CISCO CCNA1

CCNA Routing and Switching: Introduction to Networks

HOOFDSTUK 6

Network Layer

DE HOGESCHOOL
MET HET NETWERK

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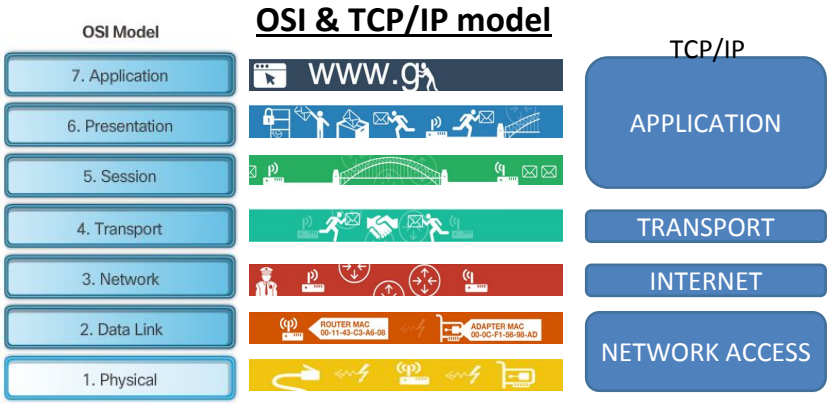
CCNA1 - Overzicht

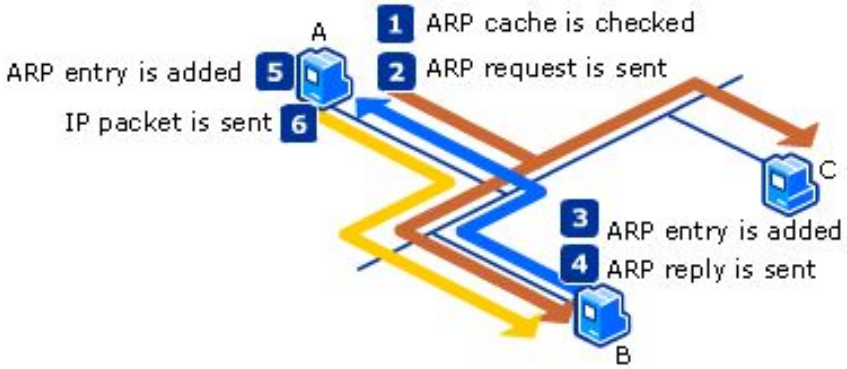
- OSI model en de belangrijkste (LAN) protocollen.
- Data Flow in een LAN
  (verklaring volgens het OSI model).
- IP en subnetting.
- Het toepassen en onderzoeken van bovenstaande 3 in Packettrace oefeningen.

CCNA1 - Overzicht

1. OSI model en de belangrijkste (LAN) protocollen.



2. Data Flow in een LAN (verklaring volgens het OSI model)



3. IP en subnetting

Situering hoofdstuk 6

Hoofdstuk 6 behandelt de network layer (in TCP/IP ook wel internet layer genoemd). De adressering op deze layer gebeurt door middel van IP-adressen. Dit hoofdstuk gaat over IPv4 en IPv6, vormgeving PDU, adressering, vergelijking IPv4/IPv6, …
Het laatste stuk van het hoofdstuk beschrijft de werking van een router. Zowel routing tables, hardware en configuratie van de router komen aan bod.

Doelstellingen:

- Begrijp de network layer. (Binnen het OSI en TCP/IP model)
- IP (definitie network layer + karakteristieken IP)
- IPv4: opbouw, PDU fields
- IPv6: waarom?, opbouw, PDU fields.
- Wat is een Default gateway?
- Begrijp de routing table!
- Hardware kennis van een router
- Configuratie router (zie ook hoofdstuk 2)

Activity & PT:

- 6.1.2.6 IP characteristics
- 6.1.3.3 & 6.1.4.6 IPv4 & 1pv6 Heaeder fields
- 6.2.2.8 Identify elements of a routing table entry
- 6.3.1.7 Identify router components
- 6.3.1.8 Exploring internetworking devices (Belangrijk??)
- 6.4.1.3 Configure initial router settings
- 6.4.3.3 PT Connect a router to a lan
- 6.4.3.4 Troubleshooting
- 6.5.1.3 Skills integration challenge

Zie leerpad op blackboard!

Leertip:

Herhaal de theorie (OSI model en dataflow) a.d.h.v. een samenvattende PT oefening. De laatste PT oefeningen van hoofdstuk 6 zijn tevens een goede herhaling.

Cisco Networking Academy
Mind Wide Open

Chapter 6:

Network Layer

Introduction to Networks v5.1

Chapter Outline

Section 6.1: Network Layer Protocols

Upon completion of this section, you should be able to:

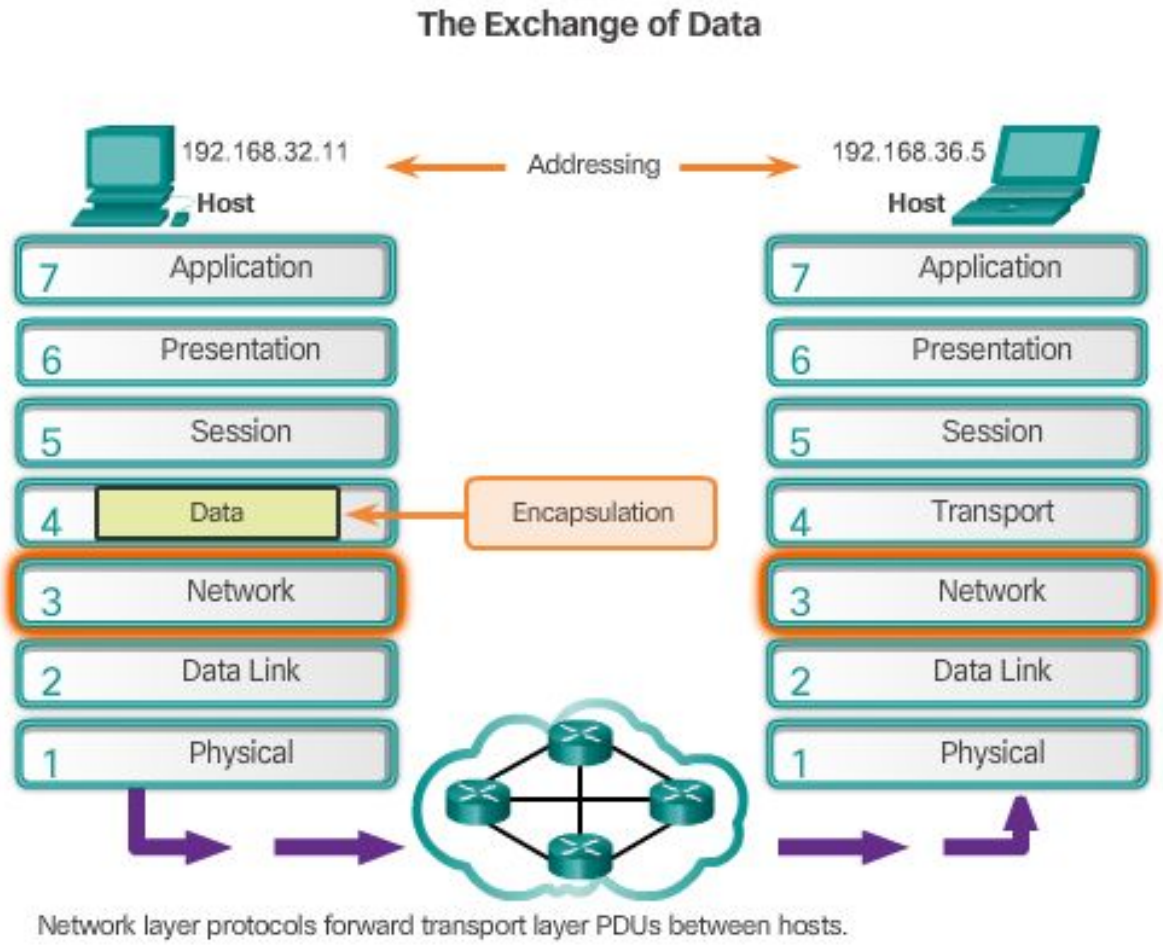
- Describe the purpose of the network layer in data communication.
- Explain why the IPv4 protocol requires other layers to provide reliability. (To include: media independent, unreliable, and connectionless.)
- Explain the role of the major header fields in the IPv4 packet.
- Explain the role of the major header fields in the IPv6 packet.

Topic 6.1.1:
Network Layer in Communication

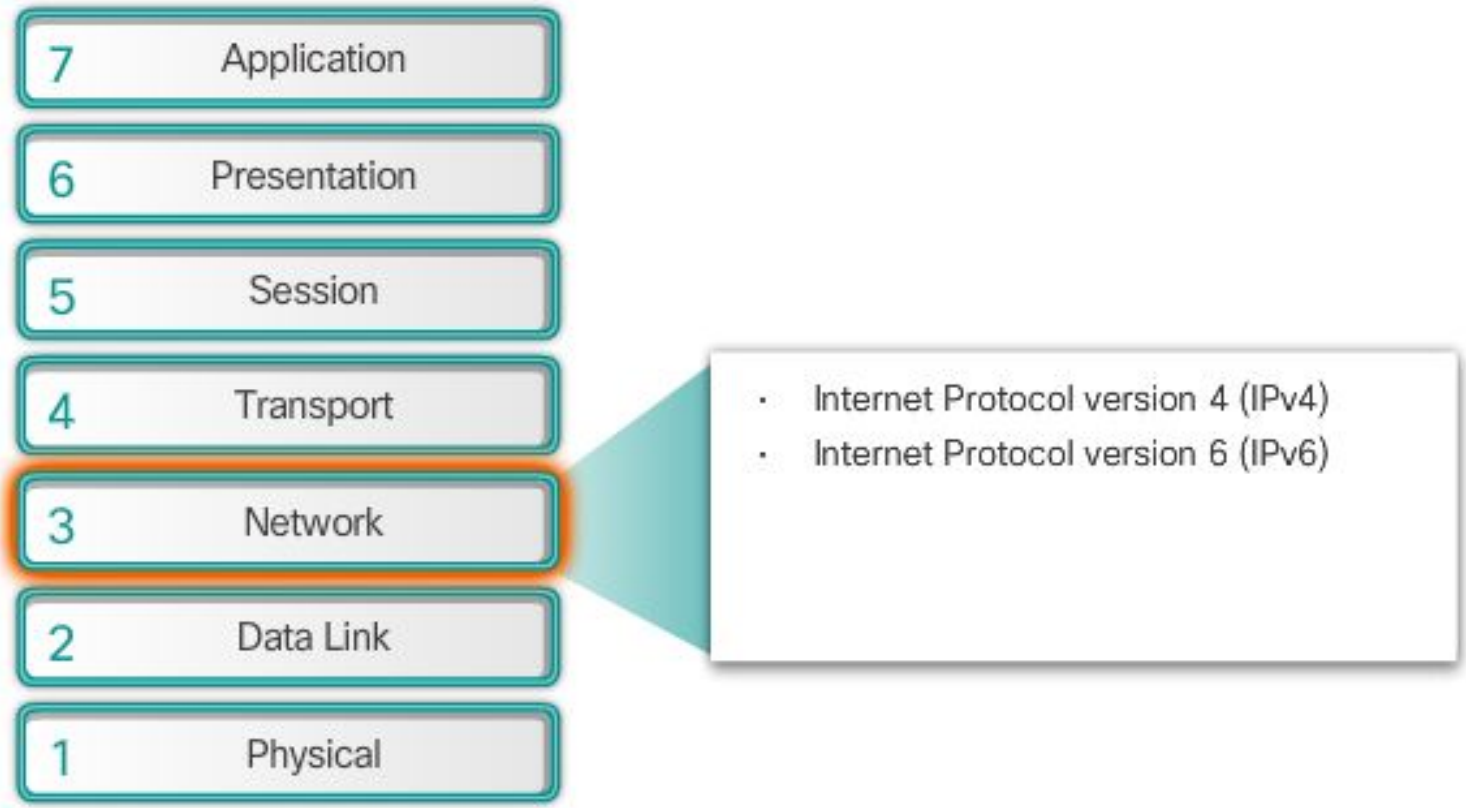
6.1.1.1 The Network Layer

End to End Transport processes

- Addressing end devices
- Encapsulation
- Routing
- De-encapsulating

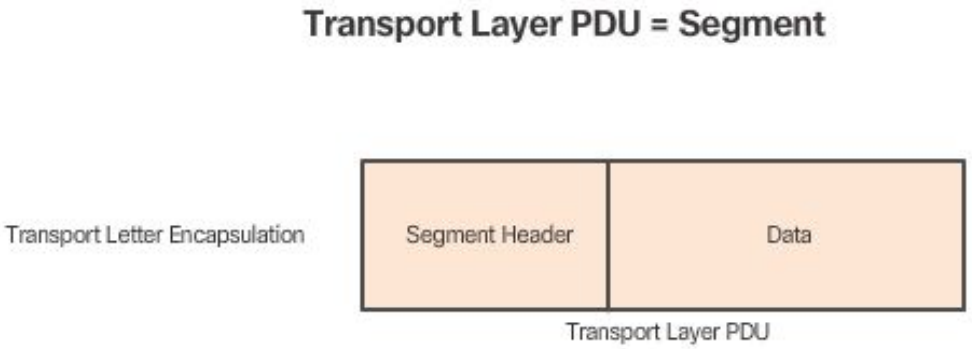


6.1.1.2 Network Layer Protocols



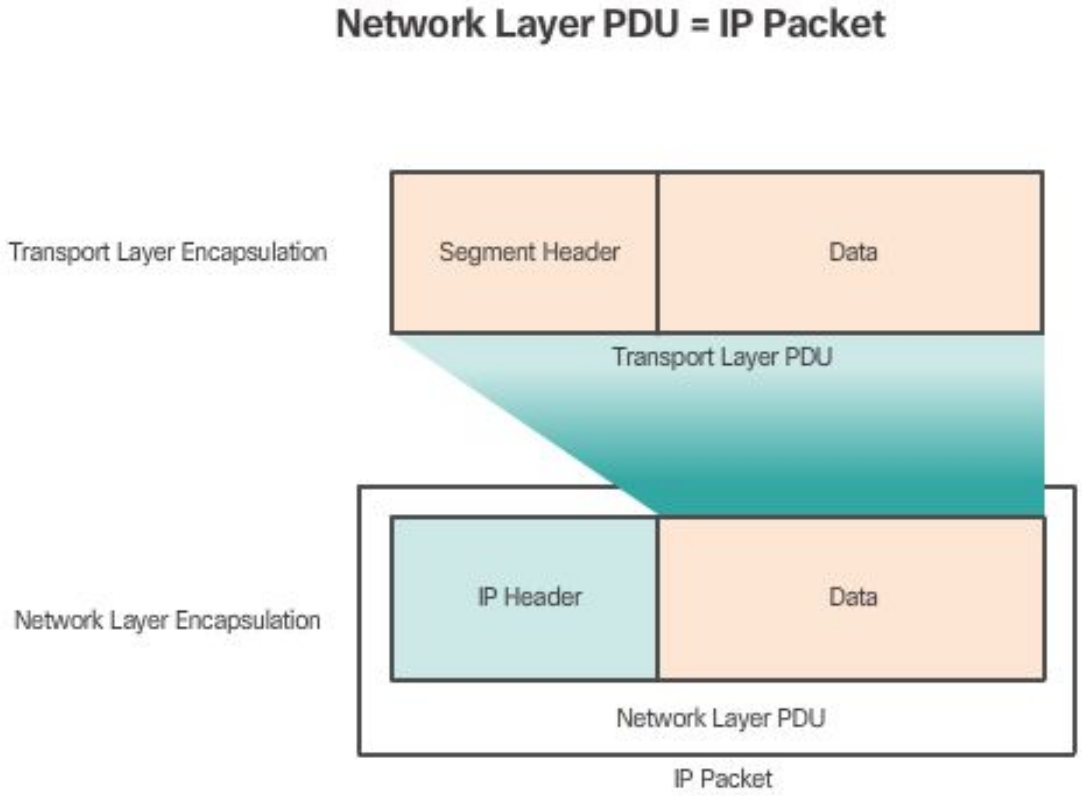
Topic 6.1.2:
Characteristics of the IP Protocol

6.1.2.1 Encapsulating IP



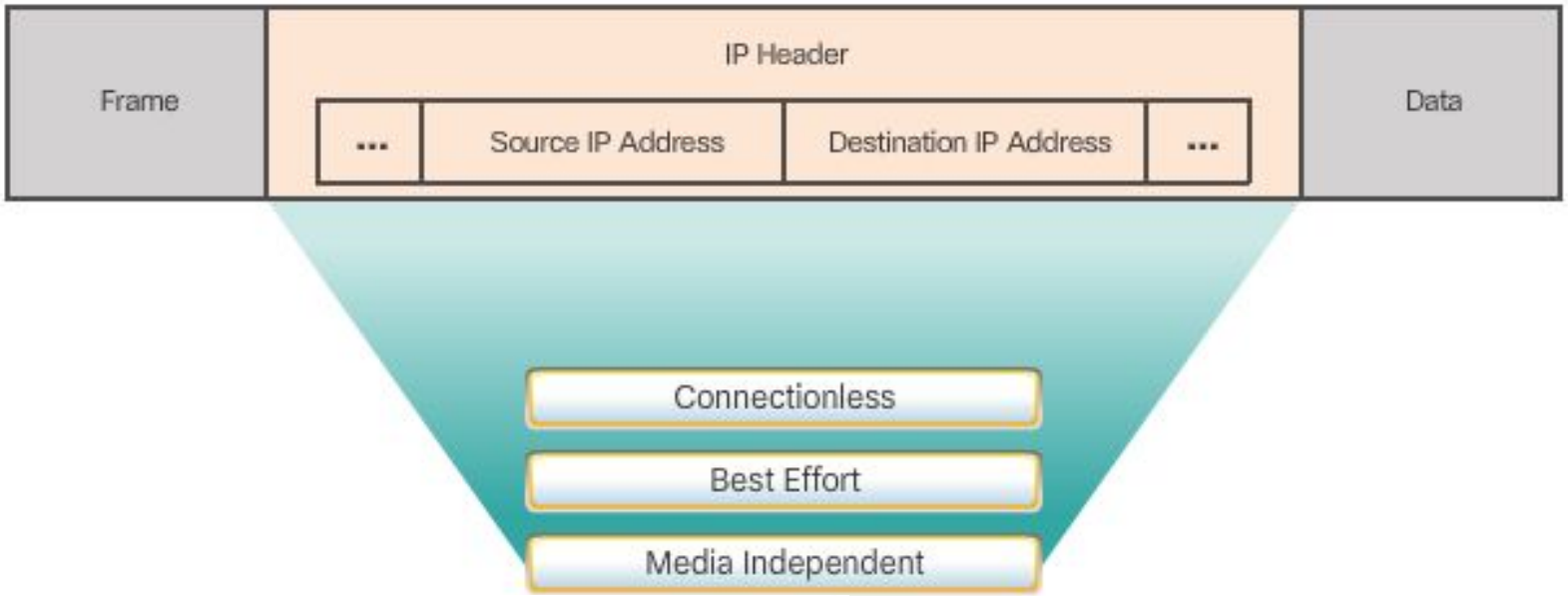
The transport layer adds a header so segments can be reassembled at the destination.

6.1.2.1 Encapsulating IP (cont.)



The network layer adds a header so packets can be routed through complex networks and reach their destination. In TCP/IP based networks, the network layer PDU is the IP Packet.

6.1.2.2 Characteristics of IP



Connectionless

No connection with the destination is established before sending data packets.

Media Independent

Operation is independent of the medium (i.e., copper, fiber optic, or wireless) carrying the data.

Best Effort

IP is inherently unreliable because packet delivery is not guaranteed.

6.1.2.3 IP - Connectionless

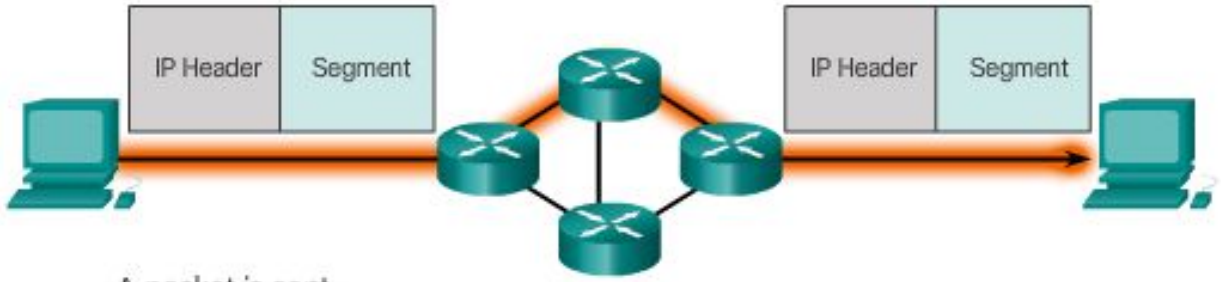
The sender doesn't know:

- If the receiver is present
- If the letter arrived
- If the receiver can read the letter

The receiver doesn't know:

- When it is coming

6.1.2.3 IP – Connectionless (cont.)



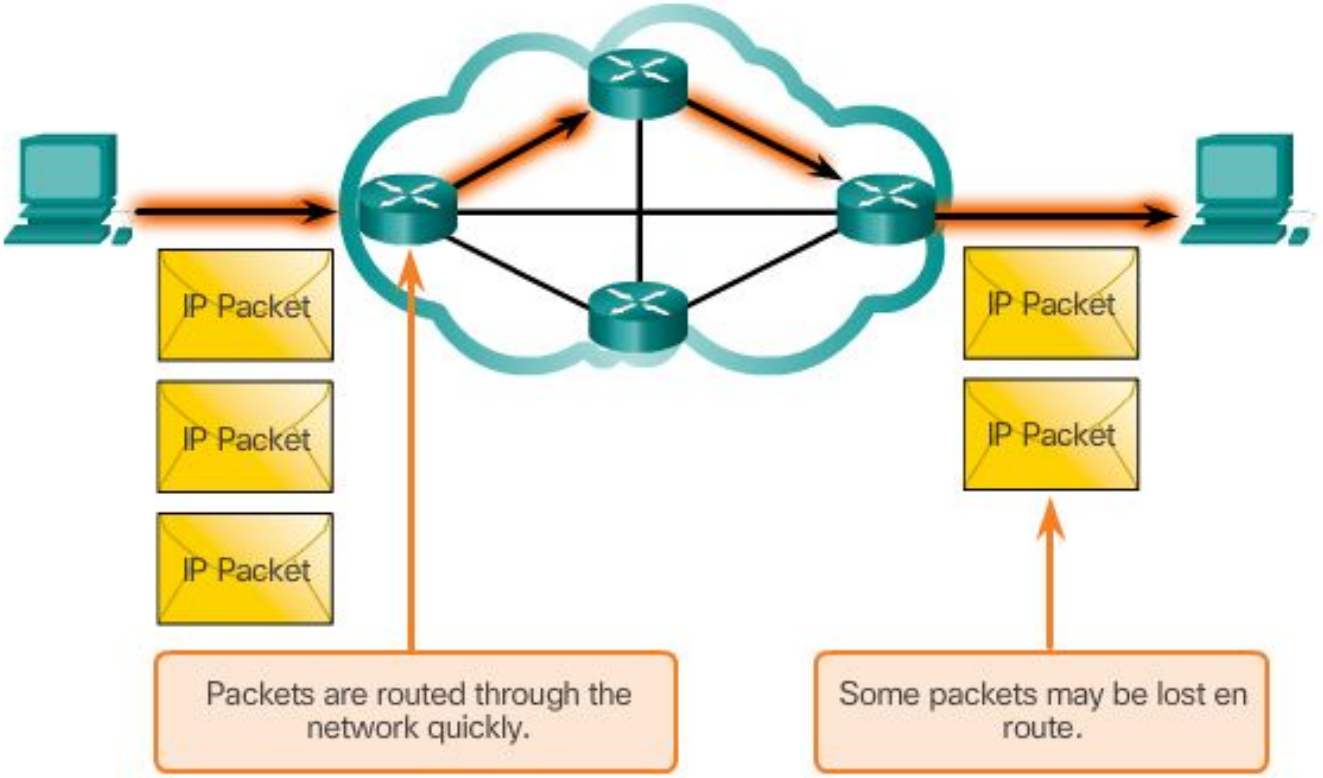
The sender doesn't know:

- If the receiver is present
- If the packet arrived
- If the receiver can read the packet

The receiver doesn't know:

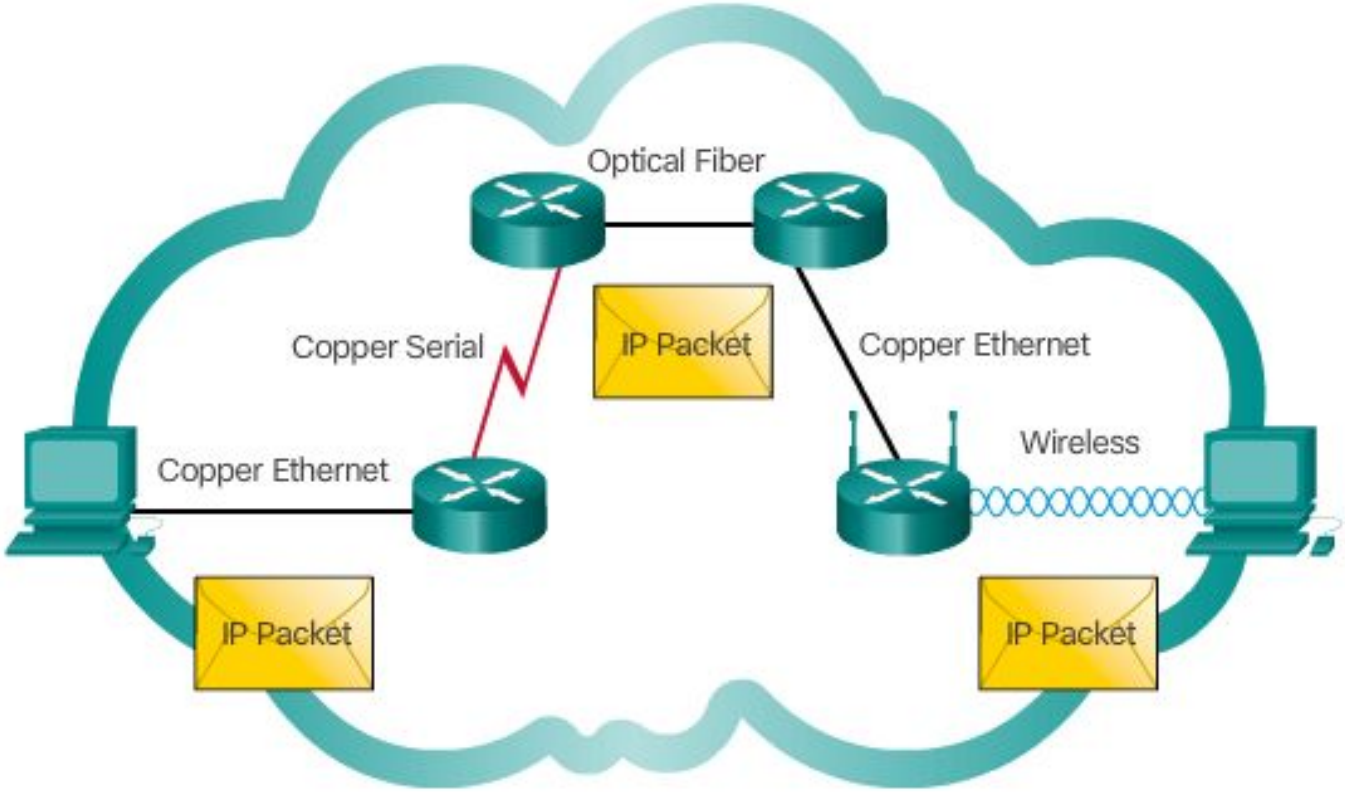
- When it is coming

6.1.2.4 IP – Best Effort Delivery



As an unreliable network layer protocol, IP does not guarantee that all sent packets will be received. Other protocols manage the process of tracking packets and ensuring their delivery.

6.1.2.5 IP – Media Independent



IP packets can travel over different media.

6.1.2.6 Activity - IP characteristics

Activity – IP Characteristics

Read each IP Characteristic. Then click Connectionless, Best Effort, or Media Independent to indicate its delivery method.

IP Characteristic
Fiber optics cabling, satellites, and wireless can all be used to route the same packet.

Delivery Method

Connectionless	Best Effort	Media Independent

Reset

6.1.2.6 Activity - IP characteristics

Activity – IP Characteristics

Read each IP Characteristic. Then click Connectionless, Best Effort, or Media Independent to indicate its delivery method.

Correct

Congratulations! You have matched the IP characteristics to their delivery methods.

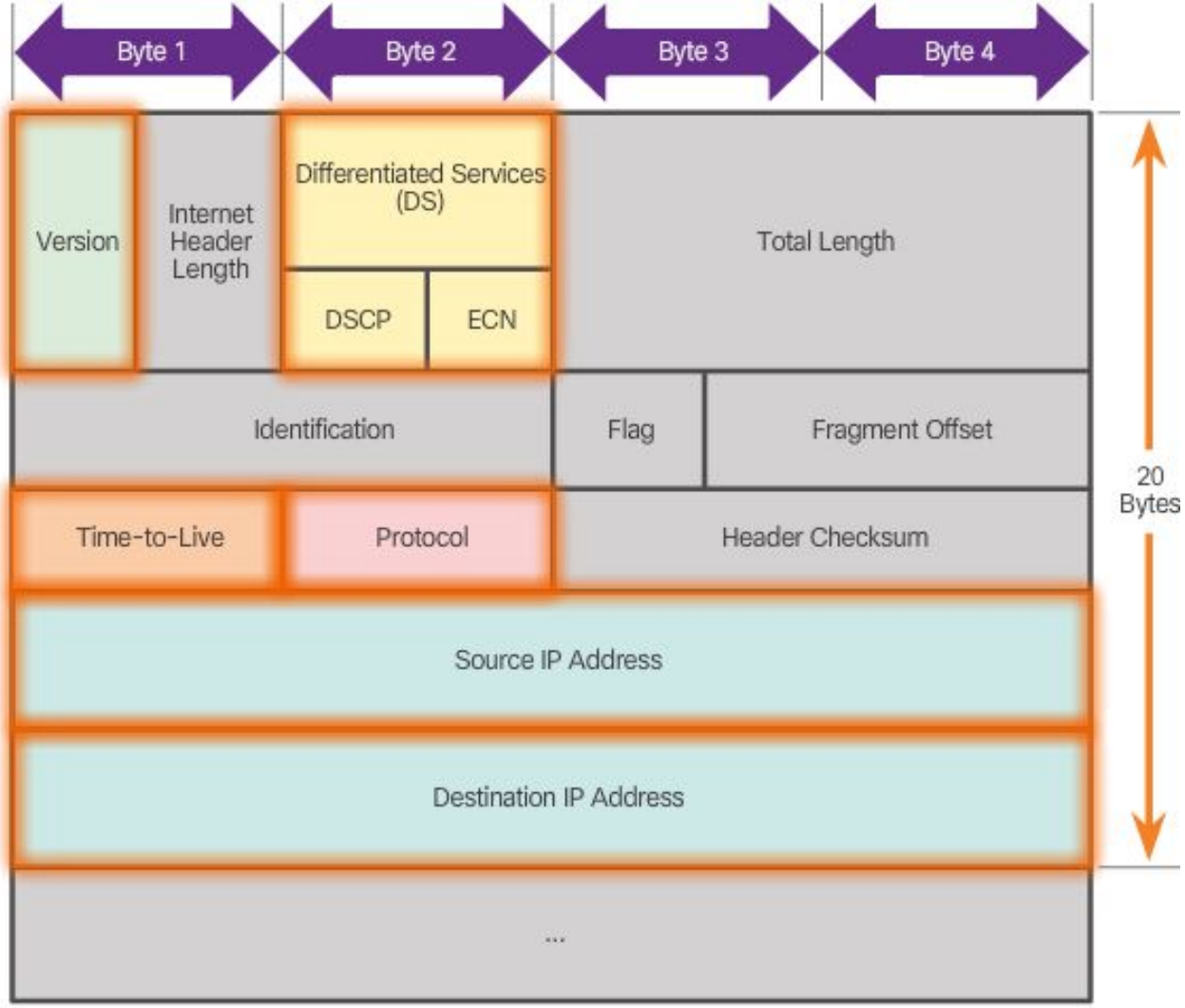
IP Characteristic	Delivery Method
Does not guarantee that the packet will be delivered fully without errors.	Best Effort

Connectionless	Best Effort	Media Independent
Will send a packet even if the destination host is not able to receive it. No contact is made with the destination host before sending a packet.	Packet delivery is not guaranteed. Does not guarantee that the packet will be delivered fully without errors.	Fiber optics cabling, satellites, and wireless can all be used to route the same packet. Will adjust the size of the packet sent depending on what type of network access will be used.

Reset

Topic 6.1.3:
IPv4 Packet

6.1.3.1 IPv4 Packet Header



- Version = 0100
- DS = Packet Priority
- TTL = Limits life of Packet
- Protocol = Upper layer protocol such as TCP
- Source IP Address = source of packet
- Destination IP Address = destination of packet

6.1.3.3 Activity – IPv4 Header Fields

Activity – Part 1: IPv4 Header Fields

Read each IPv4 header function and then click the IPv4 header field to which it belongs.

IPv4 Header Functions
Identifies the IP address of the sending host

IPv4 Header Fields

Version	Differentiated Services
Time-to-Live	Protocol
Source IP Address	Destination IP Address

Reset

6.1.3.3 Activity – IPv4 Header Fields

Activity - Part 1: IPv4 Header Fields

Read each IPv4 header function and then click the IPv4 header field to which it belongs.

Correct

Congratulations! You have matched the IPv4 header functions to their fields.

IPv4 Header Functions
Identifies the IP address of the sending host

IPv4 Header Fields

Version Always set to 0100 for IPv4	**Differentiated Services** Identifies the priority of each packet
Time-to-Live Commonly referred to as hop count	**Protocol** Identifies the upper-layer protocol to be used next
Source IP Address Identifies the IP address of the sending host	**Destination IP Address** Identifies the IP address of the recipient host

Reset

Topic 6.1.4: IPv6 Packet

6.1.4.1 Limitations of IPv4

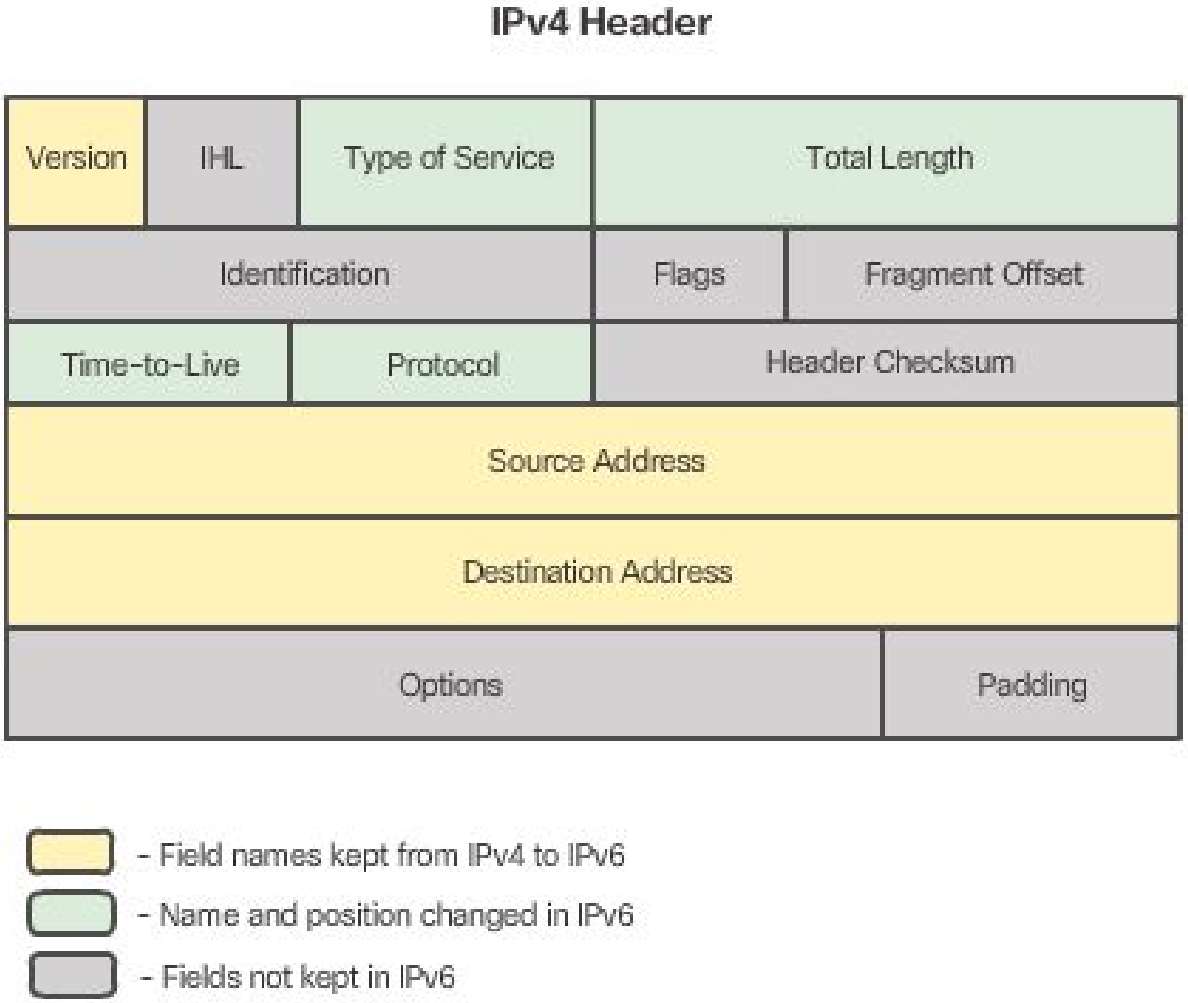
- IP address depletion
- Internet routing table expansion
- Lack of end-to-end connectivity

6.1.4.2 Introducing IPv6

- Increased address space
- Improved packet handling
- Eliminates the need for NAT

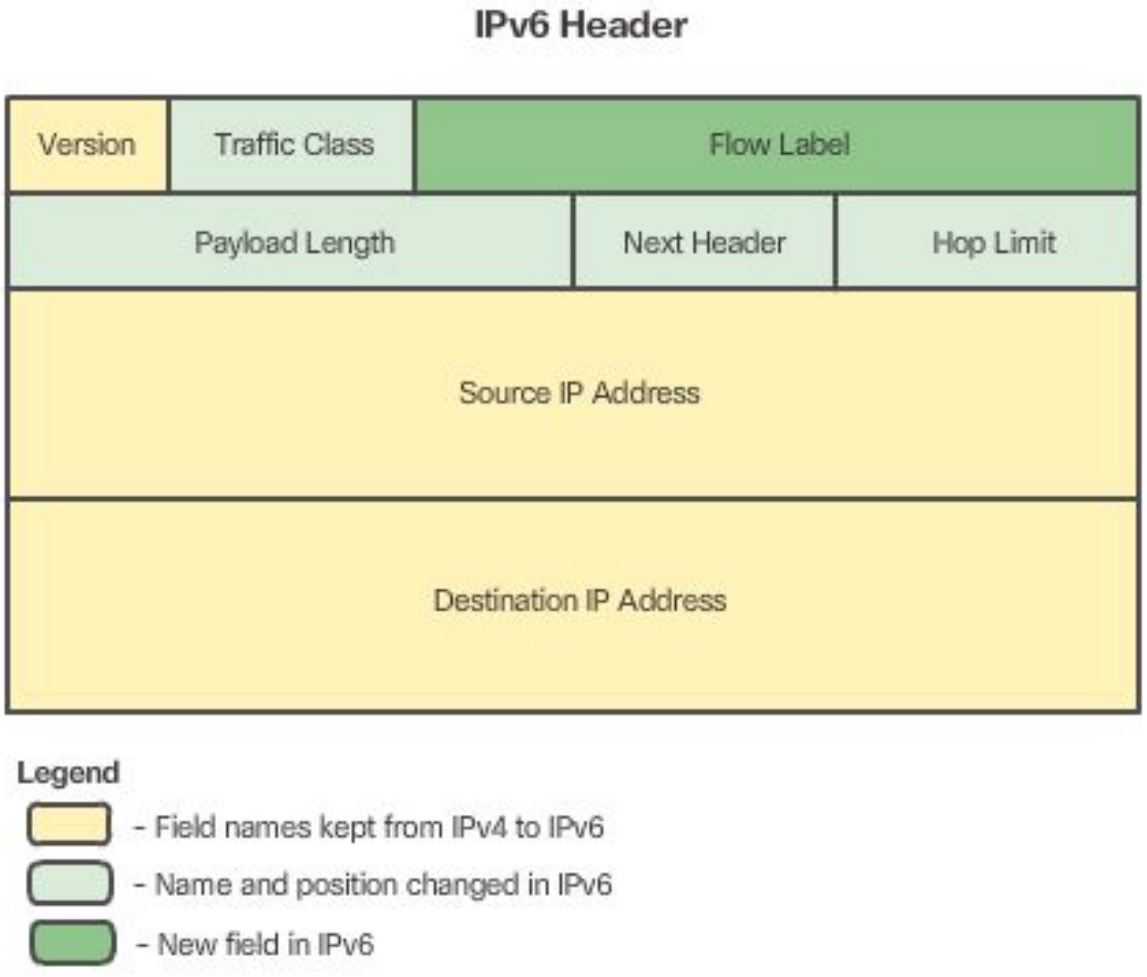
4 billion IPv4 addresses	vs.	340 undecillion IPv6 addresses
4,000,000,000		340,000,000,000,000,000,000,000,000,000,000

6.1.4.3 Encapsulating IPv6



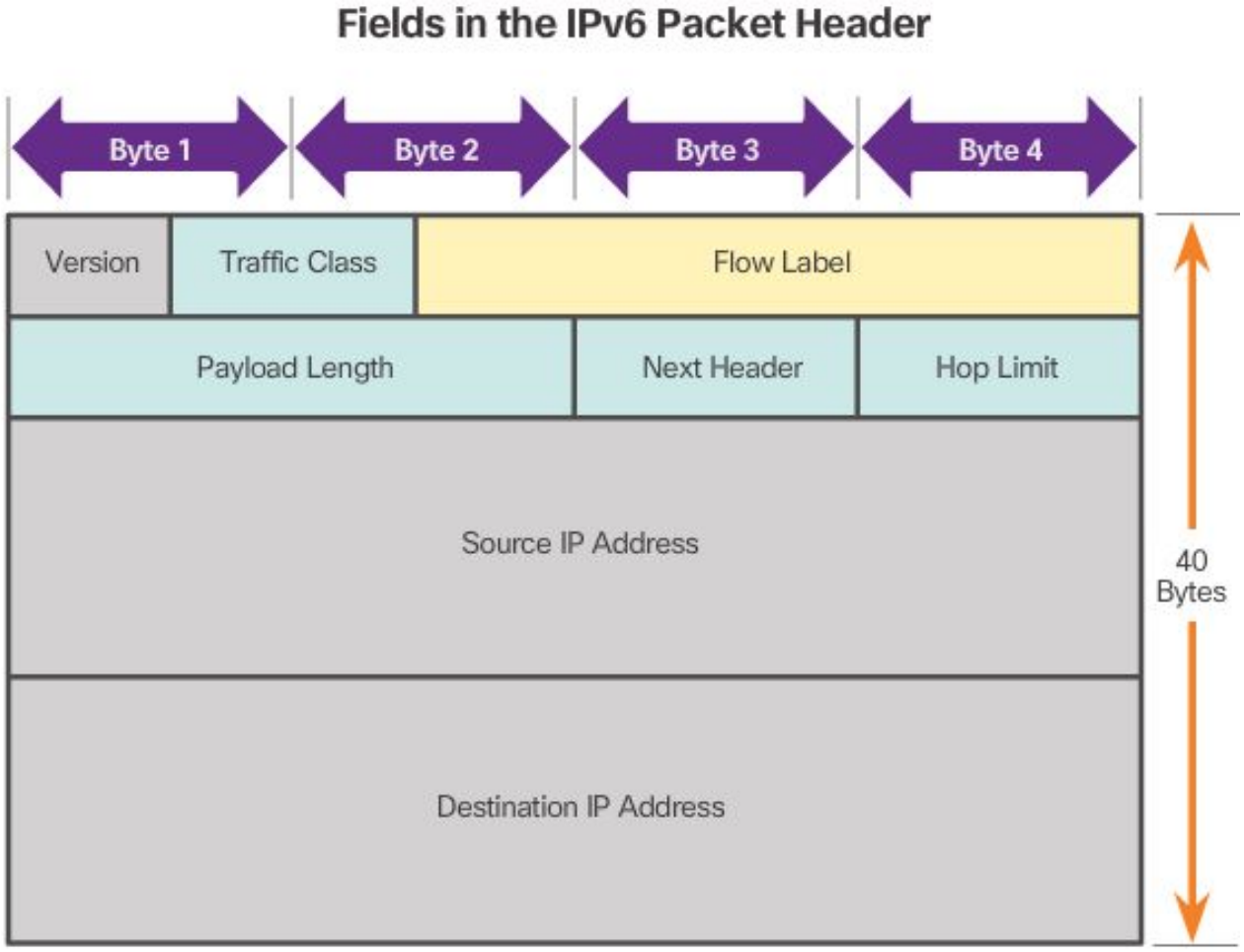
IPv6 has a simplified header

6.1.4.3 Encapsulating IPv6 (cont.)



IPv6 has a simplified header

IPv6 Packet Header

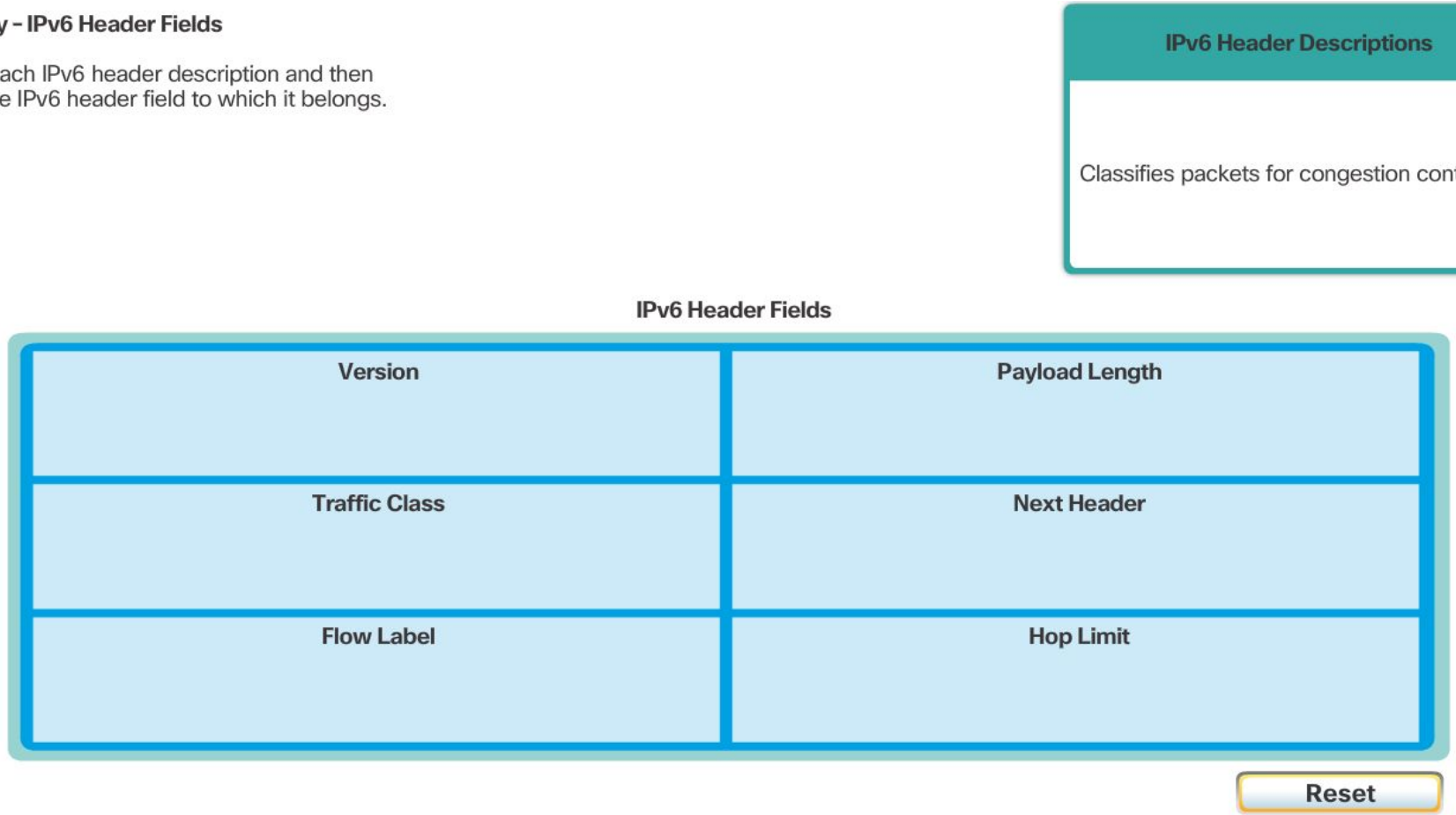


- Version = 0110
- Traffic Class = Priority
- Flow Label = same flow will receive same handling
- Payload Length = same as total length
- Next Header = Layer 4 Protocol
- Hop Limit = Replaces TTL field

6.1.4.6 Activity - IPv6 Header Fields

Activity – IPv6 Header Fields

Read each IPv6 header description and then click the IPv6 header field to which it belongs.



6.1.4.6 Activity - IPv6 Header Fields

Activity – IPv6 Header Fields

Read each IPv6 header description and then click the IPv6 header field to which it belongs.

Correct

Congratulations! You have matched the IPv6 header descriptions to their fields.

IPv6 Header Descriptions

Is always set to 0110

IPv6 Header Fields

Version Is always set to 0110	**Payload Length** Identifies the size of the data portion of the packet
Traffic Class Classifies packets for congestion control	**Next Header** Identifies the application type to the upper-layer protocol
Flow Label To suggest that all packets receive the same type of handling by IPv6 routers	**Hop Limit** When this value reaches 0, the sender is notified that the packet was not delivered

Reset

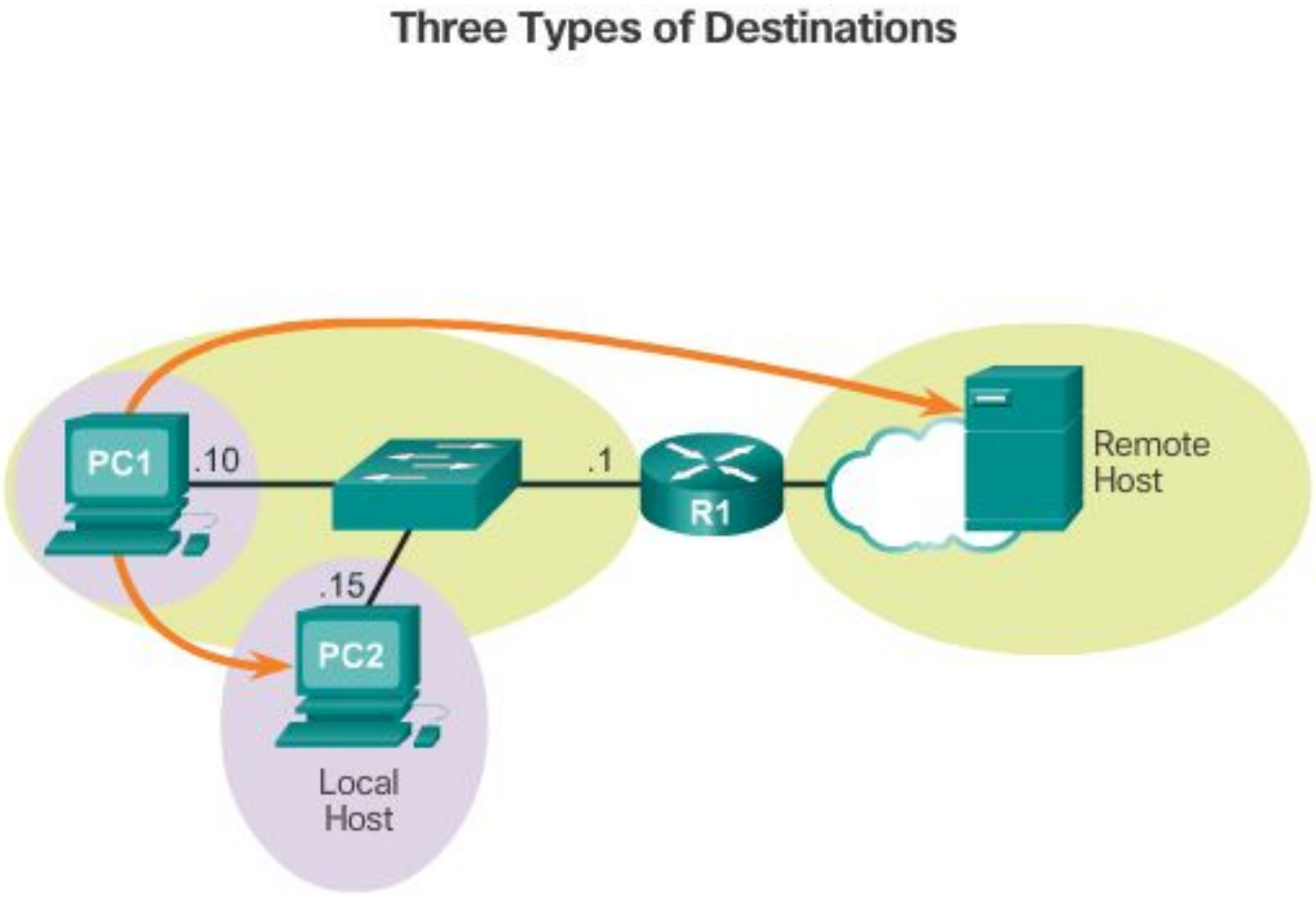
Section 6.2: Routing

Upon completion of this section, you should be able to:

- Explain how a host device uses routing tables to direct packets to itself, a local destination, or a default gateway.
- Compare a host routing table to a routing table in a router.

Topic 6.2.1:
How a Host Routes

6.2.1.1 Host Forwarding Decision

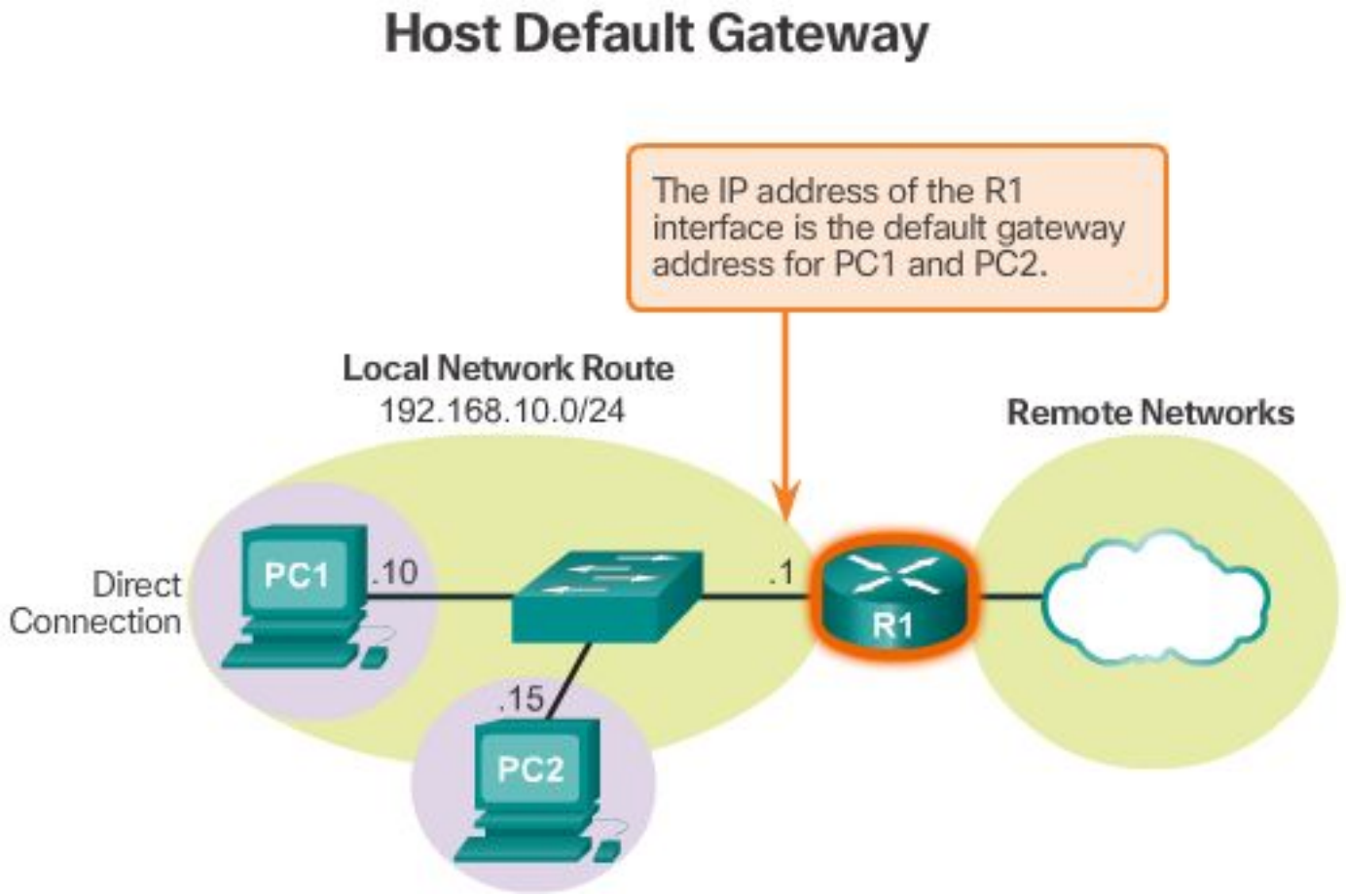


- Itself
- Local Host
- Remote Host

6.2.1.2 Default Gateway

- Routes traffic to other networks
- Has a local IP address in the same address range as other hosts on the network
- Can take data in and forward data out

6.2.1.3 Using the Default Gateway



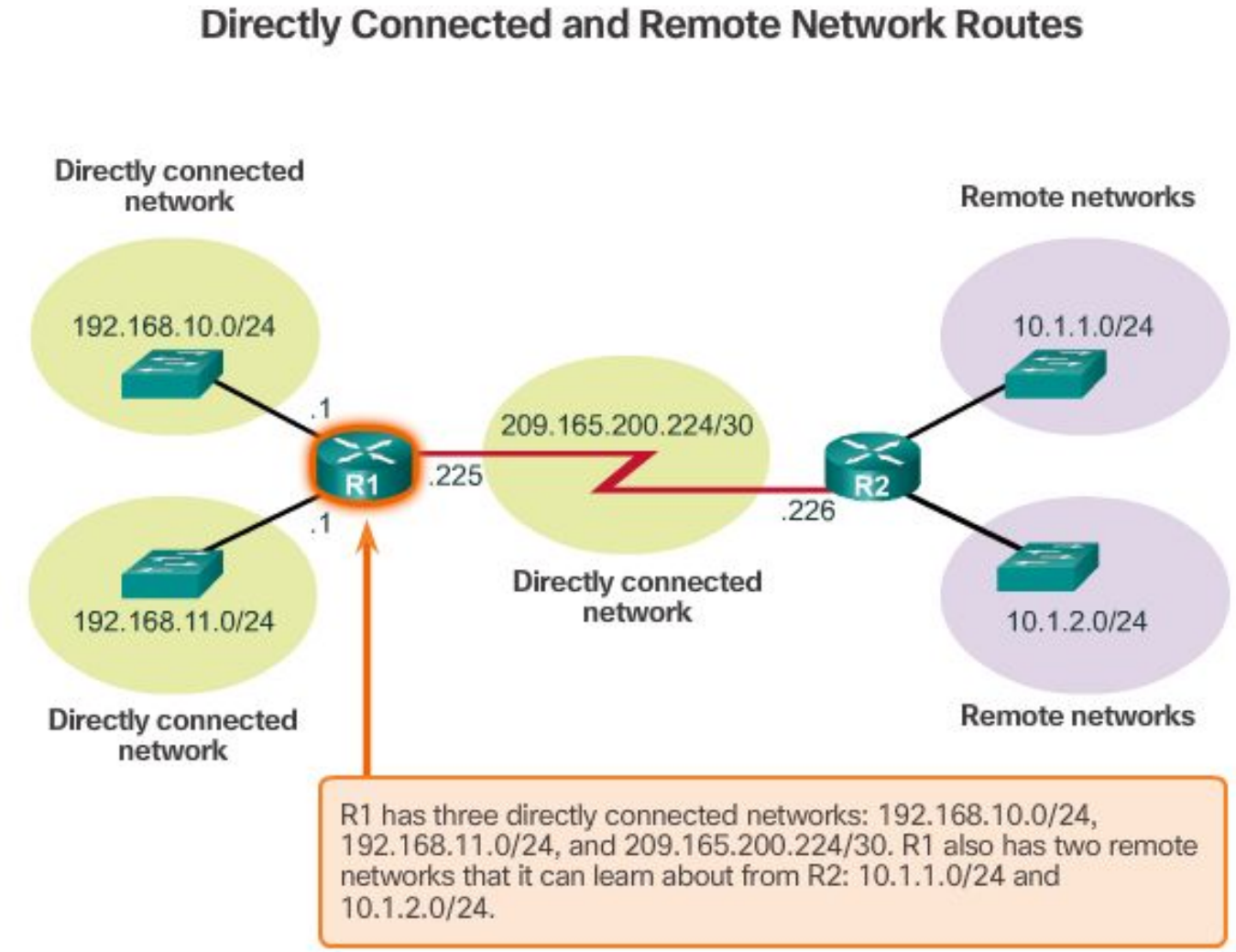
6.2.1.4 Host Routing Tables

IPv4 Routing Table for PC1


```
C:\Users\PC1>netstat -r

<output omitted>

IPv4 Route Table
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0    192.168.10.1   192.168.10.10     25
        127.0.0.0        255.0.0.0         On-link        127.0.0.1    306
        127.0.0.1  255.255.255.255         On-link        127.0.0.1    306
  127.255.255.255  255.255.255.255         On-link        127.0.0.1    306
    192.168.10.0    255.255.255.0         On-link    192.168.10.10    281
   192.168.10.10  255.255.255.255         On-link    192.168.10.10    281
  192.168.10.255  255.255.255.255         On-link    192.168.10.10    281
        224.0.0.0        240.0.0.0         On-link        127.0.0.1    306
        224.0.0.0        240.0.0.0         On-link    192.168.10.10    281
  255.255.255.255  255.255.255.255         On-link        127.0.0.1    306
  255.255.255.255  255.255.255.255         On-link    192.168.10.10    281
===========================================================================

<output omitted>
```

Topic 6.2.2:
Router Routing Tables

6.2.2.1 Router Packet Forwarding Decision

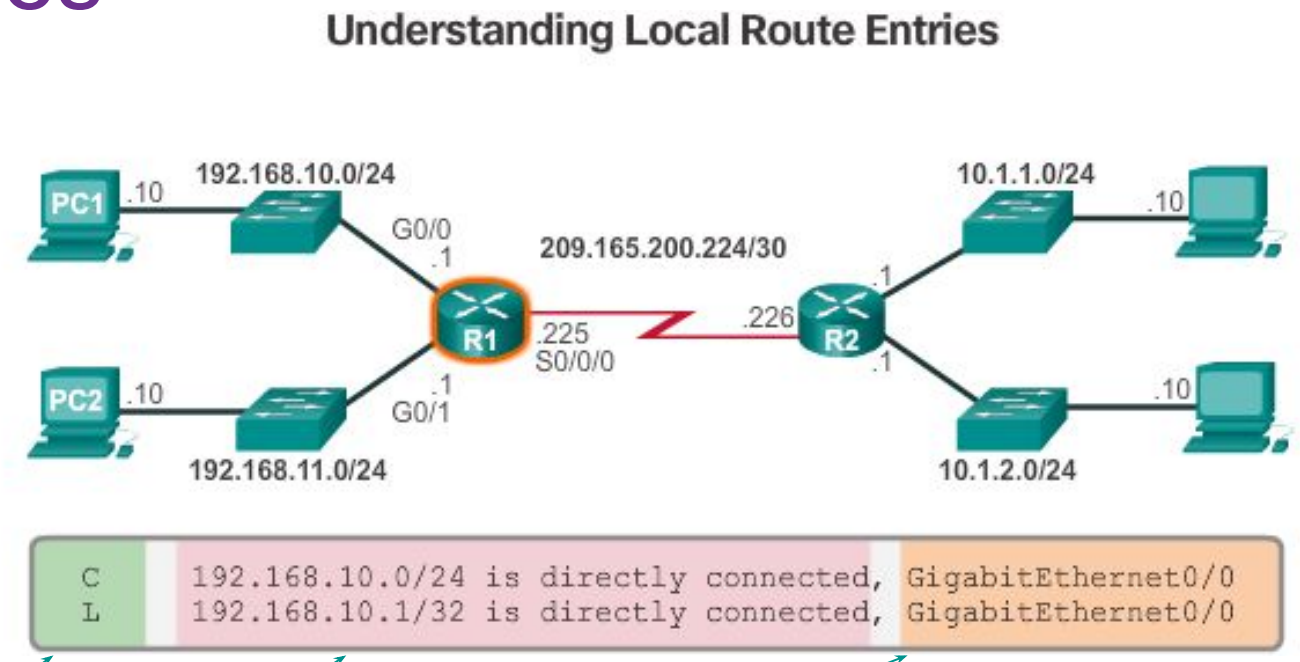


6.2.2.2 IPv4 Router Routing Table

R1 IPv4 Routing Table


```
R1#show ip route
 <output omitted>
Gateway of last resort is not set
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
D       10.1.1.0/24 [90/2170112] via 209.165.200.226, 00:00:05,
        Serial0/0/0
D       10.1.2.0/24 [90/2170112] via 209.165.200.226, 00:00:05,
        Serial0/0/0
     192.168.10.0/24 is variably subnetted, 2 subnets, 3 masks
C       192.168.10.0/24 is directly connected, GigabitEthernet0/0
L       192.168.10.1/32 is directly connected, GigabitEthernet0/0
     192.168.11.0/24 is variably subnetted, 2 subnets, 3 masks
C       192.168.11.0/24 is directly connected, GigabitEthernet0/1
L       192.168.11.1/32 is directly connected, GigabitEthernet0/1
     209.165.200.0/24 is variably subnetted, 2 subnets, 3 masks
C       209.165.200.224/30 is directly connected, Serial0/0/0
L       209.165.200.225/32 is directly connected, Serial0/0/0
```

6.2.2.4 Directly Connected Routing Table Entries

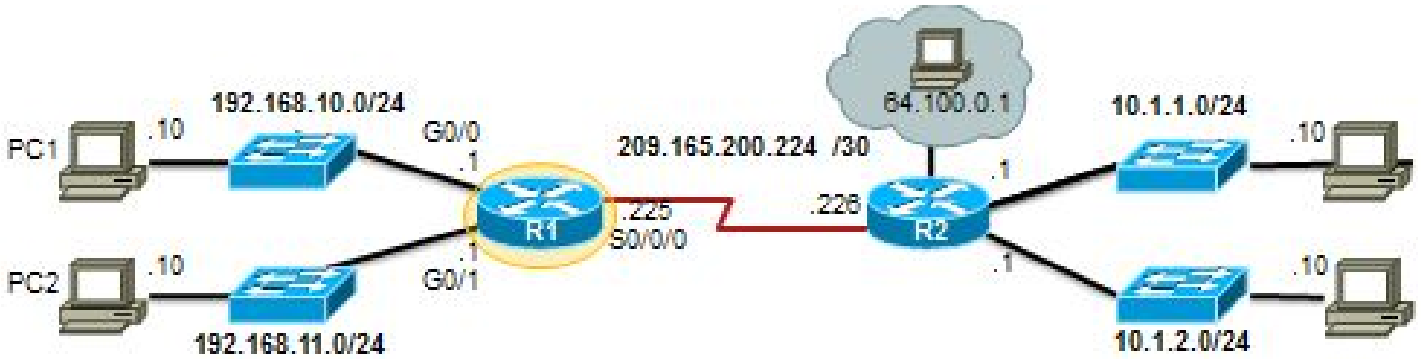


Route source – Identifies how the network was learned by the router.

Destination network – Identifies the destination network and how it was learned.

Outgoing interface – Identifies the exit interface to use to forward a packet toward the final destination.

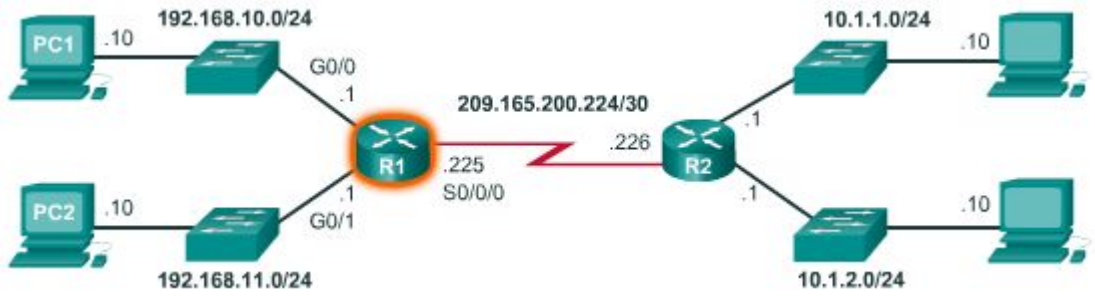
6.2.2.5 Remote Network Routing Table Entries




```
D        10.1.1.0/24 [90/2170112] via 209.165.200.226, 00:00:05, Serial0/0/0
```

A	Identifies how the network was learned by the router.
B	Identifies the destination network.
C	Identifies the administrative distance (trustworthiness) of the route source.
D	Identifies the metric to reach the remote network.
E	Identifies the next hop IP address to reach the remote network.
F	Identifies the amount of elapsed time since the network was discovered.
G	Identifies the outgoing interface on the router to reach the destination network.

6.2.2.6 Next-Hop Address




```
R1# show ip route
<output omitted>
Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
D       10.1.1.0/24 [90/2170112] via 209.165.200.226, 00:00:05,
        Serial0/0/0
D       10.1.2.0/24 [90/2170112] via 209.165.200.226, 00:00:05,
        Serial0/0/0
     192.168.10.0/24 is variably subnetted, 2 subnets, 3 masks
C       192.168.10.0/24 is directly connected, GigabitEthernet0/0
L       192.168.10.1/32 is directly connected, GigabitEthernet0/0
     192.168.11.0/24 is variably subnetted, 2 subnets, 3 masks
C       192.168.11.0/24 is directly connected, GigabitEthernet0/1
L       192.168.11.1/32 is directly connected, GigabitEthernet0/1
     209.165.200.0/24 is variably subnetted, 2 subnets, 3 masks
C       209.165.200.224/30 is directly connected, Serial0/0/0
L       209.165.200.225/32 is directly connected, Serial0/0/0
R1#
```

6.2.2.8 Activity - Identify Elements of a Routing Table Entry

Activity – Identify Elements of a Router Routing Table Entry

A partial **router** routing table entry is shown. Each section of the entry is identified by a circled letter above it.

Select the correct routing table entry section for each output.

	A	B	C	D	E	F
1. The elapsed time since the network was discovered.						
2. The administrative distance (source) and metric to reach the remote network.						
3. How the network was learned by the router.						
4. Shows the destination network.						
5. The next hop IP address to reach the remote network.						
6. The outgoing interface on the router to reach the destination network.						

Check

Reset

6.2.2.8 Activity - Identify Elements of a Routing Table Entry

Activity - Identify Elements of a Router Routing Table Entry

A partial **router** routing table entry is shown. Each section of the entry is identified by a circled letter above it.

Select the correct routing table entry section for each output.

A	B	C	D	E	F
D	192.168.1.0/24	[90/3072]	via 192.168.3.1,	00:06:03,	GigabitEthernet0/0

	A	B	C	D	E	F
1. The elapsed time since the network was discovered.					✓	
2. The administrative distance (source) and metric to reach the remote network.			✓			
3. How the network was learned by the router.	✓					
4. Shows the destination network.		✓				
5. The next hop IP address to reach the remote network.				✓		
6. The outgoing interface on the router to reach the destination network.						✓

Check

Reset

Section 6.3: Routers

Upon completion of this section, you should be able to:

- Describe the common components and interfaces of a router.
- Describe the boot-up process of a Cisco IOS router.

Topic 6.3.1:
Anatomy of a Router

6.3.1.1 A Router is a Computer/Router CPU and OS

Routers require:

- Central processing units (CPUs)
- Operating systems (OSs)

Memory consisting of:

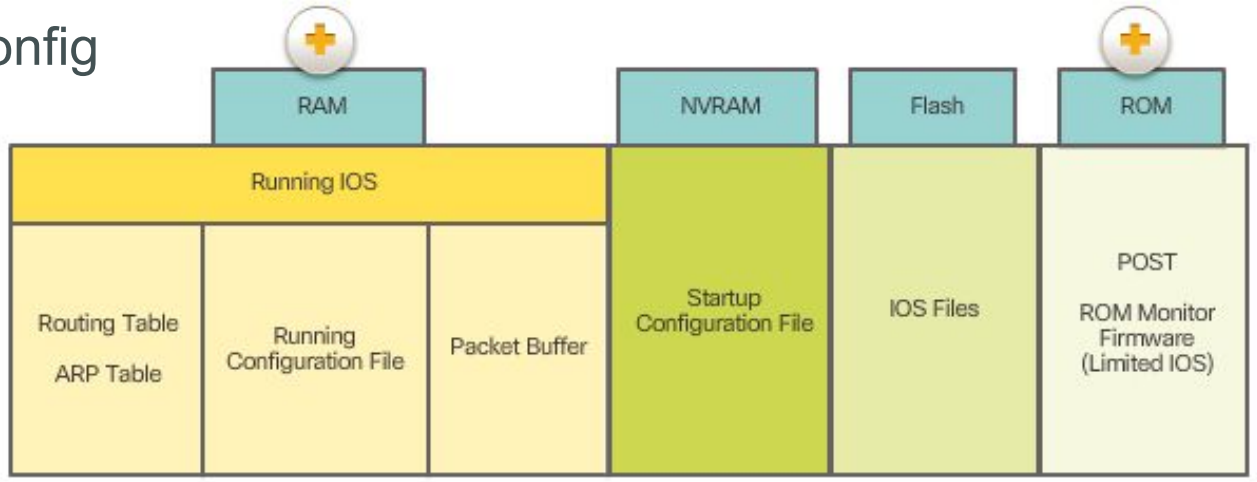
  - Random-access memory (RAM)
  - Read-only memory (ROM)
  - Nonvolatile random-access memory (NVRAM)
  - Flash

- The Cisco Internetwork Operating System (IOS) is the system software used for most Cisco devices regardless of the size and type of the device.

6.3.1.3 Router Memory

RAM uses the following applications and processes:

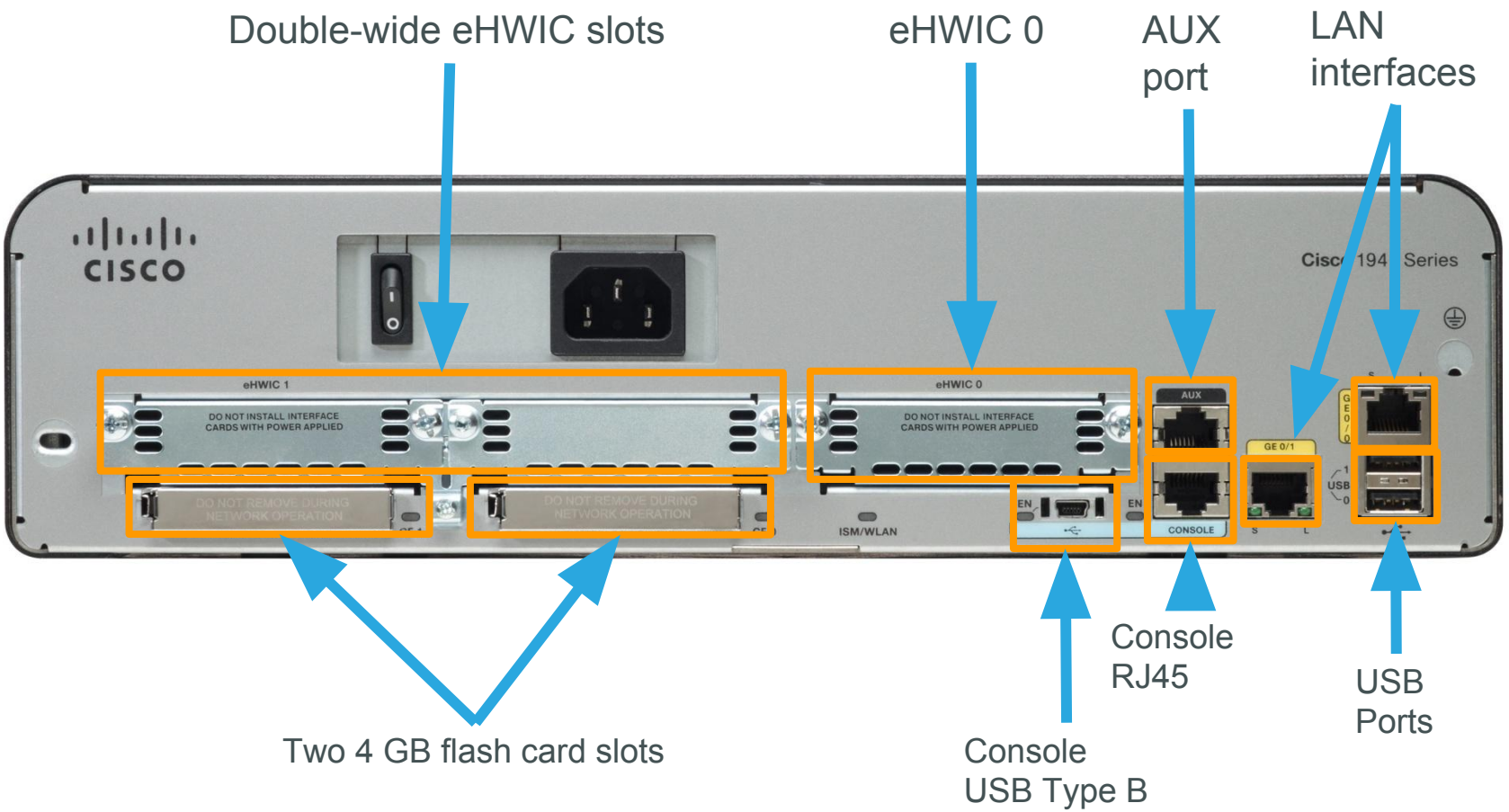
- IOS and running-config
- Routing table
- ARP cache
- Packet buffering



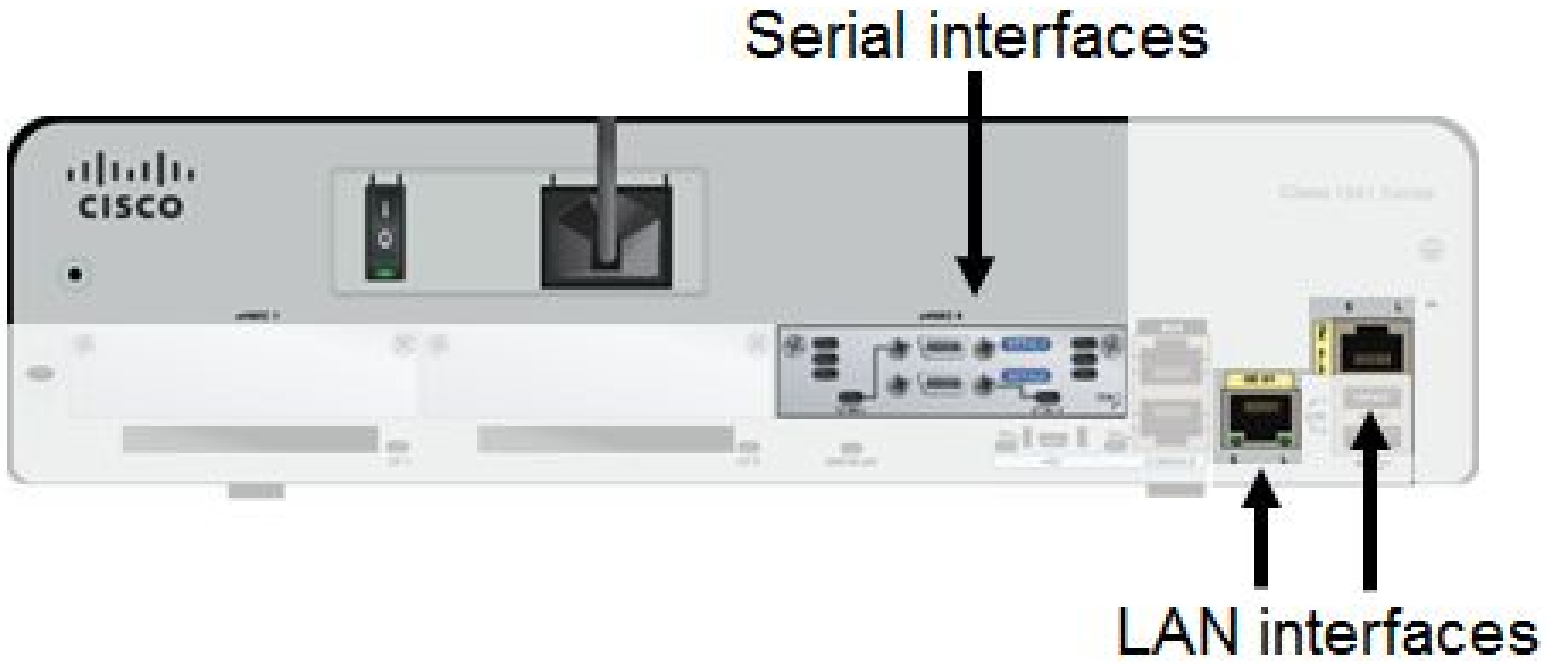
ROM stores the following:

- Bootup information that provides the startup instructions
- Power-on self-test (POST) that tests all the hardware components
- Limited IOS to provide a backup version of the IOS.

6.3.1.5 Connect to a Router



LAN and WAN Interfaces



6.3.1.7 Activity - Identify Router Components

Activity – Identify Router Components

Descriptions of router functions and hardware parts are provided in the table. Drag each router component name to its function/description.

WAN interface

AUX port

LAN interface

Telnet or SSH

Console port

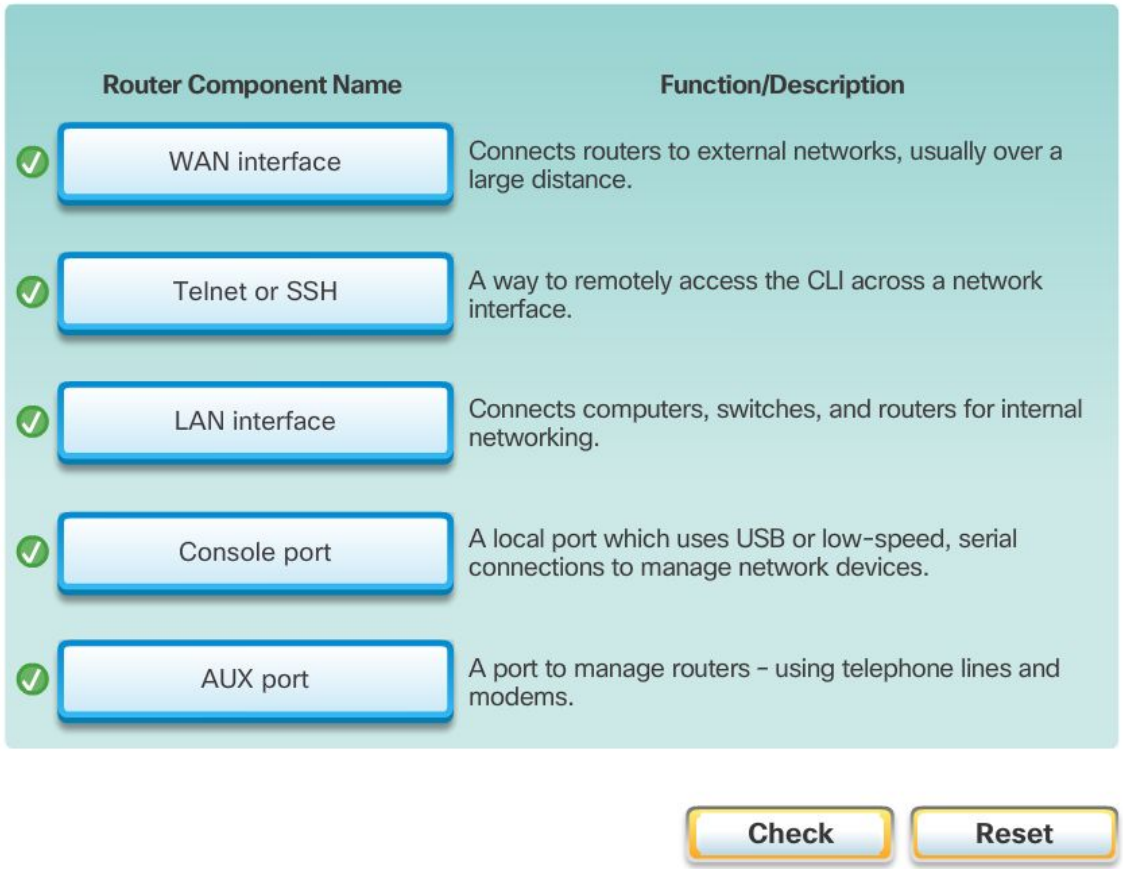
Router Component Name	Function/Description
	Connects routers to external networks, usually over a large distance.
	A way to remotely access the CLI across a network interface.
	Connects computers, switches, and routers for internal networking.
	A local port which uses USB or low-speed, serial connections to manage network devices.
	A port to manage routers – using telephone lines and modems.

Check Reset

6.3.1.7 Activity - Identify Router Components

Activity – Identify Router Components

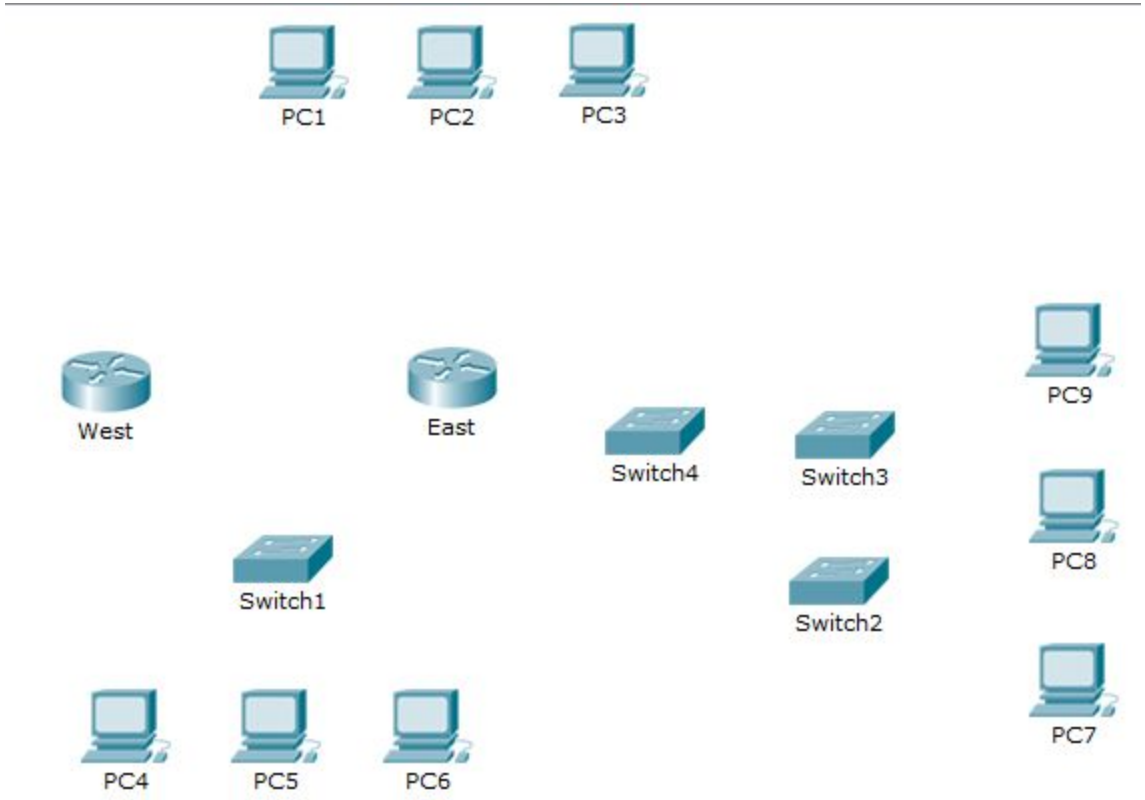
Descriptions of router functions and hardware parts are provided in the table. Drag each router component name to its function/description.



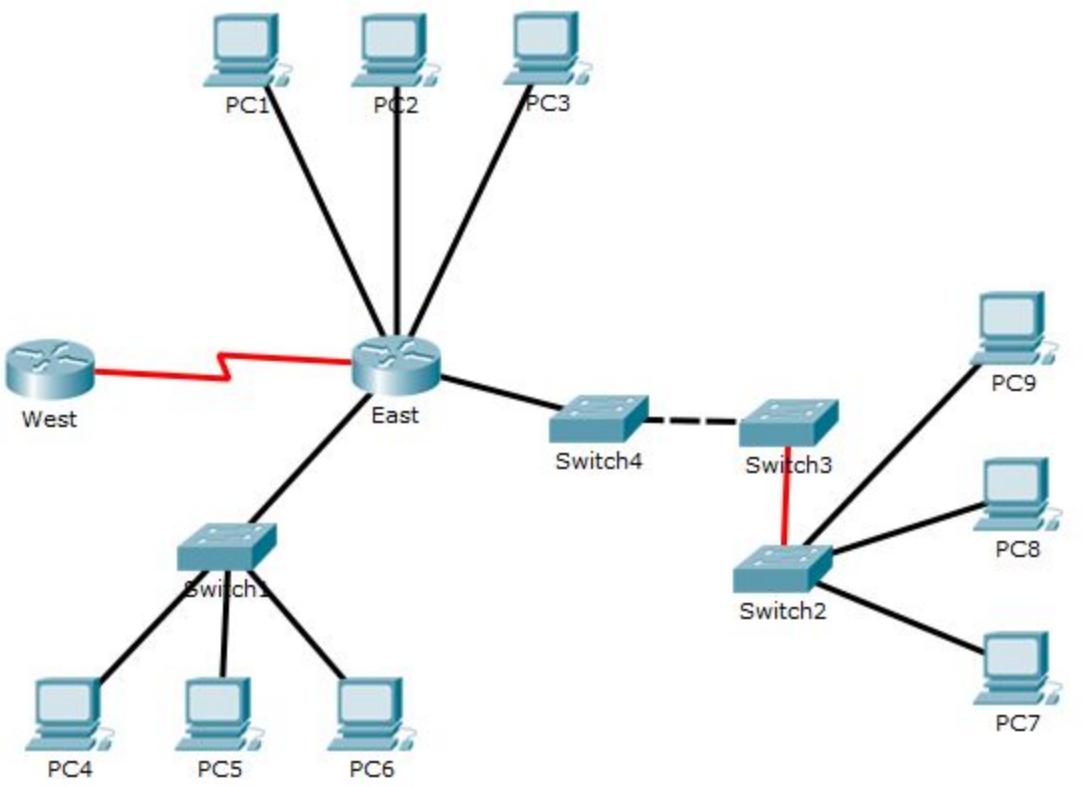
Correct

You have successfully matched the router component names to their functions/descriptions.

6.3.1.8 Packet Tracer - Exploring Internetworking Devices

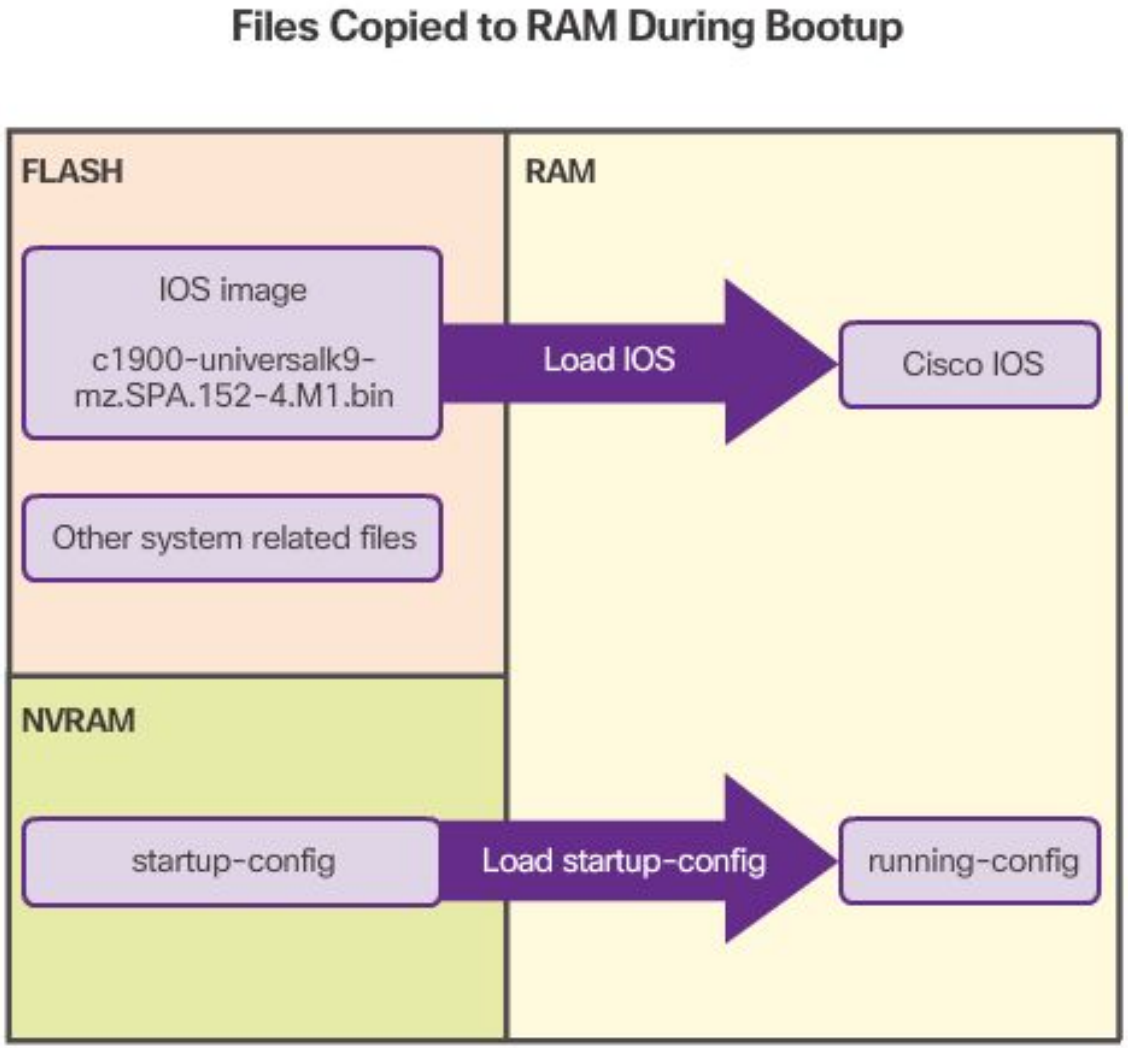


6.3.1.8 Packet Tracer - Exploring Internetworking Devices



Topic 6.3.2:
Router Boot-up

6.3.2.1 Bootset Files



6.3.2.4 Show version output

```
Router#show version
Cisco IOS Software, C1900 Software (C1900-UNIVERSALK9-M),
Version 15.2(4)M1, RELEASE SOFTWARE (fc1)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2012 by Cisco Systems, Inc.
Compiled Thu 26-Jul-12 19:34 by prod_rel_team

ROM: System Bootstrap, Version 15.0(1r)M15,
RELEASE SOFTWARE (fc1)

Router uptime is 10 hours, 9 minutes
System returned to ROM by power-on
System image file is
"flash0:c1900-universalk9-mz.SPA.152-4.M1.bin"
Last reload type: Normal Reload
Last reload reason: power-on

<output omitted>

Cisco CISCO1941/K9 (revision 1.0)
with 446464K/77824K bytes of memory.
Processor board ID FTX1636848Z
```

6.3.2.4 Show version output (cont.)

```
2 Gigabit Ethernet interfaces
2 Serial(sync/async) interfaces
1 terminal line
DRAM configuration is 64 bits wide with parity disabled.
255K bytes of non-volatile configuration memory.
250880K bytes of ATA System CompactFlash 0 (Read/Write)

<output omitted>

Technology Package License Information for Module:'c1900'

-----------------------------------------------------------------
Technology   Technology-package          Technology-package
             Current       Type          Next reboot
-----------------------------------------------------------------
ipbase       ipbasek9      Permanent     ipbasek9
security     None          None          None
data         None          None          None

Configuration register is 0x2142
(will be 0x2102 at next reload)
```

Section 6.4: Configure a Cisco Router

Upon completion of this section, you should be able to:

- Configure initial settings on a Cisco IOS router.
- Configure two active interfaces on a Cisco IOS router.
- Configure devices to use the default gateway.

Topic 6.4.1:
Configure Initial Settings

6.4.1.1 Basic Switch Configuration Steps

6.4.1.2 Basic Router Configuration Steps

6.4.1.3 Packet Tracer - Configure Initial Router Settings

Terminal

```
Image text-base: 0x2100F918, data-base: 0x24729040

This product contains cryptographic features and is subject to United
States and local country laws governing import, export, transfer and
use. Delivery of Cisco cryptographic products does not imply
third-party authority to import, export, distribute or use encryption.
Importers, exporters, distributors and users are responsible for
compliance with U.S. and local country laws. By using this product you
agree to comply with applicable laws and regulations. If you are unable
to comply with U.S. and local laws, return this product immediately.

A summary of U.S. laws governing Cisco cryptographic products may be found at:
http://www.cisco.com/wwl/export/crypto/tool/stqrg.html

If you require further assistance please contact us by sending email to
export@cisco.com.

Cisco CISCO1941/K9 (revision 1.0) with 491520K/32768K bytes of memory.
Processor board ID FTX152400KS
4 FastEthernet interface(s)
2 Gigabit Ethernet interfaces
2 Low-speed serial(sync/async) network interface(s)
DRAM configuration is 64 bits wide with parity disabled.
255K bytes of non-volatile configuration memory.
249856K bytes of ATA System CompactFlash 0 (Read/Write)

Press RETURN to get started!
```

6.4.1.3 Packet Tracer - Configure Initial Router Settings

```
Router>enable
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#line console 0
Router(config-line)#pass
Router(config-line)#password letmein
Router(config-line)#exit
Router(config)#ena
Router(config)#enable pa
Router(config)#enable password cisco
Router(config)#enable secret itsasecret
Router(config)#bann
Router(config)#banner mot
Router(config)#banner motd "Unauthorized access is strictly prohibited"
Router(config)#
```

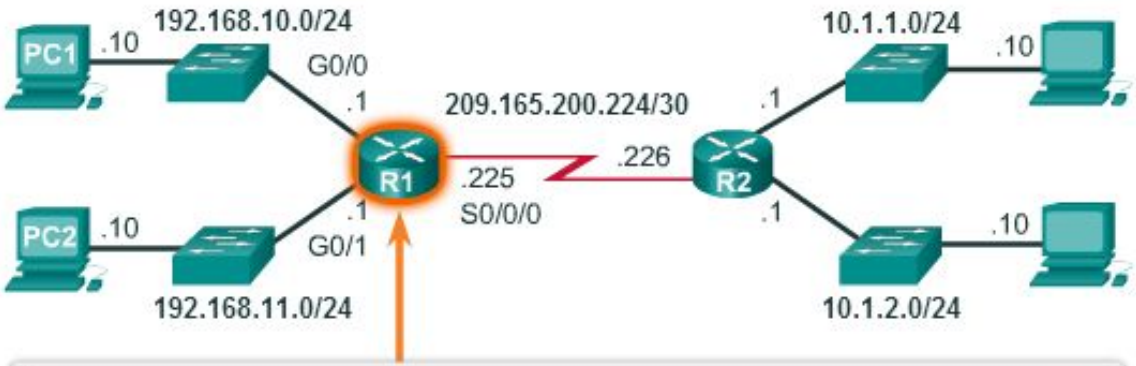
6.4.2.1 Configure Router Interfaces

- **Configure the interface**
  - **interface** *type-and-number*
  - **description** *description-text*
  - **ip address** *ipv4-address subnet-mask*
  - **no shutdown**


```
R1#conf t
Enter configuration commands, one per line.
End with CNTL/Z.
R1(config)#
R1(config)#interface gigabitethernet 0/0
R1(config-if)#ip address 192.168.10.1 255.255.255.0
R1(config-if)#description Link to LAN-10
R1(config-if)#no shutdown
%LINK-5-CHANGED: Interface GigabitEthernet0/0,
changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet0/0,changed state to up
```

6.4.2.2 Verify Interface Configuration

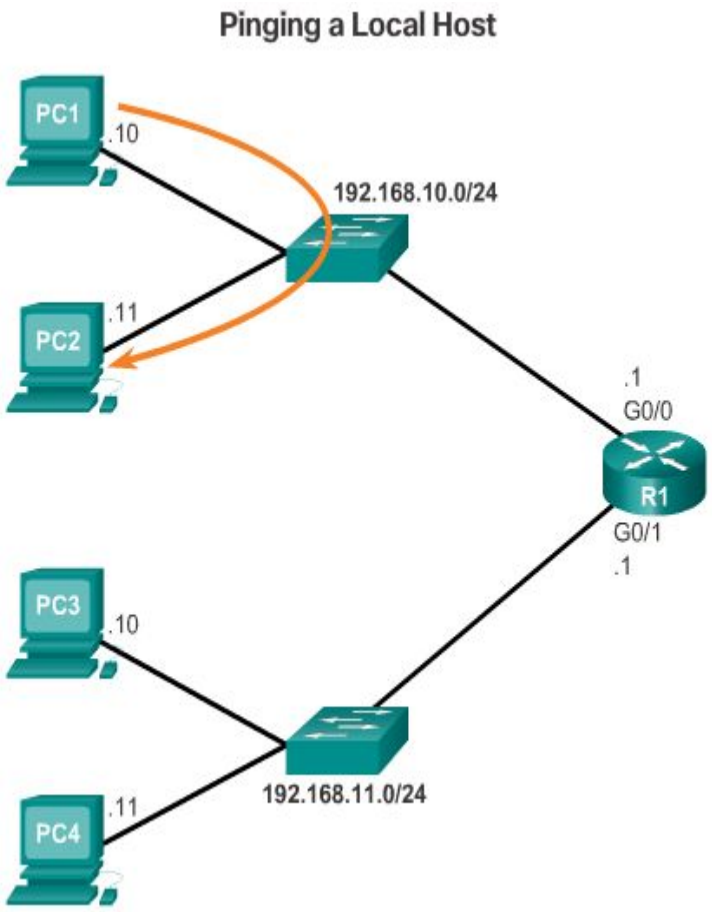
- **show ip route -** Displays the contents of the IPv4 routing table stored in RAM.
- **show interfaces -**Displays statistics for all interfaces on the device.
- **show ip interface -**Displays the IPv4 statistics for all interfaces on a router.

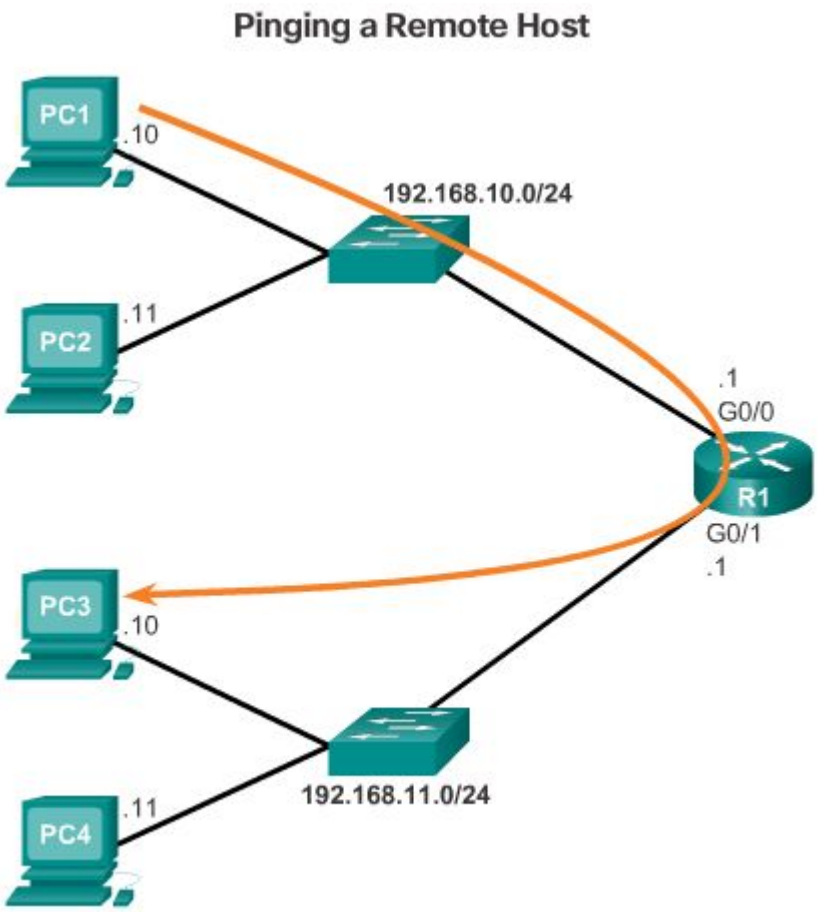



```
R1#show ip interface brief
Interface              IP-Address      OK?  Method Status

GigabitEthernet0/0     192.168.10.1    YES  manual up
GigabitEthernet0/1     192.168.11.1    YES  manual up
Serial0/0/0            209.165.200.225 YES  manual up
Serial0/0/1            unassigned      YES  NVRAM  administratively do
Vlan1                  unassigned      YES  NVRAM  administratively do
R1#
R1#ping 209.165.200.226

Type escape sequence to abort.
```

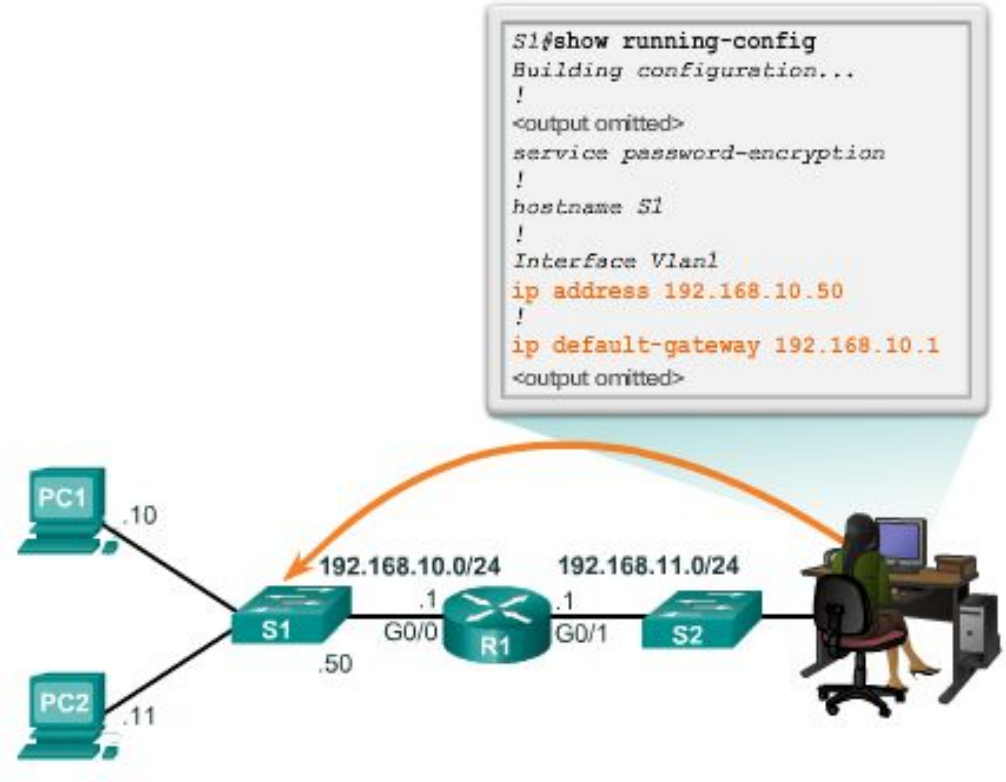
Topic 6.4.3:
Configure the Default Gateway

6.4.3.1 Default Gateway for a Host



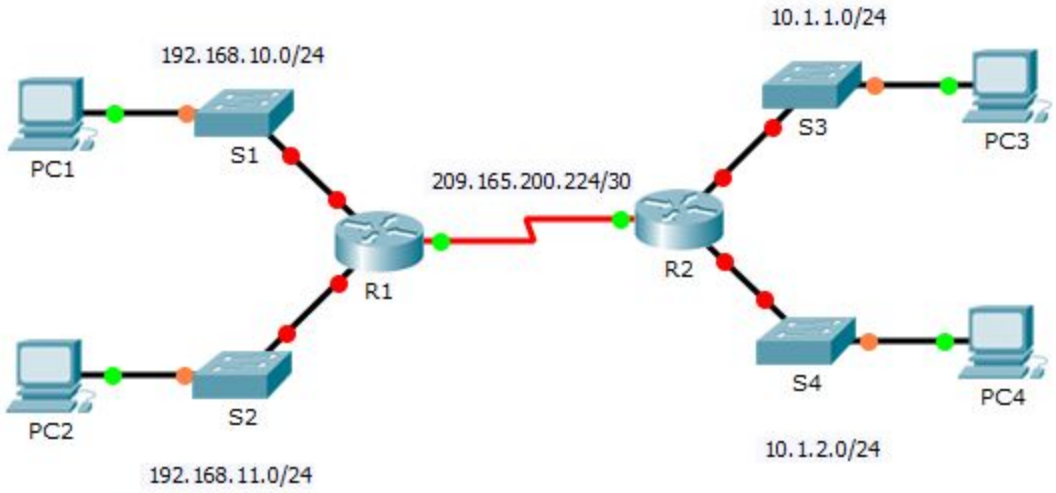


6.4.3.2 Default Gateway for a Switch

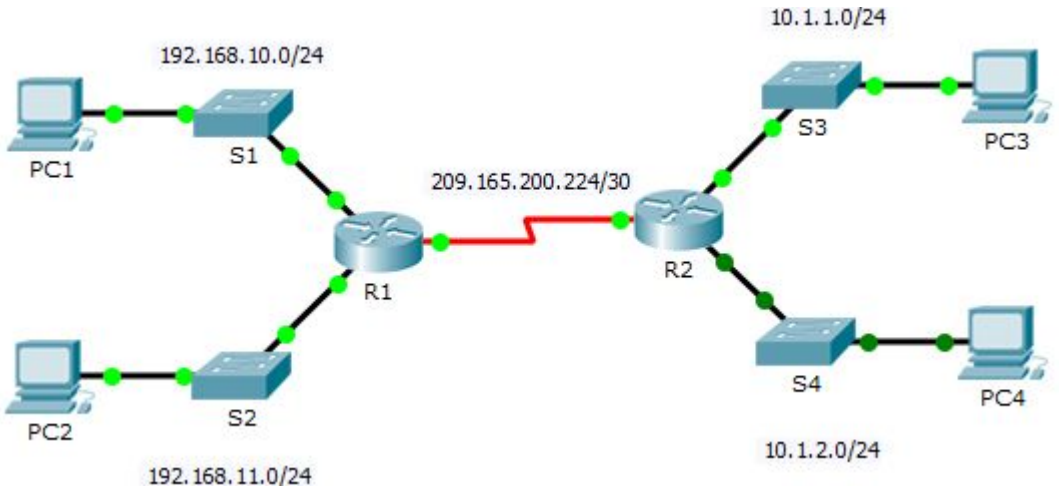


If the default gateway was not configured on S1, response packets from S1 would not be able to reach the administrator at 192.168.11.10. The administrator would not be able to manage the device remotely.

6.4.3.3 Packet Tracer – Connect a Router to a LAN

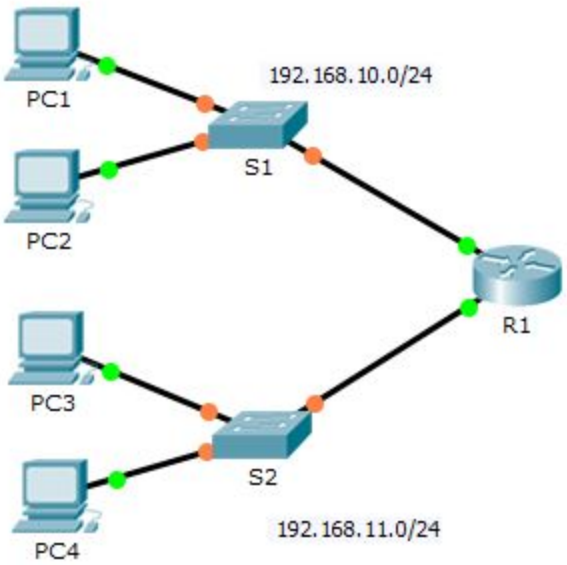


6.4.3.3 Packet Tracer – Connect a Router to a LAN




```
R1#enable
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface gig0/0
R1(config-if)#ip address 192.168.10.1 255.255.255.0
R1(config-if)#description LAN connection to S1
R1(config-if)#no shutdown
R1(config-if)#exit
```

6.4.3.4 Packet Tracer – Troubleshooting Default Gateway Issues

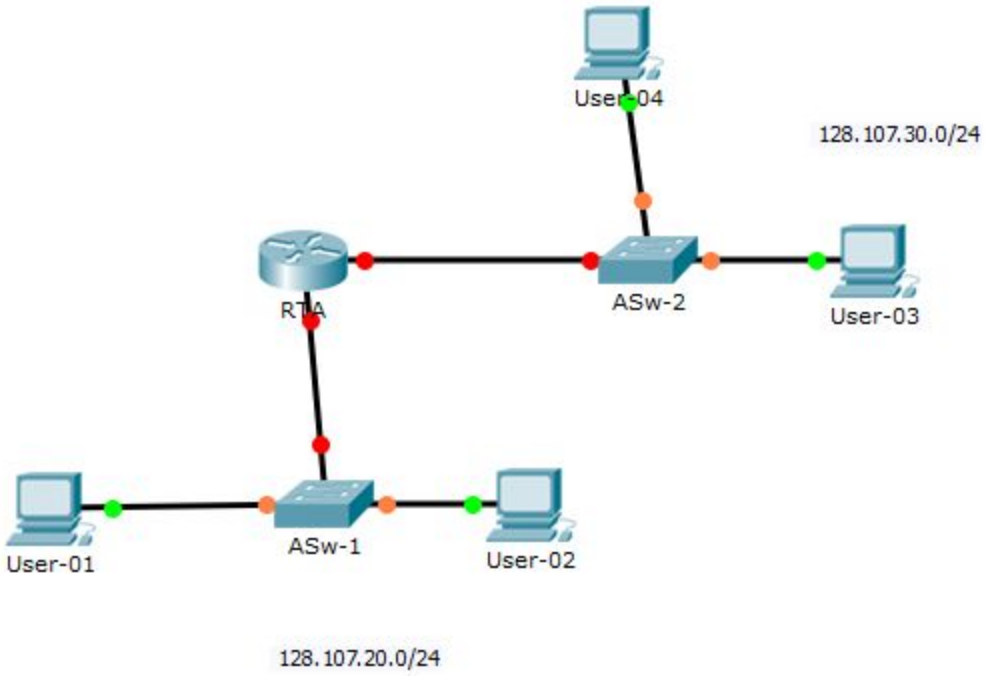


Section 6.5: Summary

Chapter Objectives:

- Explain how network layer protocols and services support communications across data networks.
- Explain how routers enable end-to-end connectivity in a small to medium-sized business network.
- Explain how devices route traffic in a small to medium-sized business network.
- Configure a router with basic configurations.

6.5.1.3 Packet Tracer – Skills Integration Challenge



Thank you.

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Mind Wide Open