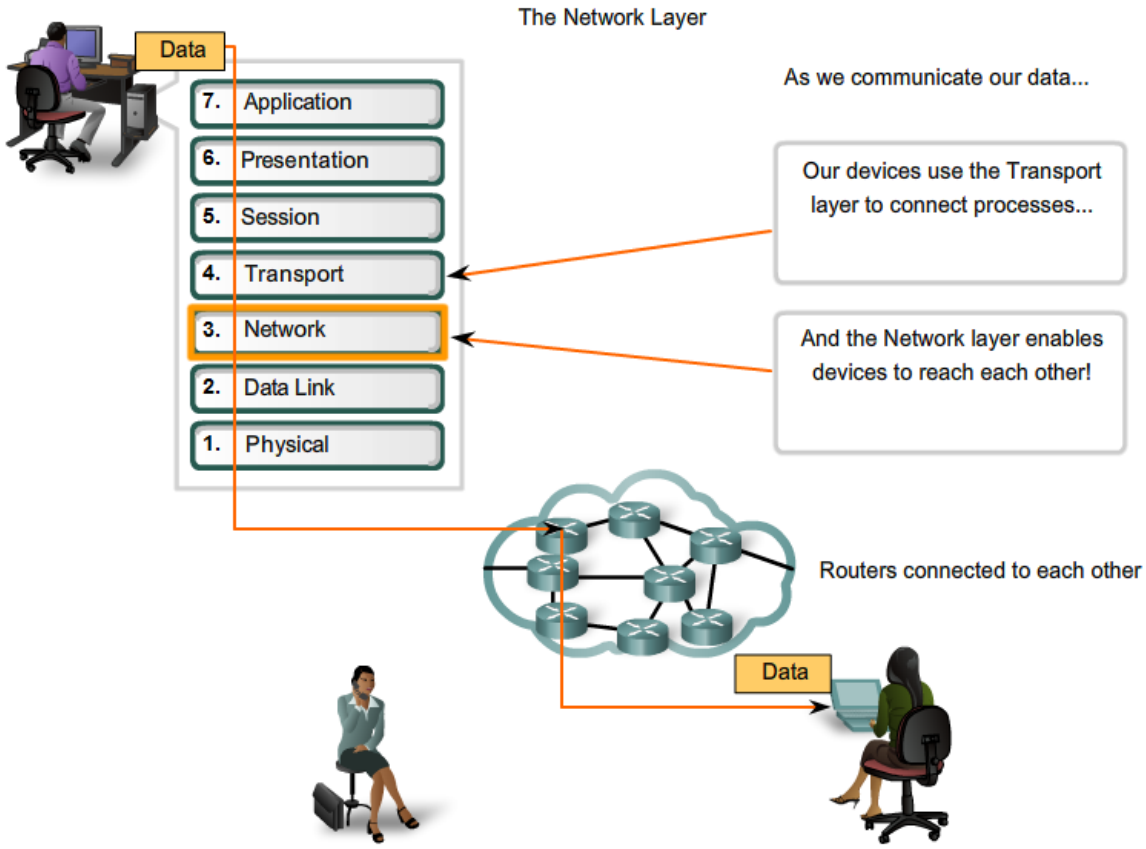
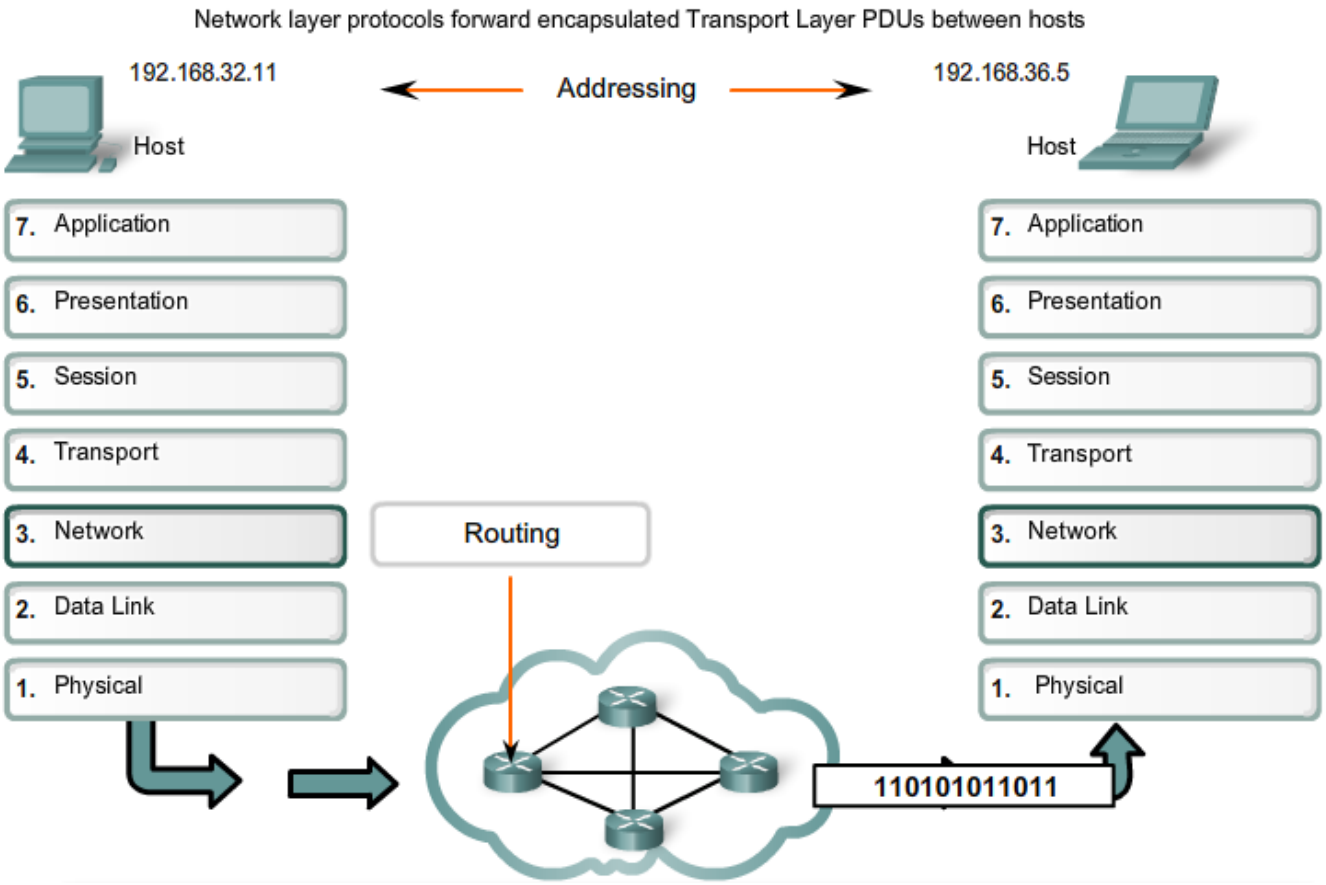
Network Layer

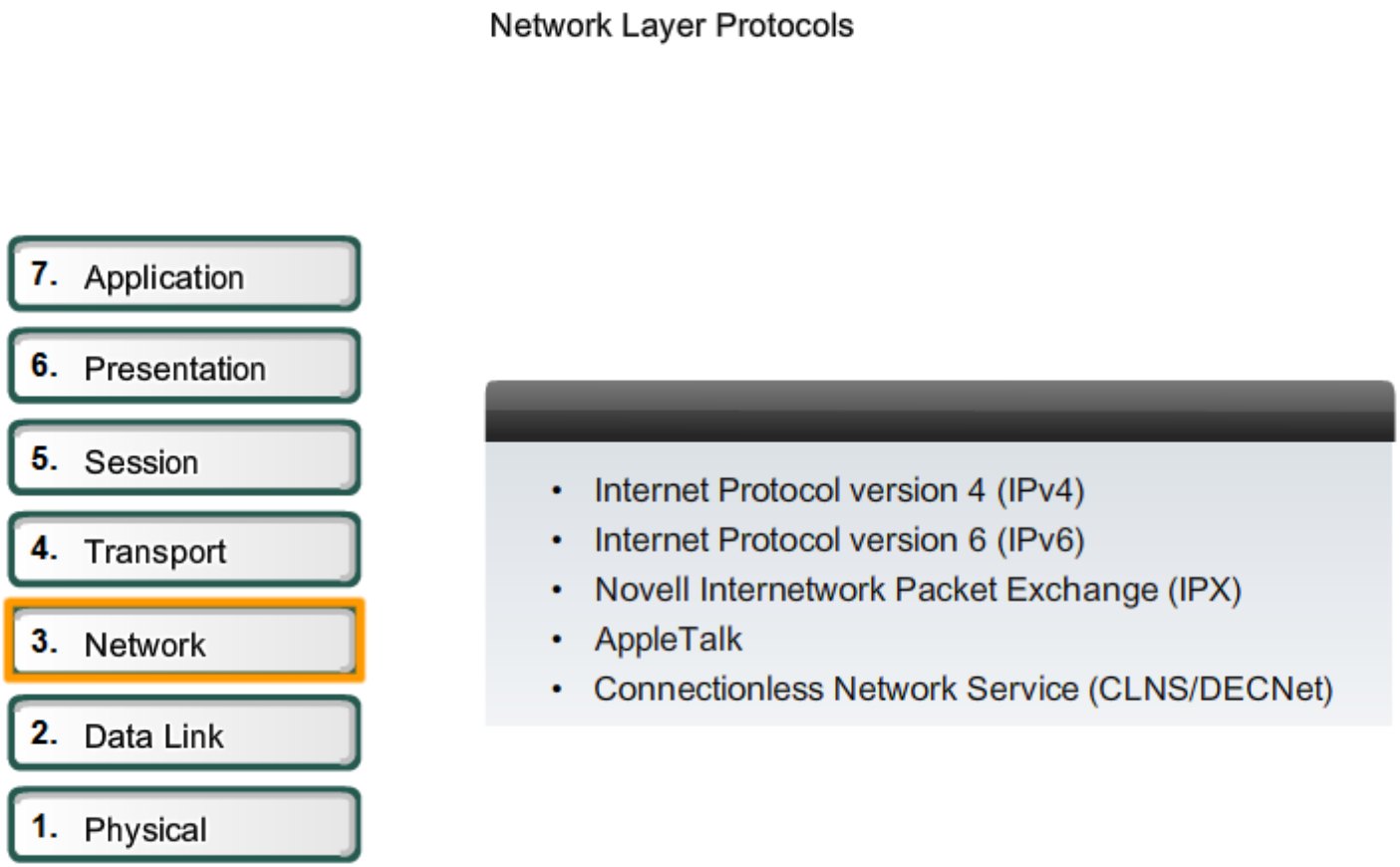
Introduction



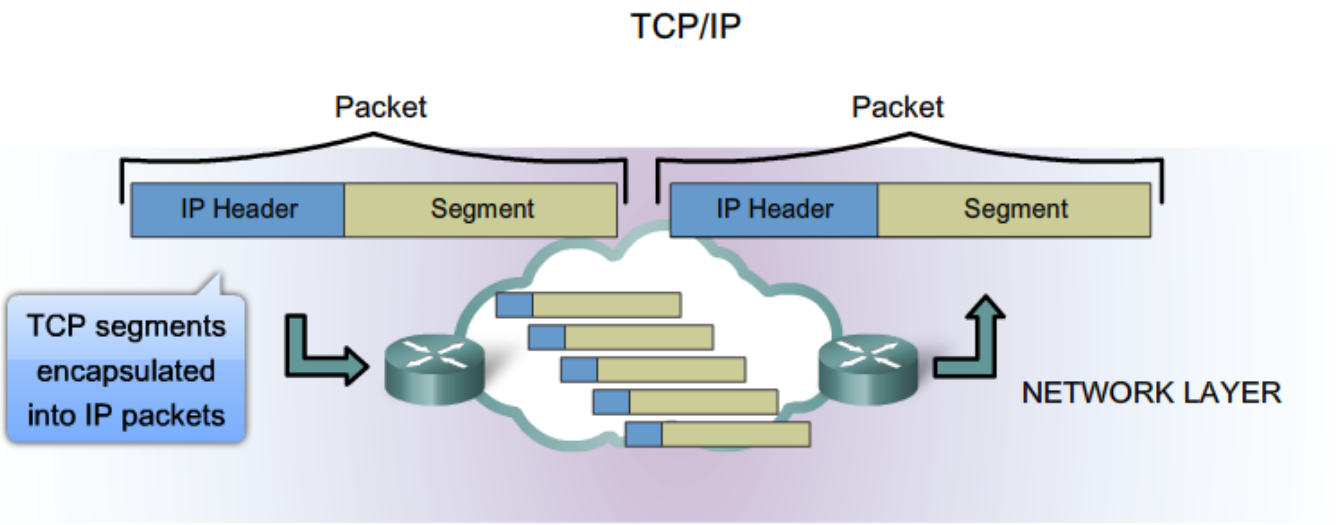
Network Layer – Communication Form Host to Host



Network Layer – Communication Form Host to Host…



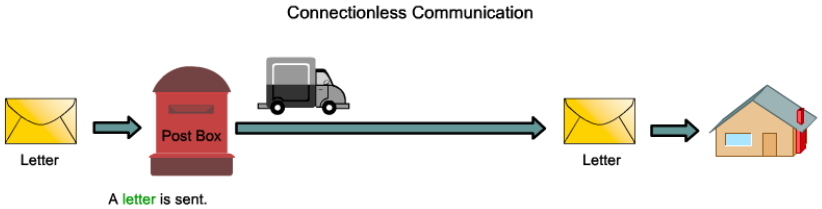
The IPv4 protocol- example network layer Protocol



IP Packets flow through the internetwork.

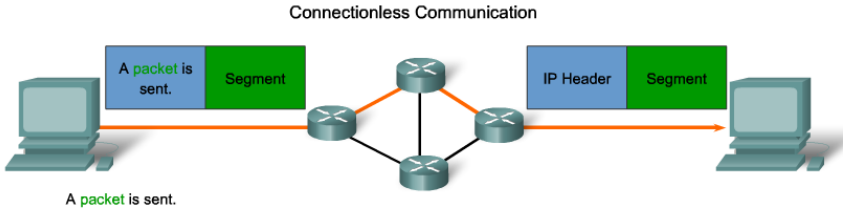
- Connectionless - No connection is established before sending data packets.
- Best Effort (unreliable) - No overhead is used to guarantee packet delivery.
- Media Independent - Operates independently of the medium carrying the data.

The IPv4 protocol- connectionless



The sender doesn't know:	The receiver doesn't know:
• if the receiver is present • if the letter arrived • if the receiver can read the letter	• when it is coming

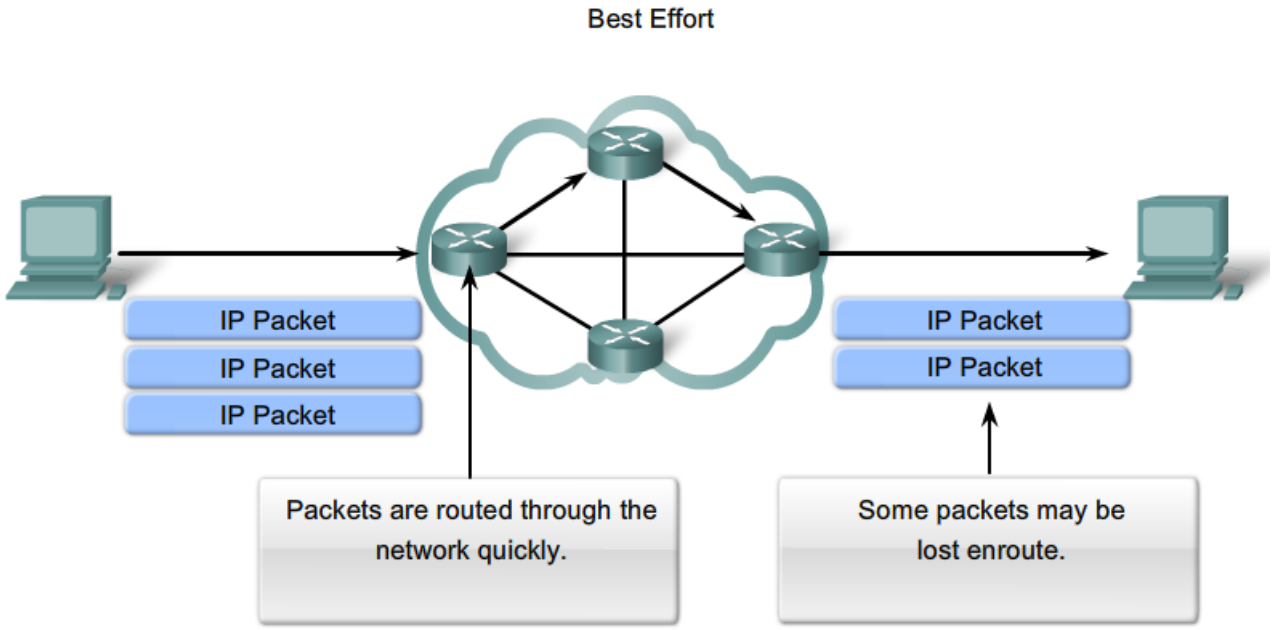
POSTAL ROUTES | DATA NETWORKS



The sender doesn't know:	The receiver doesn't know:
• if the receiver is present • if the packet arrived • if the receiver can read the packet	• when it is coming

POSTAL ROUTES | DATA NETWORKS

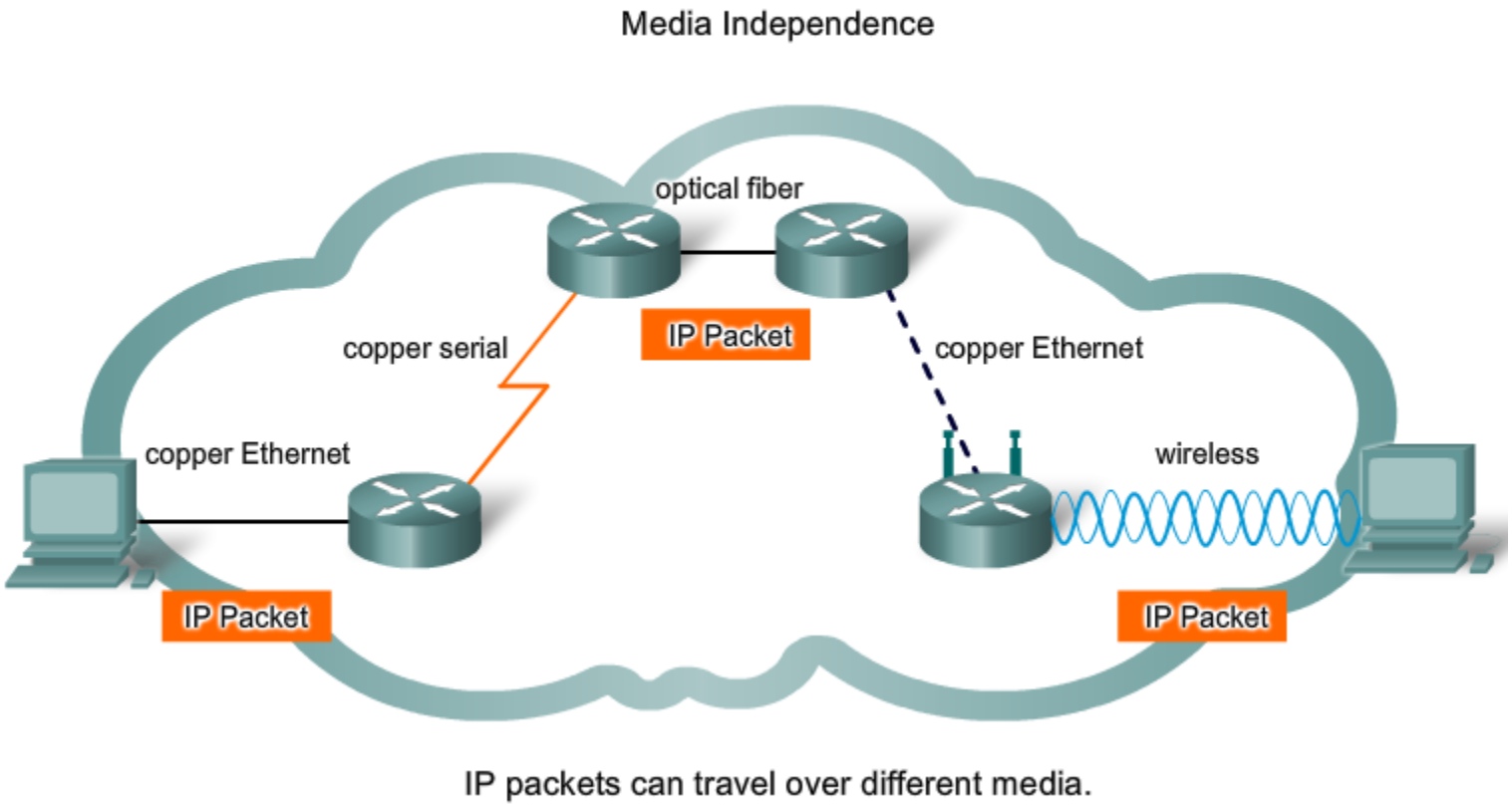
The IPv4 protocol- Best Effort



As an unreliable Network layer protocol, IP does not guarantee that all sent packets will be received.

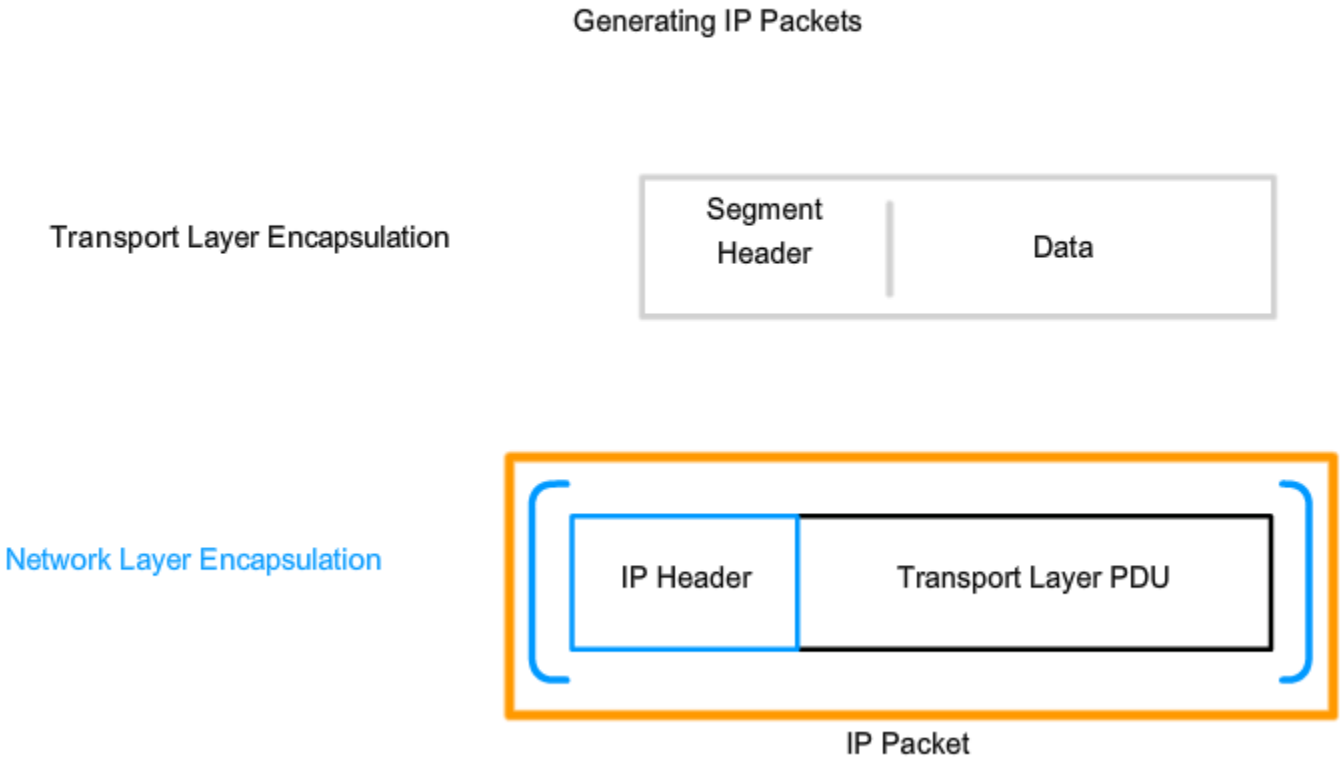
Other protocols manage the process of tracking packets and ensuring their delivery.

The IPv4 protocol- Media Independent



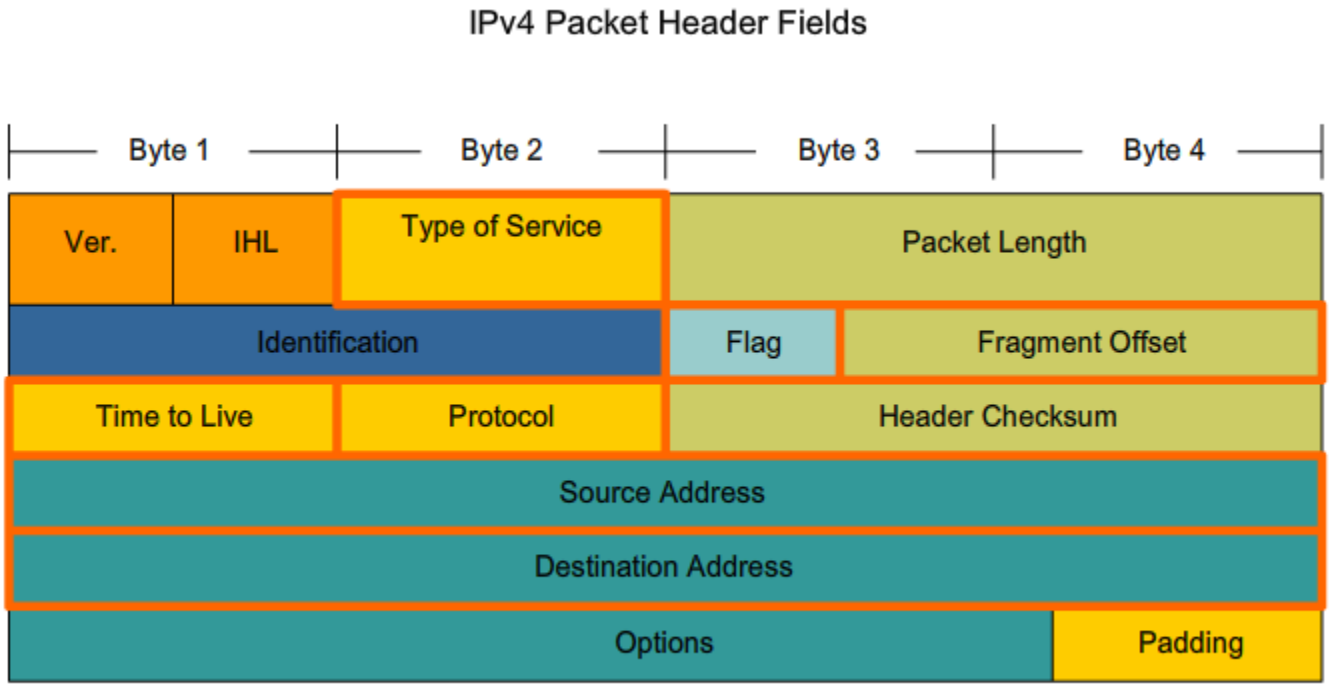
IP packets can travel over different media.

IPv4-Packaging the Transport layer PDU

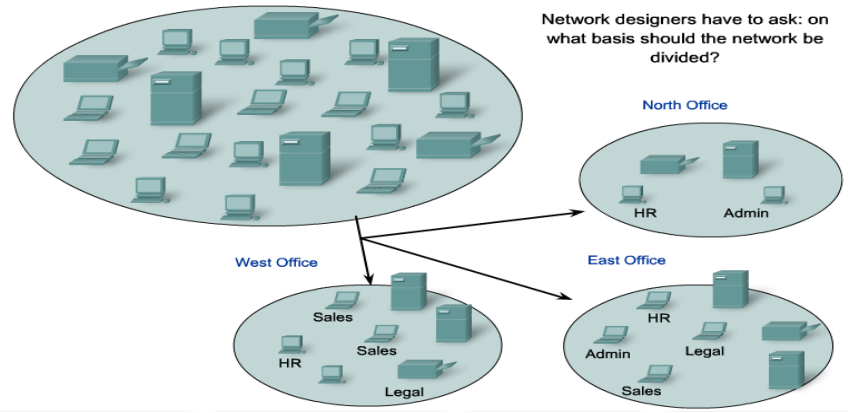


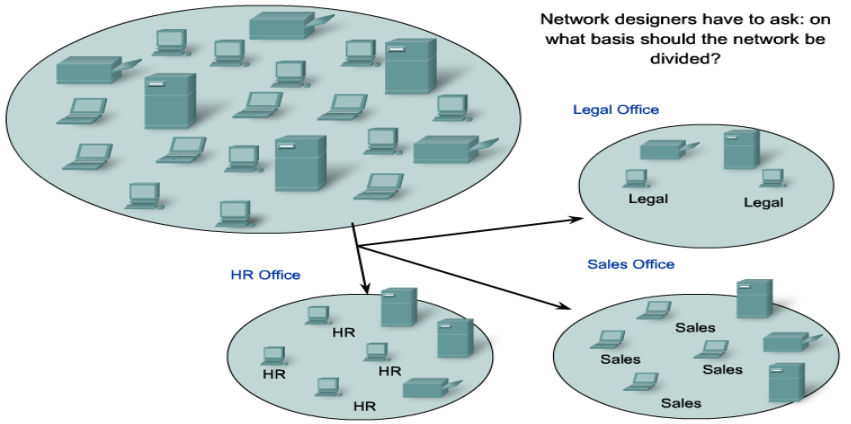
In TCP/IP based networks, the Network layer PDU is the IP packet.

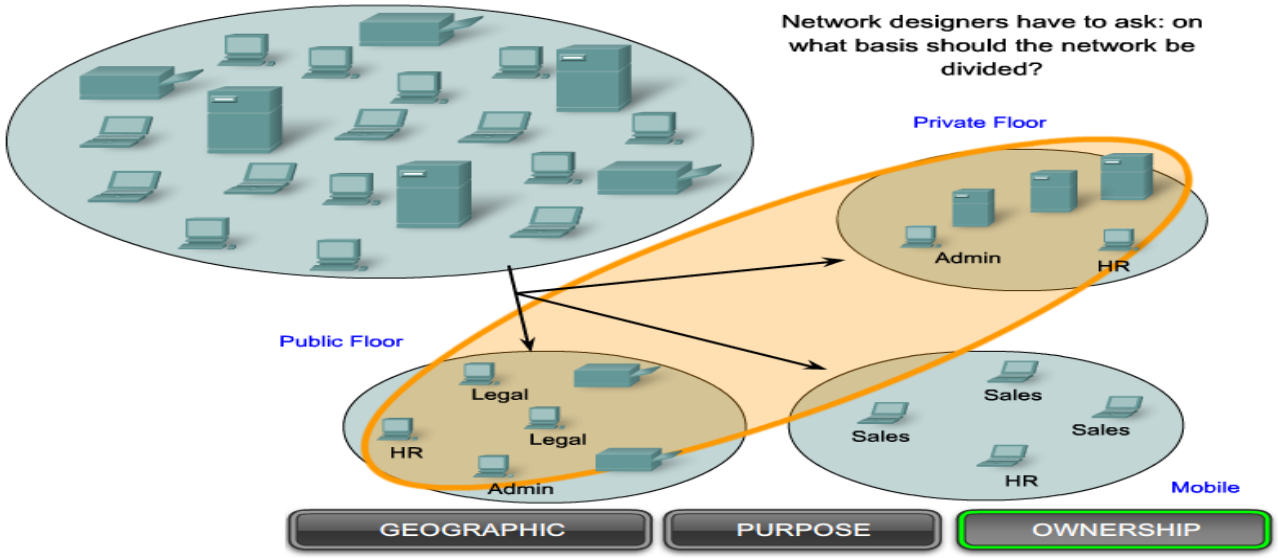
IPv4 Packet Header



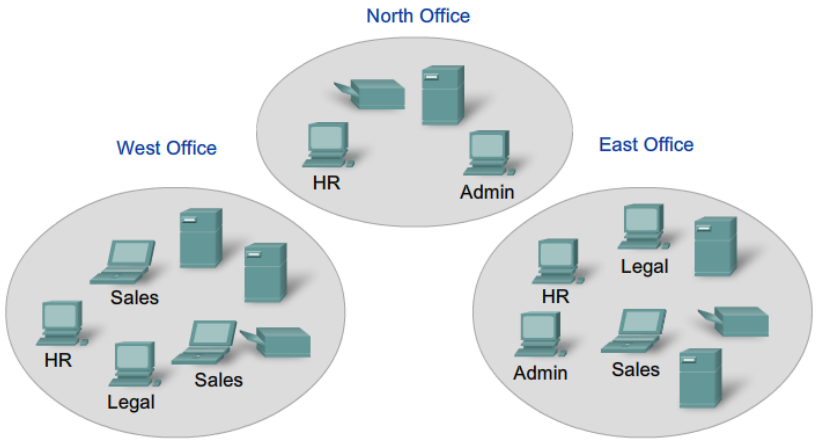
Dividing Networks







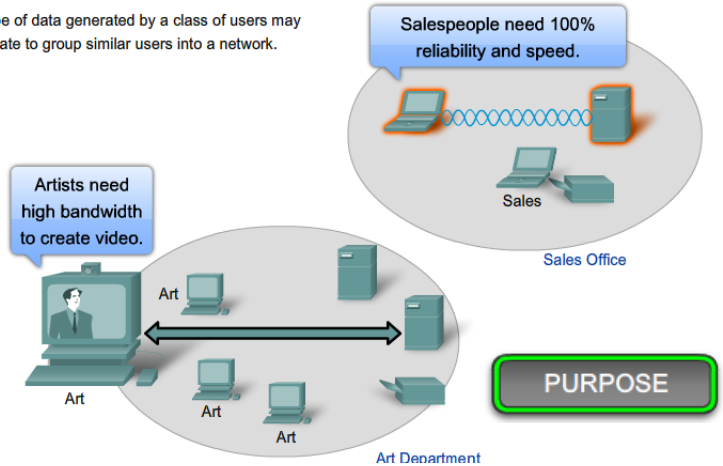
Separating Hosts into Common Groups



The simple fact of wiring together the physical network can make geographic location a logical place to start when segmenting a network.

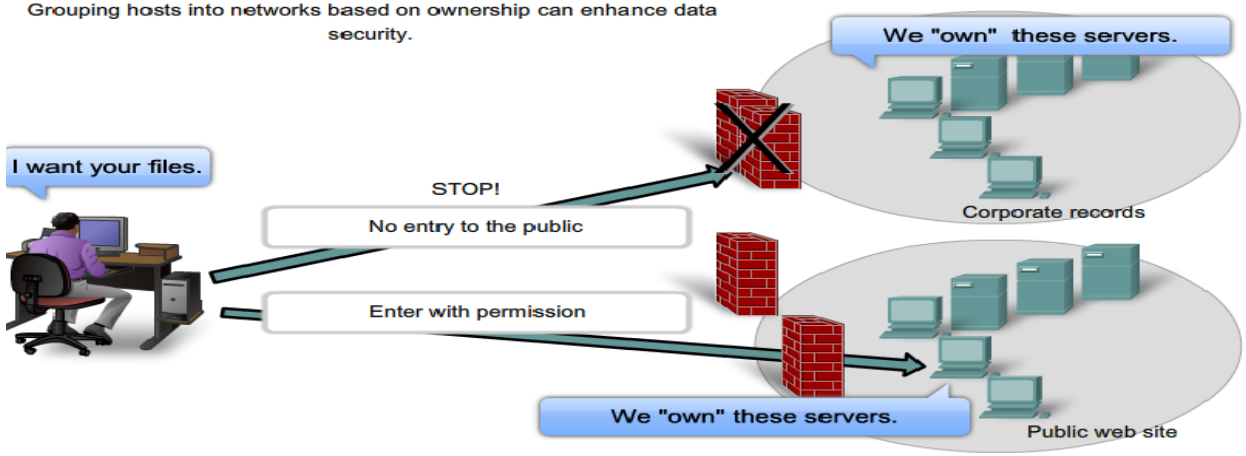
GEOGRAPHIC

The volume and type of data generated by a class of users may make it appropriate to group similar users into a network.



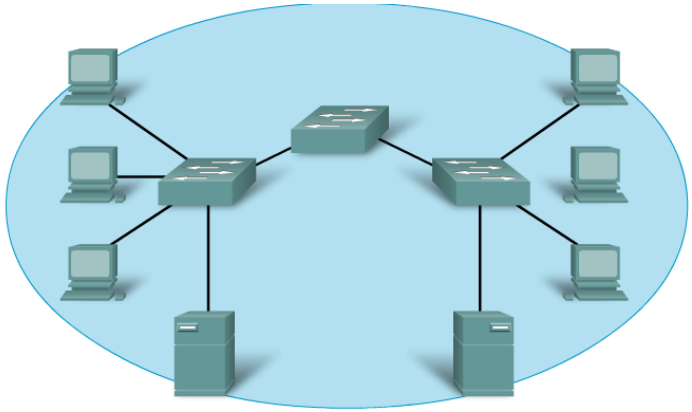
PURPOSE

Grouping hosts into networks based on ownership can enhance data security.

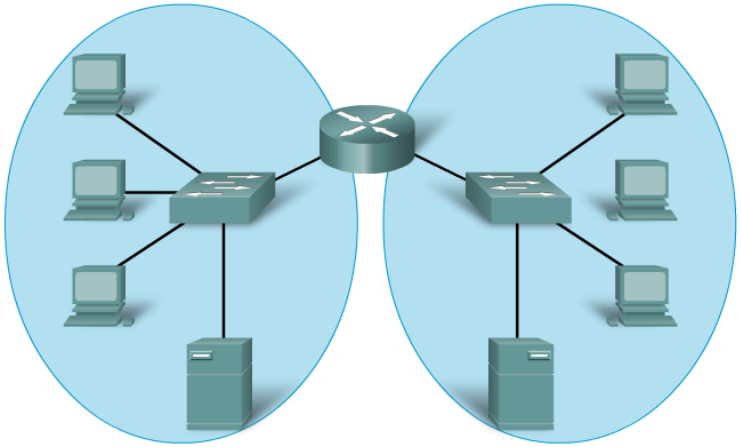


OWNERSHIP

Why Separating Host into Networks? Performance



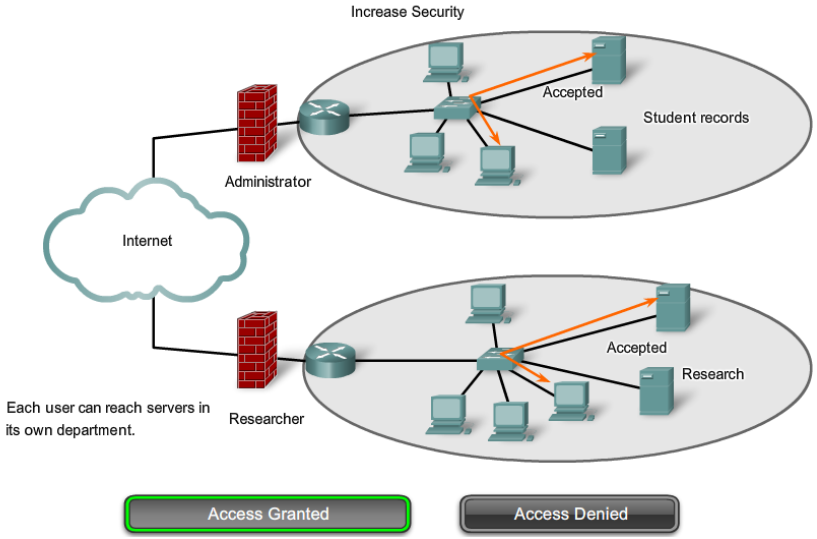
All devices in this network are connected in one broadcast domain when the switch is set to the factory default settings. Since switches forward broadcasts by default, broadcasts are processed by all devices in this network.

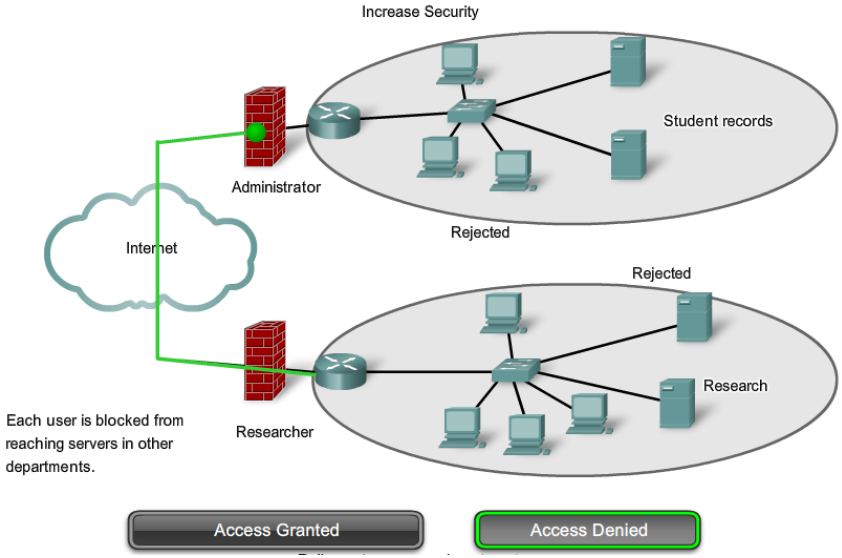


Replacing the middle switch with a router creates 2 IP subnets, hence, 2 distinct broadcast domains. All devices are connected but local broadcasts are contained.

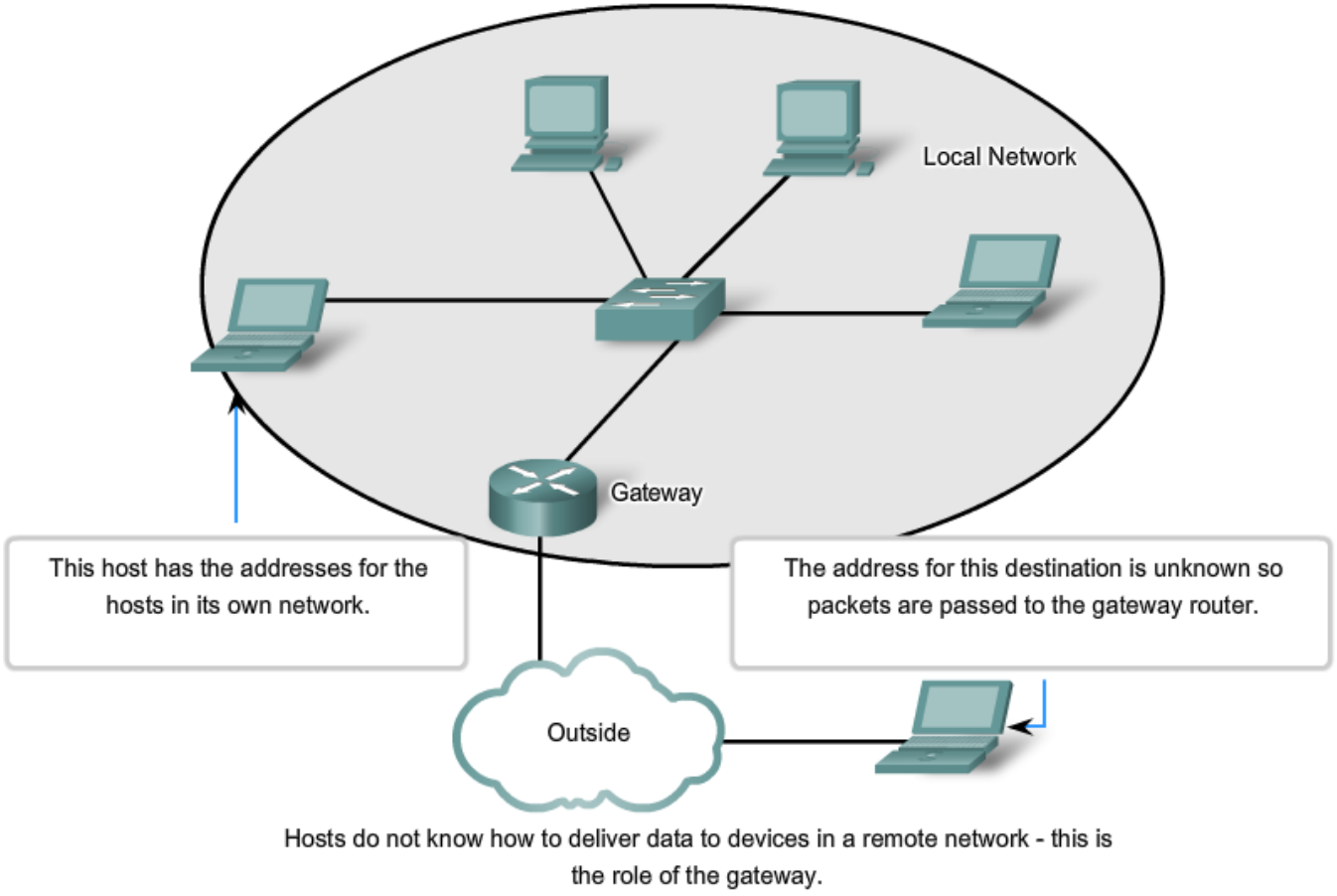
Optimize Grouping

Why Separating Host into Networks? Security

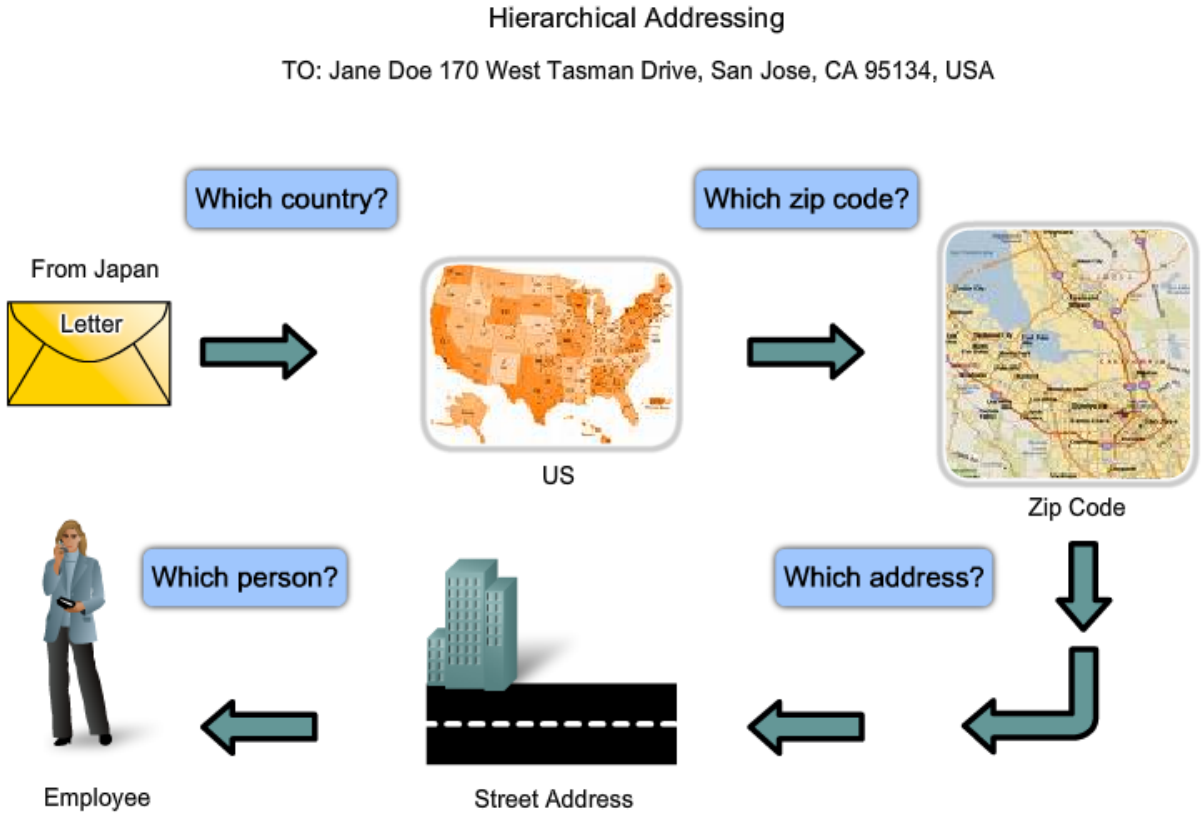




Why Separating Host into Networks? Address Management

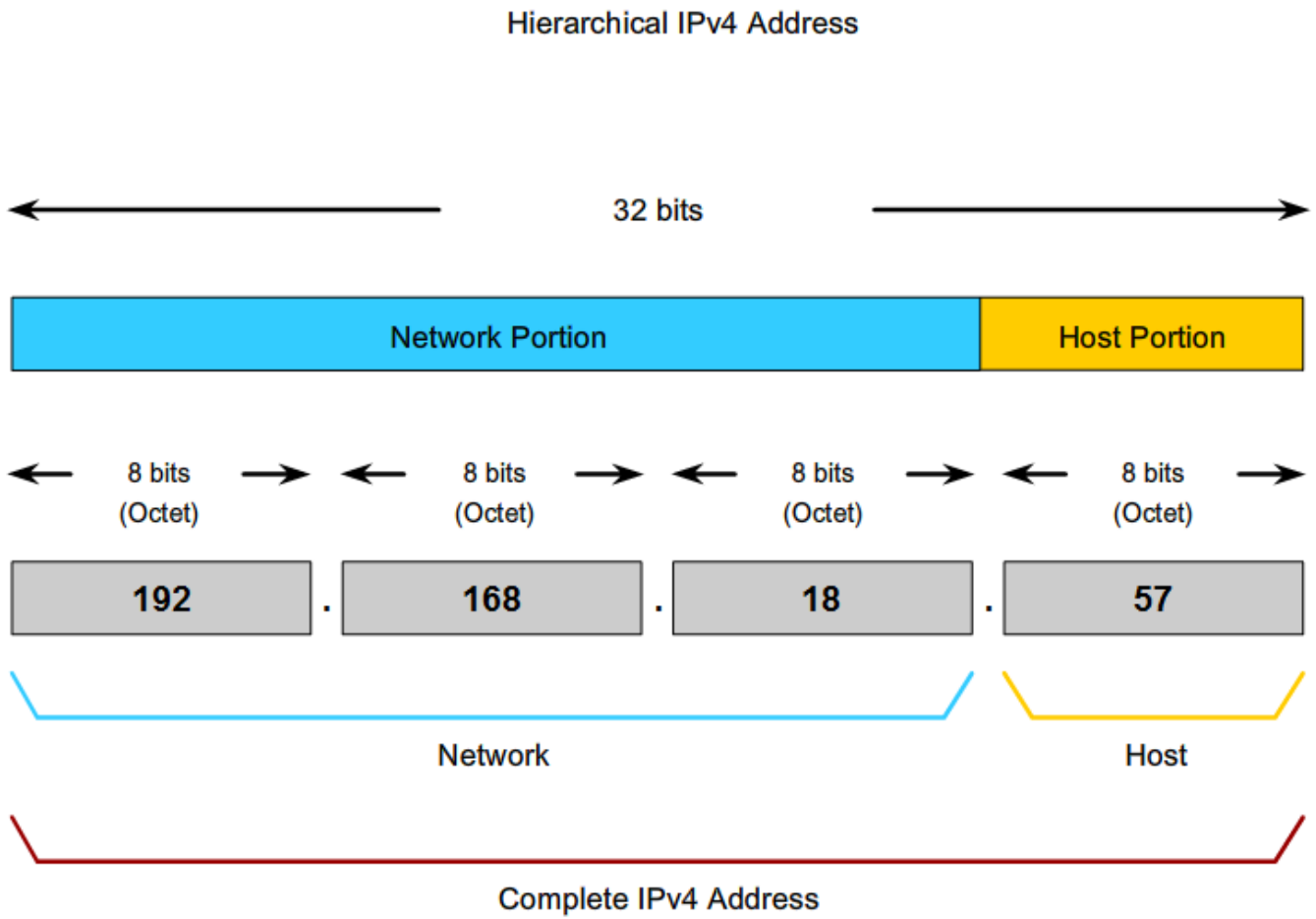


How do we Separate Hosts into Networks

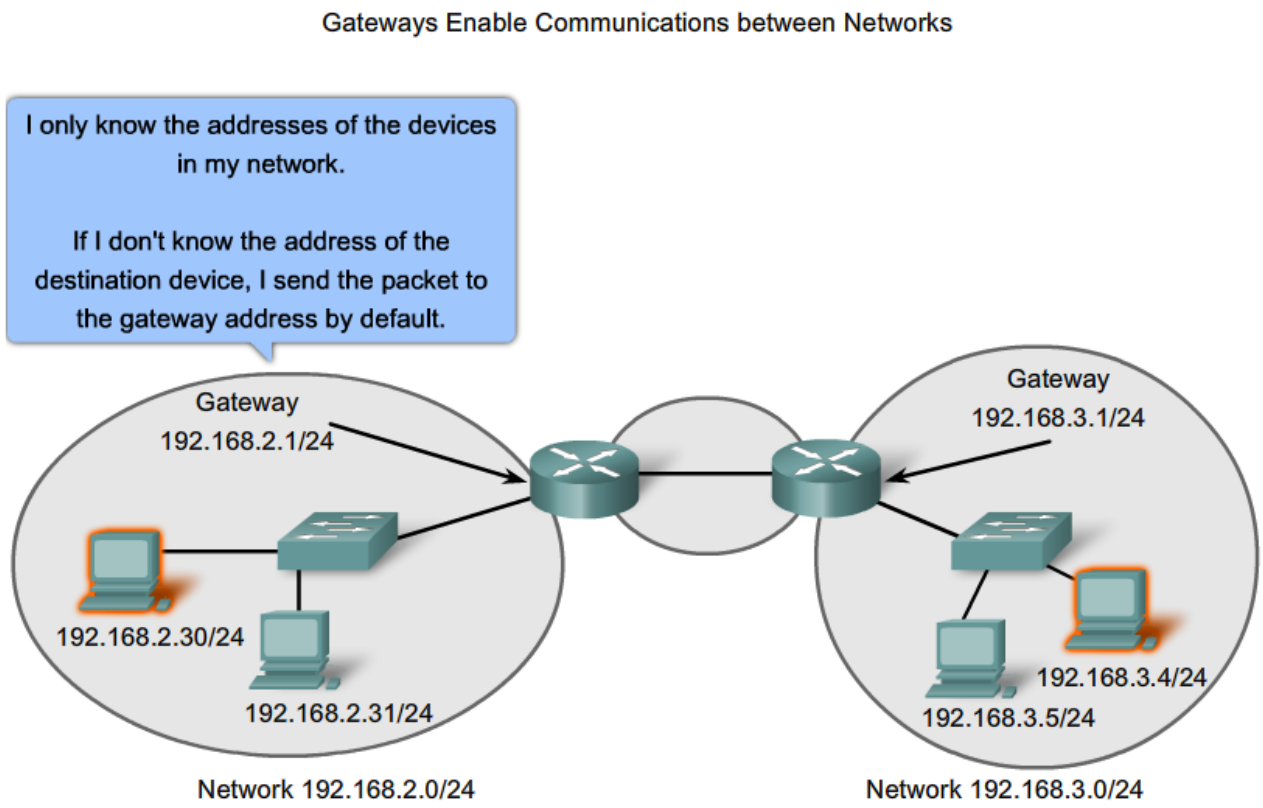


At each step of delivery, the post office need only examine the next hierarchical level.

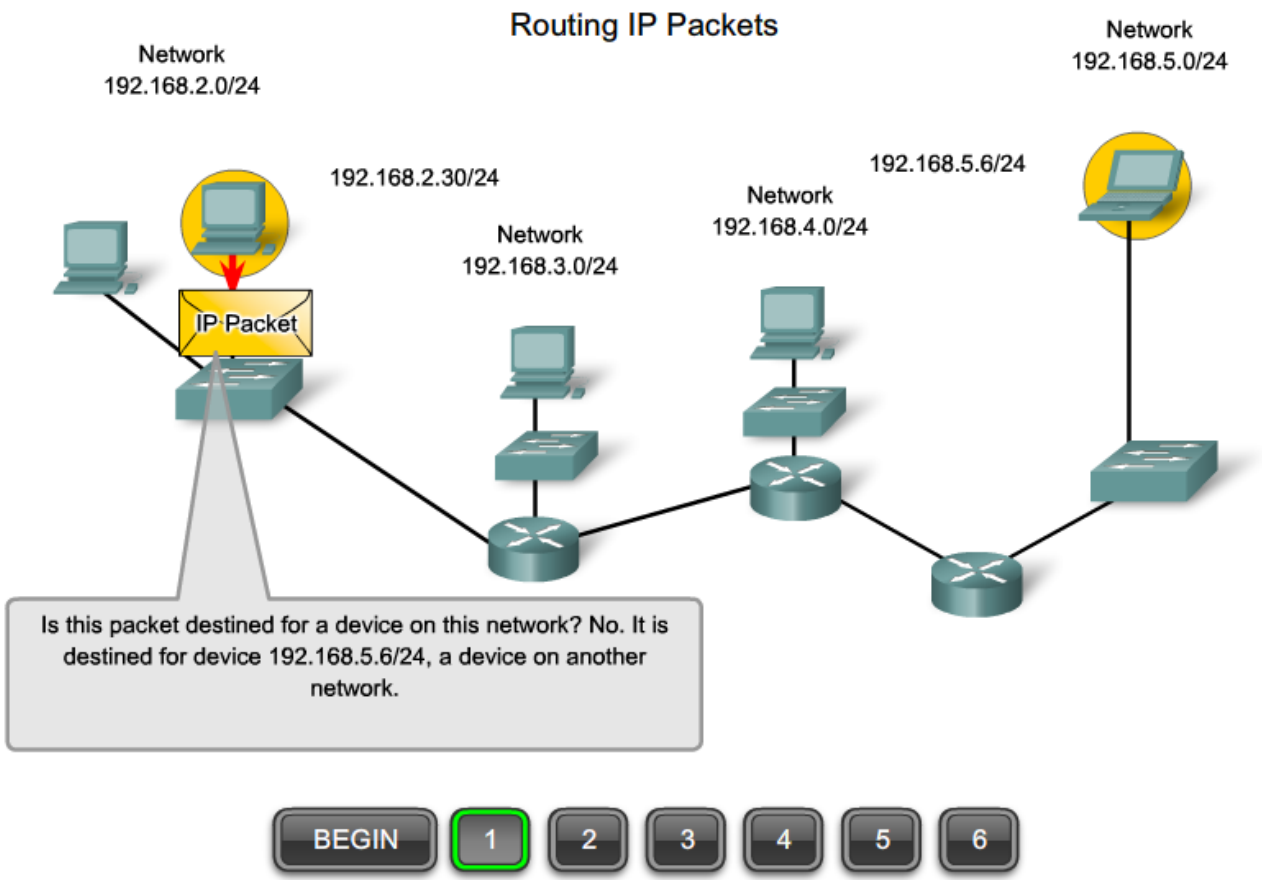
Dividing the Networks- a Network of Networks



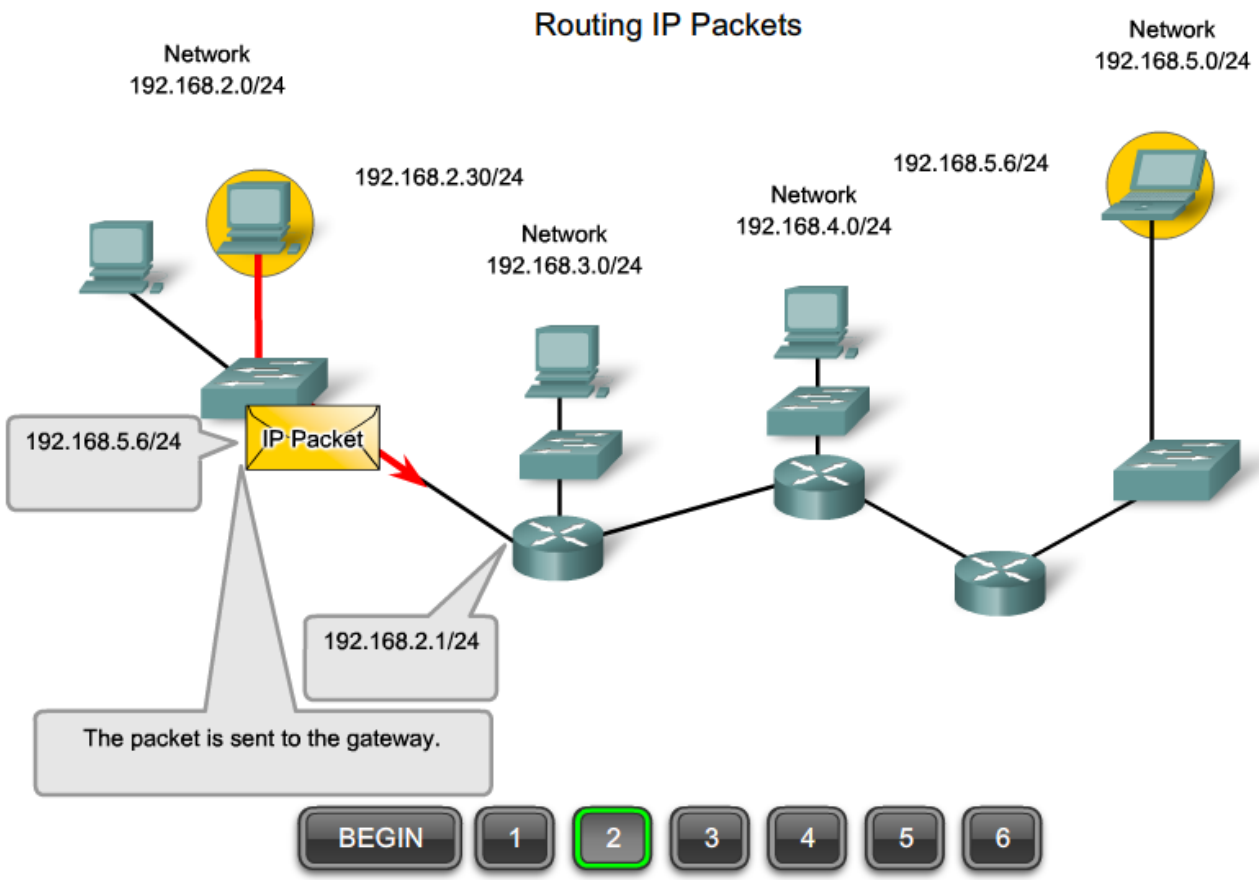
Device Parameters



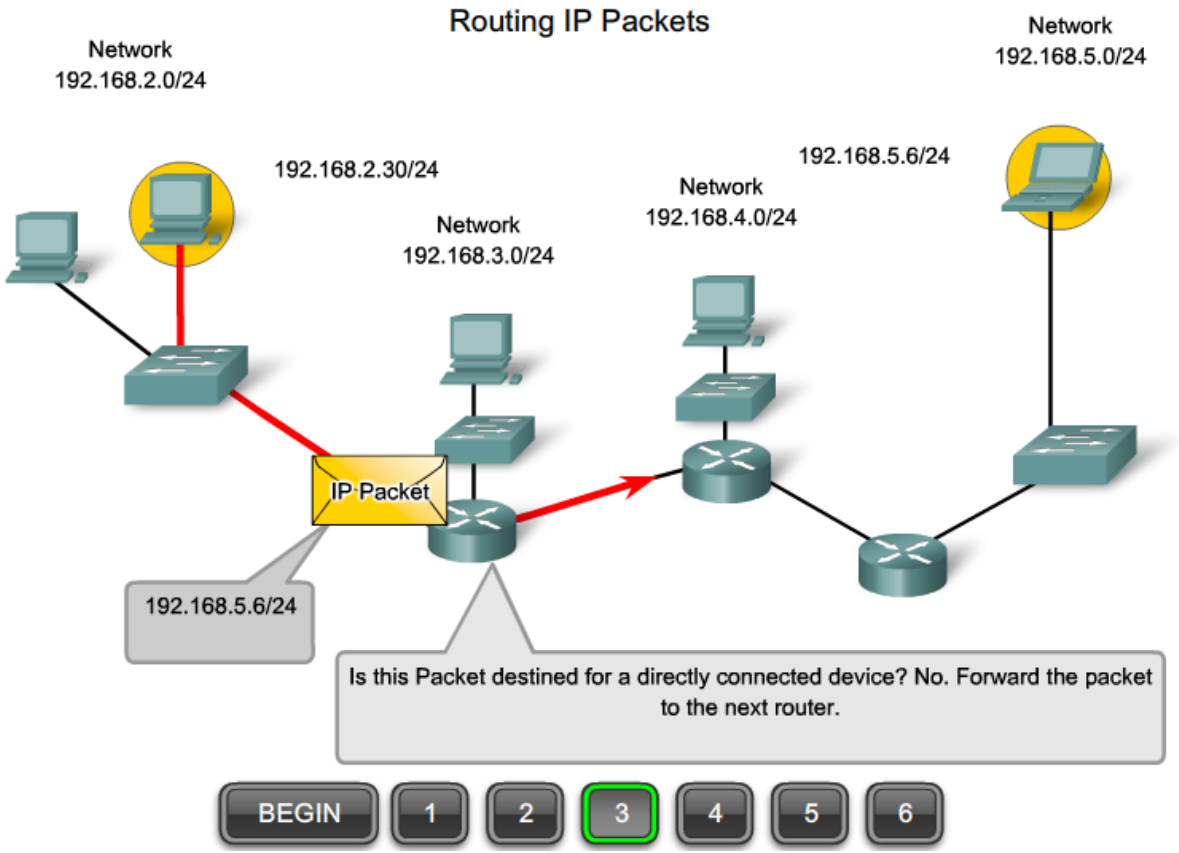
IP Packets


Routing IP Packets
Network
192.168.2.0/24
192.168.2.30/24
IP Packet
Network
192.168.3.0/24
Network
192.168.4.0/24
192.168.5.6/24
Network
192.168.5.0/24
Is this packet destined for a device on this network? No. It is destined for device 192.168.5.6/24, a device on another network.
BEGIN
1
2
3
4
5
6

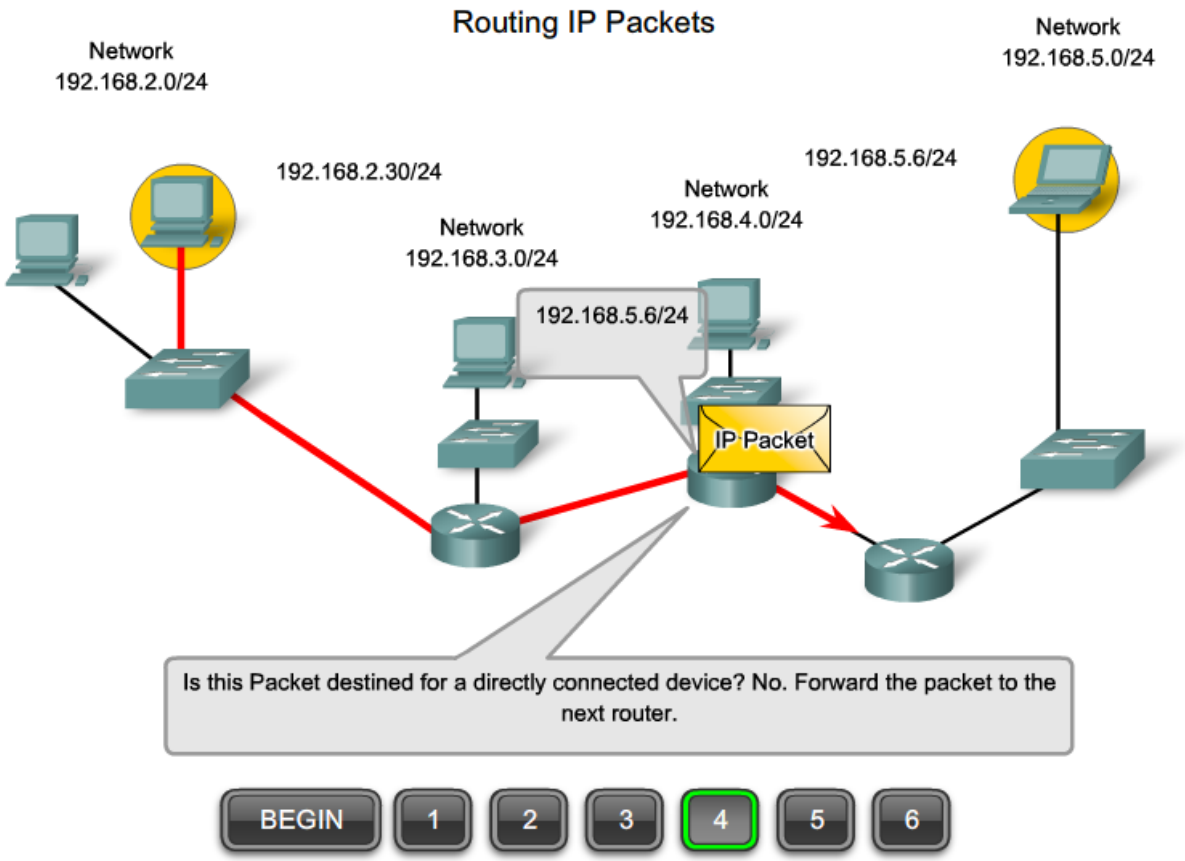
IP Packets


Routing IP Packets
Network
192.168.2.0/24
192.168.2.30/24
Network
192.168.3.0/24
Network
192.168.4.0/24
192.168.5.6/24
Network
192.168.5.0/24
192.168.5.6/24
IP Packet
192.168.2.1/24
The packet is sent to the gateway.
BEGIN
1
2
3
4
5
6

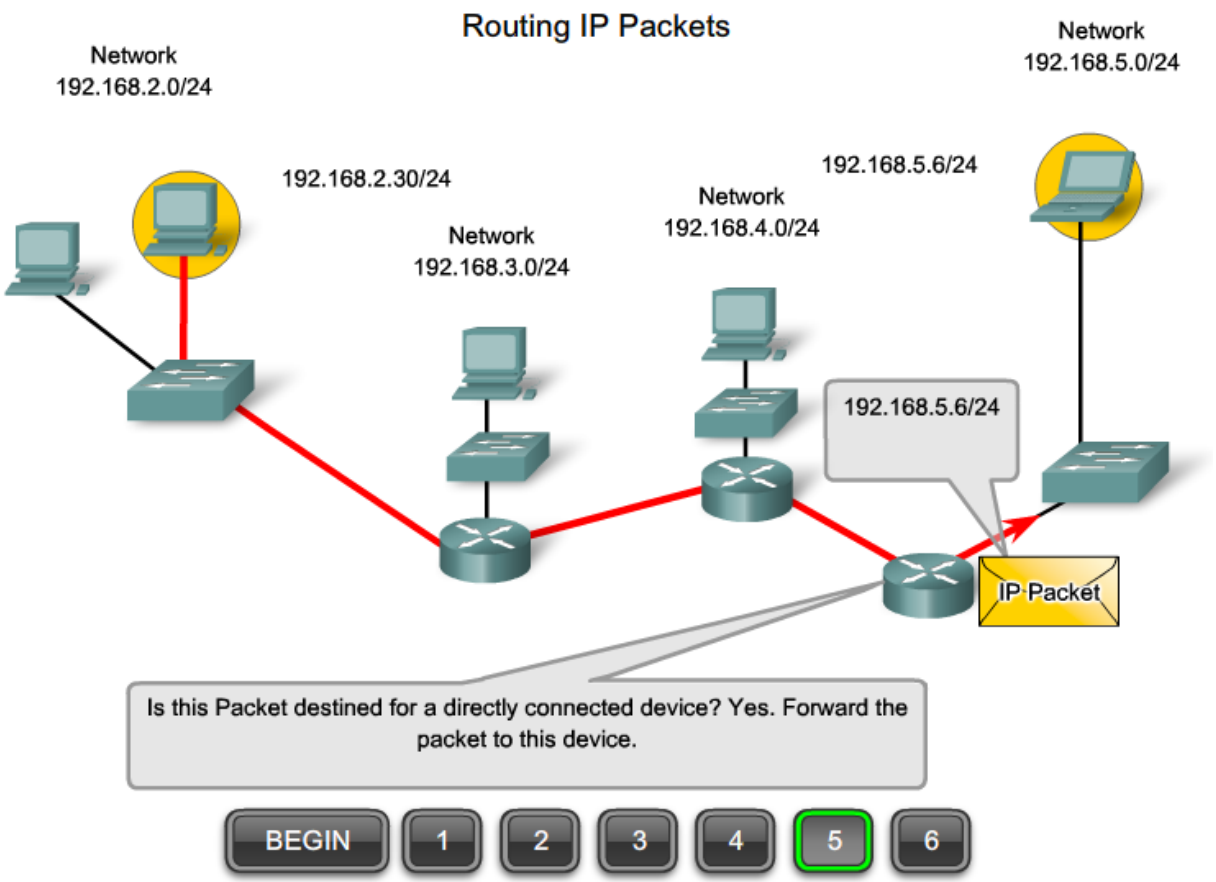
IP Packets


Routing IP Packets
Network
192.168.2.0/24
192.168.2.30/24
Network
192.168.3.0/24
Network
192.168.4.0/24
192.168.5.6/24
Network
192.168.5.0/24
IP Packet
192.168.5.6/24
Is this Packet destined for a directly connected device? No. Forward the packet to the next router.
BEGIN
1
2
3
4
5
6

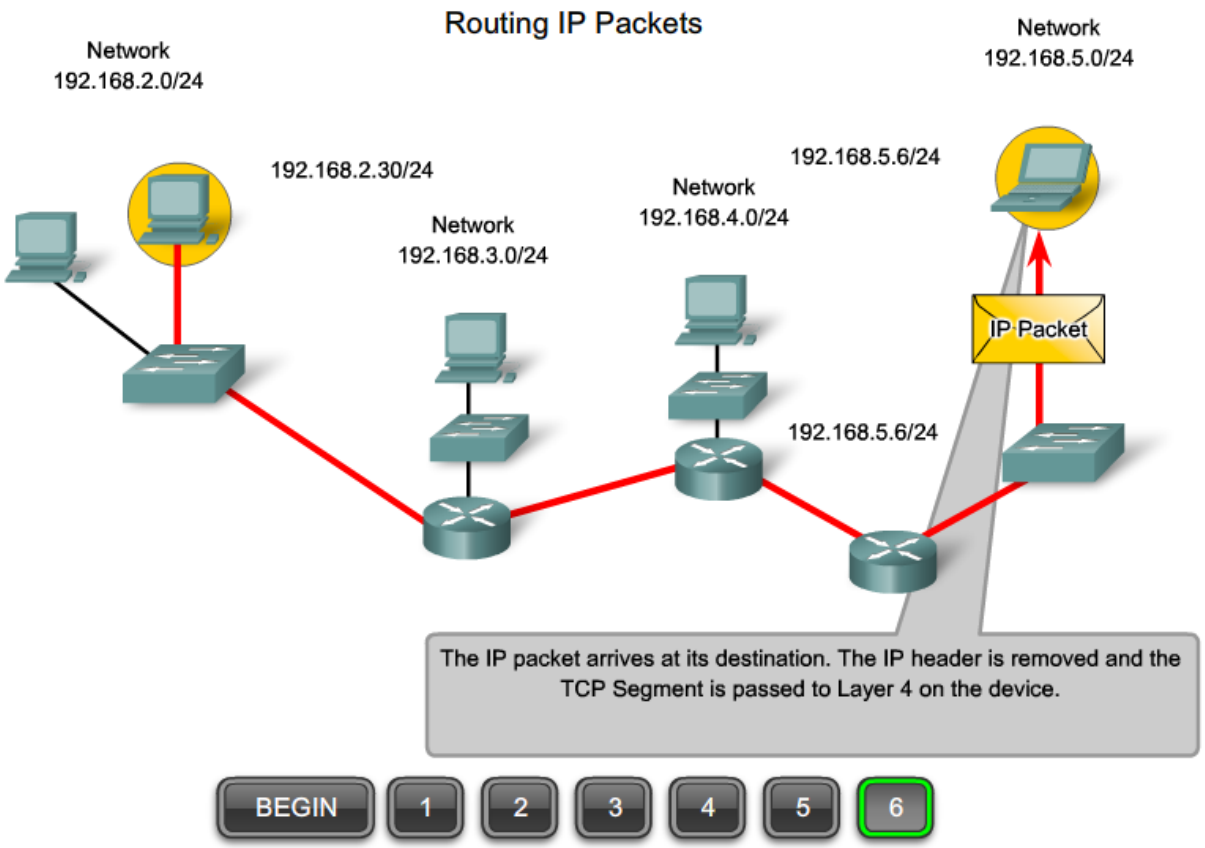
IP Packets


Routing IP Packets
Network
192.168.2.0/24
Network
192.168.5.0/24
192.168.2.30/24
192.168.5.6/24
Network
192.168.4.0/24
Network
192.168.3.0/24
192.168.5.6/24
IP Packet
Is this Packet destined for a directly connected device? No. Forward the packet to the next router.
BEGIN
1
2
3
4
5
6

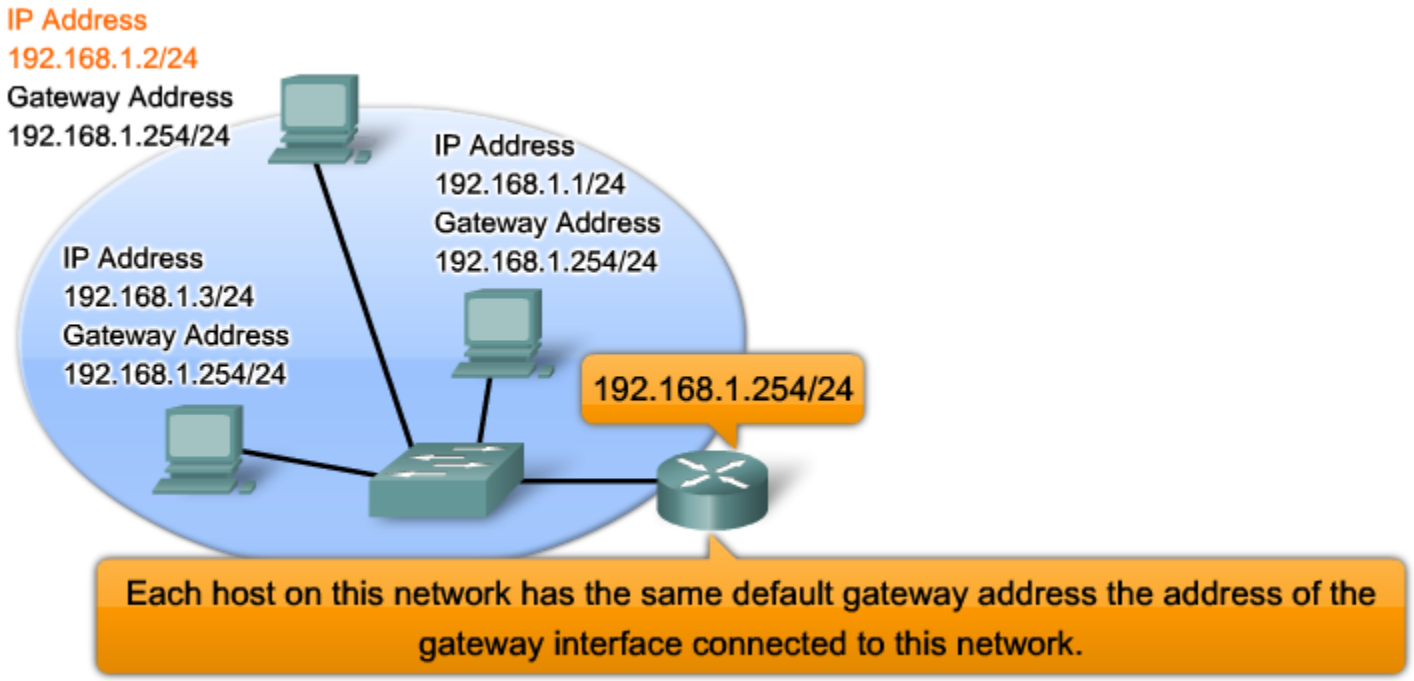
IP Packets

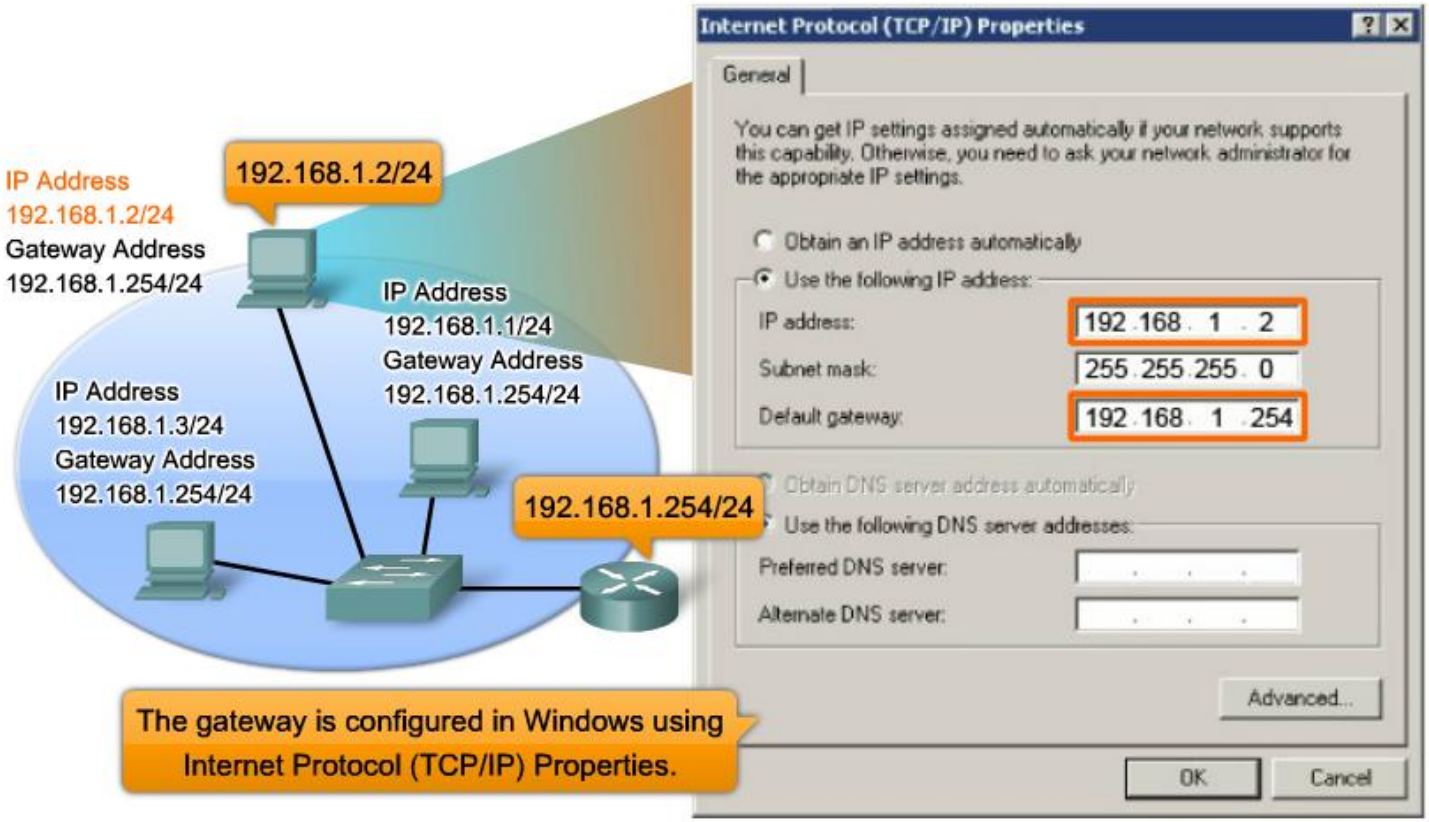

Routing IP Packets
Network
192.168.2.0/24
192.168.2.30/24
Network
192.168.3.0/24
Network
192.168.4.0/24
192.168.5.6/24
Network
192.168.5.0/24
192.168.5.6/24
IP Packet
Is this Packet destined for a directly connected device? Yes. Forward the packet to this device.
BEGIN
1
2
3
4
5
6

IP Packets


Routing IP Packets
Network
192.168.2.0/24
192.168.2.30/24
Network
192.168.3.0/24
Network
192.168.4.0/24
192.168.5.6/24
Network
192.168.5.0/24
IP Packet
192.168.5.6/24
The IP packet arrives at its destination. The IP header is removed and the TCP Segment is passed to Layer 4 on the device.
BEGIN
1
2
3
4
5
6

IP packets Carrying data End to End




IP Address
192.168.1.2/24
Gateway Address
192.168.1.254/24
192.168.1.2/24
IP Address
192.168.1.1/24
Gateway Address
192.168.1.254/24
IP Address
192.168.1.3/24
Gateway Address
192.168.1.254/24
192.168.1.254/24
Internet Protocol (TCP/IP) Properties
General
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Obtain an IP address automatically
Use the following IP address:
IP address: 192.168.1.2
Subnet mask: 255.255.255.0
Default gateway: 192.168.1.254
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server:
Alternate DNS server:
Advanced...
OK
Cancel
The gateway is configured in Windows using Internet Protocol (TCP/IP) Properties.

The Gateway

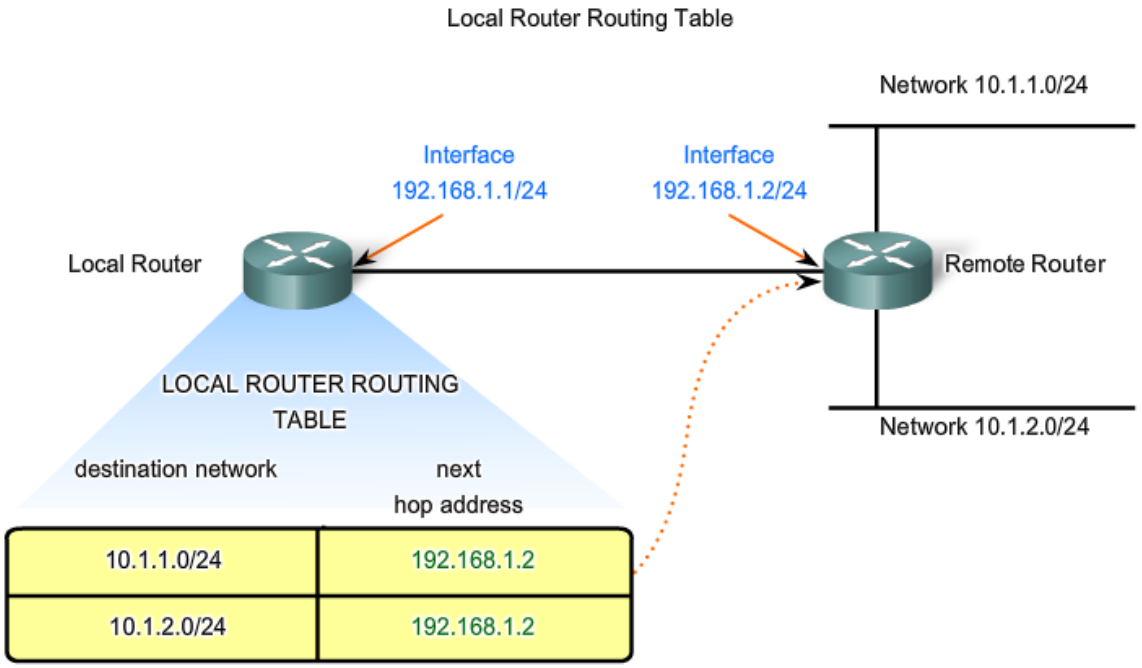
Confirming the Gateway Settings

```
C:\>ipconfig

Windows IP Configuration

Ethernet adapter Local Area Connection:

        Connection-specific DNS Suffix  . :
     ① IP Address. . . . . . . . . . . . : 192.168.1.2
     ② Subnet Mask . . . . . . . . . . . : 255.255.255.0
     ③ Default Gateway . . . . . . . . . : 192.168.1.254
```

Default gateway address for this host computer

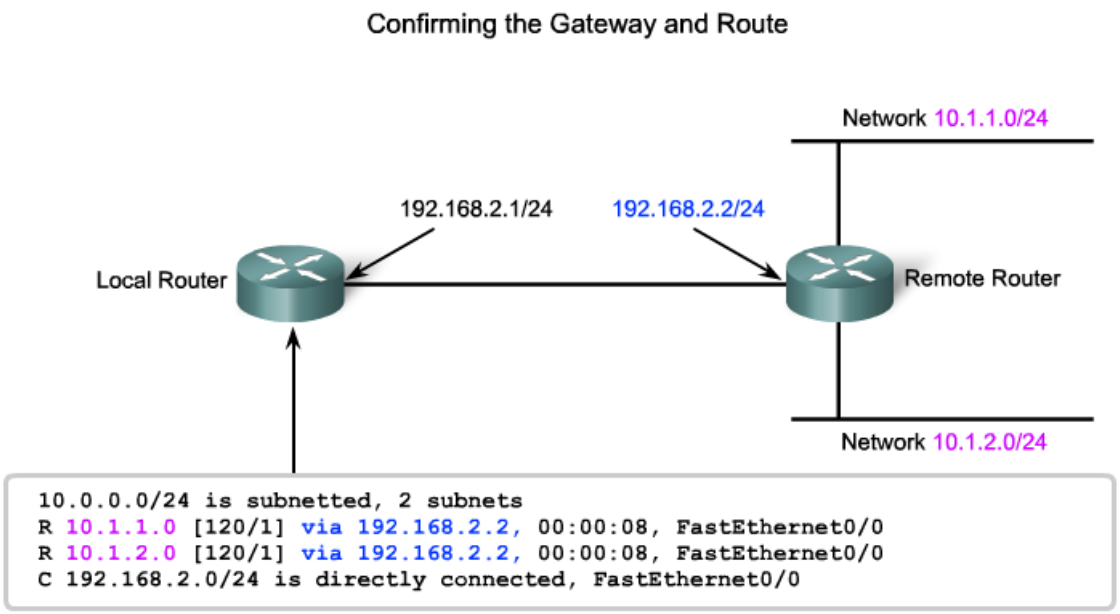
Sample `ipconfig` output showing default gateway address

The Gateway



The next hop for both networks 10.1.1.0/24 and 10.1.2.0/24 from Local Router is 192.168.1.2

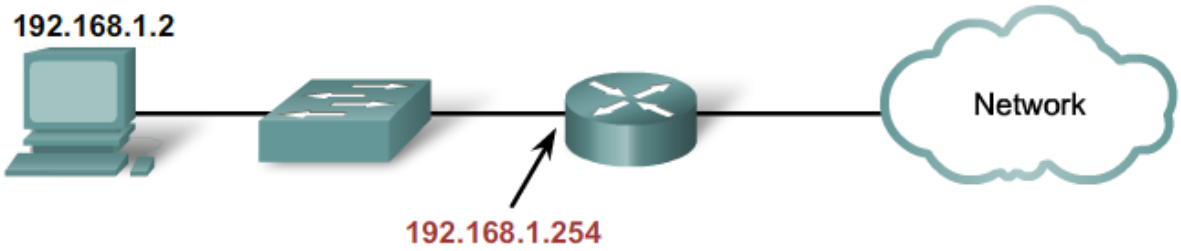
A Route



This is the routing table output of Local Router when the `"show ip route"` is issued.

The next hop for networks 10.1.1.0/24 and 10.1.2.0/24 from Local Router is 192.168.2.2.

Host Routing Table




```
Interface List
0x2 ...00 0f fe 26 f7 7b ...  Gigabit Ethernet - Packet Scheduler Miniport
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0    192.168.1.254     192.168.1.2      20
      192.168.1.0    255.255.255.0      192.168.1.2     192.168.1.2      20
Default Gateway:     192.168.1.254
// output omitted //
===========================================================================
```

This is an example of a routing table on an end device after the `netstat -r` command is issued. Note that it has a route to its network (192.168.1.0) and a default route (0.0.0.0) to the router gateway for all other networks.

Routing Table Entries

Route Entries in a Routing Table

Packets with destination host addresses in one of the network ranges shown will be matched with the next hop that leads to that network.

Routing Table Entries

The routing table shows the default route 0.0.0.0.

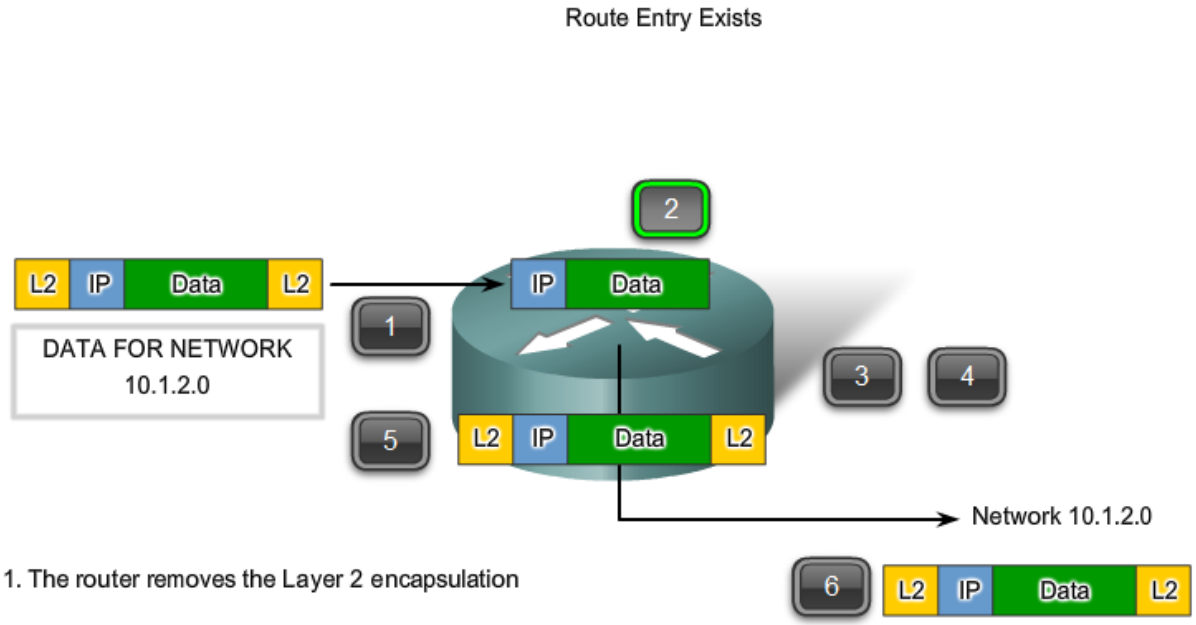
```
Gateway of last resort is 192.168.2.2 to network 0.0.0.0
   10.0.0.0/24 is subnetted, 2 subnets
R     10.1.1.0 [120/1] via 192.168.2.2, 00:00:08, FastEthernet0/0
R     10.1.2.0 [120/1] via 192.168.2.2, 00:00:08, FastEthernet0/0
C     192.168.2.0/24 is directly connected, FastEthernet0/0
S*    0.0.0.0/0 [1/0] via 192.168.2.2
```

Packets with destination hosts addresses not in one of the network ranges shown will be forwarded to the gateway of last resort.

The Next-Hop

Routing Table Output with Next Hops

Packet Forwarding

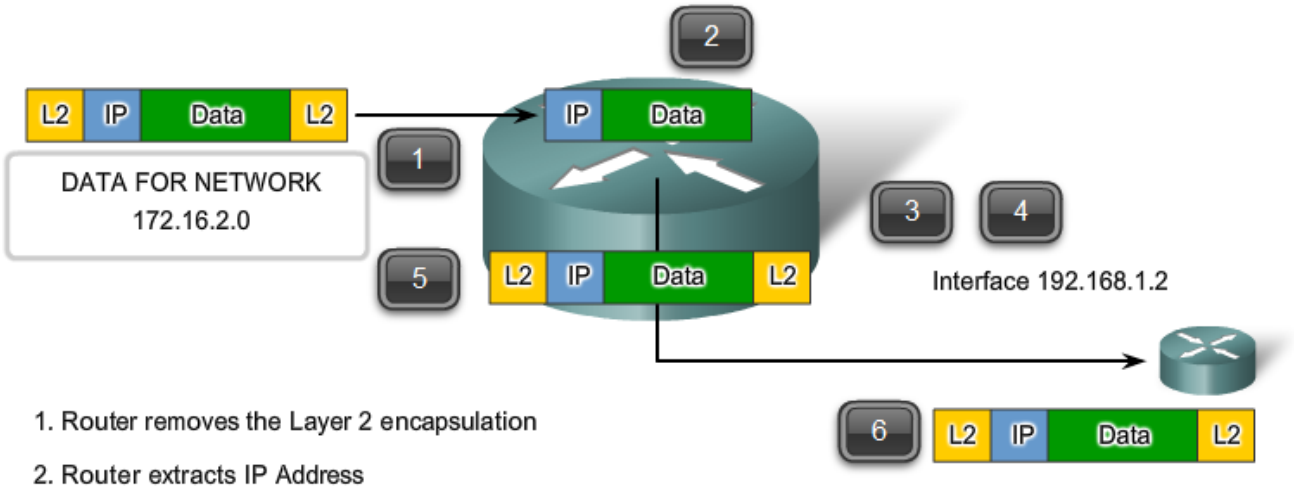


1. The router removes the Layer 2 encapsulation
2. Router extracts the destination IP address
3. Router checks the routing table for a match
4. Network 10.1.2.0 is found in the routing table
5. Router re-encapsulates the packet
6. Packet is sent to Network 10.1.2.0

Packet Forwarding…

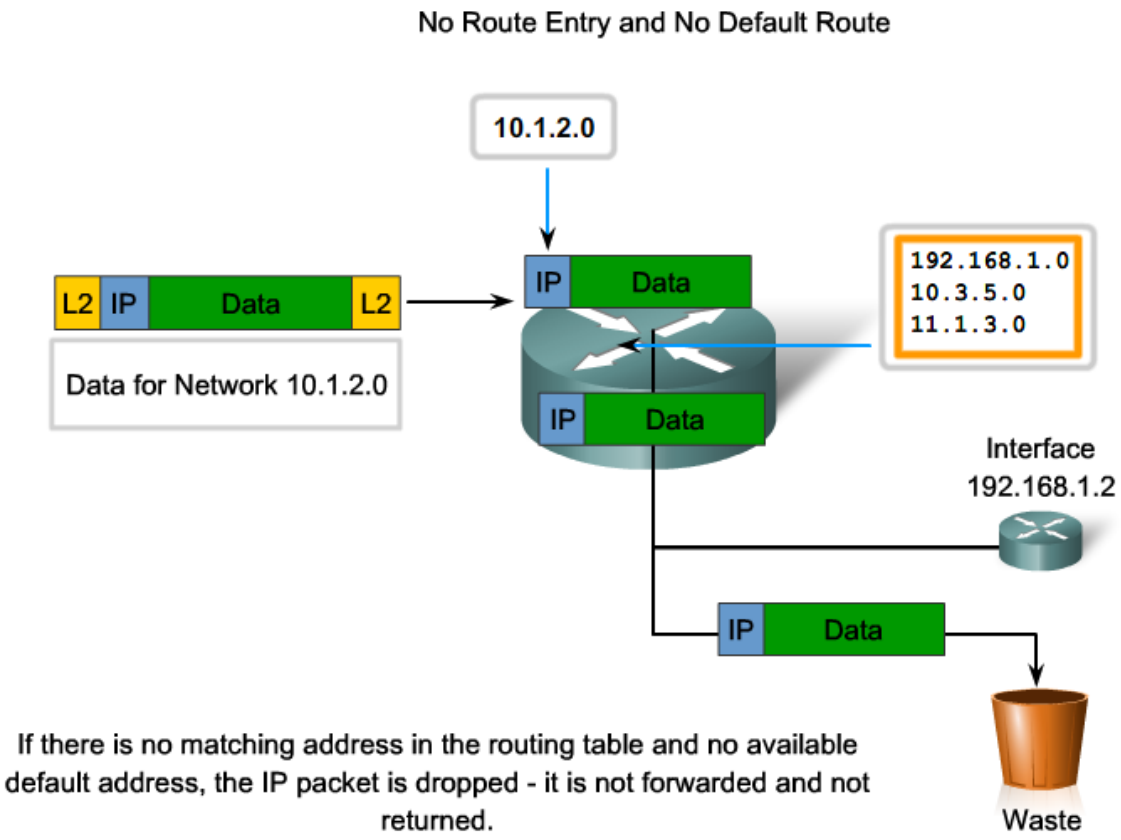
No Route Entry But Default Route Exists

Roll over to see the steps the router takes.

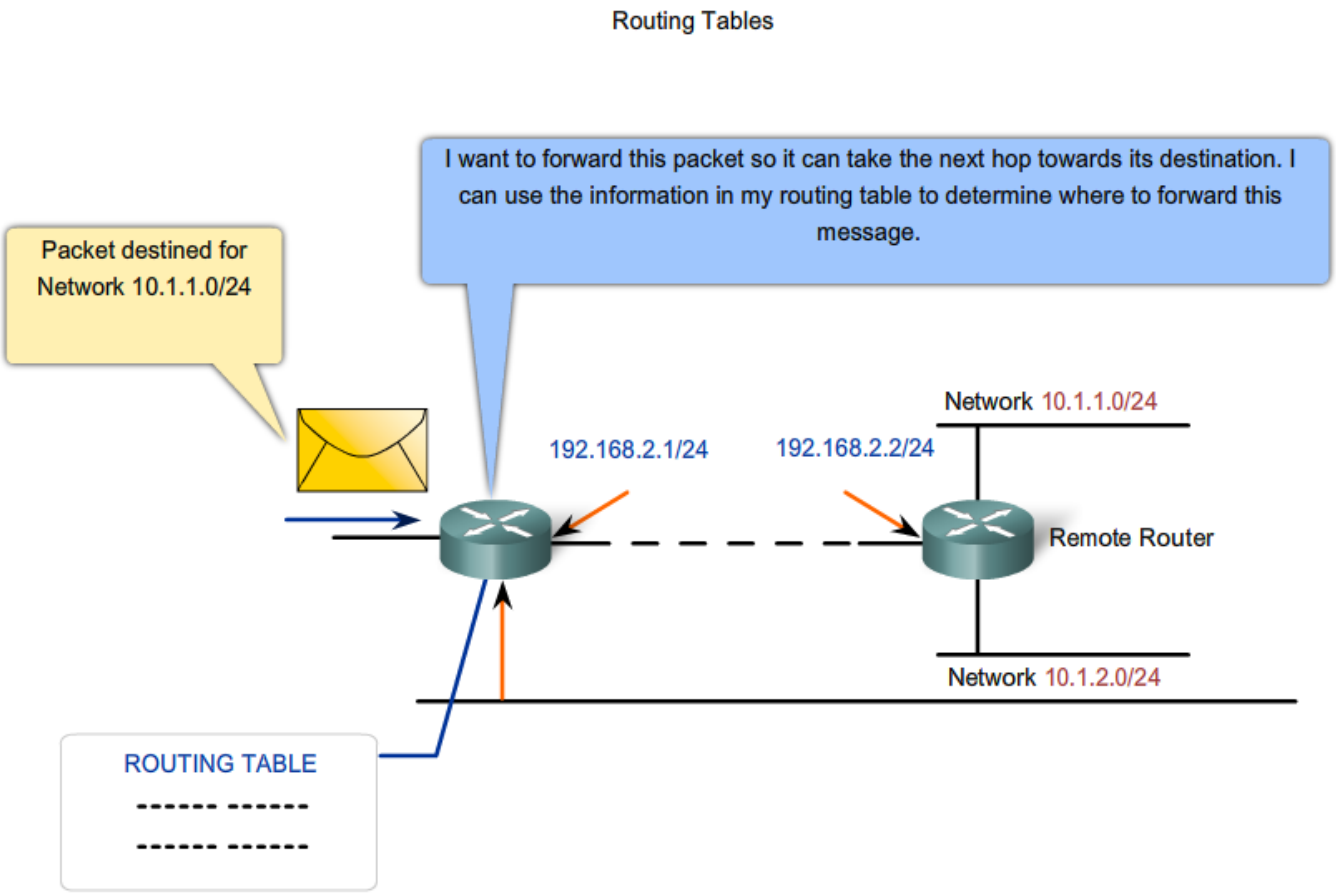


1. Router removes the Layer 2 encapsulation
2. Router extracts IP Address
3. Router checks the routing table for a match
4. Network 172.16.2.0 not in the routing table but default route to 192.168.1.2 exists
5. Router re-encapsulates the packet
6. Packet is sent to Interface 192.168.1.2

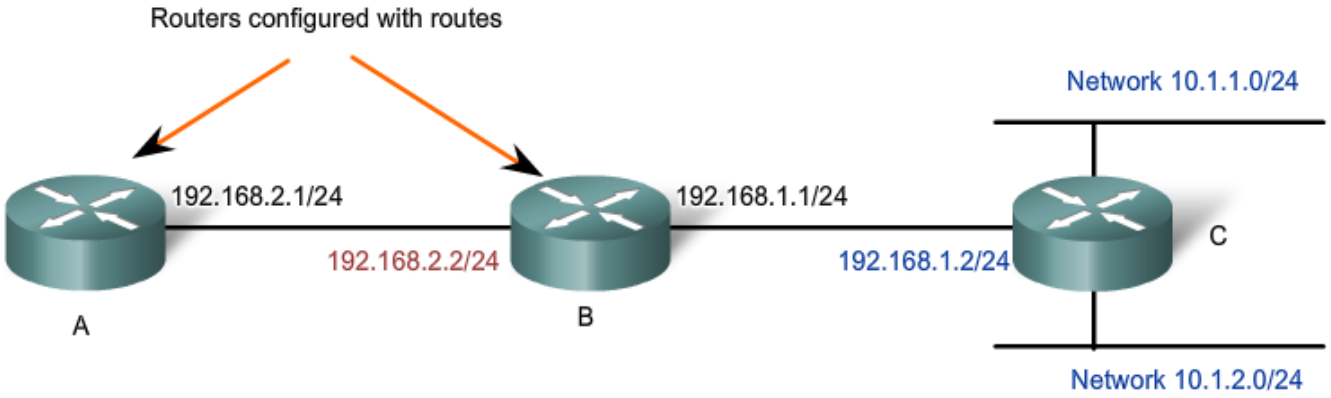
Packet Forwarding…



Routing Protocol



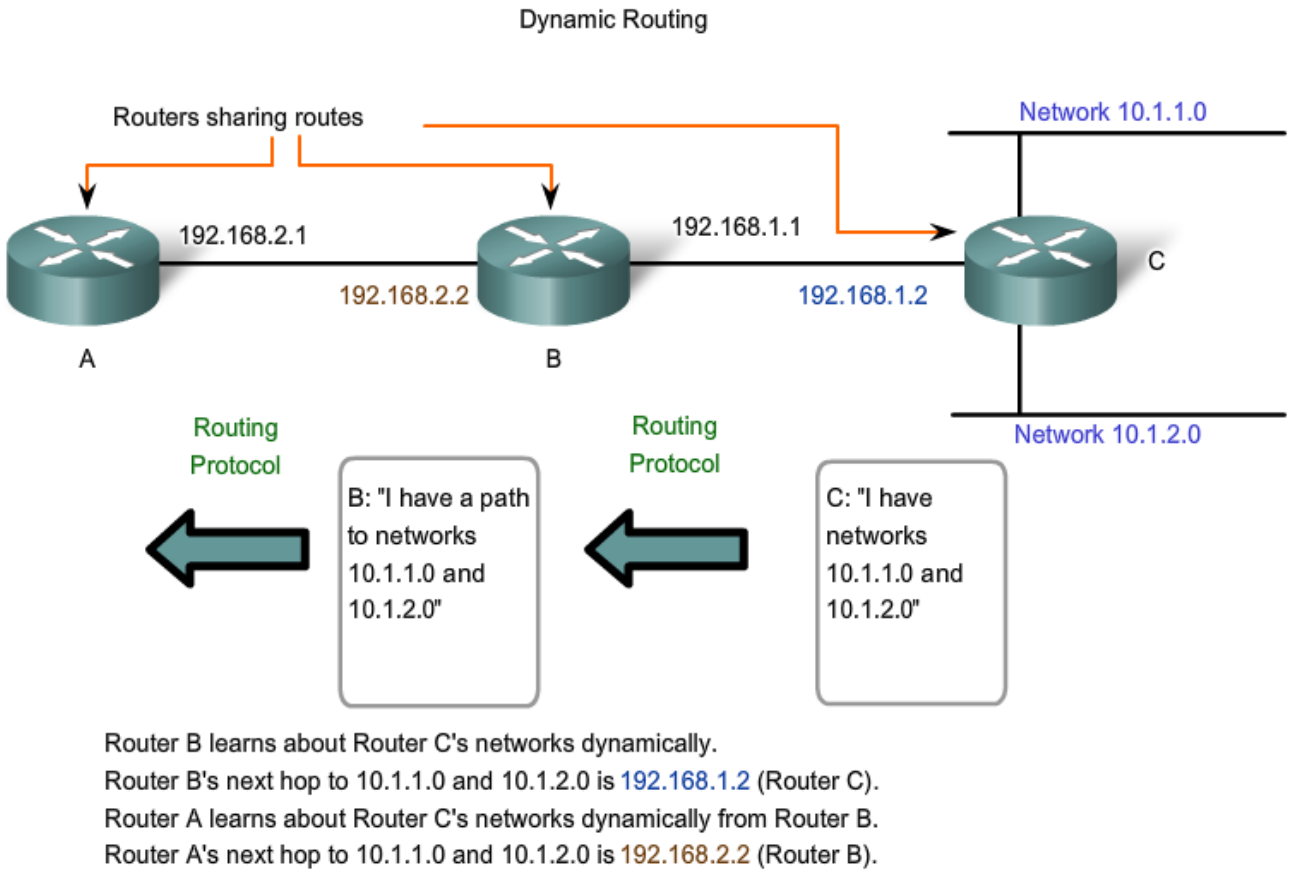
Static Routing



Router A:
192.168.2.2/24 configured manually as next hop for networks 10.1.1.0/24 and 10.1.2.0/24

Router B:
192.168.1.2/24 configured manually as next hop for networks 10.1.1.0/24 and 10.1.2.0/24

Dynamic Routing



Router B learns about Router C's networks dynamically.
Router B's next hop to 10.1.1.0 and 10.1.2.0 is 192.168.1.2 (Router C).
Router A learns about Router C's networks dynamically from Router B.
Router A's next hop to 10.1.1.0 and 10.1.2.0 is 192.168.2.2 (Router B).