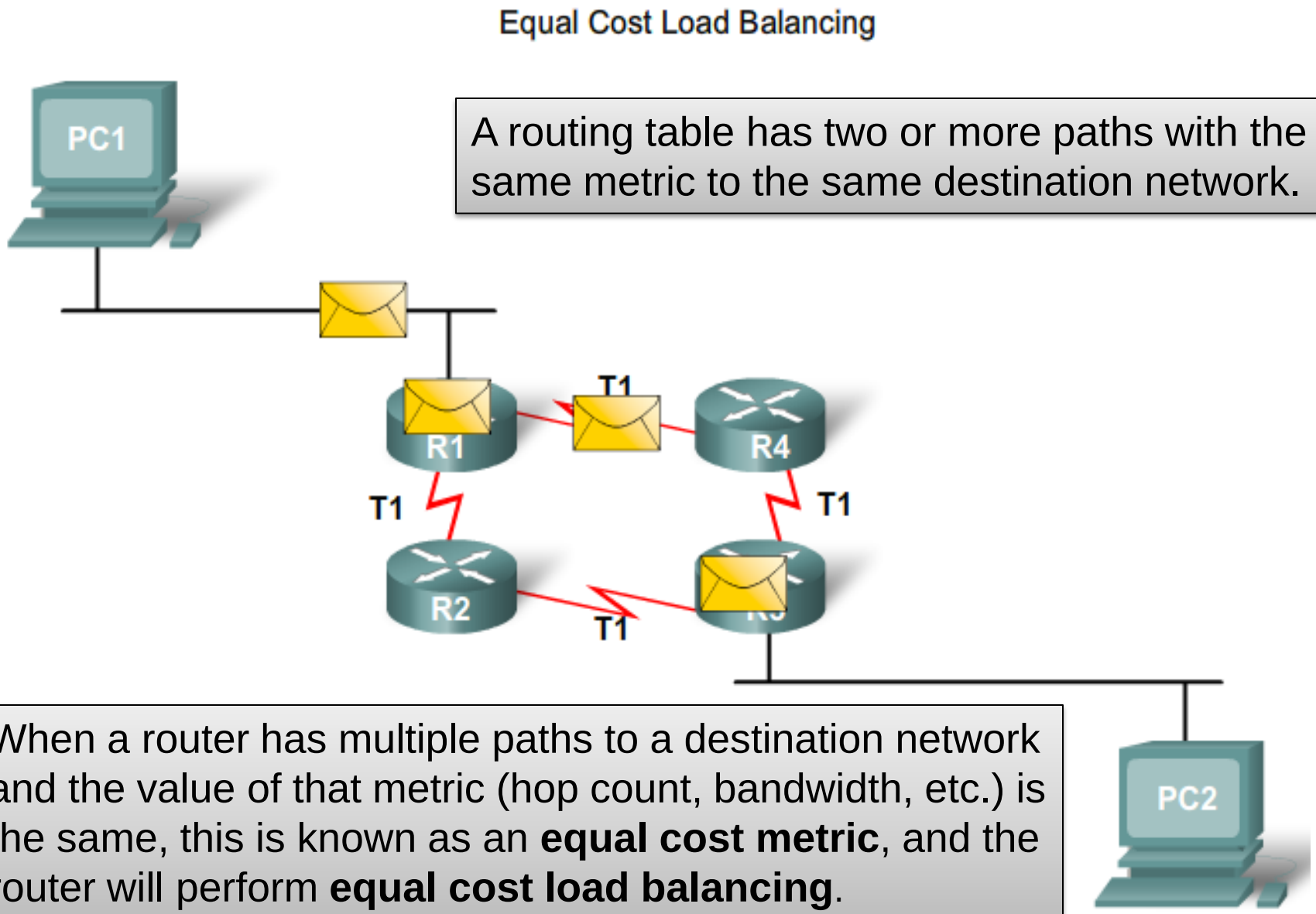
1.4.2 Best Path and Metric



Note: Speed is technically not an accurate description of bandwidth because all bits travel at the same speed over the same physical medium. Bandwidth is more accurately defined as the number of bits that can be transmitted over a link per second.

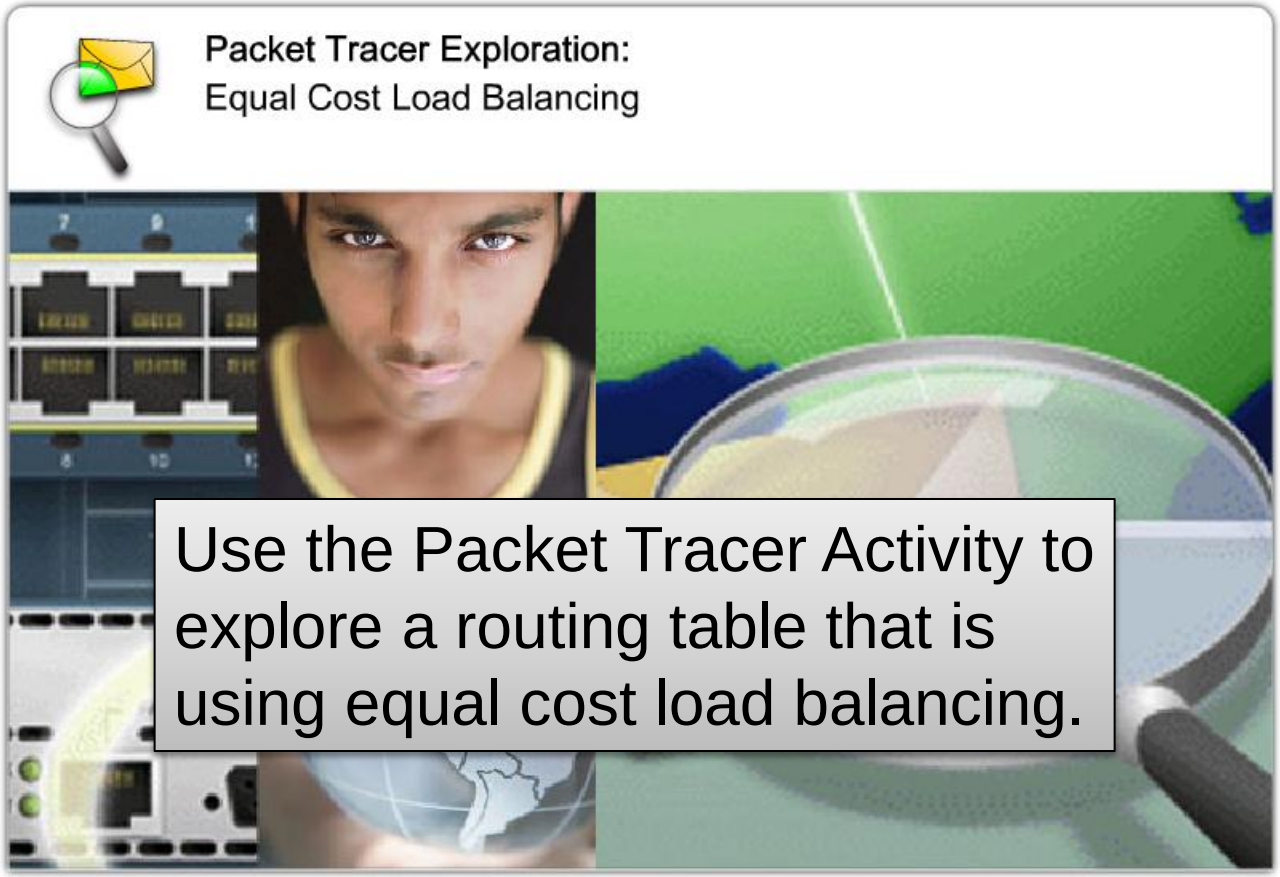
1.4.2 Best Path and Metric

1.4.3 Equal Cost Load Balancing



When a router has multiple paths to a destination network and the value of that metric (hop count, bandwidth, etc.) is the same, this is known as an **equal cost metric**, and the router will perform **equal cost load balancing**.

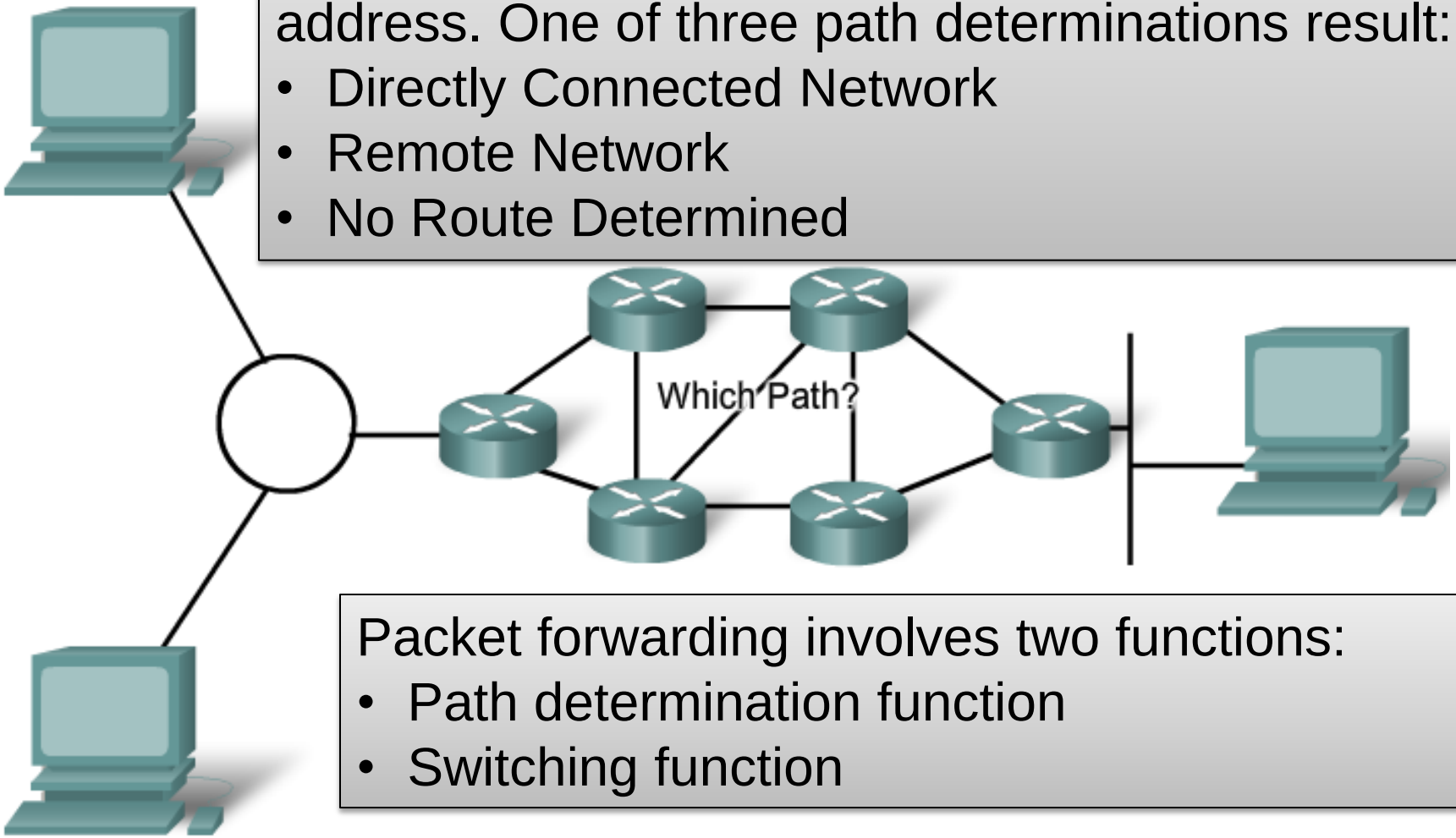
1.4.3 Equal Cost Load Balancing



1.4.4 Path Determination

The router searches its routing table for a network address that matches the packet's destination IP address. One of three path determinations result:

- Directly Connected Network
- Remote Network
- No Route Determined



Packet forwarding involves two functions:

- Path determination function
- Switching function

Routers determine the best path to the destination

1.4.5 Switching Function

What does a router do with a packet received from one network and destined for another network? The router performs the following three major steps:

1. Decapsulates the Layer 3 packet by removing the Layer 2 frame header and trailer.

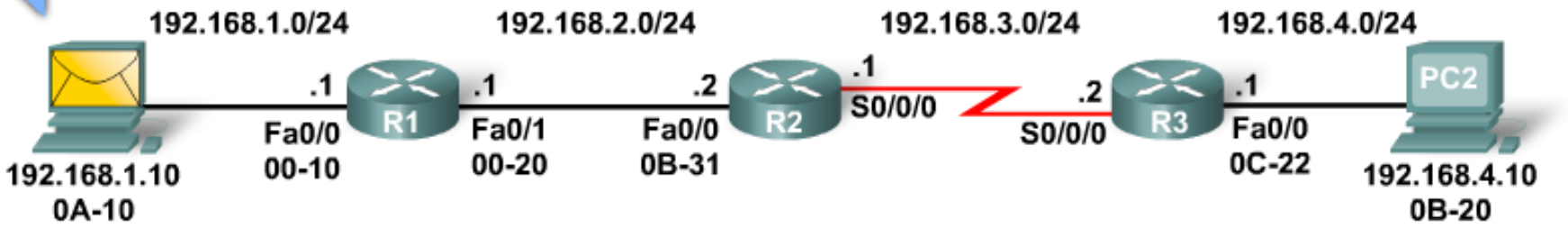
2. Examines the destination IP address of the IP packet to find the best path in the routing table.

3. Encapsulates Layer 3 packet into a new Layer 2 frame and forwards the frame out the exit interface.

1.4.5 Switching Function

A day in the life of a packet: Step 1

Since PC2 is on different network, I'll encapsulate packet and send it to the router on MY network. Let me find that MAC address….



Layer 2 Data Link Frame

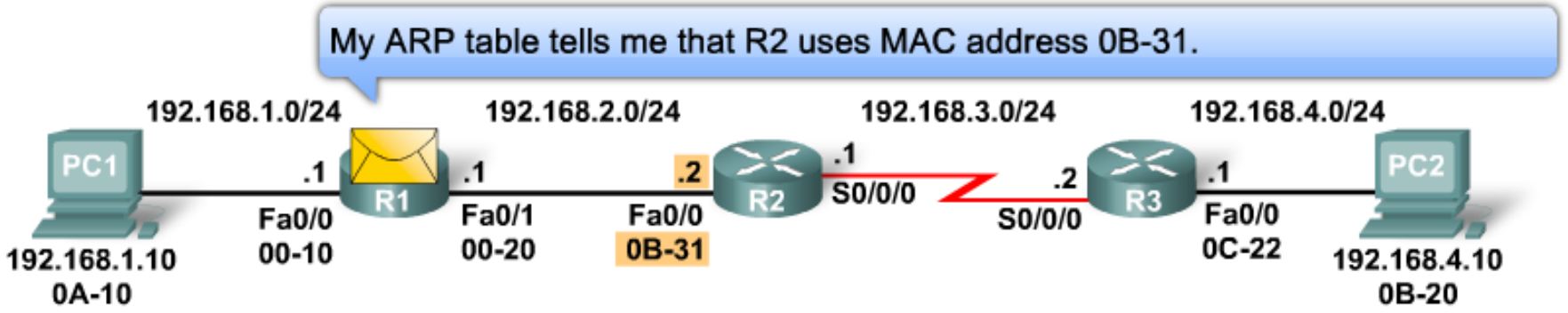
Packet's Layer 3 data

Dest. MAC 00-10	Source MAC 0A-10	Type 800	Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer

PC1's ARP Cache for R1	
IP Address	MAC Address
192.168.1.1	00-10

1.4.5 Switching Function

A day in the life of a packet: Step 2



Layer 2 Data Link Frame | Packet's Layer 3 data

Dest. MAC 0B-31		Type 800	Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer

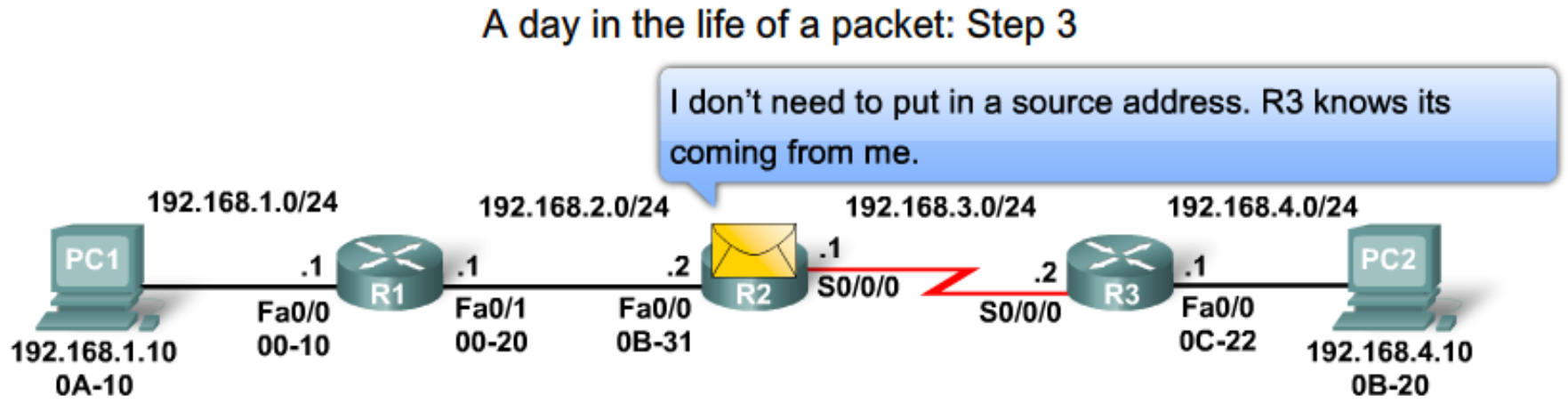
R1's ARP Cache

IP Address	MAC Address
192.168.2.2	0B-31

R2's Routing Table

Network	Hops	Next-hop-IP	Exit Interface
192.168.1.0/24	0	Dir. Connect.	Fa0/0
192.168.2.0/24	0	Dir. Connect.	Fa0/1
192.168.3.0/24	1	192.168.2.2	Fa0/1
192.168.4.0/24	2	192.168.2.2	Fa0/1

1.4.5 Switching Function



Layer 2 Data Link Frame

Packet's Layer 3 data

				Dest. IP 2.168.4.10	IP fields	Data	Trailer

lops	Next-hop-IP	Exit Interface
	192.168.2.1	Fa0/0
	Dir. Connect.	Fa0/0
	Dir. Connect.	S0/0/0
	192.168.3.2	S0/0/0

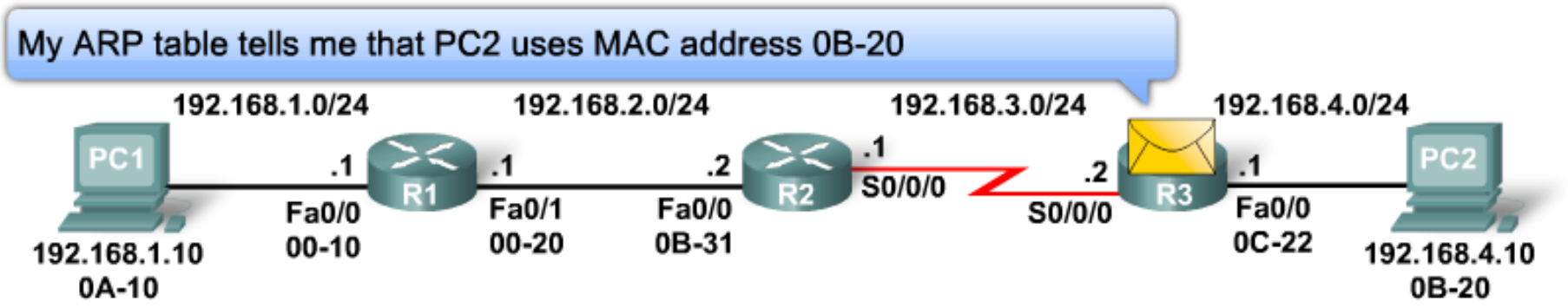
1. Router R2 examines the destination MAC address, which matches the MAC address of the receiving interface, FastEthernet 0/0. R1 will therefore copy the frame into its buffer.

2. R2 sees that the Ethernet Type field is 0x800, which means that the Ethernet frame contains an IP packet in the data portion of the frame.

3. R2 decapsulates the Ethernet frame

1.4.5 Switching Function

A day in the life of a packet: Step 4



Layer 2 Data Link Frame

Packet's Layer 3 data

Dest. MAC 0B-20	Source MAC 0C-22	Type 800	Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer

R3's ARP Cache

IP Address	MAC Address
192.168.4.10	0B-20

R3's Routing Table

Network	Hops	Next-hop-IP	Exit Interface
192.168.1.0/24	2	192.168.3.1	S0/0/0
192.168.2.0/24	1	192.162.3.1	S0/0/0
192.168.3.0/24	0	Dir. Connect.	S0/0/0
192.168.4.0/24	0	Dir. Connect.	Fa0/0

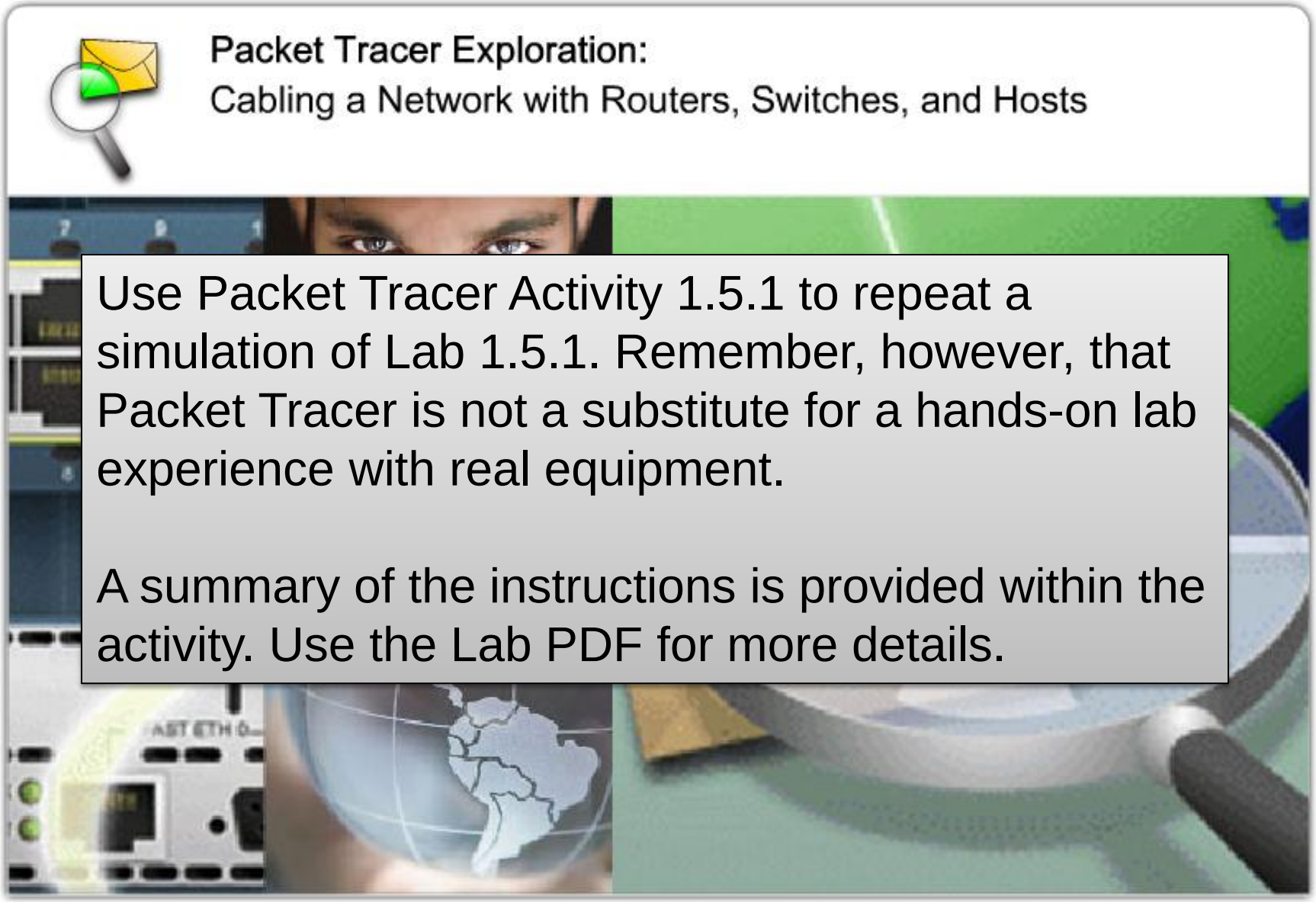
1.5.1 Cabling a Network and Basic Router Configuration

Hands-on Lab:

Cabling a Network and Basic Router Configuration

Complete this for a solid review of device cabling, establishing a console connection, and command-line interface (CLI) basics

1.5.1 Cabling a Network and Basic Router Configuration



Packet Tracer Exploration:
Cabling a Network with Routers, Switches, and Hosts

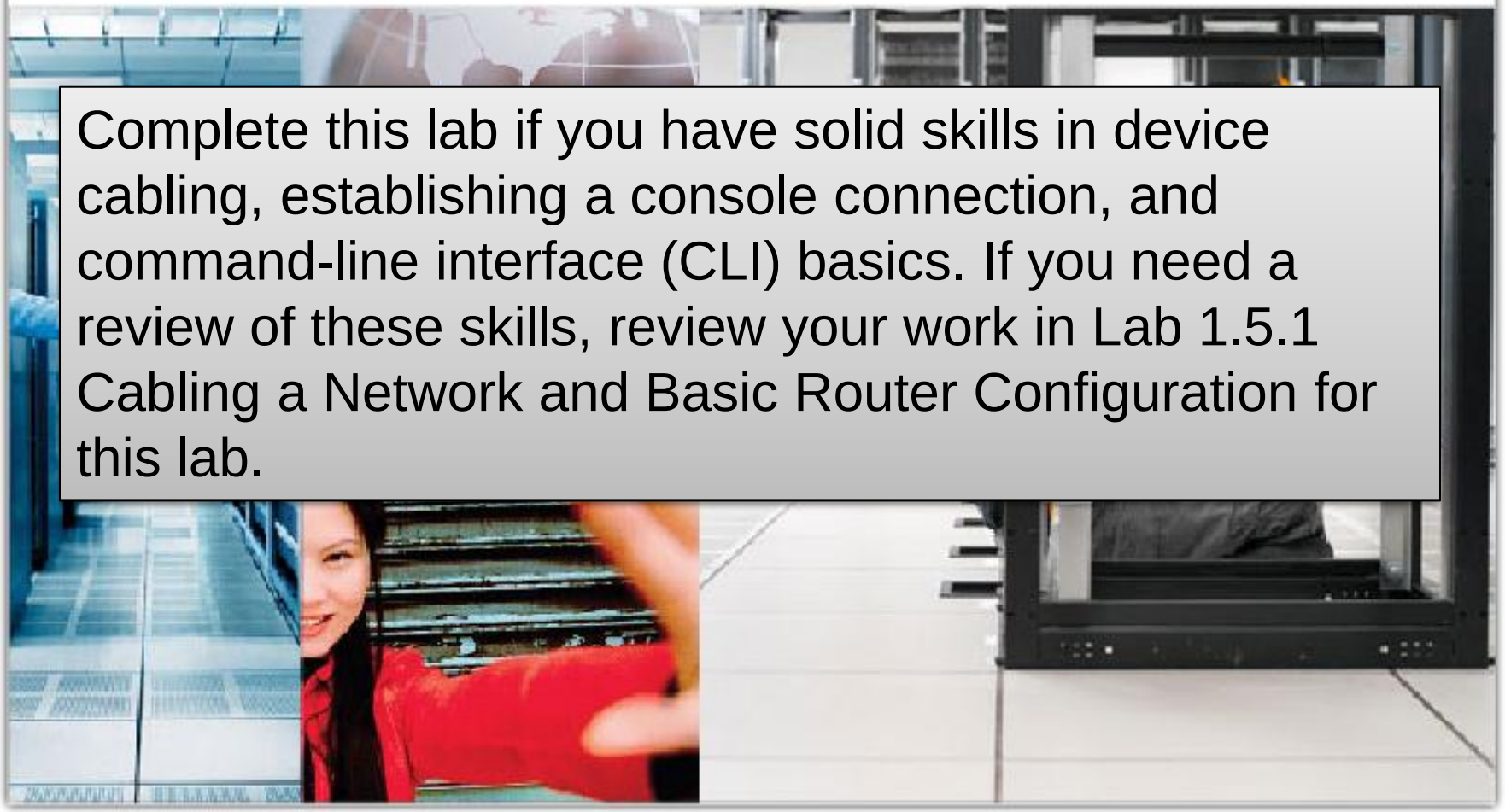
Use Packet Tracer Activity 1.5.1 to repeat a simulation of Lab 1.5.1. Remember, however, that Packet Tracer is not a substitute for a hands-on lab experience with real equipment.

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

1.5.2 Basic Router Configuration

Hands-on Lab:

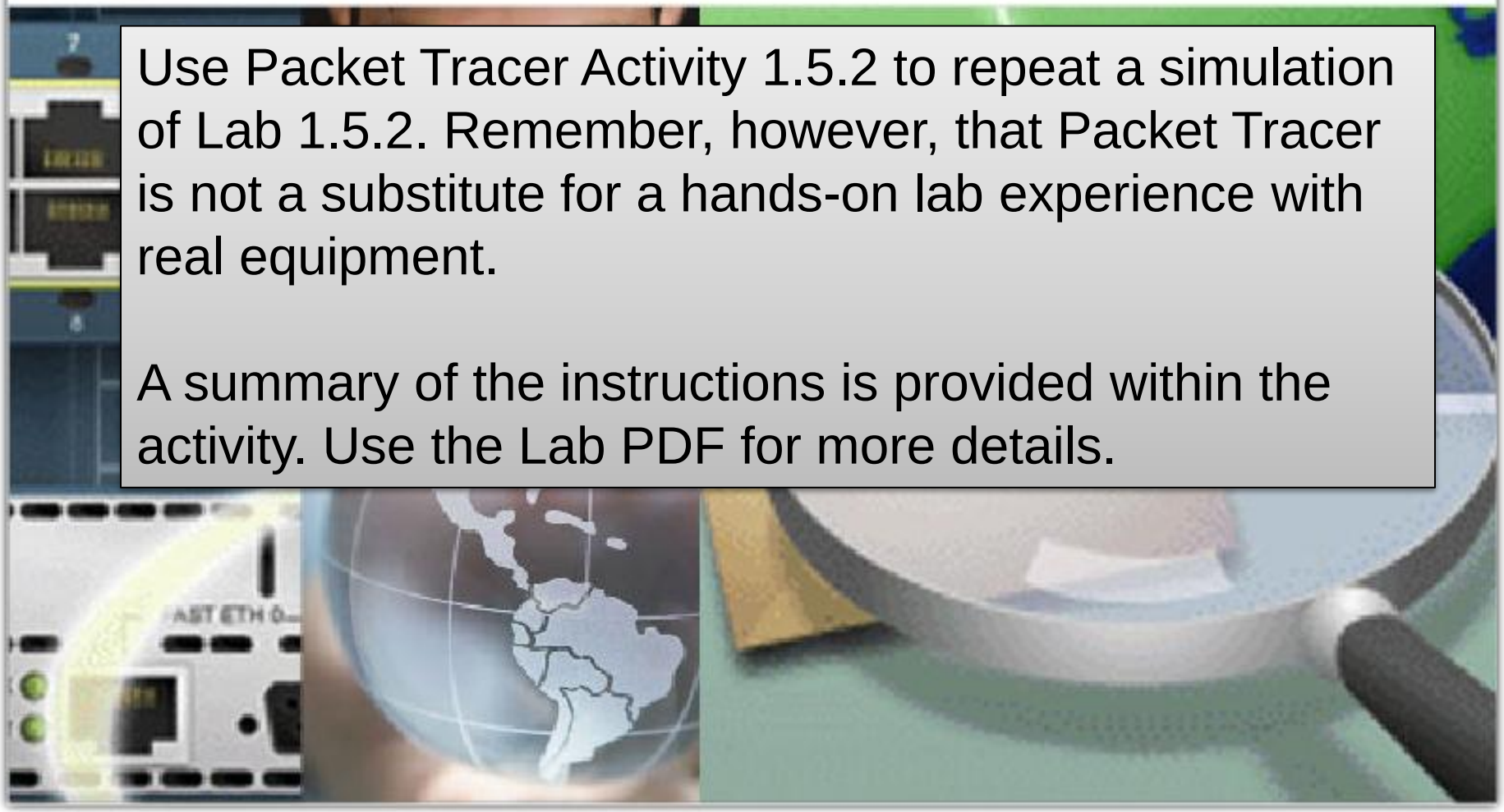
Basic Router Configuration



Complete this lab if you have solid skills in device cabling, establishing a console connection, and command-line interface (CLI) basics. If you need a review of these skills, review your work in Lab 1.5.1 Cabling a Network and Basic Router Configuration for this lab.

1.5.2 Basic Router Configuration

Packet Tracer Exploration:
Basic Router Configuration

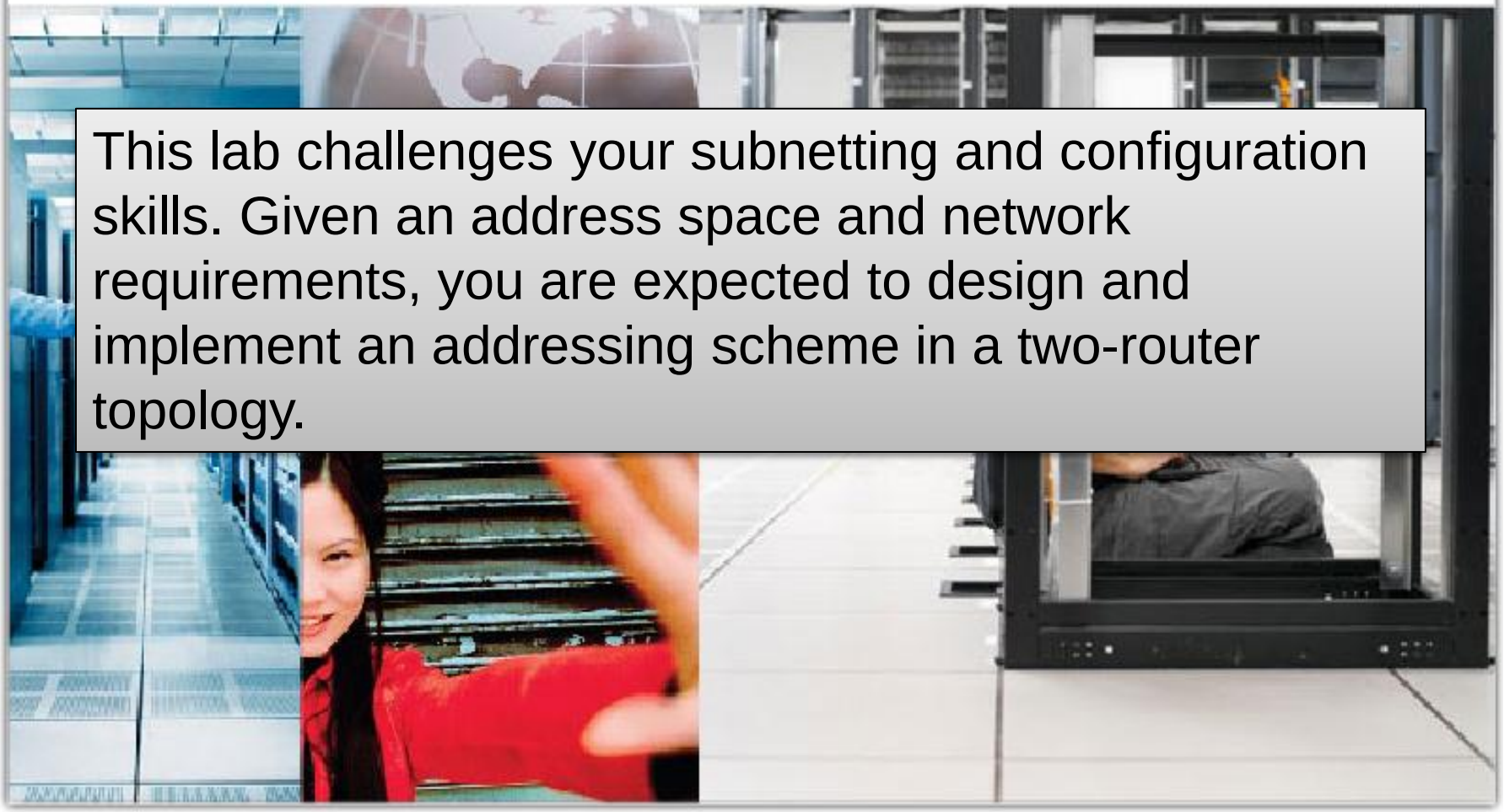


Use Packet Tracer Activity 1.5.2 to repeat a simulation of Lab 1.5.2. Remember, however, that Packet Tracer is not a substitute for a hands-on lab experience with real equipment.

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

1.5.3 Challenge Router Configuration

Hands-on Lab:
Challenge Router Configuration



This lab challenges your subnetting and configuration skills. Given an address space and network requirements, you are expected to design and implement an addressing scheme in a two-router topology.

1.5.3 Challenge Router Configuration

Packet Tracer Exploration:
Challenge Router Configuration

Use Packet Tracer Activity 1.5.3 to repeat a simulation of Lab 1.5.3. 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.

1.6.1 Summary and Review

1841 Integrated Services Router

In this chapter, you have learned to:

- Identify a router as a computer with an operating system (OS) and hardware designed for the routing process.
- Demonstrate the ability to configure devices and apply addresses.
- Describe the structure of a routing table.
- Describe how a router determines a path and switches packets.

1.6.1 Summary and Review

Packet Tracer Exploration:
Ch1 - Packet Tracer Skills Integration Challenge

The Packet Tracer Skills Integration Challenge Activity for this chapter integrates all the knowledge and skills you acquired in previous courses and the first chapter of this course. In this activity, you build a network from the ground up. Starting with an addressing space and network requirements, you must implement a network design that satisfies the specifications.

Packet Tracer Skills Integration Instructions (PDF)

1.6.1 Summary and Review

To Learn More

Create a topology similar to that in 1.4.5.2, with several routers, and a LAN at each end. On one LAN add a client host, and on the other end add a web server. On each LAN include a switch between the computer and the router. Assume that each router has a route to each of the LANs, similar to that in 1.4.5.2.

What happens when the host requests a web page from the web server? Look at all of the processes and protocols involved starting with the user entering a URL such as www.cisco.com. This includes protocols learned in Exploration 1 as well as information learned in this chapter.

1.6.1 Summary and Review

1.6.1 Summary and Review

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