Cisco Networking Academy
Mind Wide Open

Chapter 6: Network Layer

Introduction to Networks v5.1

Chapter Outline

1. Introduction
2. Network Layer Protocols
3. Routing
4. Summary

Topic 6.1.2:
Characteristics of the IP Protocol

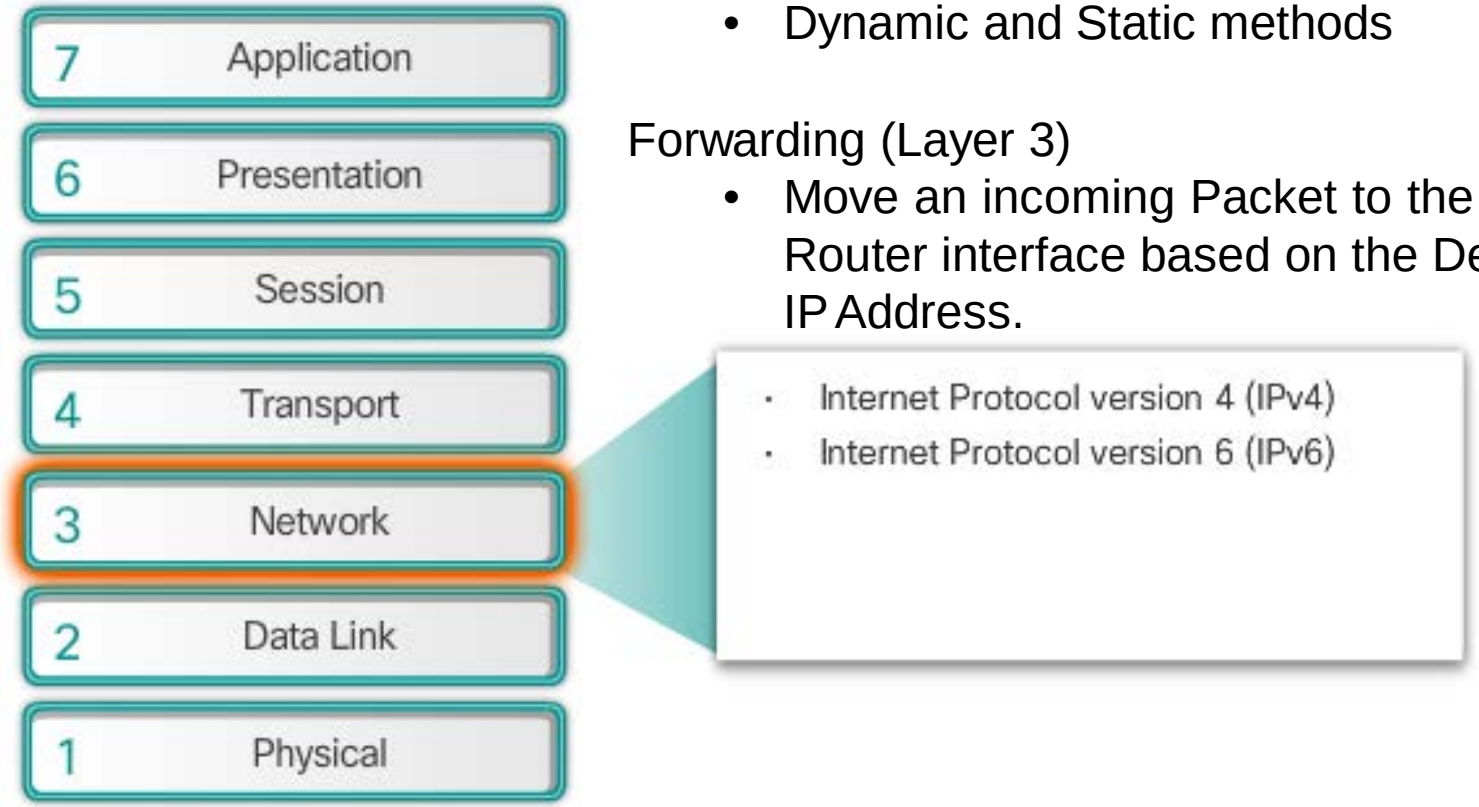
Network Layer Protocols

Responsible for:
Routing:

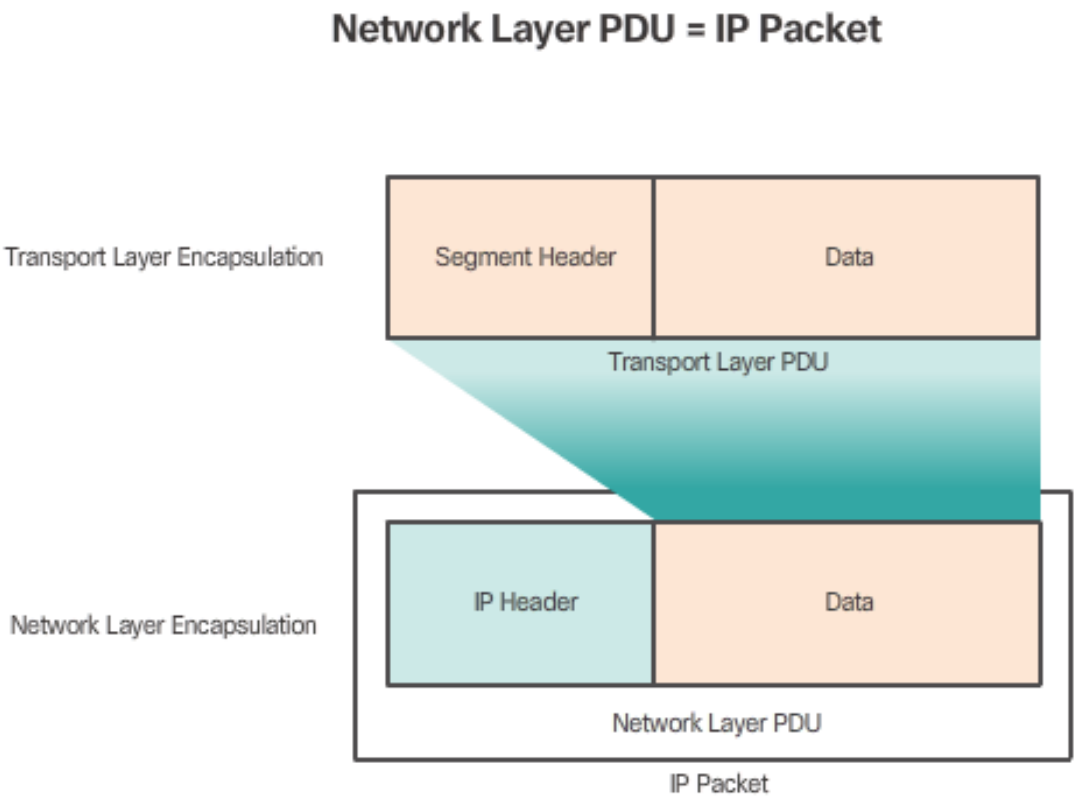
- Determine the path to reach relevant destination networks
- Dynamic and Static methods

Forwarding (Layer 3)

- Move an incoming Packet to the next hop Router interface based on the Destination IP Address.

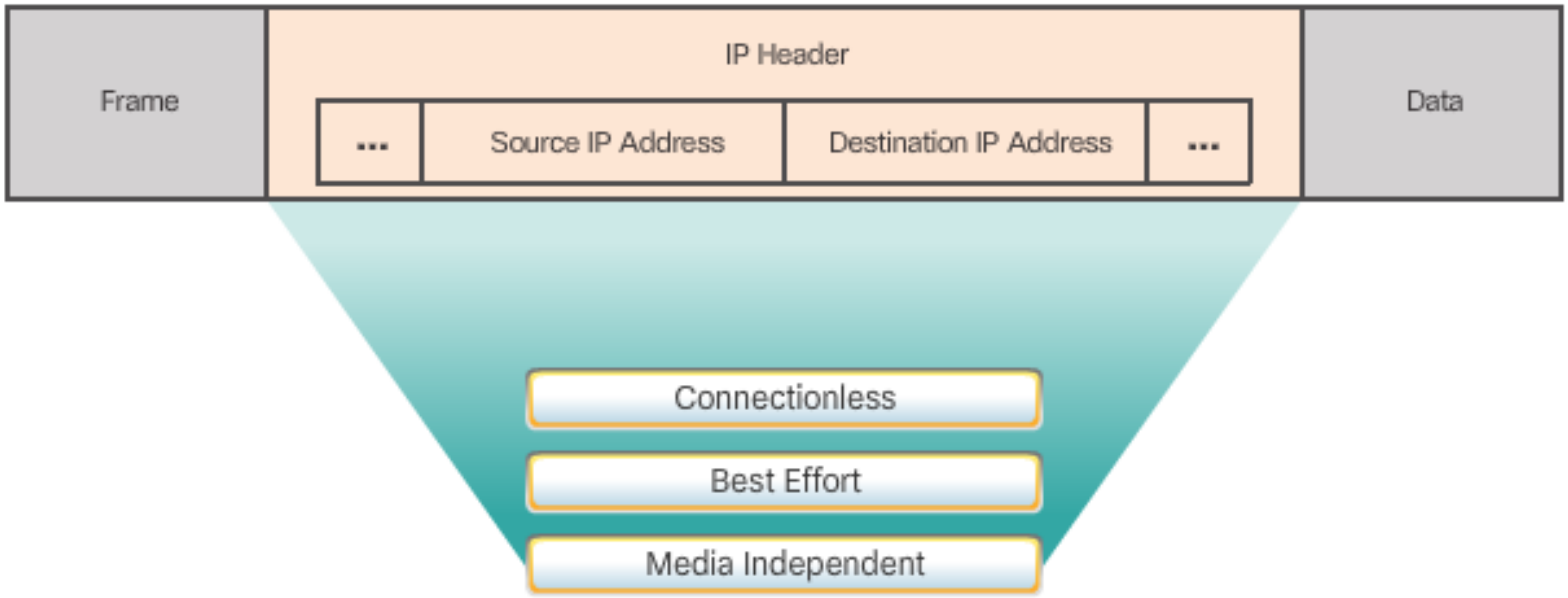


Encapsulating IP (cont.)



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.

Characteristics of IP

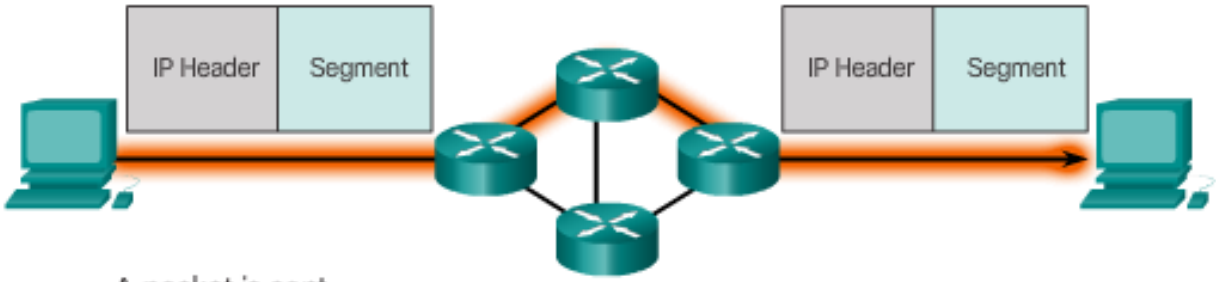


Connectionless

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

IP – Connectionless

Connection Management is done at the Transport Layer



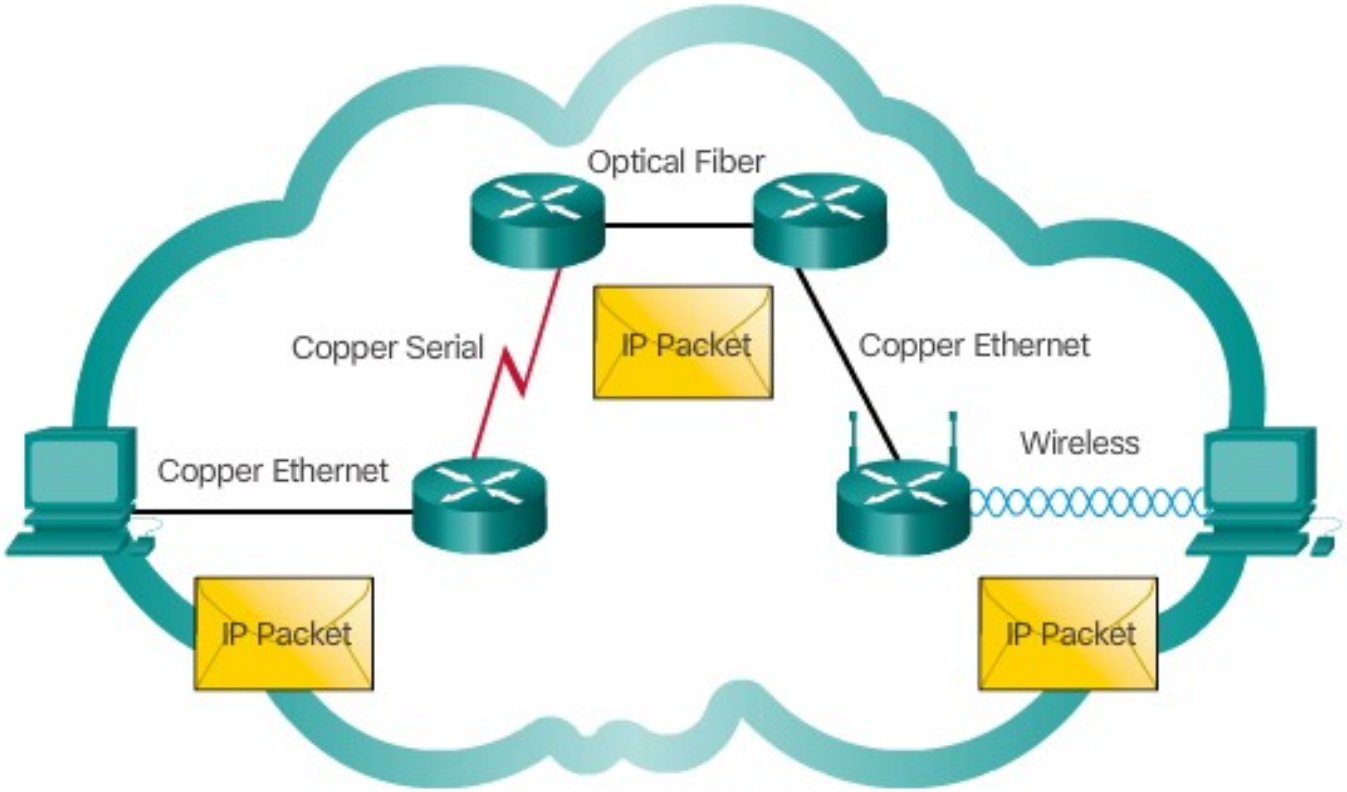
The sender doesn't know:

- 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
- **If the packets have arrived out of sequence**

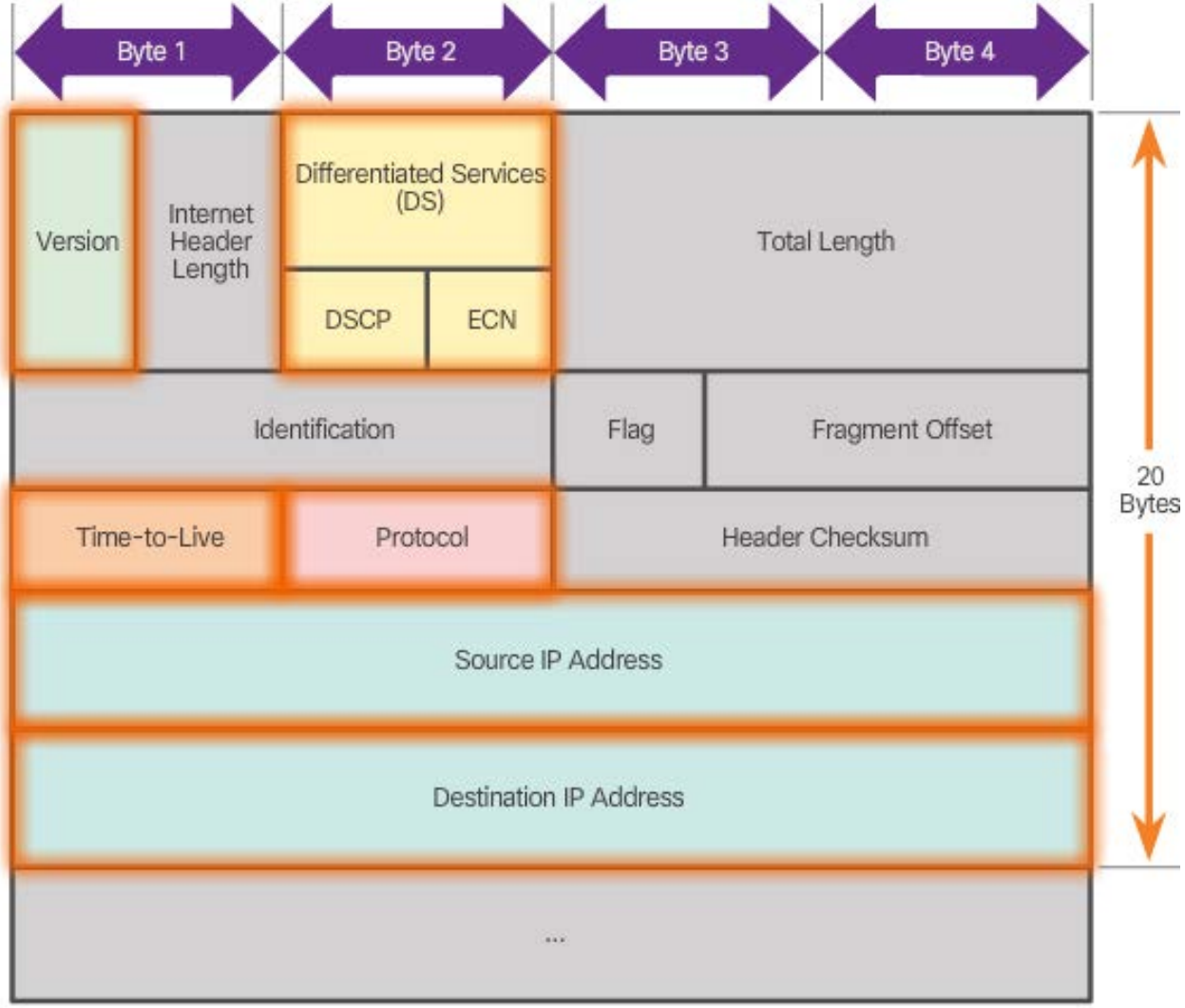
IP – Media Independent



IP packets can travel over different media.

Topic 6.1.3:
IPv4 Packet

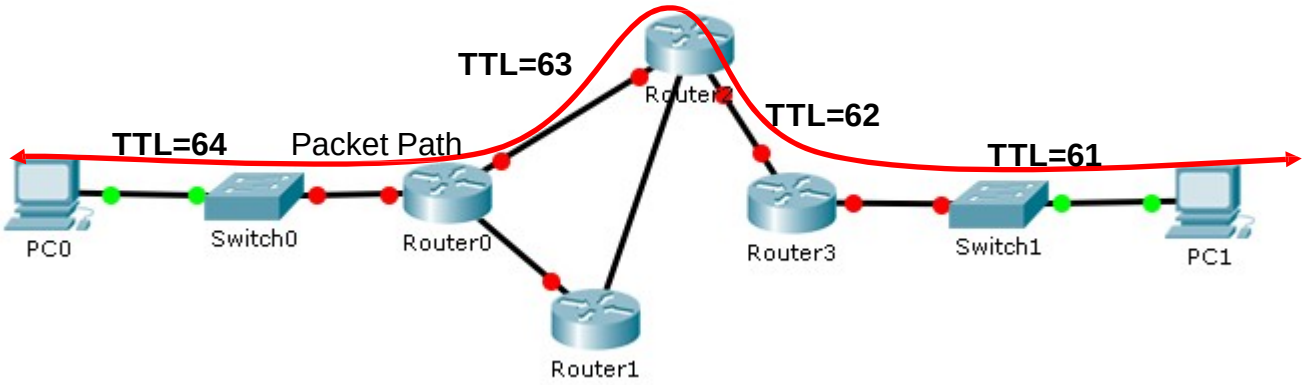
IPv4 Packet Header



- Version = 0100 (binary)
- DS = Packet Priority
- TTL = Limits life of Packet
- Protocol = Upper layer protocol: TCP=6 or UDP=17
- Source IP Address = source of packet
- Destination IP Address = destination of packet

Time-to-Live TTL

- TTL value ranges from 0 – 255.
- TTL value is set by device (i.e. Microsoft 10 sets TTL = 64)
- TTL value is decremented at each Router.
- Packet is dropped if TTL =0 before it reaches its destination.
- ICMP message is returned to the source device if TTL=0.
- Prevents packets from getting “stuck” in infinite forwarding loop



Topic 6.1.4:
IPv6 Packet

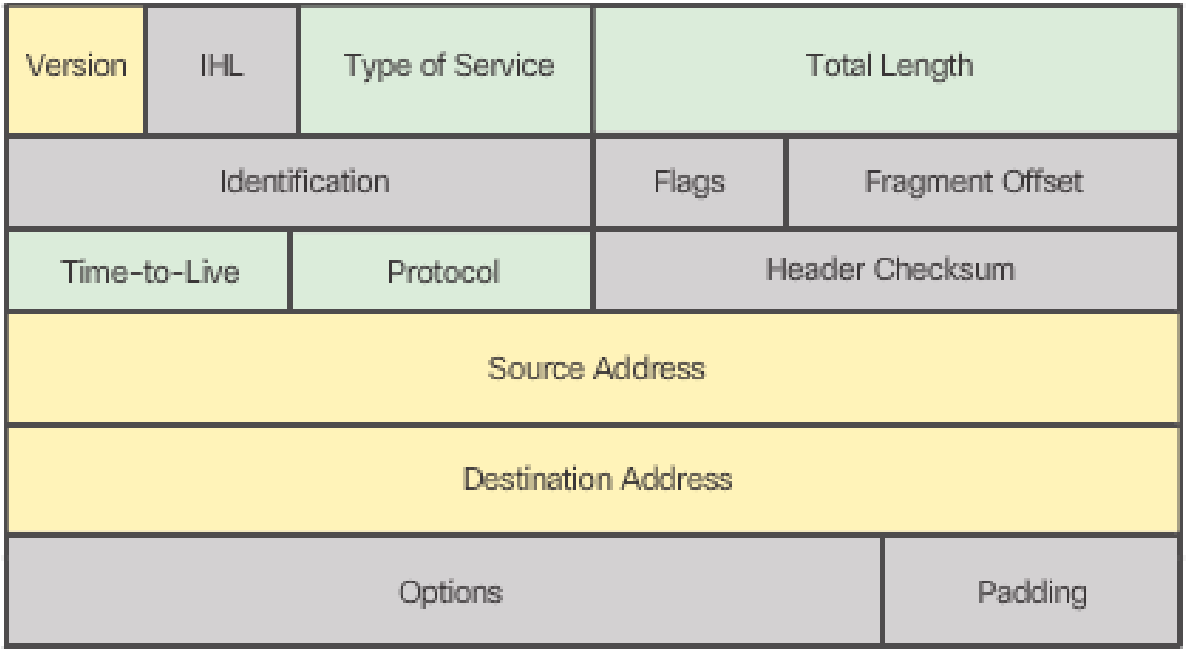
Introducing IPv6

- Increased address space to 128 bits
- Improved packet handling
- Eliminates the need for NAT (Network Address Translation)

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

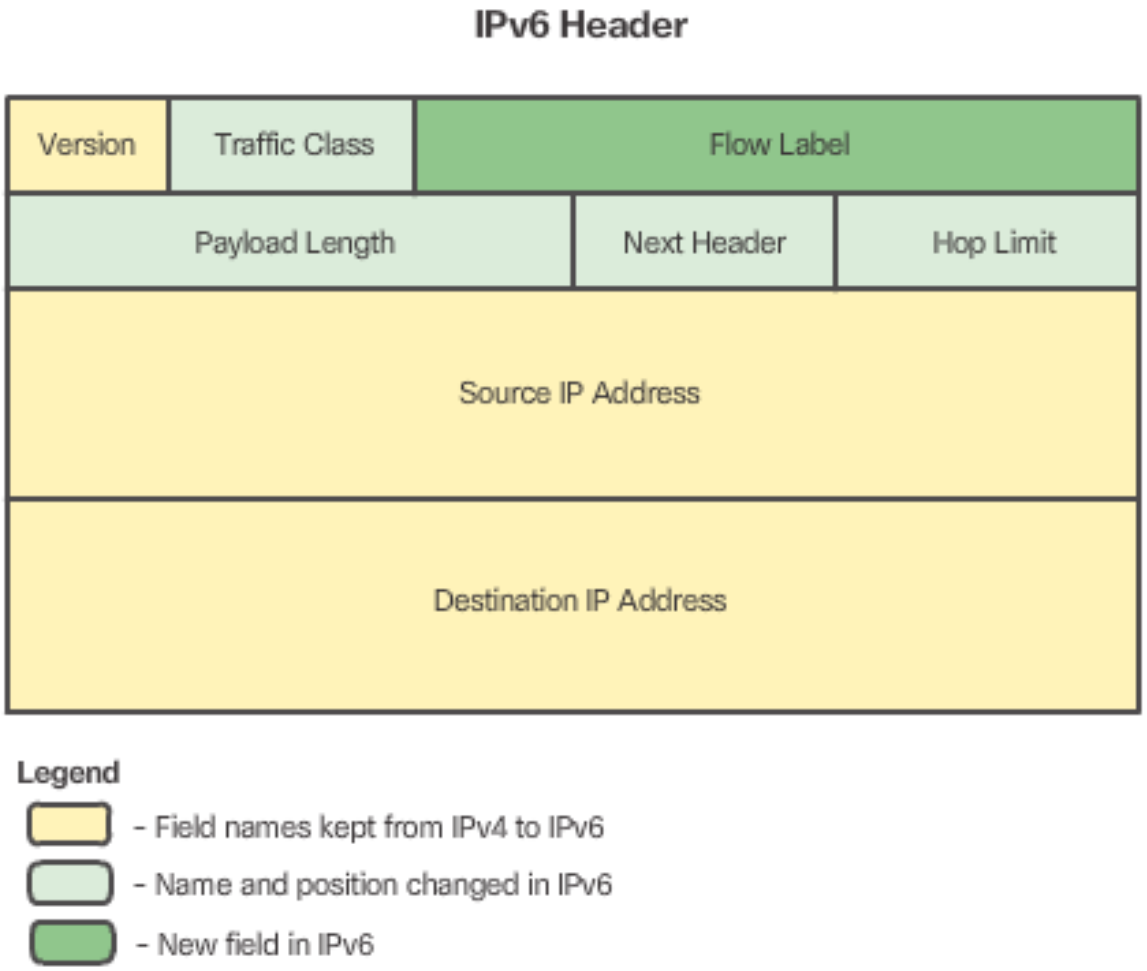
Encapsulating IPv6

IPv4 Header



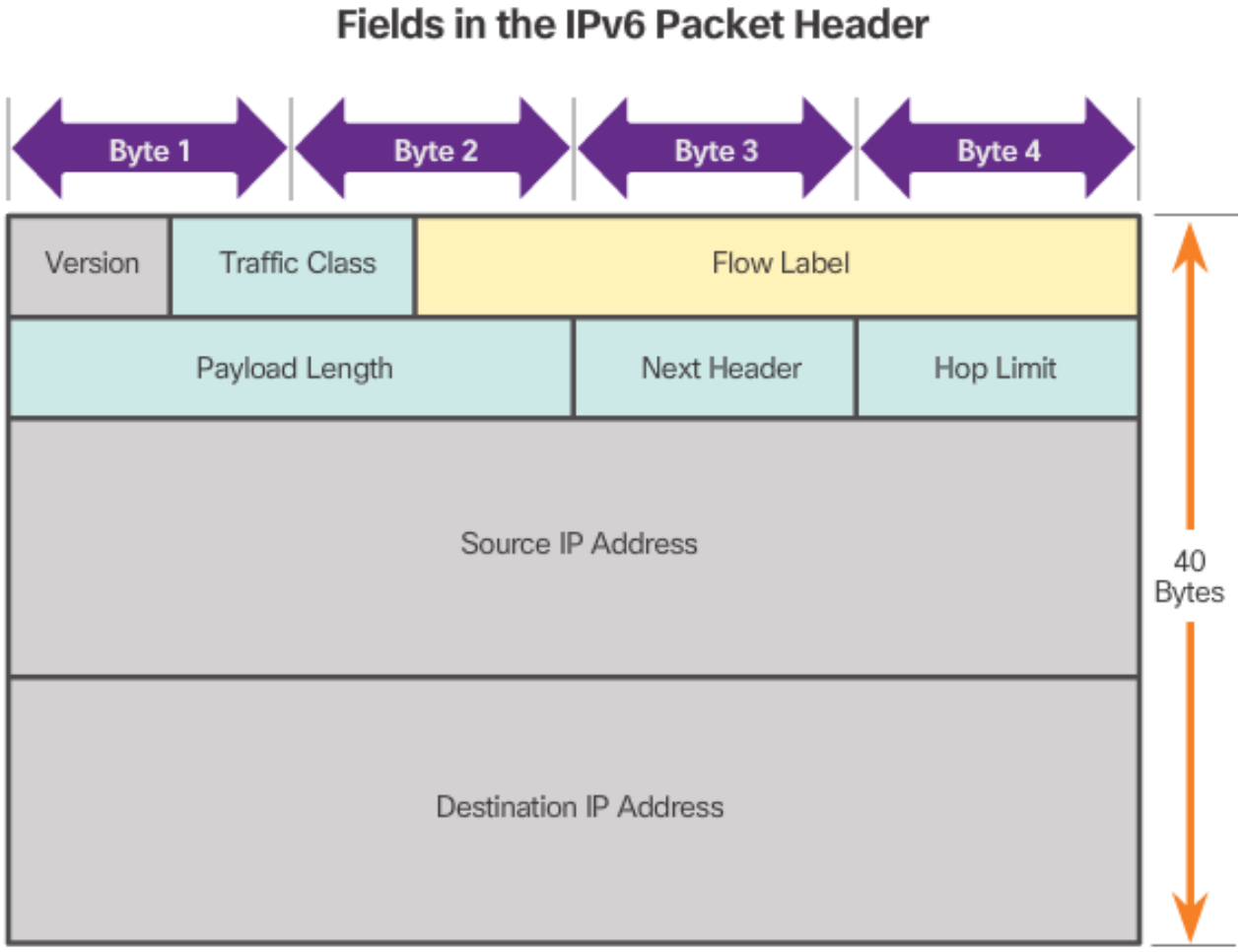
IPv6 has a simplified header

Encapsulating IPv6 (cont.)



IPv6 has a simplified header

IPv6 Packet Header



- Version = 0110 (binary)
- 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

Section 6.2: Routing

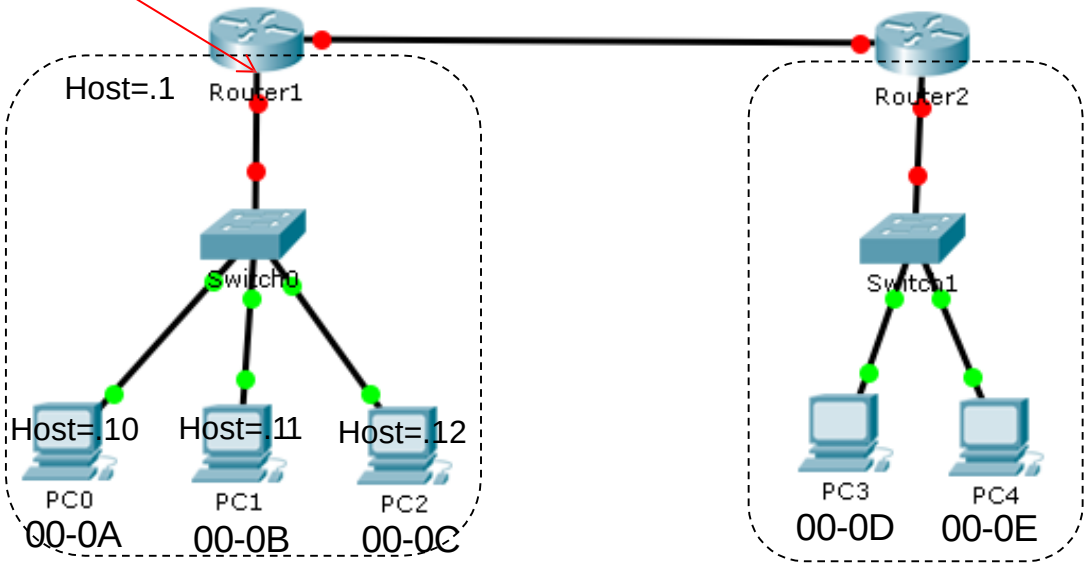
Upon completion of this section, you should be able to:

- 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 (i.e. End Device) Routes

Default Gateway

Default Gateway =
Router1 Interface IP Addr
(for Network Segment 1)



Network Segment 1

IP Network Address:
192.168.**1**.0
255.255.255.0

Network Segment 2

IP Network Address:
192.168.**2**.0
255.255.255.0

If Source IP Network Address EQUAL Destination IP Network Address then:

- Destination end device is on same network segment
- Switch frame to destination device

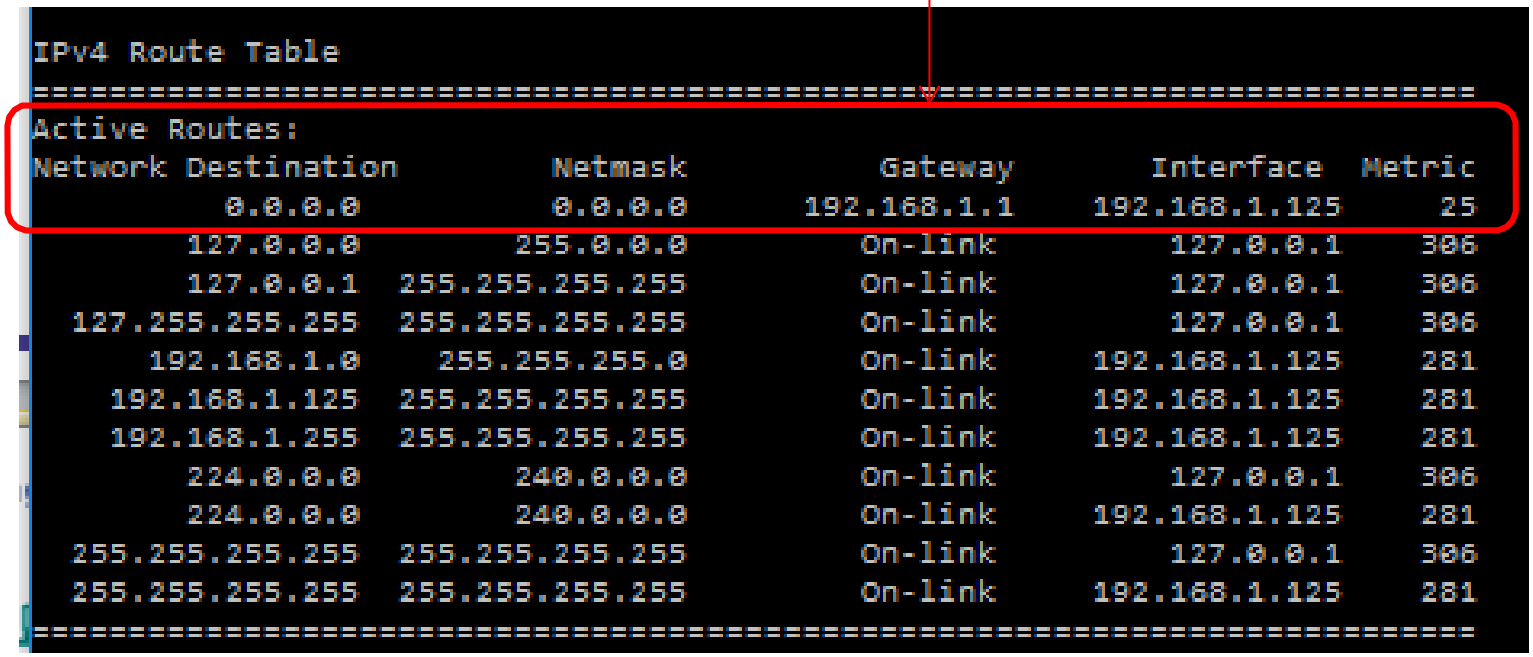
If Source IP Network Address NOT EQUAL Destination IP Network Address then:

- Destination end device is on a different network segment
- Switch frame to Default Router – Default Router will forward packet to Destination Network

Host Routing Tables

From a PC Command Prompt Enter:
route print
OR
netstat -r

Default Gateway
Indicated by Destination = 0.0.0.0



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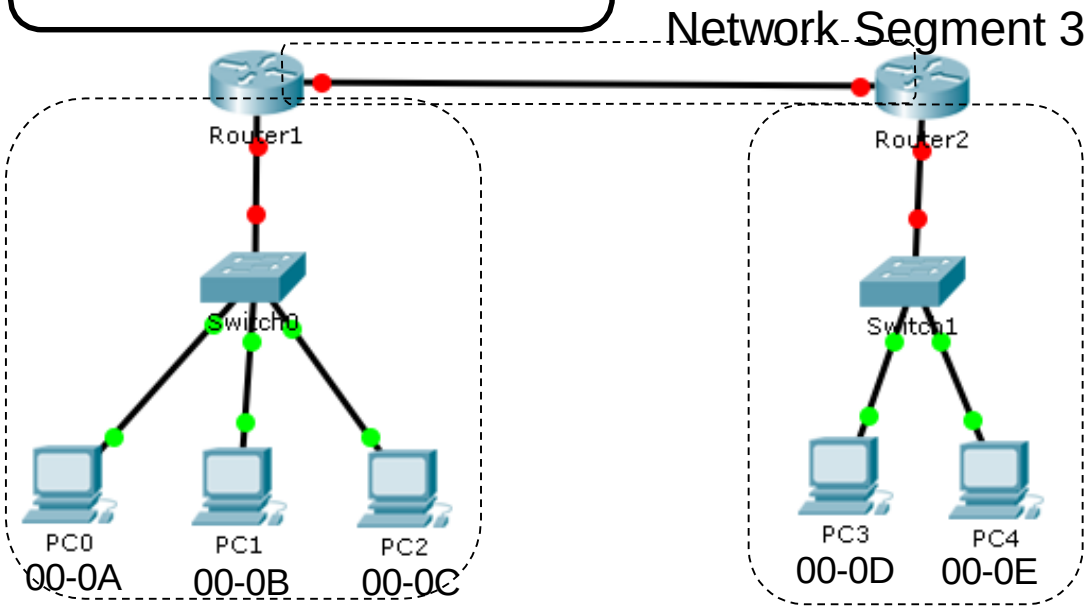
IPv4 Route Table
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0    192.168.1.1    192.168.1.125     25
        127.0.0.0        255.0.0.0         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
      192.168.1.0    255.255.255.0         On-link    192.168.1.125    281
    192.168.1.125  255.255.255.255         On-link    192.168.1.125    281
    192.168.1.255  255.255.255.255         On-link    192.168.1.125    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    192.168.1.125    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    192.168.1.125    281
===========================================================================
```

Topic 6.2.2:
Router Routing Tables

IP Packet Forwarding

Routing Table

Dest Network	Next Hop
192.168.2.0/24	IP Addr of Rtr2



Network Segment 1

IP Network Address:
192.168.**1**.0
255.255.255.0

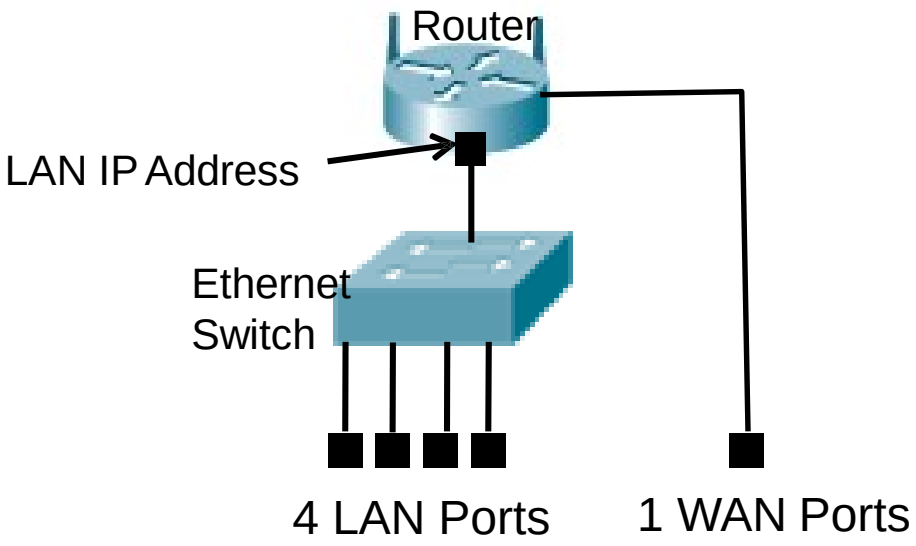
Network Segment 2

IP Network Address:
192.168.**2**.0
255.255.255.0

- Ethernet Switches forward frames between end devices that are on the same network segment using MAC addresses.
- Routers forward packets to remote networks and network segments using IP Addresses.
- Router interfaces define a network segment.
- Each end device will have an IP Address whose Network Address is the same as the Network segment.
- End devices with the same network address are on the same network segment.

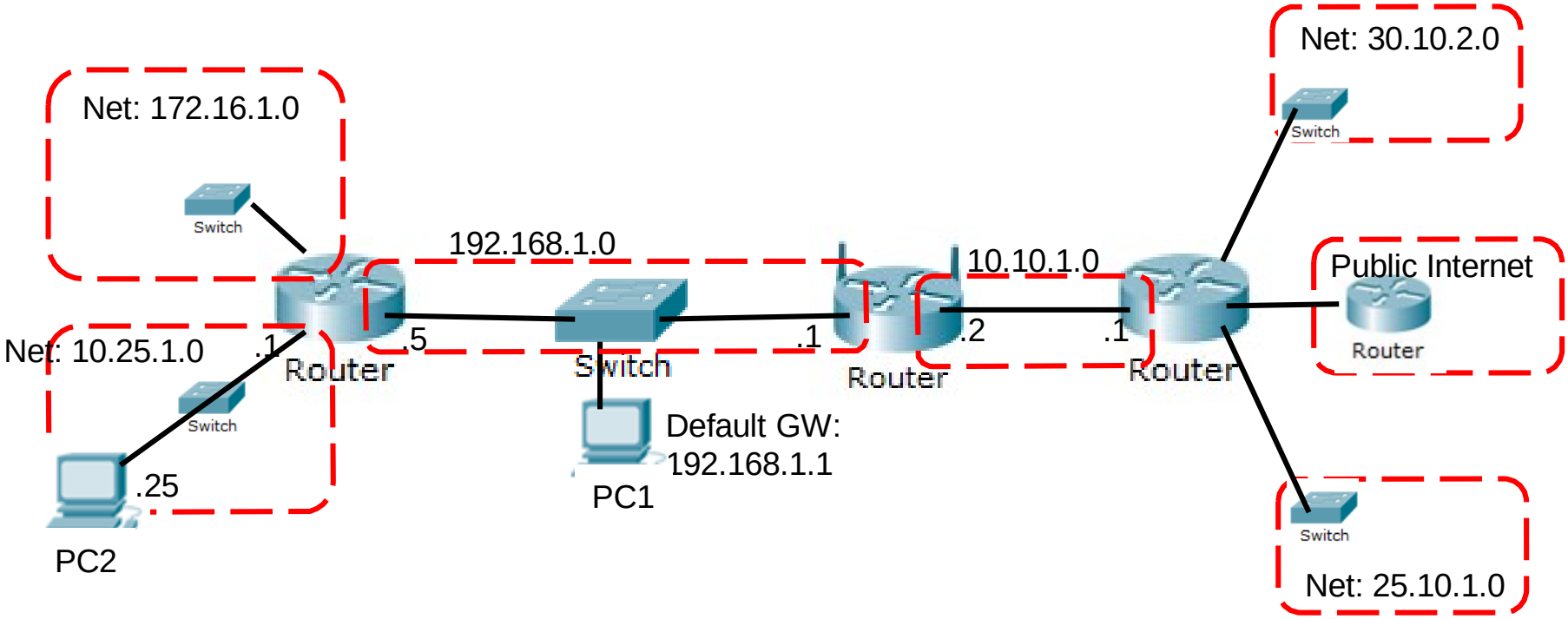
Router Ports

Lab Router



Equivalent Schematic

IPv4 Router Routing Table - 1



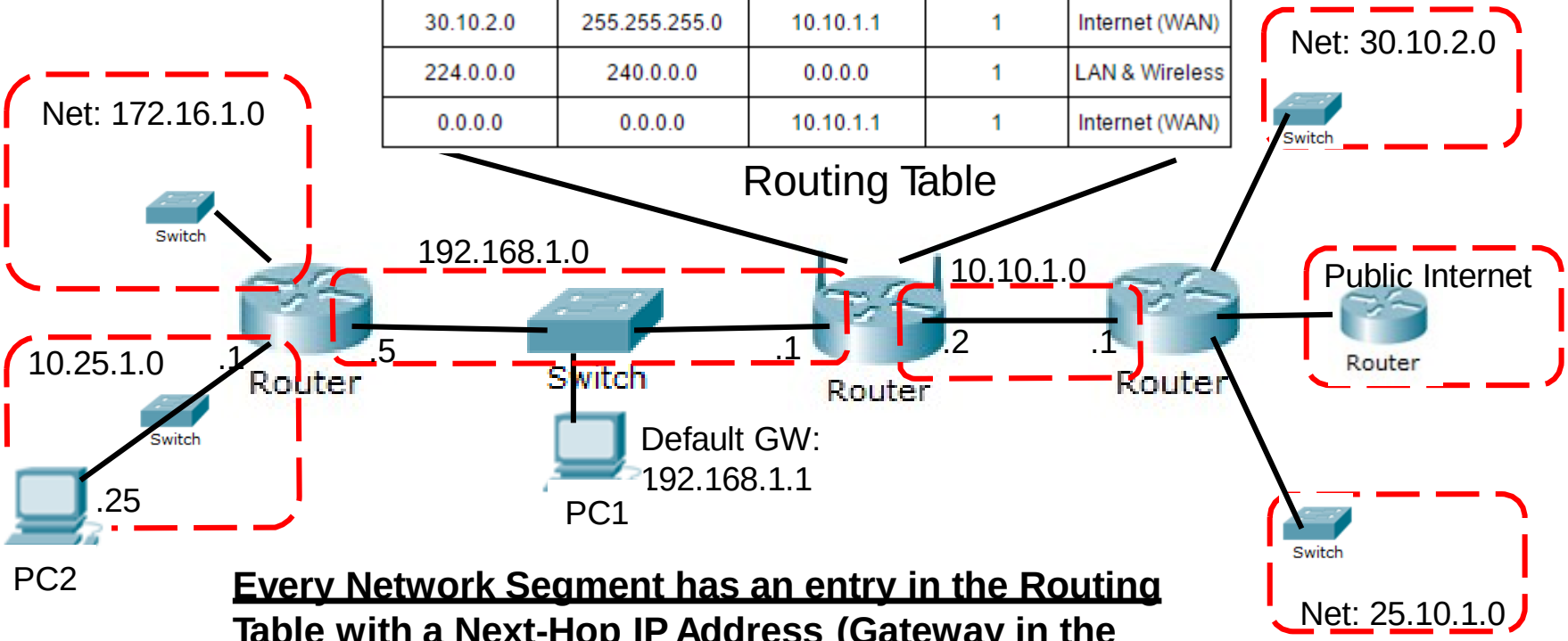
Consider the above network which includes several network segments.

IPv4 Router Routing Table - 2

Connected Networks

Destination LAN IP	Subnet Mask	Gateway	Hop Count	Interface
25.10.1.0	255.255.255.0	10.10.1.1	1	Internet (WAN)
192.168.1.0	255.255.255.0	0.0.0.0	1	LAN & Wireless
10.10.1.0	255.255.255.0	0.0.0.0	1	Internet (WAN)
172.16.1.0	255.255.255.0	192.168.1.5	1	LAN & Wireless
10.25.1.0	255.255.255.0	192.168.1.5	1	LAN & Wireless
30.10.2.0	255.255.255.0	10.10.1.1	1	Internet (WAN)
224.0.0.0	240.0.0.0	0.0.0.0	1	LAN & Wireless
0.0.0.0	0.0.0.0	10.10.1.1	1	Internet (WAN)

Routing Table



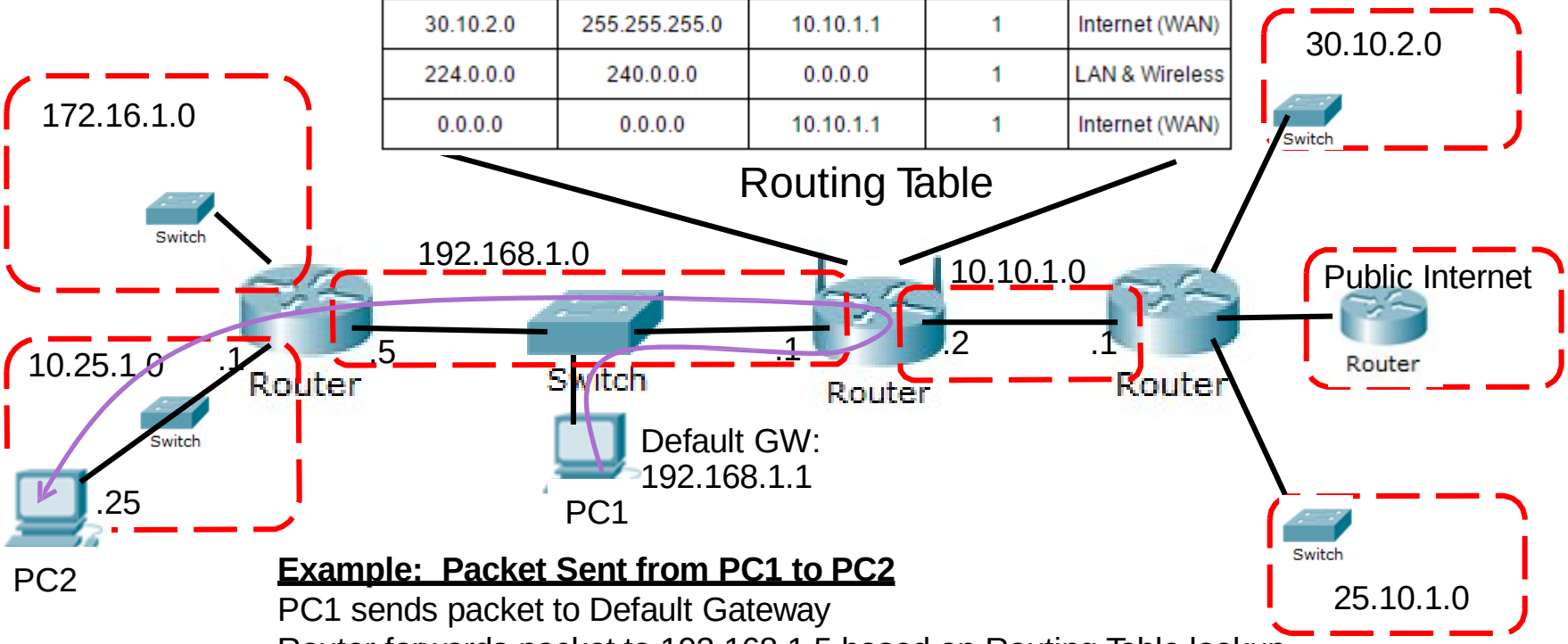
Every Network Segment has an entry in the Routing Table with a Next-Hop IP Address (Gateway in the Table)

Forwarding to a Remote Network

Connected Networks

Destination LAN IP	Subnet Mask	Gateway	Hop Count	Interface
25.10.1.0	255.255.255.0	10.10.1.1	1	Internet (WAN)
192.168.1.0	255.255.255.0	0.0.0.0	1	LAN & Wireless
10.10.1.0	255.255.255.0	0.0.0.0	1	Internet (WAN)
172.16.1.0	255.255.255.0	192.168.1.5	1	LAN & Wireless
10.25.1.0	255.255.255.0	192.168.1.5	1	LAN & Wireless
30.10.2.0	255.255.255.0	10.10.1.1	1	Internet (WAN)
224.0.0.0	240.0.0.0	0.0.0.0	1	LAN & Wireless
0.0.0.0	0.0.0.0	10.10.1.1	1	Internet (WAN)

Routing Table



Example: Packet Sent from PC1 to PC2

PC1 sends packet to Default Gateway
Router forwards packet to 192.168.1.5 based on Routing Table lookup
Router forwards packet to egress interface
Router does ARP to get PC2 MAC Addres
Router egress interfaces forwards frame to PC2

The Default Route

Connected Networks

Default Route

Destination LAN IP	Subnet Mask	Gateway	Hop Count	Interface
25.10.1.0	255.255.255.0	10.10.1.1	1	Internet (WAN)
192.168.1.0	255.255.255.0	0.0.0.0	1	LAN & Wireless
10.10.1.0	255.255.255.0	0.0.0.0	1	Internet (WAN)
172.16.1.0	255.255.255.0	192.168.1.5	1	LAN & Wireless
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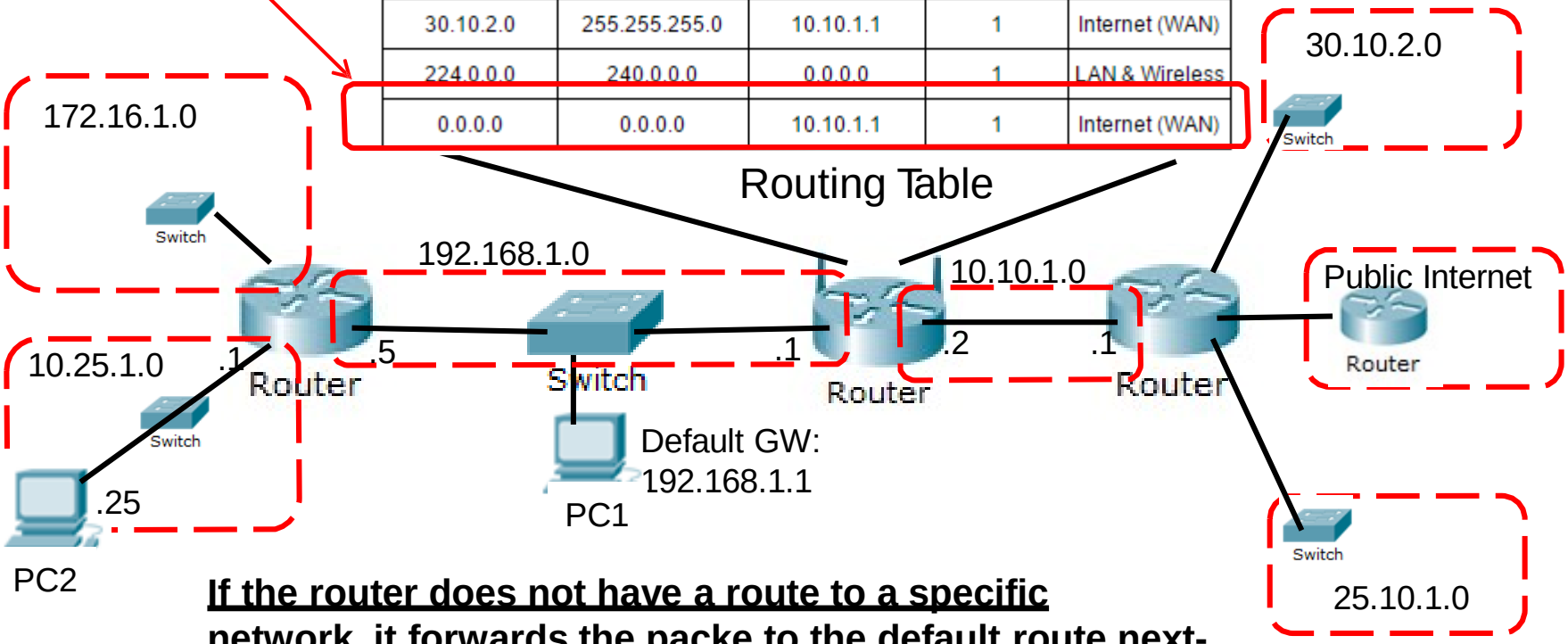
224.0.0.0	240.0.0.0	0.0.0.0	1	LAN & Wireless
0.0.0.0	0.0.0.0	10.10.1.1	1	Internet (WAN)

Routing Table



If the router does not have a route to a specific network, it forwards the packe to the default route next-hop address.

Thank you.

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