Chapter 6: Network Layer

Introduction to Networks v6.0

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Chapter 6 - Sections & Objectives

6.1 Network Layer Protocols

- Describe the purpose of the network layer in data communication.
- Explain why the IPv4 protocol requires other layers to provide reliability.
- Explain the role of the major header fields in the IPv4 and IPv6 packet.

6.2 Routing

- 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.

6.3 Routers

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

6.4 Configure a Cisco Router

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

6.1 Network Layer Protocols

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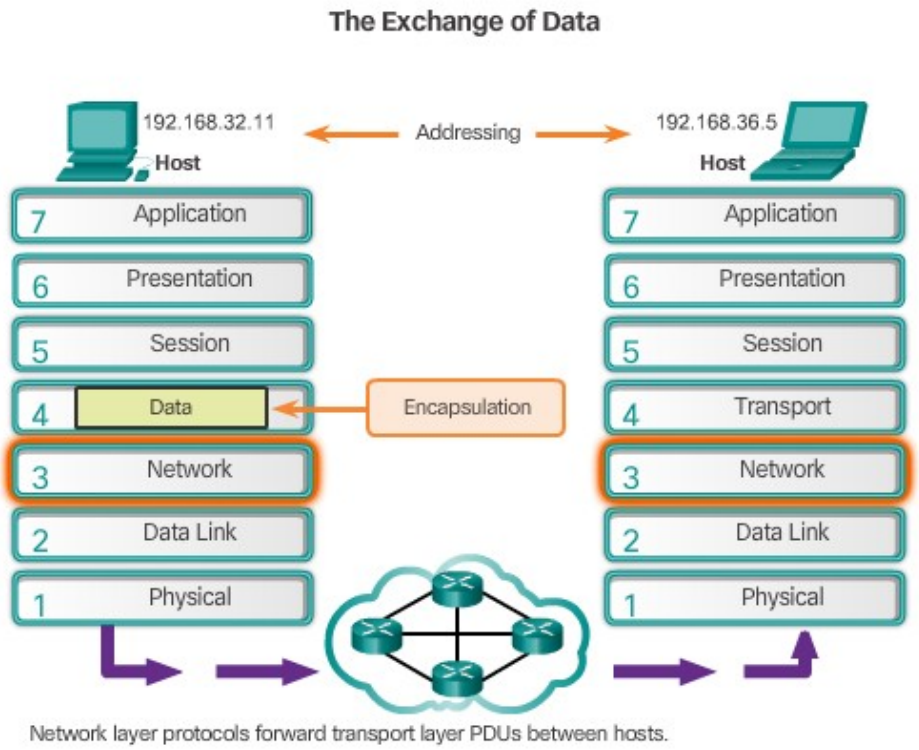
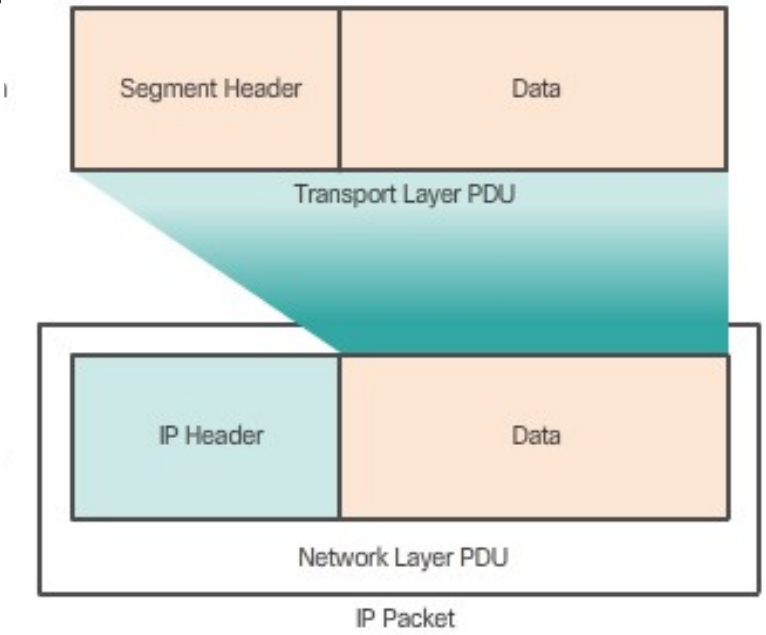
Network Layer in Communications

- The Network Layer
  - End to End Transport processes
  - Addressing end devices
  - Encapsulation
  - Routing
  - De-encapsulating
- Network Layer Protocols
  - IPv4
  - IPv6



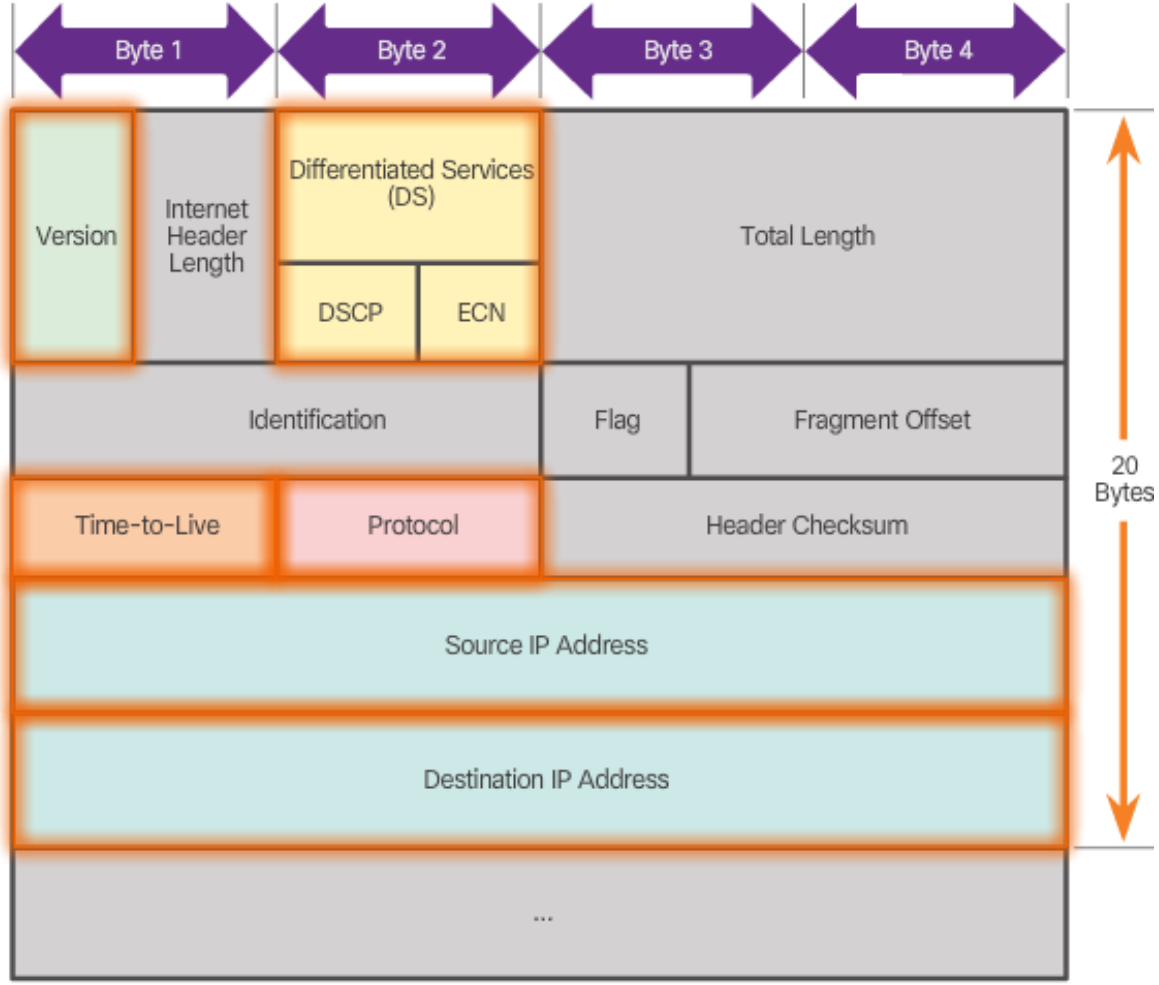
Characteristics of the IP Protocol

- Encapsulating IP
  - Segments are encapsulated into IP packets for transmission.
  - The network layer adds a header so packets can be routed to the destination.
- IP - Connectionless
  - Sender doesn't know if the receiver is listening or the message arrived on time.
  - Receiver doesn't know data is coming.
- IP – Best Effort Delivery
  - No guarantees of delivery are made.
- IP – Media Independent
  - IP can travel over different types of media.



IPv4 Packet

- IPv4 Packet Header



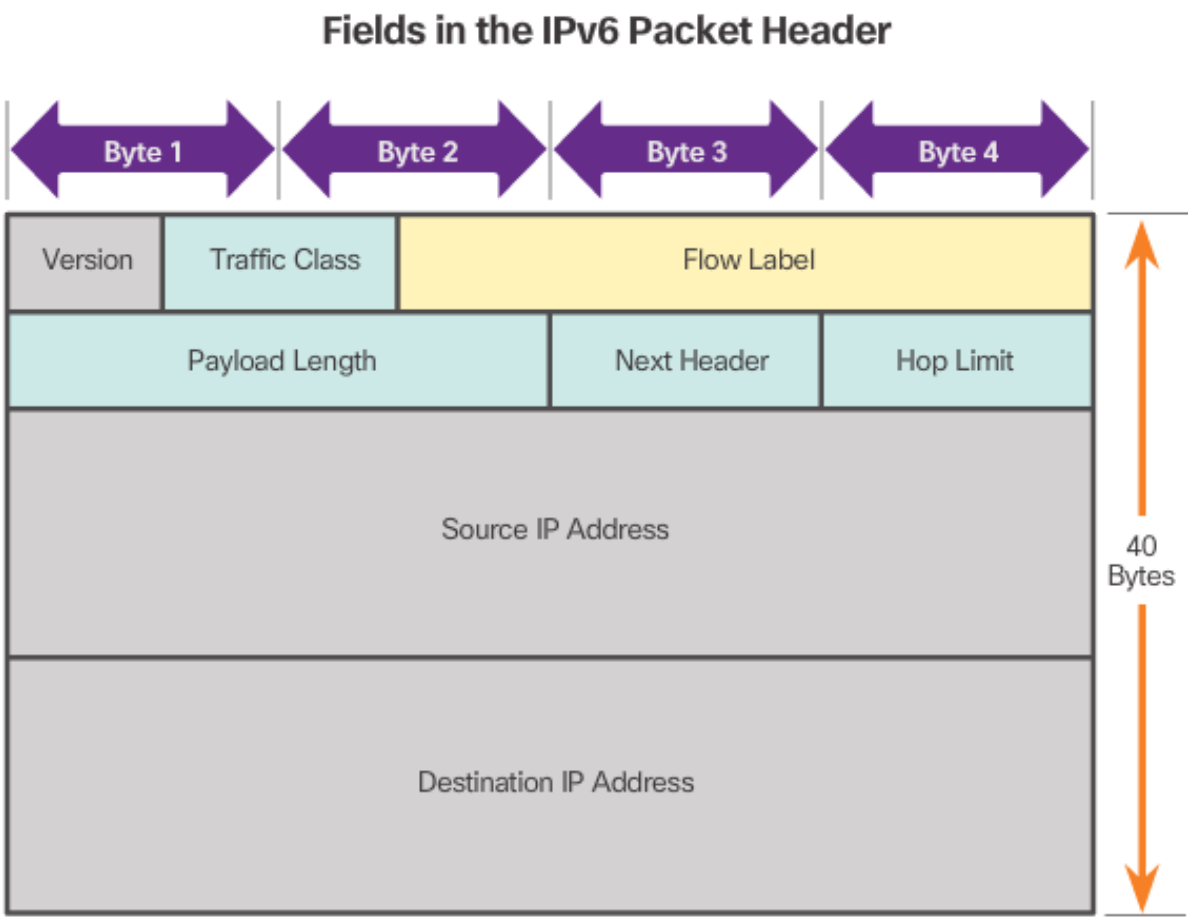
- Version = 0100
- DS = Packet Priority
- TTL = Limits life of Packet
- Protocol = Upper layer protocol such as TCP
- Source IP Address = source of packet
- Destination IP Address = destination of packet

IPv6 Packet

- Limitations of IPv4
  - IP address depletion
  - Internet routing table expansion
  - Lack of end-to-end connectivity
- Introducing IPv6
  - Increased address space
  - Improved packet handling
  - Eliminates the need for NAT
- EncapsulatingIPv6
  - Simplified header format
  - No checksum process requirement
  - More efficient Options Header mechanism
  - Flow Label field makes it more efficient.
- IPv6 Packet Header
  - xx

IPv6 Packet (Cont.)

- IPv6 Packet Header
  - xx



- 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

6.2 Routing

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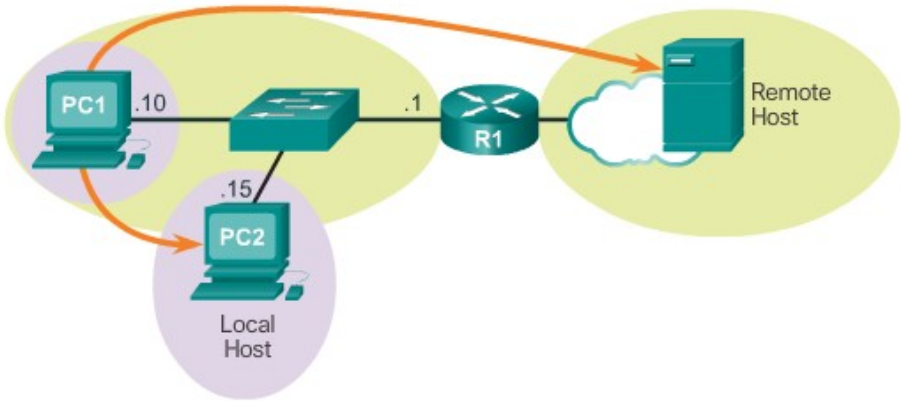
How a Host Routes

- Host Forwarding Decision
  - Three types of destination: itself, local host, remote host.
- 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
- Using the Default Gateway
  - Hosts will use the default gateway when sending packets to remote networks.
- Host Routing Tables
  - Use the **netstat –r** command to display the host routing table on a Windows machine.



How a Host Routes (Cont.)

IPv4 Routing Table for PC1

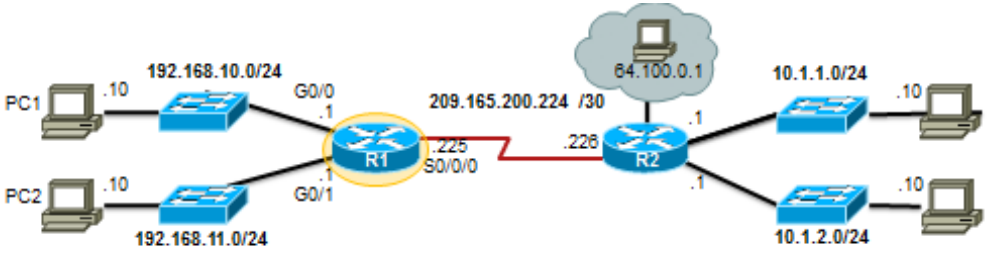

```
C:\Users\PC1>netstat -r

<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>
```

Router Routing Tables

- Router Packet Forwarding Decision
  - Routers and hosts forward packets in a similar fashion.
  - The main difference is that routers have more interfaces while hosts often have only one.
  - Devices on directly connected networks can be reached directly.
  - Devices on remote networks are reached through gateway.
- IPv4 Router Routing Table
  - The router routing table stores network routes the router knows about.
  - Use the **show ip route** command to display the routing table on a Cisco router.
  - The router routing table also has information on: how the route was learned, its trustworthiness and rating.
  - It also contains which interface to use to reach that specifc destination.
- Directly Connected Routing Table Entries
  - C - Identifies a directly-connected network, automatically created when an interface is configured with an IP address and activated.
  - L - Identifies that this is a local interface. This is the IPv4 address of the interface on the router.
- Remote Network Routing Table Entries
  - Xx

Router Routing Tables (Cont.)

- Remote Network Routing Table Entries
  - Remote destinations can't be reached directly.
  - Remote routes contain the address of the intermediate network device to be used to reach the destination.
- Next-Hop Address
  - Next-Hop address is the address of the intermediate device used to reach a specifc remote destination.




```
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.

6.3 Routers

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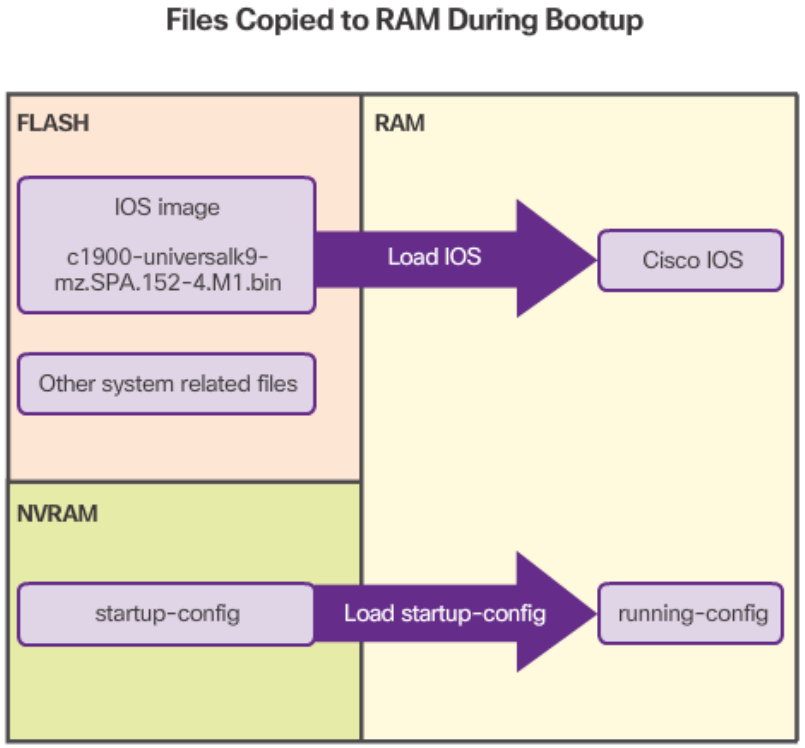
Anatomy of a Router

- A Router is a Computer
  - Routers have CPU, memory and I/O devices
  - Cisco routers use IOS as their operating system.
- Router Memory
  - Just as a computer, routers have memory.
  - Routers contain RAM, ROM, NVRAM and Flash memory.
- Inside a Router
  - Routers have the same general structure.
- Connect to a Router
  - Routers have may ports to support connections.
- LAN and WAN Interfaces
  - Routers have LAN and WAN ports.
  - Different models ship with different ports.
  - Ethernet is very common on different router models.

Anatomy of a Router

- Bootset Files
  - IOS image file, stored in the Flash, contains the IOS.
  - The Flash also stores other system files.
  - The NVRAM stores configuration parameters.
- Router Bootup Process
  1. Perform the POST and load the bootstrap program.
  2. Locate and load the Cisco IOS software.
  3. Locate and load the startup configuration file or enter setup mode
- Show Version Output
  - The show version command is very useful.
  - It provides information on the amounts of memory installed, what IOS images was loaded during boot and more.



6.4 Configuring a Cisco Router

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Configure Initial Settings

- Basic Switch Configuration Steps
  - Configure device name
  - Secure EXEC mode
  - Secure VTY lines
  - Secure privilege EXEC mode
  - Secure all passwords
  - Provide legal notification
  - Configure the management SVI
  - Save the configuration

- Basic Router Configuration Steps
  - Configure device name
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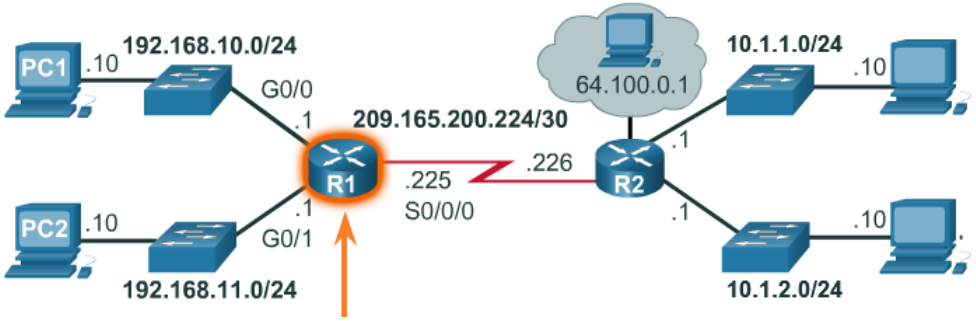


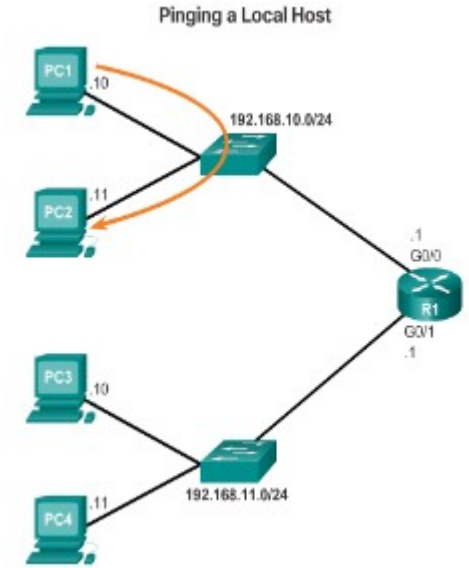
Configure Interfaces

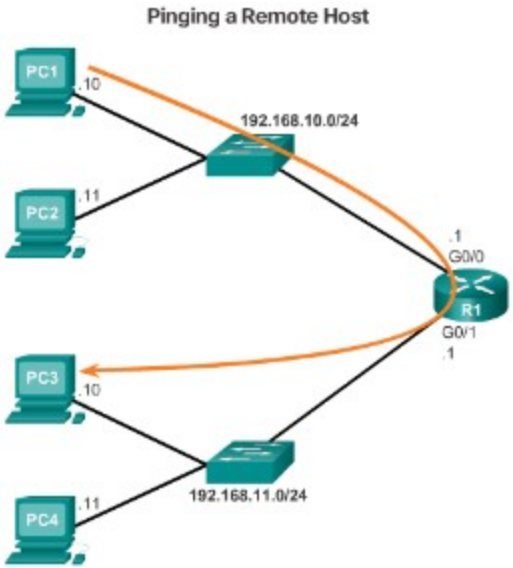
- Configure Router Interfaces
  - Enter the interface sub-configuration mode.
  - Add a description to the Interface (optional)
  - Configure an IPv4 or IPv6 address.
  - Activate the interface with a **no shutdown** command
- Verify Interface Configuration
  - **show ip route** - Displays the contents 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#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
```

Configure the Default Gateway

- Default Gateway for a Host





- Default Gateway for a Switch
  - A default gateway is required for remote network communication.
  - If a switch is to be managed via its VTY lines, it needs a default gateway.
  - Use the **ip default-gateway** command to configure the default gateway for a switch.

6.5 Chapter Summary

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Summary

- 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.