Static Routing & Dynamic Routing Protocol

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Routing Concepts

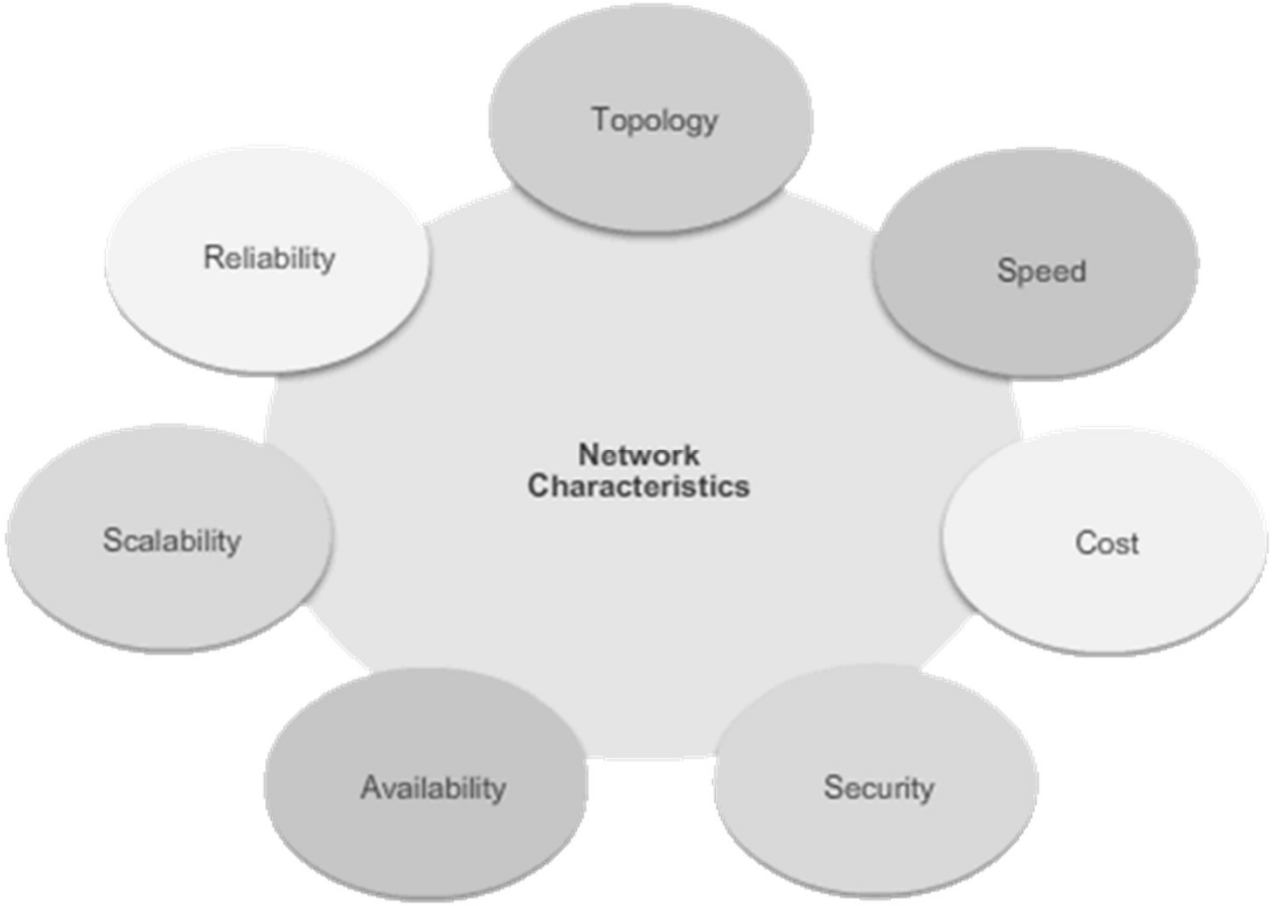
- Functions of a Router
- Connect Devices
- Initial Configuration of a Router
- Routing Decisions
- Routing Operation
- The Routing Table

Static Routing

- Static Routing Implementation
- Configure Static and Default Routes
- Review of CIDR and VLSM
- Summary and Floating Static Routes
- Troubleshoot Static and Default Route Issues

Functions of a Router

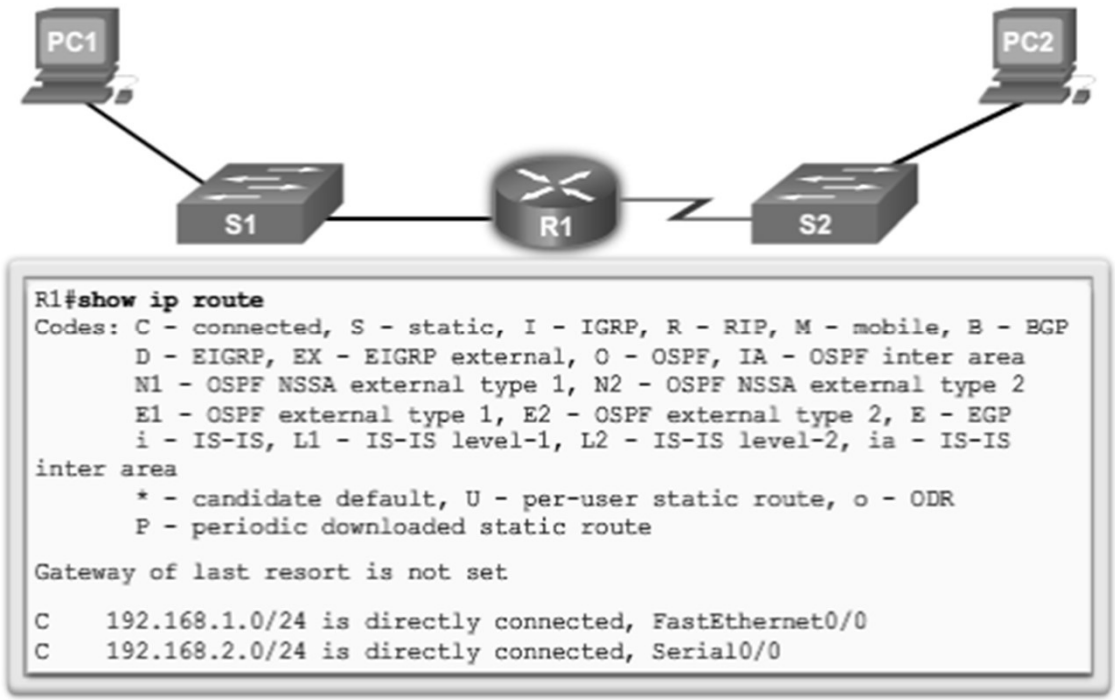
- Characteristics of a Network



Functions of a Router

- Why Routing?
  - The router is responsible for the routing of traffic between networks.

Routers Route Packets



Cisco IOS command line interface (CLI) can be used to view the route table.

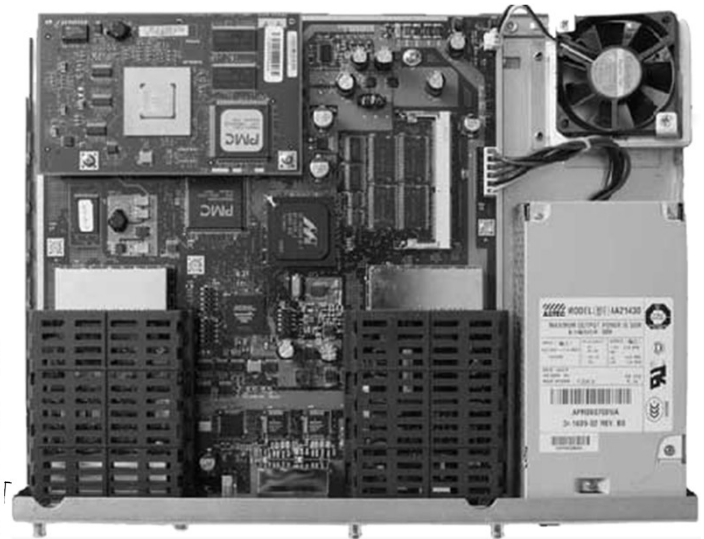
Functions of a Router

- Routers are Computers
  - Routers are specialized computers containing the following required components to operate:
    - Central processing unit (CPU)
    - Operating system (OS) - Routers use Cisco IOS
    - Memory and storage (RAM, ROM, NVRAM, Flash, hard drive)
  - Routers utilize the following memory:

Memory	Volatile / Non-Volatile	Stores
RAM	Volatile	• Running IOS • Running configuration file • IP routing and ARP tables • Packet buffer
ROM	Non-Volatile	• Bootup instructions • Basic diagnostic software • Limited IOS
NVRAM	Non-Volatile	• Startup configuration file
Flash	Non-Volatile	• IOS • Other system files

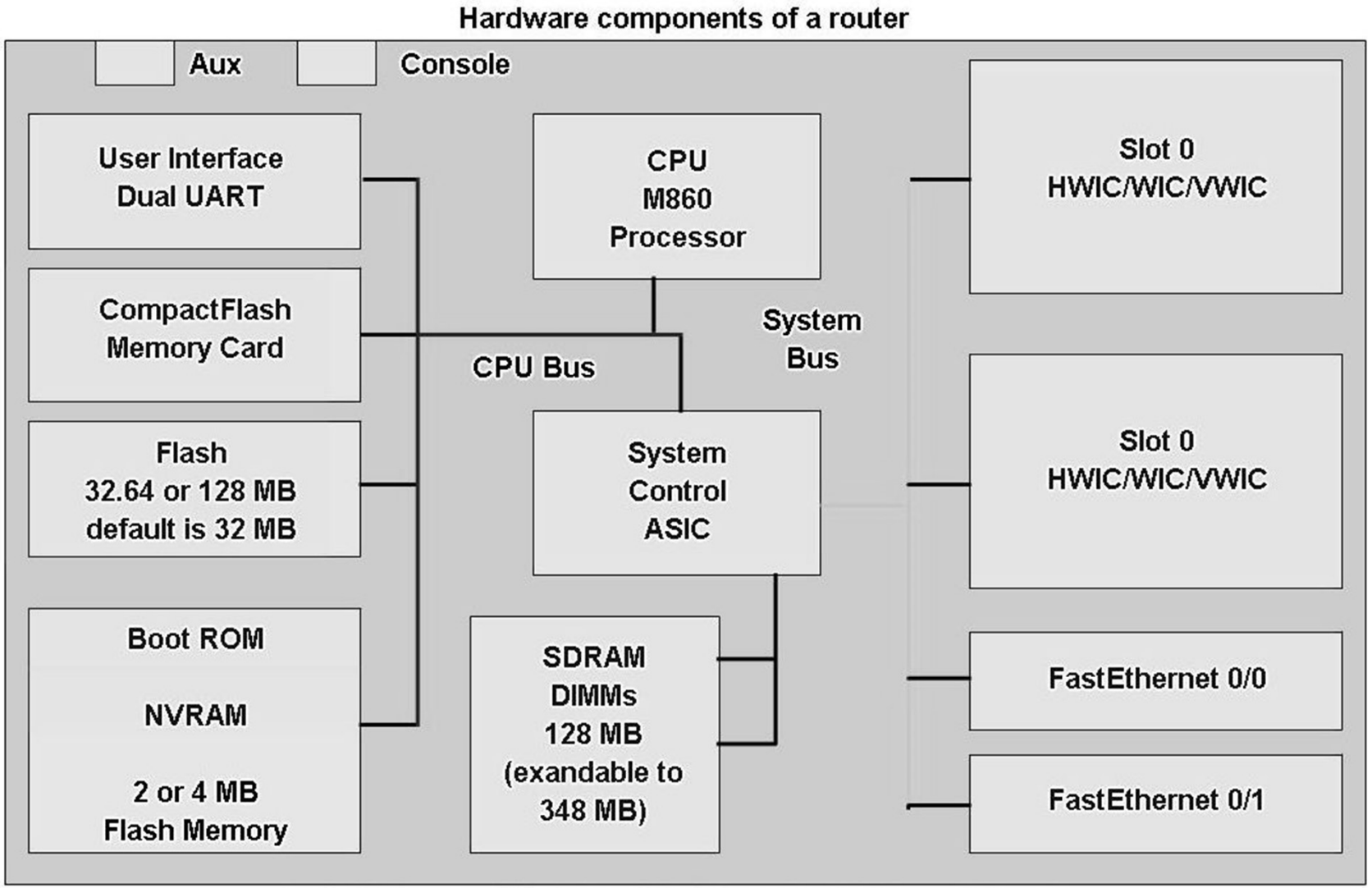
Functions of a Router

- Router components and their functions"
  - **CPU** - Executes operating system instructions
  - **Random access memory (RAM)** - Contains the running copy of configuration file. Stores routing table. RAM contents lost when power is off
  - **Read-only memory (ROM)** - Holds diagnostic software used when router is powered up. Stores the router's bootstrap program.
  - **Non-volatile RAM (NVRAM)** - Stores startup configuration. This may include IP addresses (Routing protocol, Hostname of router)
  - **Flash memory** - Contains the operating system (Cisco IOS)
  - **Interfaces** - There exist multiple physical interfaces that are used to connect network. Examples of interface types:
    - Ethernet / fast Ethernet interfaces
    - Serial interfaces
    - Management interfaces



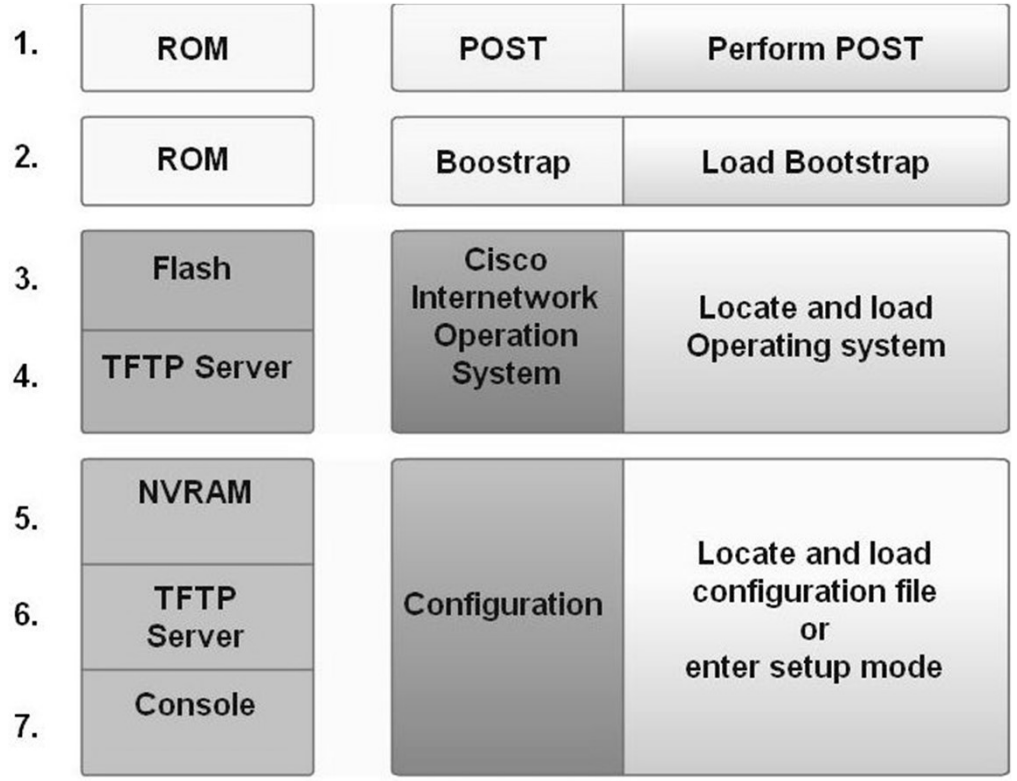
Functions of a Router

- Router components



Functions of a Router

- Router as a Computer
- Major phases to the router boot-up process
  - Test router hardware
    - Power-On Self Test (POST)
    - Execute bootstrap loader
  - Locate & load Cisco IOS software
    - Locate IOS
    - Load IOS
  - Locate & load startup configuration file or enter setup mode
    - Bootstrap program looks for configuration file




```
System Bootstrap, Version 12.3(8r)T8, RELEASE SOFTWARE (fc1)
Cisco 1841 (revision 5.0) with 114688K/16384K bytes of memory.

Self decompressing the image :
############################################################################################ [OK]

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(c) (1) (ii) of the Rights in Technical Data and Computer
Software clause at DFARS sec. 252.227-7013.

           --- System Configuration Dialog ---

Continue with configuration dialog? [yes/no]: no
```
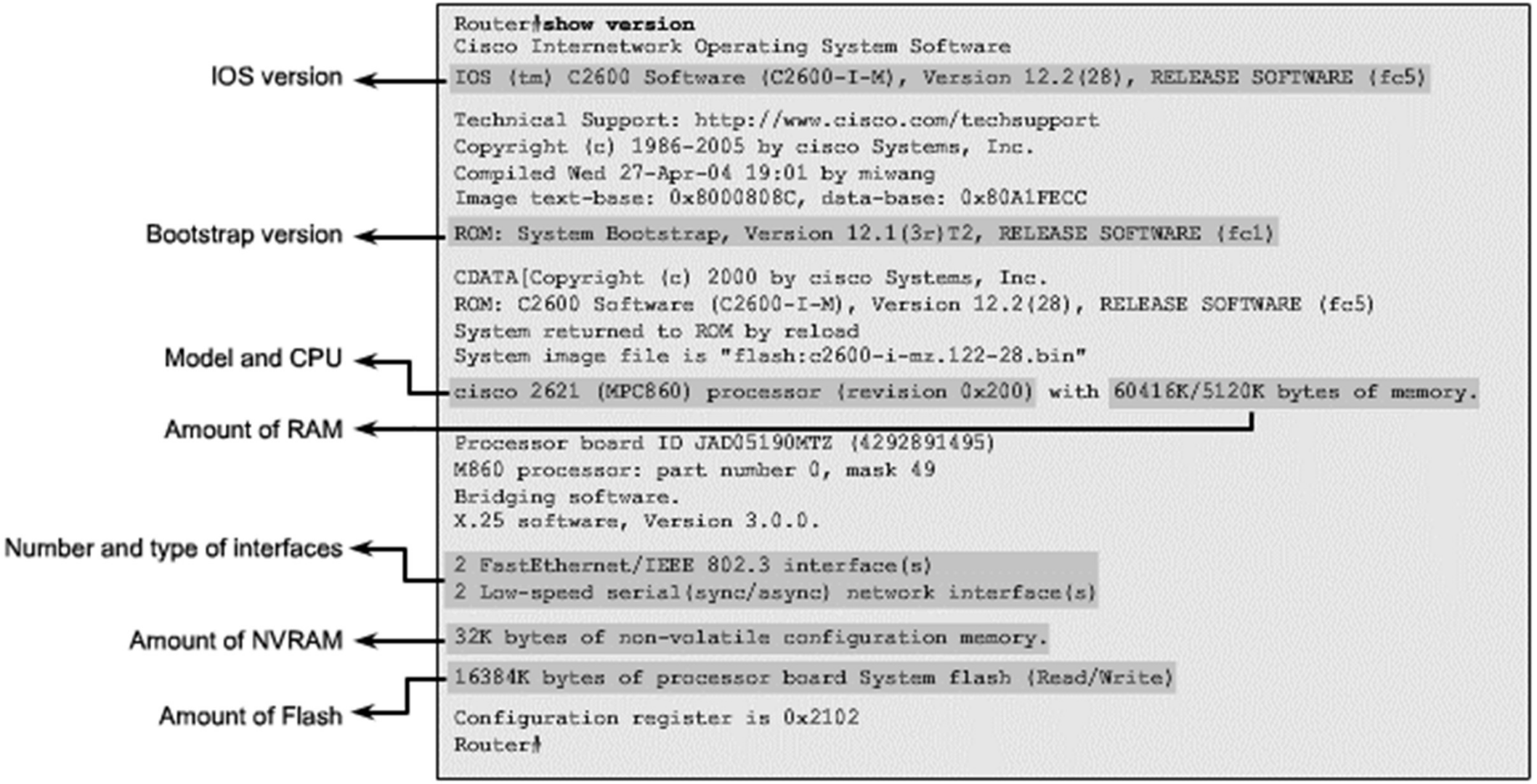
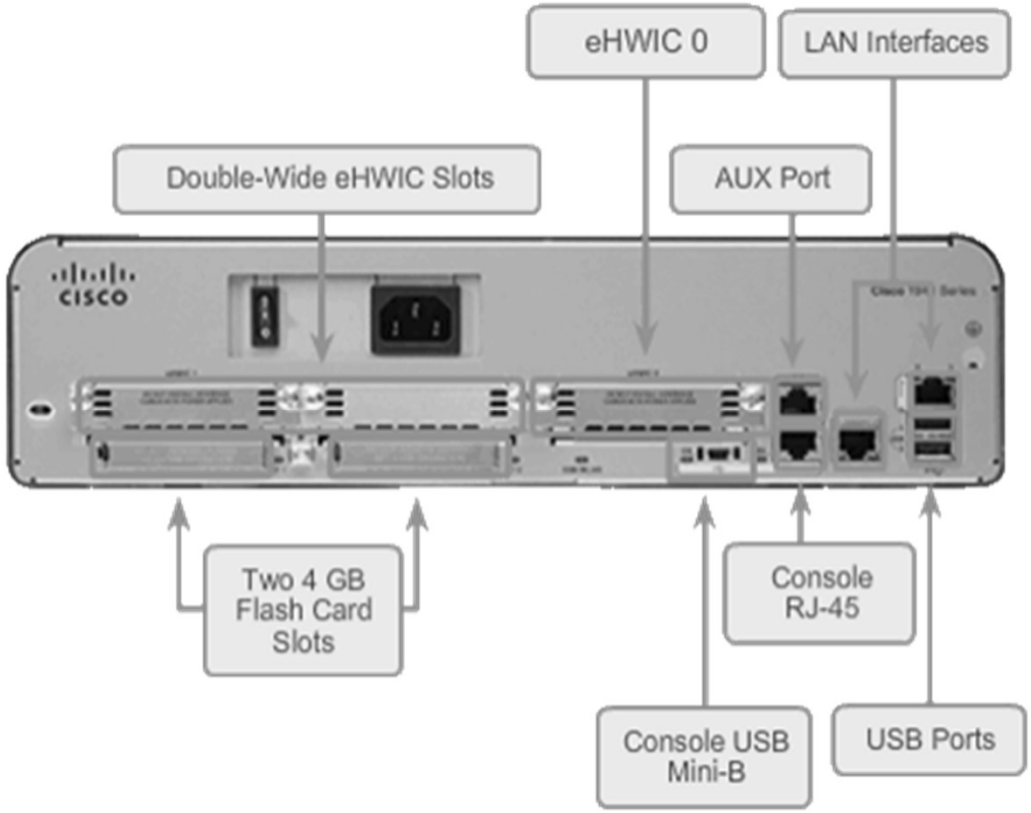

Functions of a Router



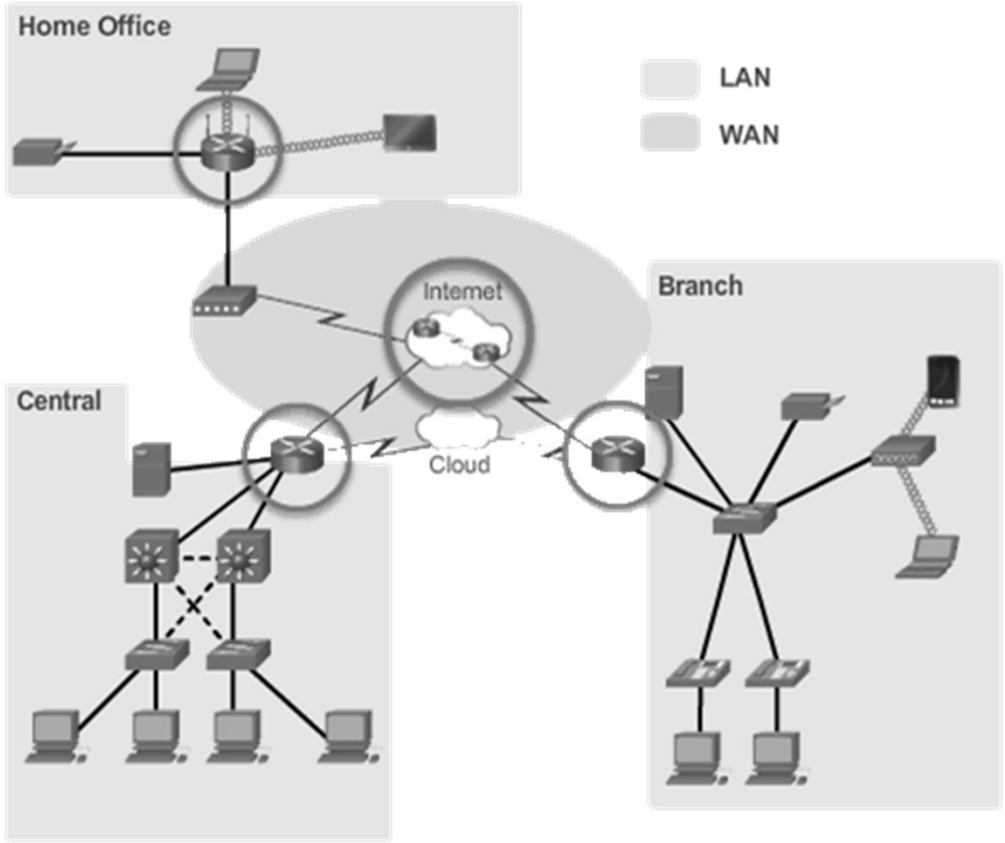
Functions of a Router

- Routers are Computers
  - Routers use specialized ports and network interface cards to interconnect to other networks



Functions of a Router

- Routers Interconnect Networks
  - Routers can connect multiple networks.
  - Routers have multiple interfaces, each on a different IP network.

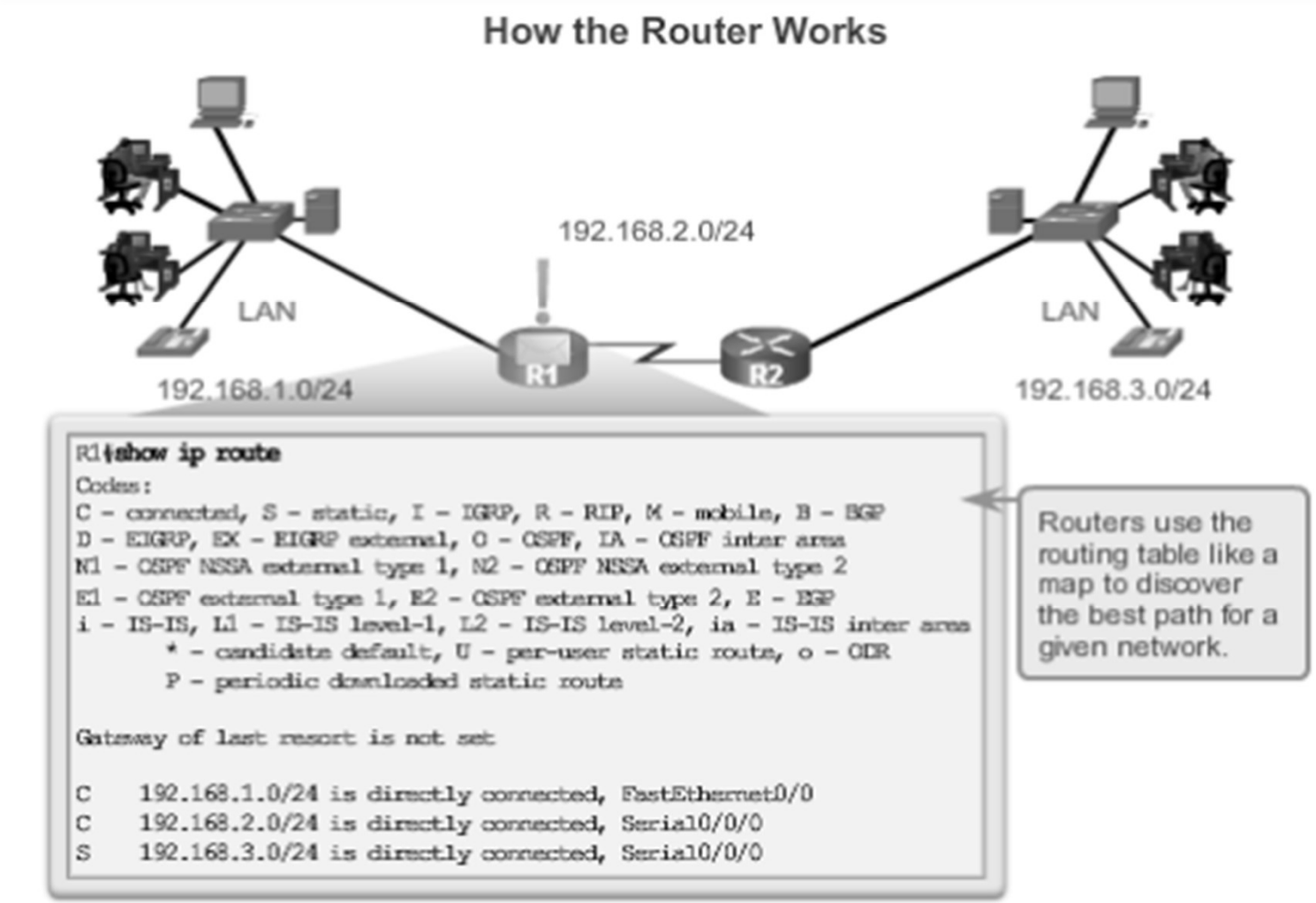


Functions of a Router

- Routers Choose Best Paths
  - Determine the best path to send packets
    - Uses its routing table to determine path
  - Forward packets toward their destination
    - Forwards packet to interface indicated in routing table.
    - Encapsulates the packet and forwards out toward destination.
  - Routers use static routes and dynamic routing protocols to learn about remote networks and build their routing tables.

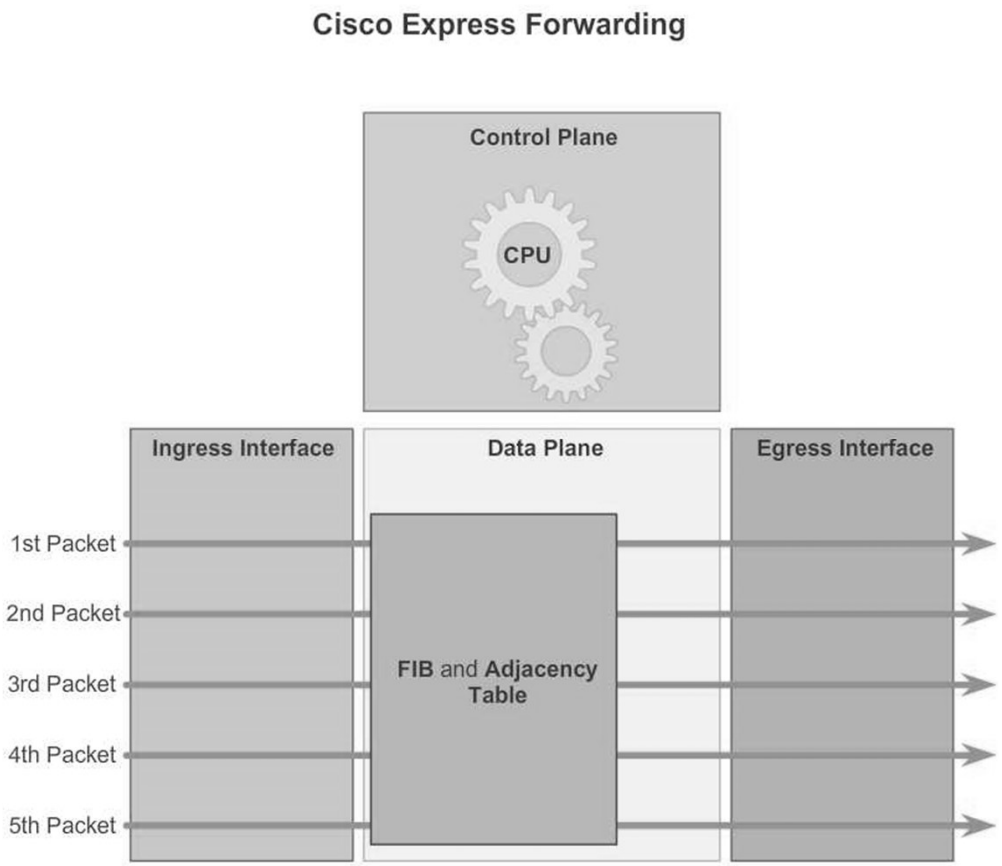
Functions of a Router

- Routers Choose Best Paths



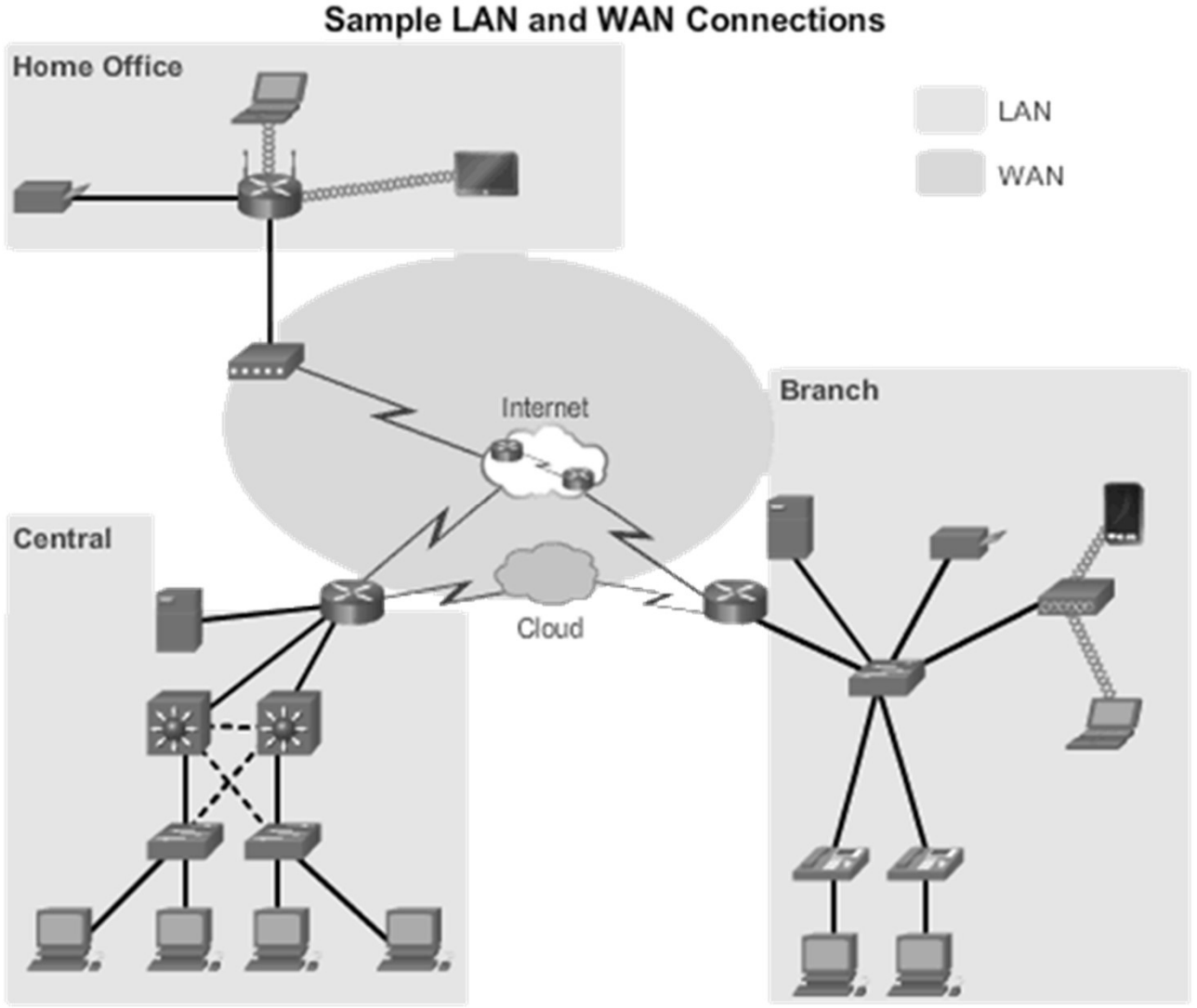
Functions of a Router

- Packet Forwarding Methods



- **Process switching** - An older packet forwarding mechanism still available for Cisco routers.
- **Fast switching** - A common packet forwarding mechanism which uses a fast-switching cache to store next hop information.
- **Cisco Express Forwarding (CEF)** - The most recent, fastest, and preferred Cisco IOS packet-forwarding mechanism. Table entries are not packet-triggered like fast switching but change-triggered.

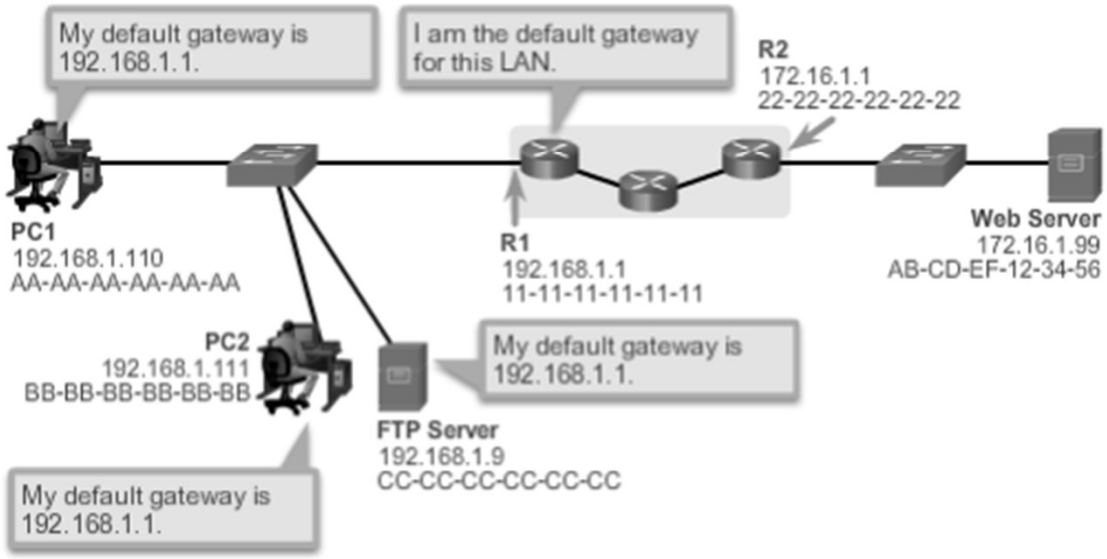
Connect Devices



Connect Devices

- Default Gateways
- To enable network access devices must be configured with the following IP address information
  - IP address - Identifies a unique host on a local network.
  - Subnet mask - Identifies the host's network subnet.
  - Default gateway - Identifies the router a packet is sent to to when the destination is not on the same local network subnet.

Destination MAC Address	Source MAC Address	Source IP Address	Destination MAC Address	Data
11-11-11-11-11-11	AA-AA-AA-AA-AA-AA	192.168.1.110	172.16.1.99	



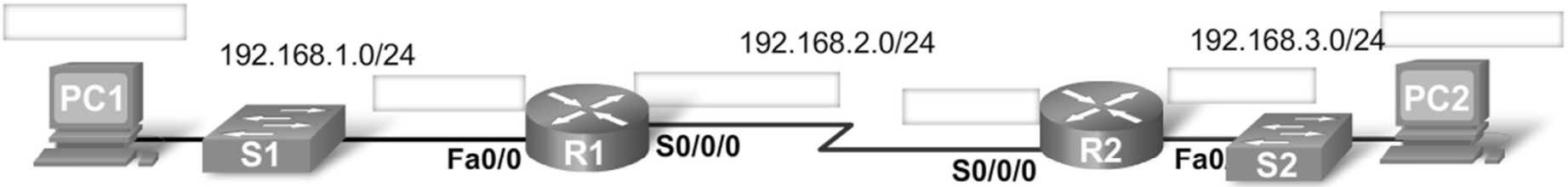
Connect Devices

- Document Network Addressing
  - Network Documentation should include at least the following in a topology diagram and addressing table:
    - Device names
    - Interfaces
    - IP addresses and subnet mask
    - Default gateways

Connect Devices

- Document Network Addressing

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		255.255.255.0	N/A
	S0/0/0		255.255.255.0	N/A
PC1	N/A	192.168.1.10	255.255.255.0	192.168.1.1
PC2	N/A		255.255.255.0	

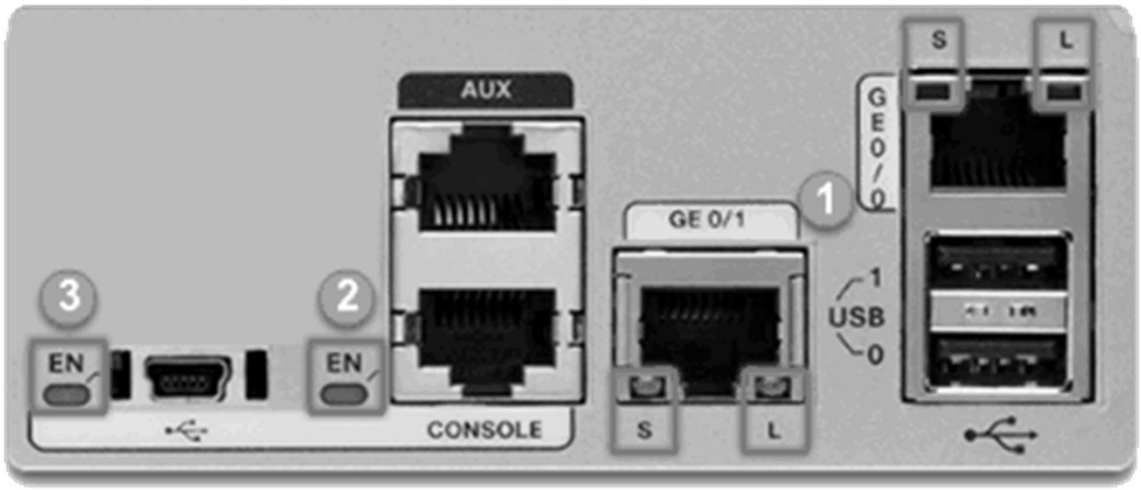
Connect Devices

- Enable IP on a Host
  - Statically Assigned IP address - host is manually assigned the IP address, subnet mask and default gateway. DNS server IP address can also be assigned.
    - Used to identify specific network resources such as network servers and printers
    - Can be used in very small networks with few hosts.
  - Dynamically Assigned IP Address - IP Address information is dynamically assigned by a server using Dynamic Host Configuration Protocol (DHCP)
    - Most hosts acquire their IP address information through DHCP
    - DHCP services can be provided by Cisco routers

Connect Devices

- Device LEDs

CISCO 1941 LEDs

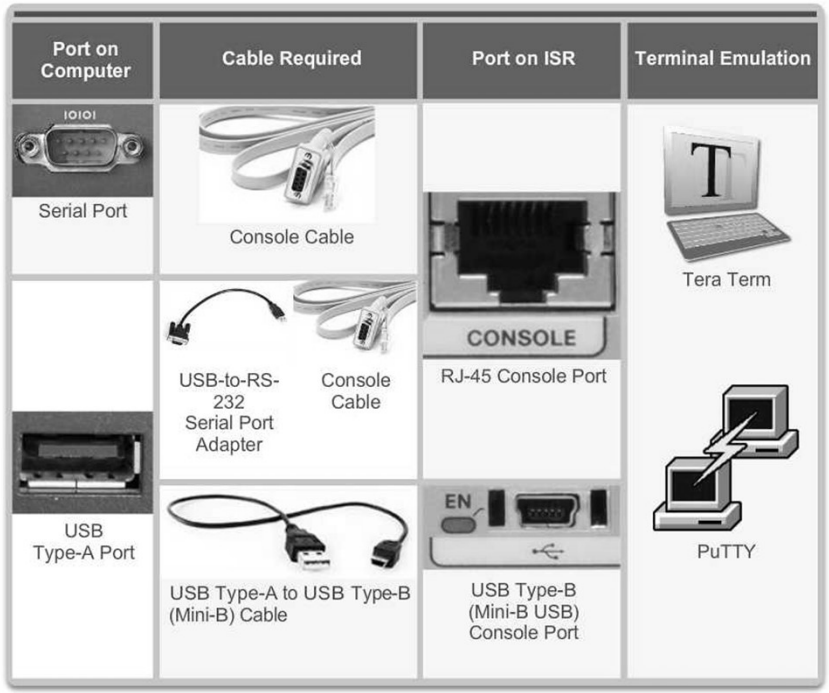


#	Port	LED	Color	Description
1	GE0/0 and GE0/1	S (Speed)	1 blink + pause	Port operating at 10 Mb/s
			2 blink + pause	Port operating at 100 Mb/s
			3 blink + pause	Port operating at 1000 Mb/s
		L (Link)	Green	Link is active
			Off	Link is inactive
2	Console	EN	Green	Port is active
			Off	Port is inactive
3	USB	EN	Green	Port is active
			Off	Port is inactive

Connect Devices

- Console Access
  - Console access requires:
    - Console cable - RJ-45-to-DB-9 console cable
    - Terminal emulation software - Tera Term, PuTTY, HyperTerminal

Ports and Cables



Basic Settings on a Router

- Configure Basic Router Settings
  - Name the device : `hostname` ***name***
  - Secure management access : `enable secret` ***password***
  - Configure a banner : `banner motd #` ***text*** `#`
  - Configured an Interface : `interface` ***type slot/port***
    - address and subnet mask : `ip address` ***x.x.x.x y.y.y.y***
    - Activated : `no shutdown`
    - serial cable end labeled DCE : `clock rate` ***56000***
  - Configure a Loopback Interface

    `interface loopback` ***number***
    `ip address` ***x.x.x.x y.y.y.y***

Verify Connectivity of Directly Connected Networks

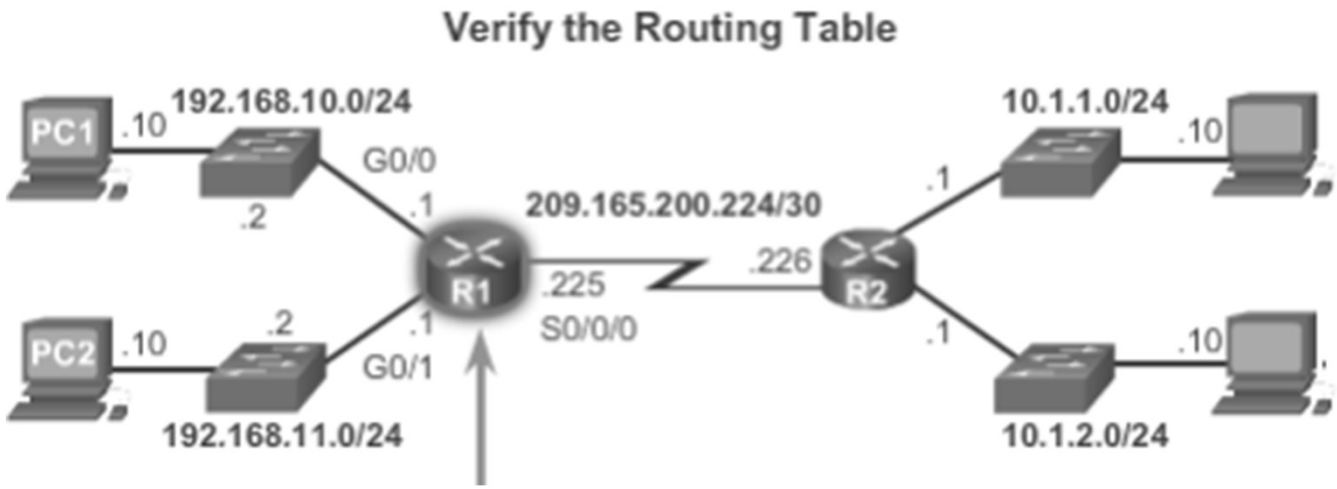
- Verify Interface Settings
  - Show commands to verify operation and configuration of interface.

```
show ip interface brief
show ip route
show running-config
```

  - Show commands to gather more detailed interface information.

```
show interfaces
show ip interface
```

Verify Connectivity of Directly Connected Networks




```
Gateway of last resort is not set

     192.168.10.0/24 is variably subnetted, 2 subnets, 2 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, 2 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, 2 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
Router#
```

```
Gateway of last resort is not set

C    192.168.10.0/24 is directly connected, FastEthernet0/0
C    192.168.11.0/24 is directly connected, FastEthernet0/1
     209.165.200.0/30 is subnetted, 1 subnets
C       209.165.200.224 is directly connected, Serial0/0
Router#
```

```
interface GigabitEthernet0/0
 ip address 192.168.10.1 255.255.255.0
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 ip address 192.168.11.1 255.255.255.0
 duplex auto
 speed auto
!
interface GigabitEthernet0/2
 no ip address
 duplex auto
 speed auto
 shutdown
!
interface Serial0/0/0
 ip address 209.165.200.225 255.255.255.252
!
interface Serial0/0/1
 no ip address
 clock rate 2000000
 shutdown
!
```

```
Router#sh ip int brief
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0     192.168.10.1    YES manual up                    up
GigabitEthernet0/1     192.168.11.1    YES manual up                    up
GigabitEthernet0/2     unassigned      YES unset  administratively down down
Serial0/0/0            209.165.200.225 YES manual up                    up
Serial0/0/1            unassigned      YES unset  administratively down down
Vlan1                  unassigned      YES unset  administratively down down
Router#
```

Verify Connectivity of Directly Connected Networks

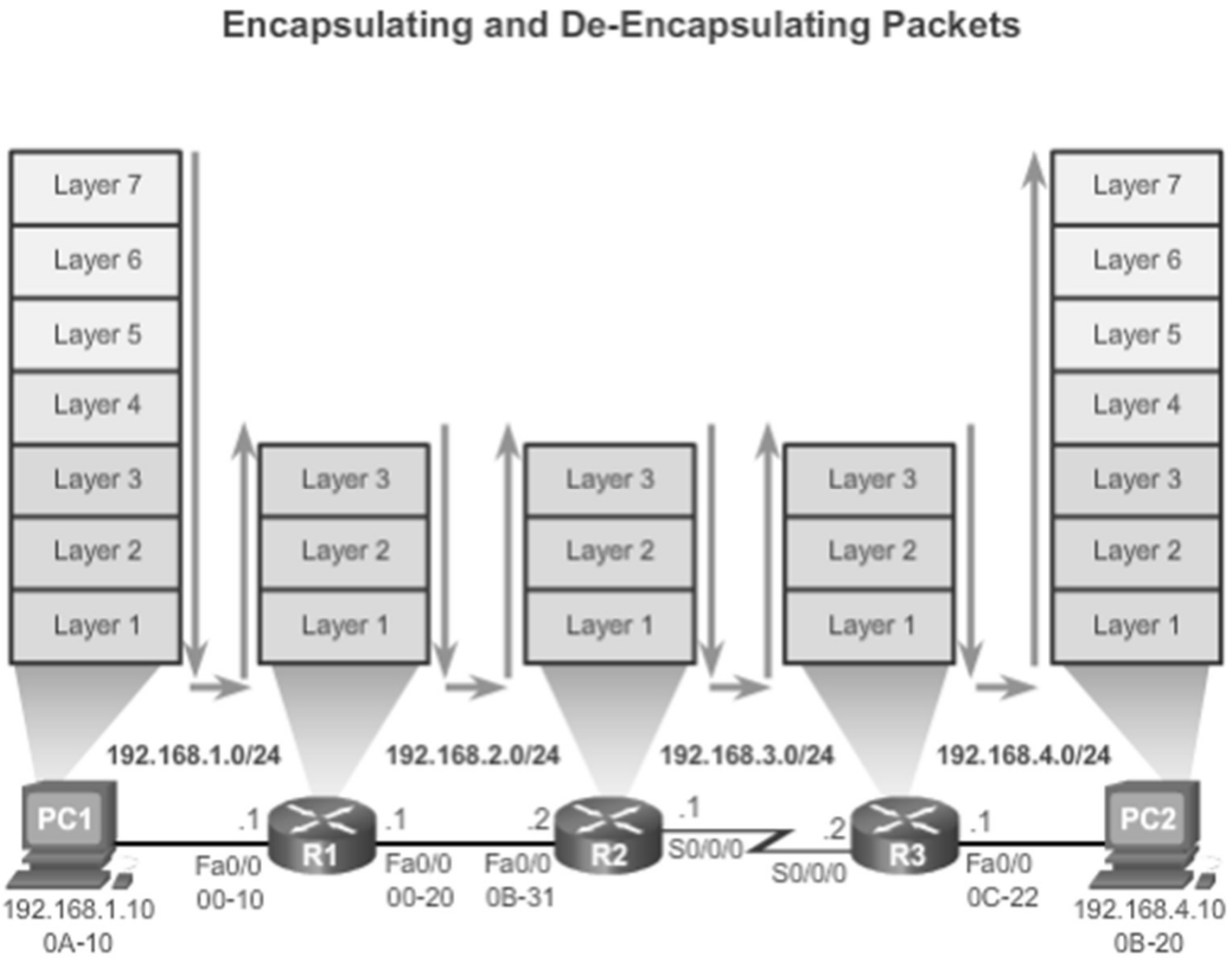
- Filter Show Command Output
  - Use the terminal lengthnumbercommand to specify the number of lines to be displayed. A value of 0 (zero) prevents the router from pausing between screens of output.
  - To filter specific output of commands use the (|)pipe character after show command. Parameters that can be used after pipe include:
    - section, include, exclude, begin

```
R1#show ip interface brief
Interface                  IP-Address      OK? Method Status
Embedded-Service-Engine0/0 unassigned      YES unset  admini
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 unset  admini

R1#show ip interface brief | exclude unassigned
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
```

```
R1#show ip interface brief
Interface                  IP-Address      OK? Method Status
Embedded-Service-Engine0/0 unassigned      YES unset  administ
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 unset  administ
R1#
R1#show ip interface brief | include up
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
R1#
```

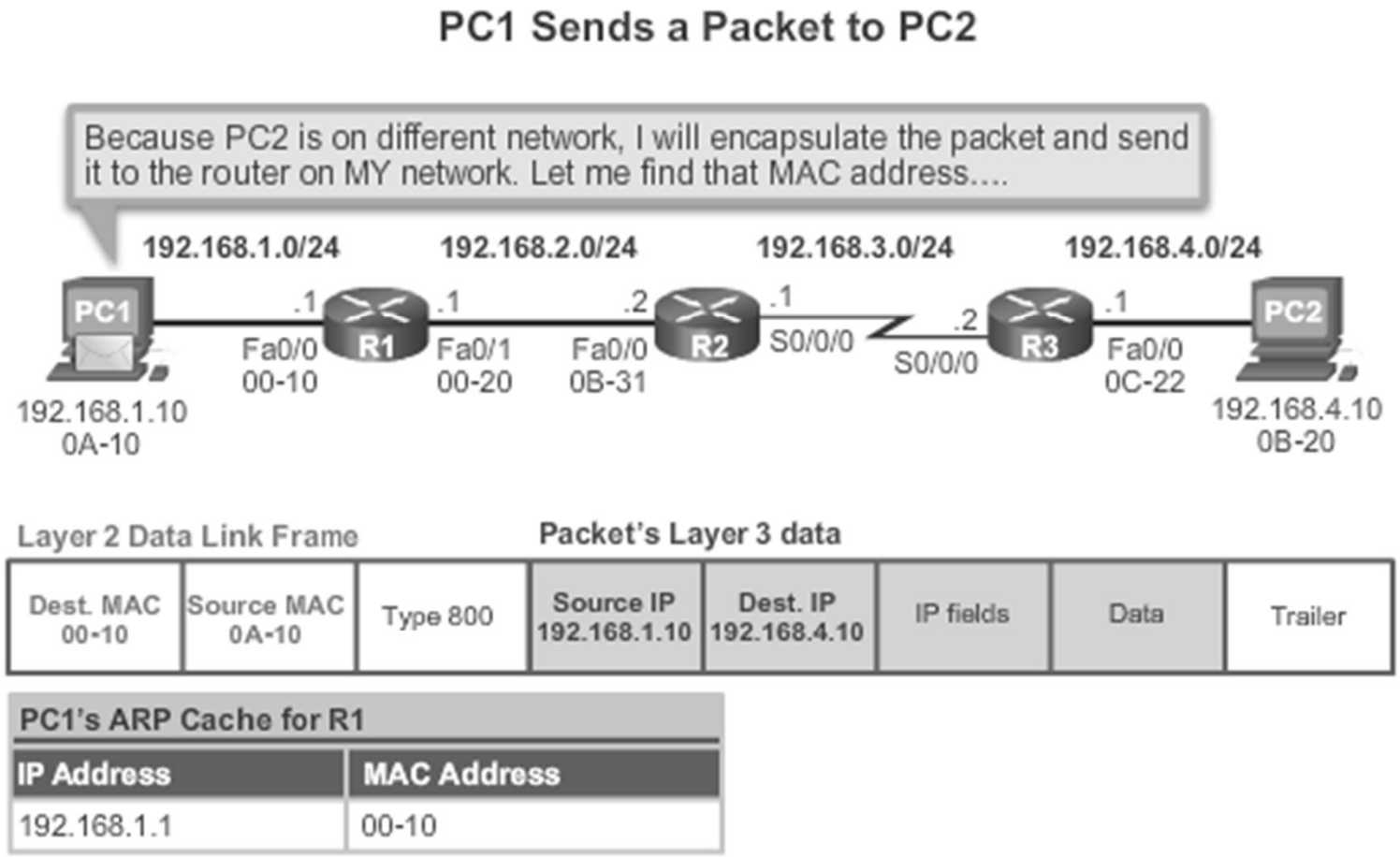
Switching Packets between Networks

- Router Switching Functions



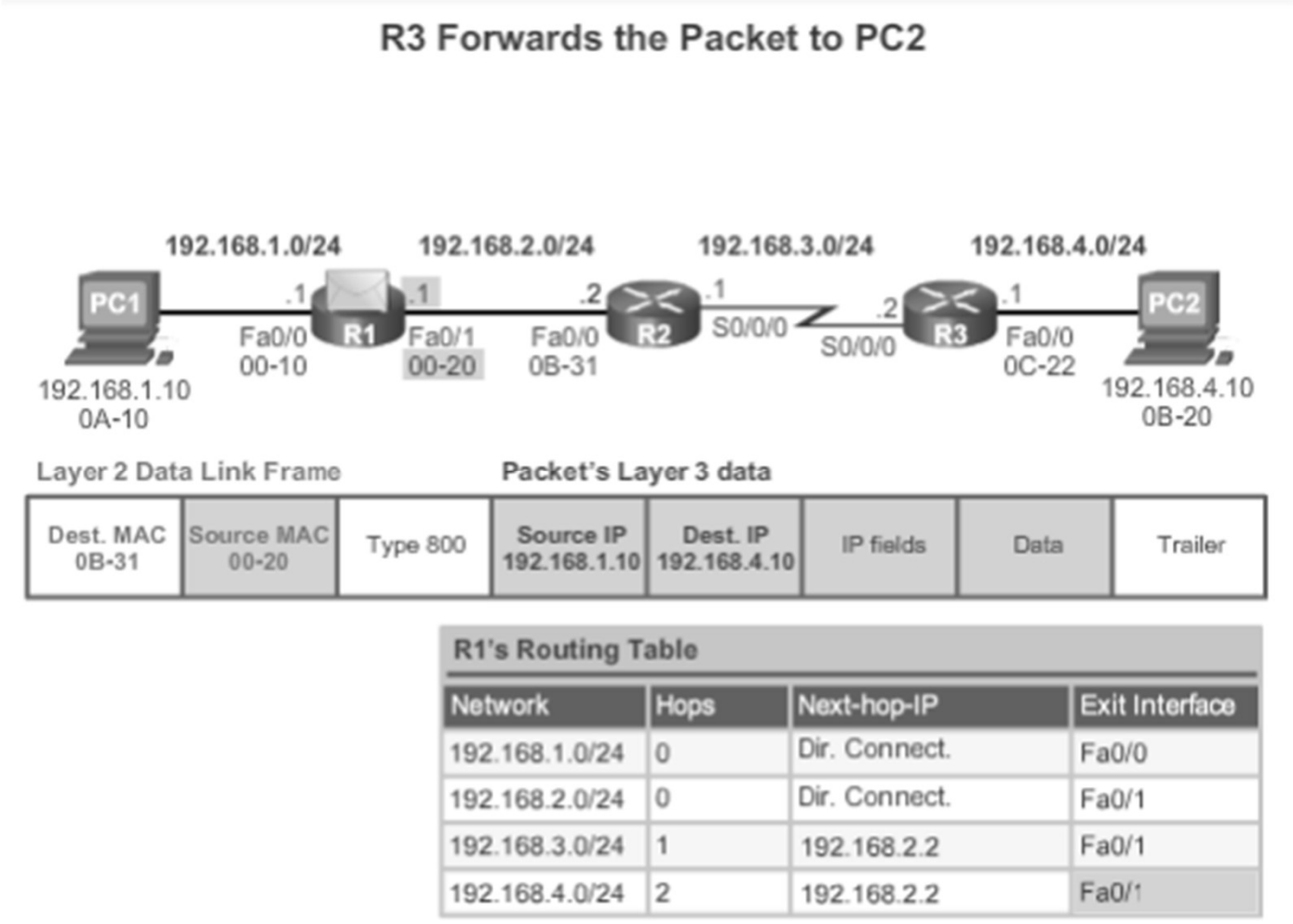
Switching Packets between Networks

- Send a Packet



Switching Packets between Networks

- Forward to the Next Hop



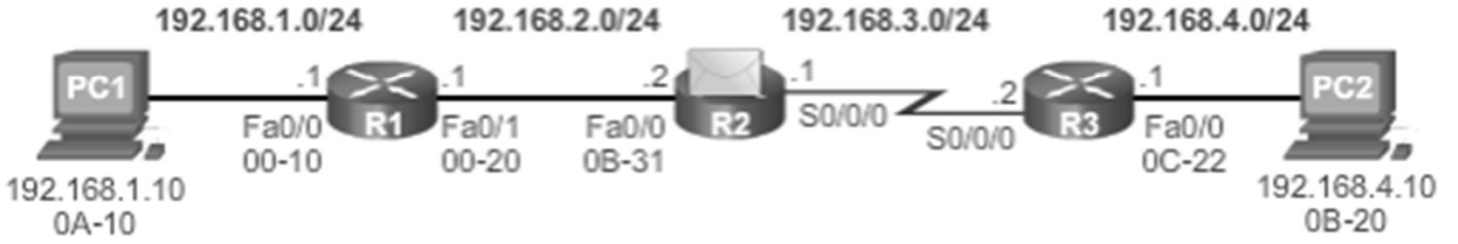
R1's Routing Table

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

Switching Packets between Networks

- Packet Routing

R2 Forwards the Packet to R3



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

Address Ox8F	Control 0x00	Type 800	Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer

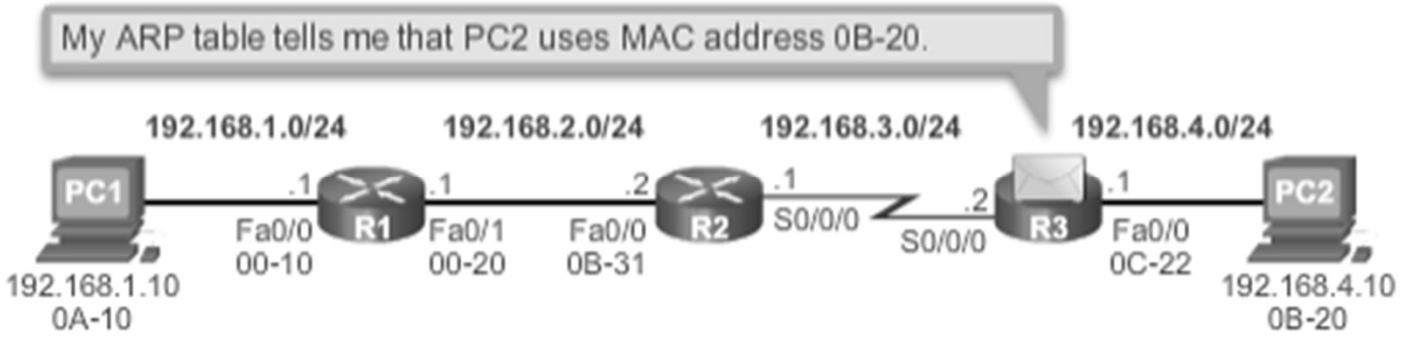
R2's Routing Table

Network	Hops	Next-hop-IP	Exit Interface
192.168.1.0/24	1	192.168.3.1	Fa/0/0
192.168.2.0/24	0	Dir. Connect.	Fa/0/0
192.168.3.0/24	0	Dir. Connect.	S0/0/0
192.168.4.0/24	1	192.162.3.2	S0/0/0

Switching Packets between Networks

- Reach the Destination

R3 Forwards the Packet to PC2



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

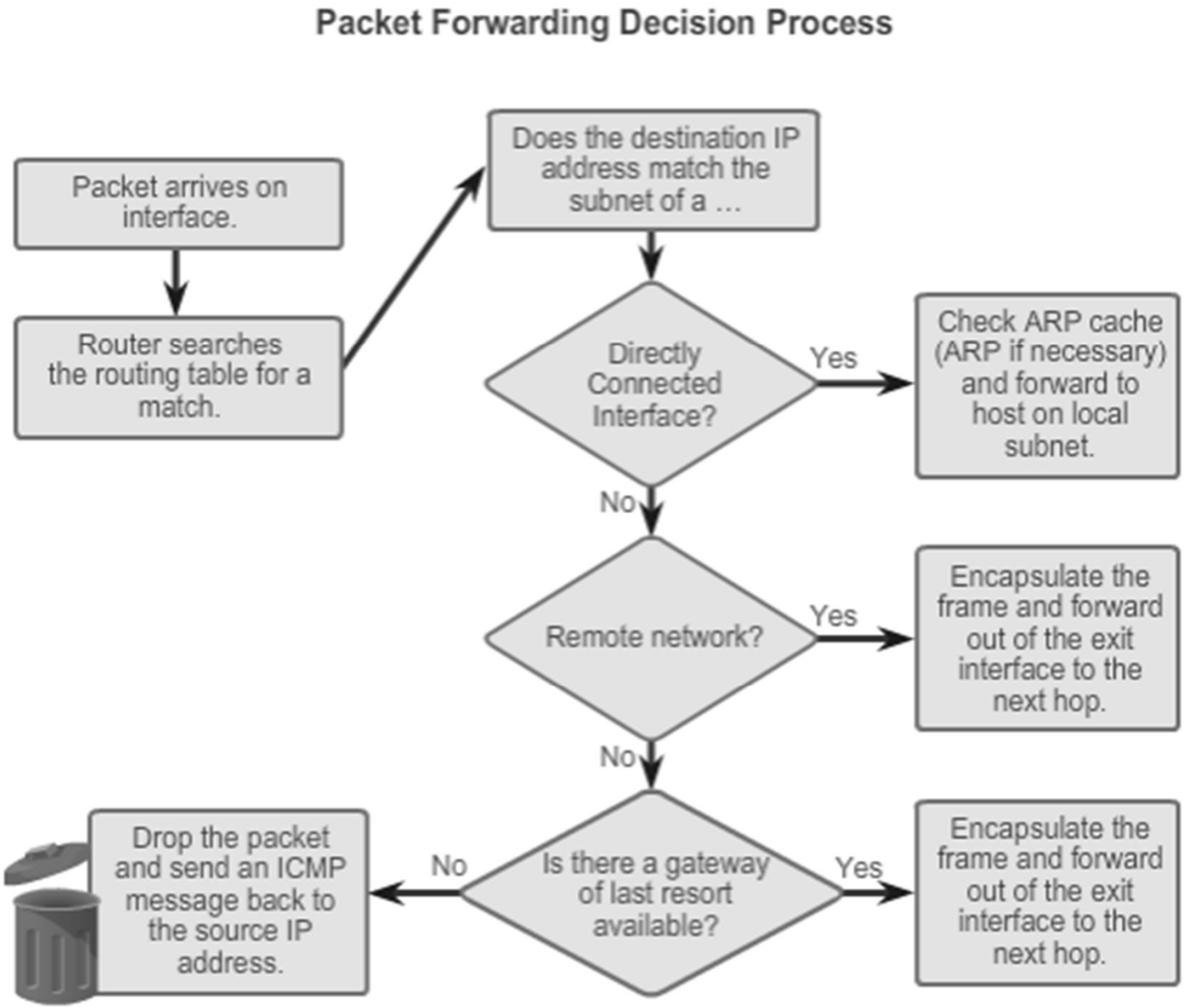
R3's ARP Cache

IP Address	MAC Address
192.168.4.10	0B-20

R3's Routing Table

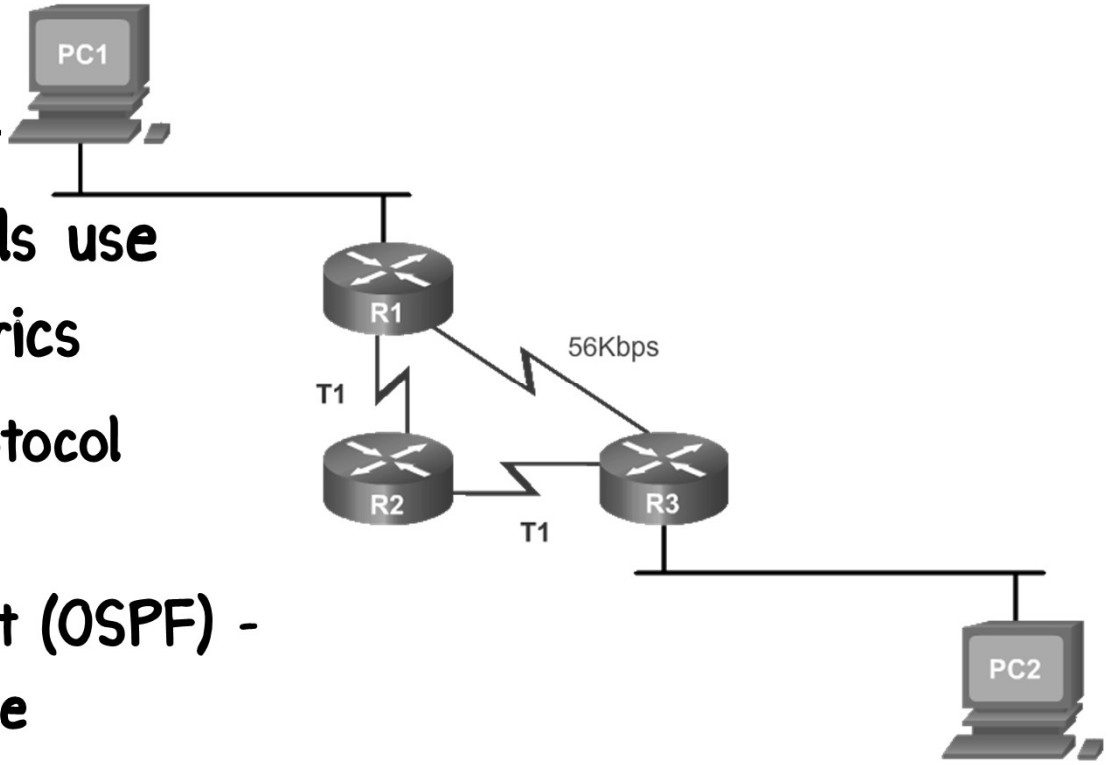
Network	Hops	Next-hop-IP	Exit Interface
192.168.1.0/24v	2	192.168.3.1	S0/0/0
192.168.2.0/24	1	192.162.3.1	S0/0/0
192.168.3.0/24	0	Dir. Connect.	S0/0/0
192.168.4.0/24	0	Dir. Connect.	Fa0/0

Path Determination



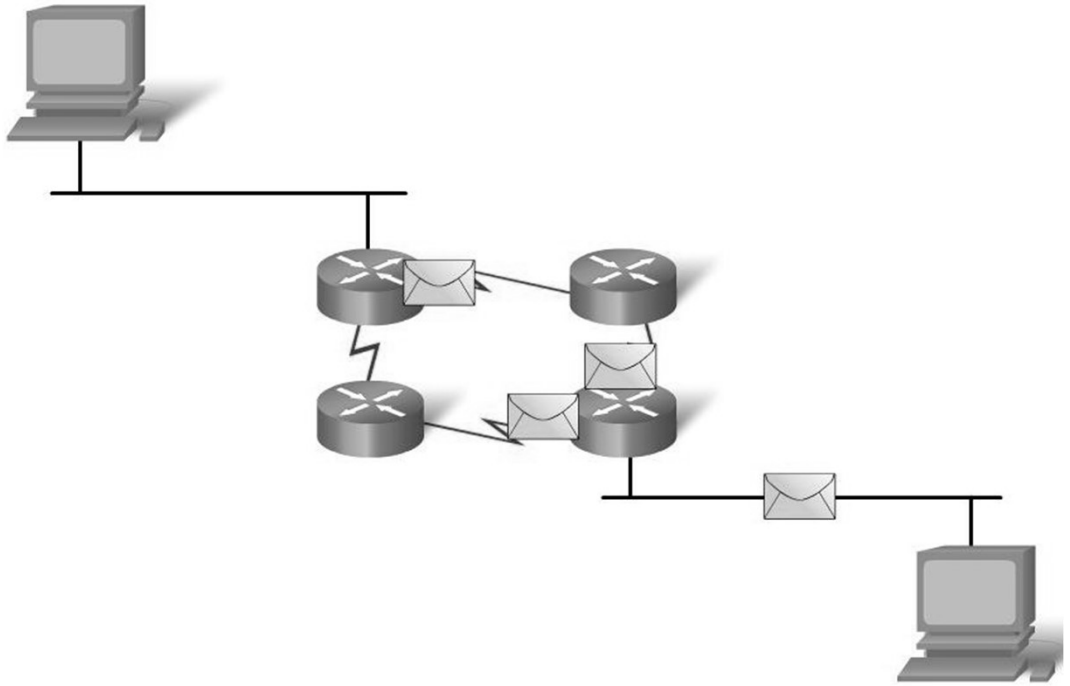
Path Determination

- Best Path : lowest metric
  - Dynamic routing protocols use their own rules and metrics
    - Routing Information Protocol (RIP) - Hop count
    - Open Shortest Path First (OSPF) - Cost based on cumulative bandwidth from source to destination
    - Enhanced Interior Gateway Routing Protocol (EIGRP) - Bandwidth, delay, load, reliability



Path Determination

- Load Balancing
  - When a router has two or more paths to a destination with equal cost metrics, then the router forwards the packets using both paths equally.



Path Determination

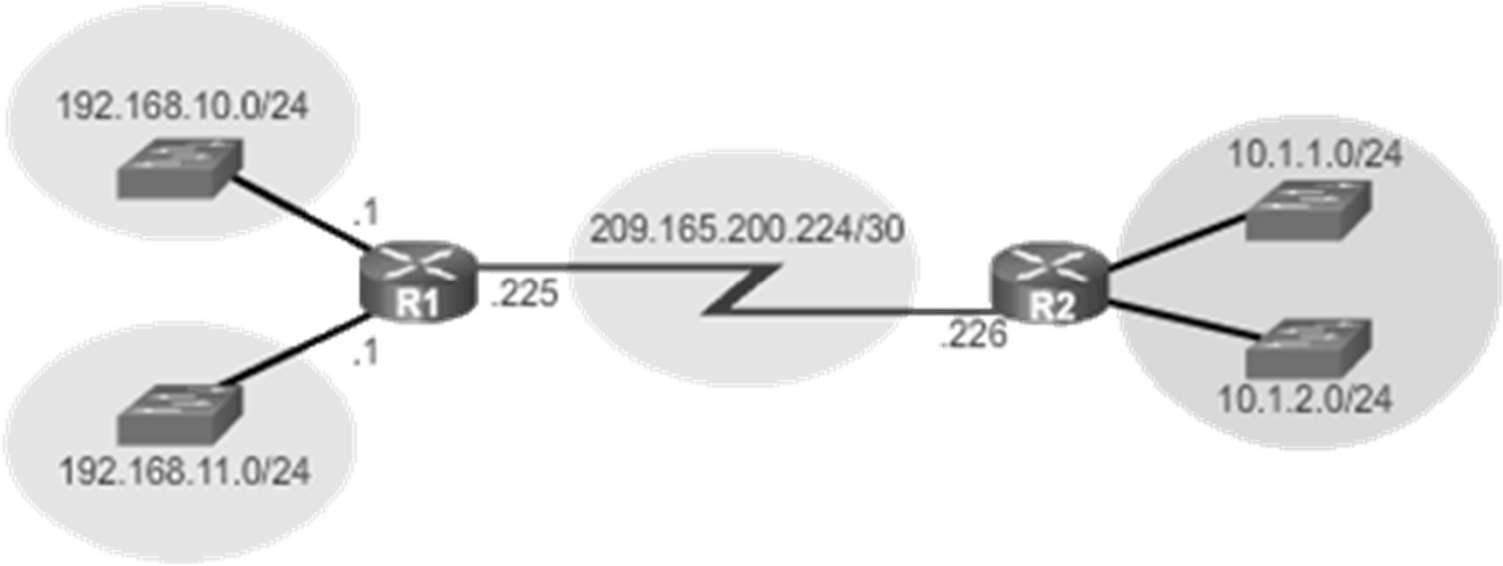
- Administrative Distance (AD) : "trustworthiness"

Default Administrative Distances

Route Source	Administrative Distance
Connected	0
Static	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
External EIGRP	170
Internal BGP	200

The Routing Table

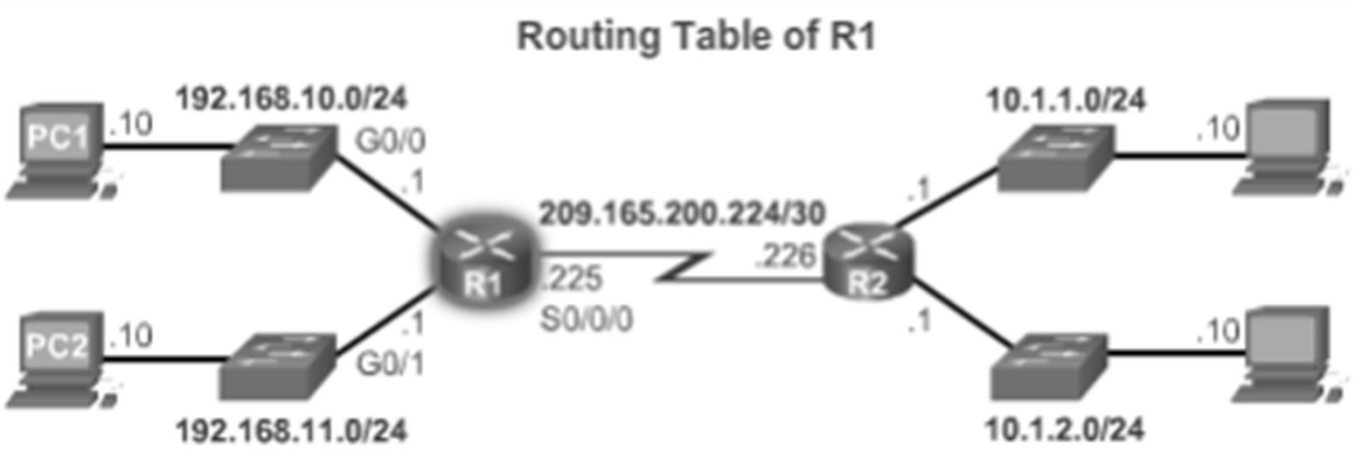
- Routing Table is a file stored in RAM that contains information about
  - Directly Connected Routes
  - Remote Routes
  - Network or Next hop Associations



The Routing Table

- Routing Table Sources
  - Show ip route command is used to display the contents of the routing table
    - **Link local Interfaces** -Added to the routing table when an interface is configured. (displayed in IOS 15 or newer)
    - **Directly connected interfaces** -Added to the routing table when an interface is configured and active.
    - **Static routes** - Added when a route is manually configured and the exit interface is active.
    - **Dynamic routing protocol** - Added when EIGRP or OSPF are implemented and networks are identified.

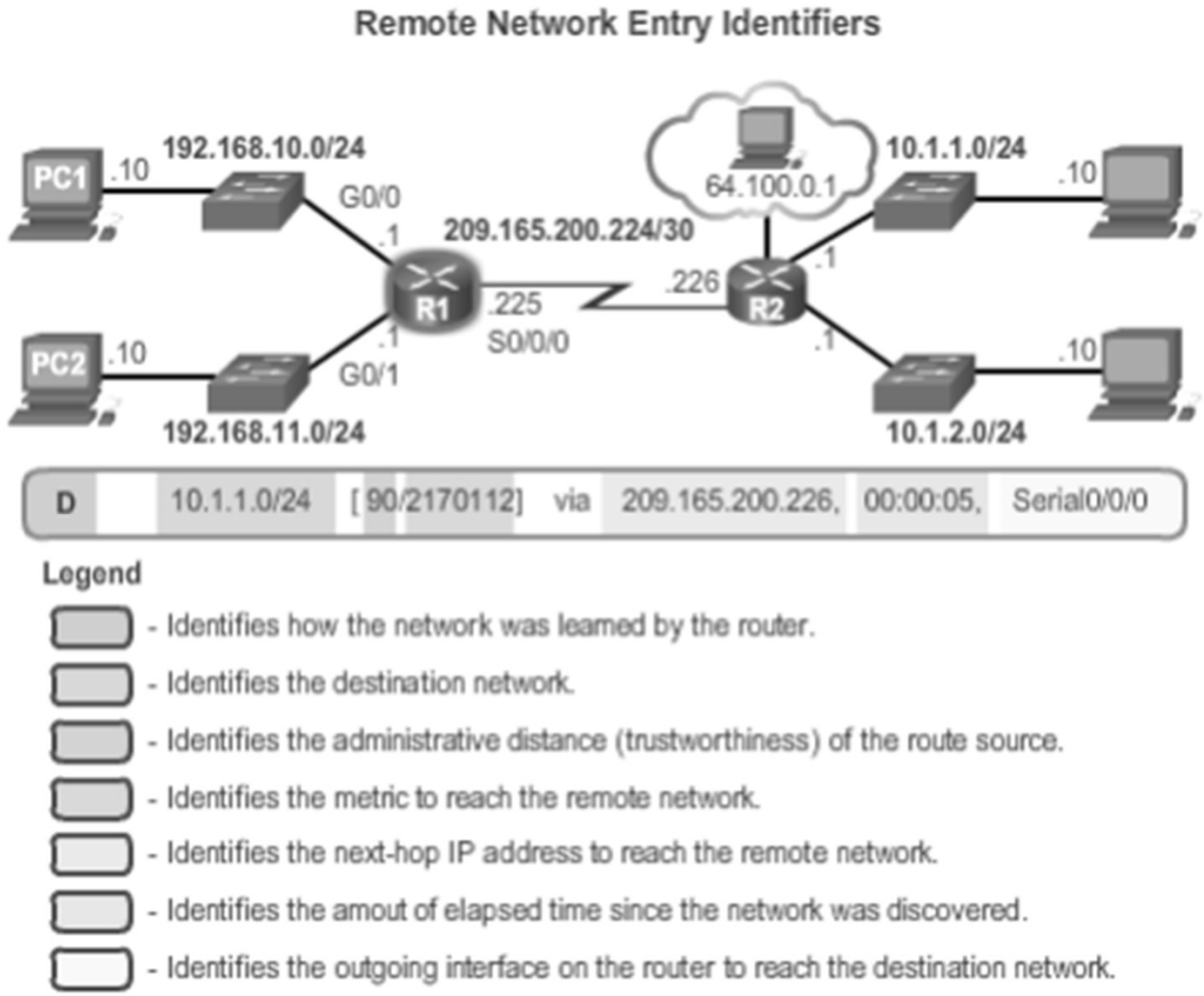
The Routing Table




```
Router#sh ip ro
Codes: L - local, C - connected, S - static, 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

     10.0.0.0/24 is subnetted, 2 subnets
D       10.1.1.0/24 [90/2172416] via 209.165.200.226, 00:01:51, Serial0/0/0
D       10.1.2.0/24 [90/2172416] via 209.165.200.226, 00:01:51, Serial0/0/0
     192.168.10.0/24 is variably subnetted, 2 subnets, 2 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, 2 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, 2 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
Router#
```

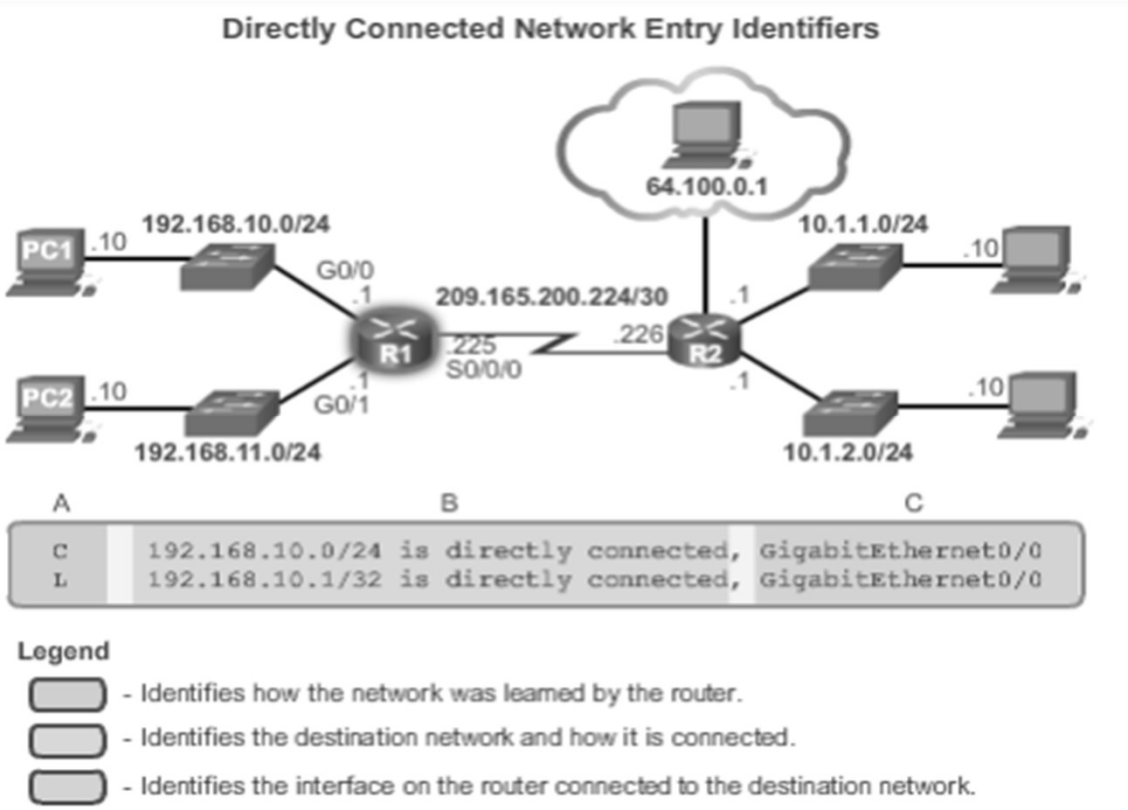
The Routing Table

- Remote Network Routing Entries



Directly Connected Routes

- A newly deployed router, without any configured interfaces, has an empty routing table.
- An active, configured directly connected interface creates two routing table entries
  - Link Local (L)
  - Directly Connected (C)



Routing

- Reach Remote Networks
  - A router can learn about remote networks in one of two ways:
    - Manually - Remote networks are manually entered into the route table using static routes.
    - Dynamically - Remote routes are automatically learned using a dynamic routing protocol.

Routing

- Static Routing
- Dynamic Routing Protocols
  - Exterior Routing Protocols
    - BGP
  - Interior Gateway Routing Protocols
    - RIP - Routing Information Protocol
    - OSPF - Open Shortest Path First
    - EIGRP - Enhanced Interior Gateway Routing Protocol
    - IS-IS - Intermediate System-to-Intermediate System

Static Routing

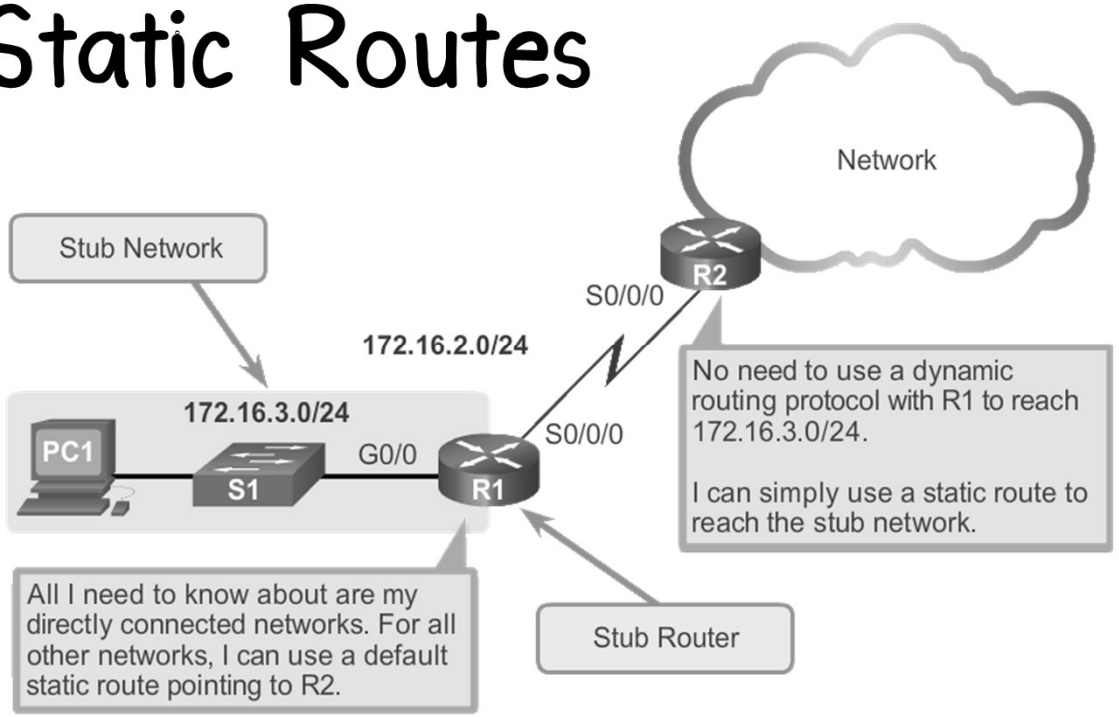
- Advantages
- Disadvantages
- When to Use Static Routes

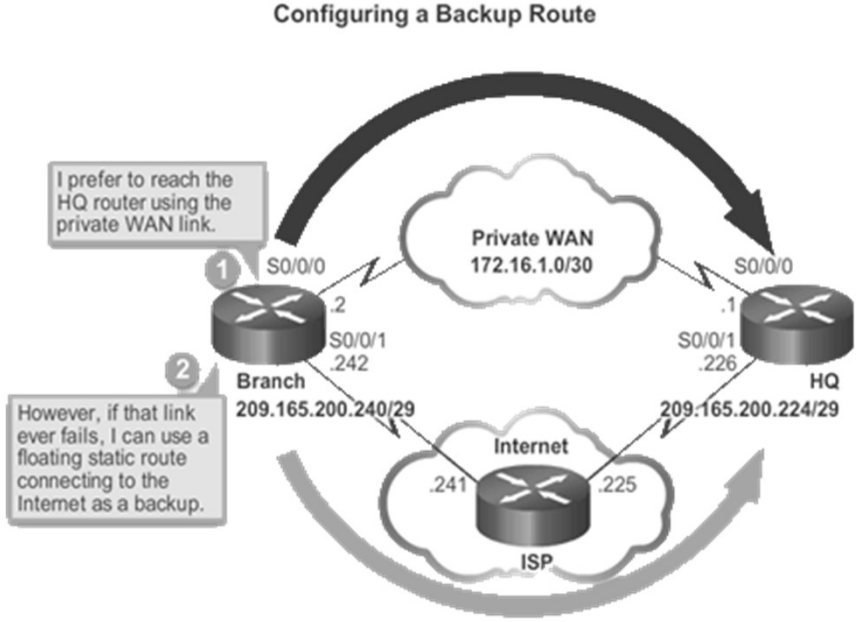
Types of Static Routes

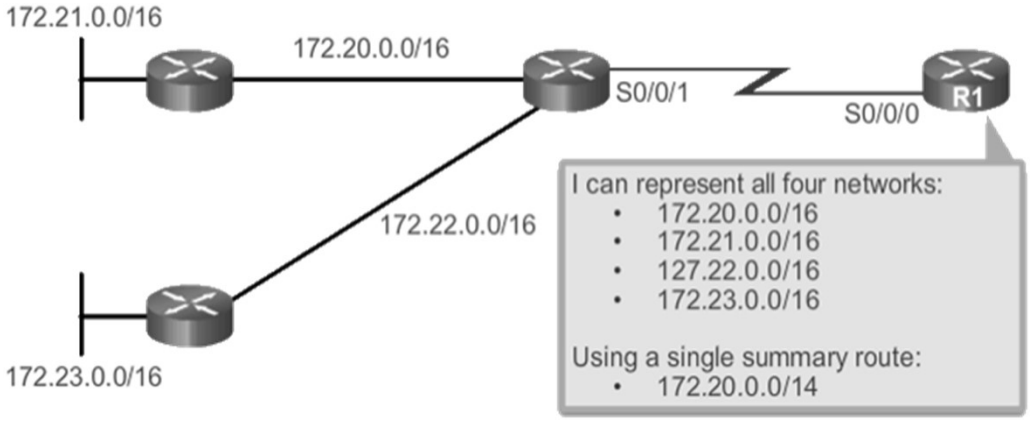
- Static Route Applications
  - Static Routes are often used to:
    - Connect to a specific network
      - Provide a Gateway of Last Resort for a stub network
      - Reduce the number of routes advertised by summarizing several contiguous networks as one static route
      - Create a backup route in case a primary route link fails

Types of Static Routes

- Standard Static Route
- Default Static Route
- Summary Static Route
- Floating Static Route







Configure IPv4 Static Routes

ip route Command Syntax

```
Router(config)#ip route network-address subnet-mask
{ip-address | exit-intf}
```

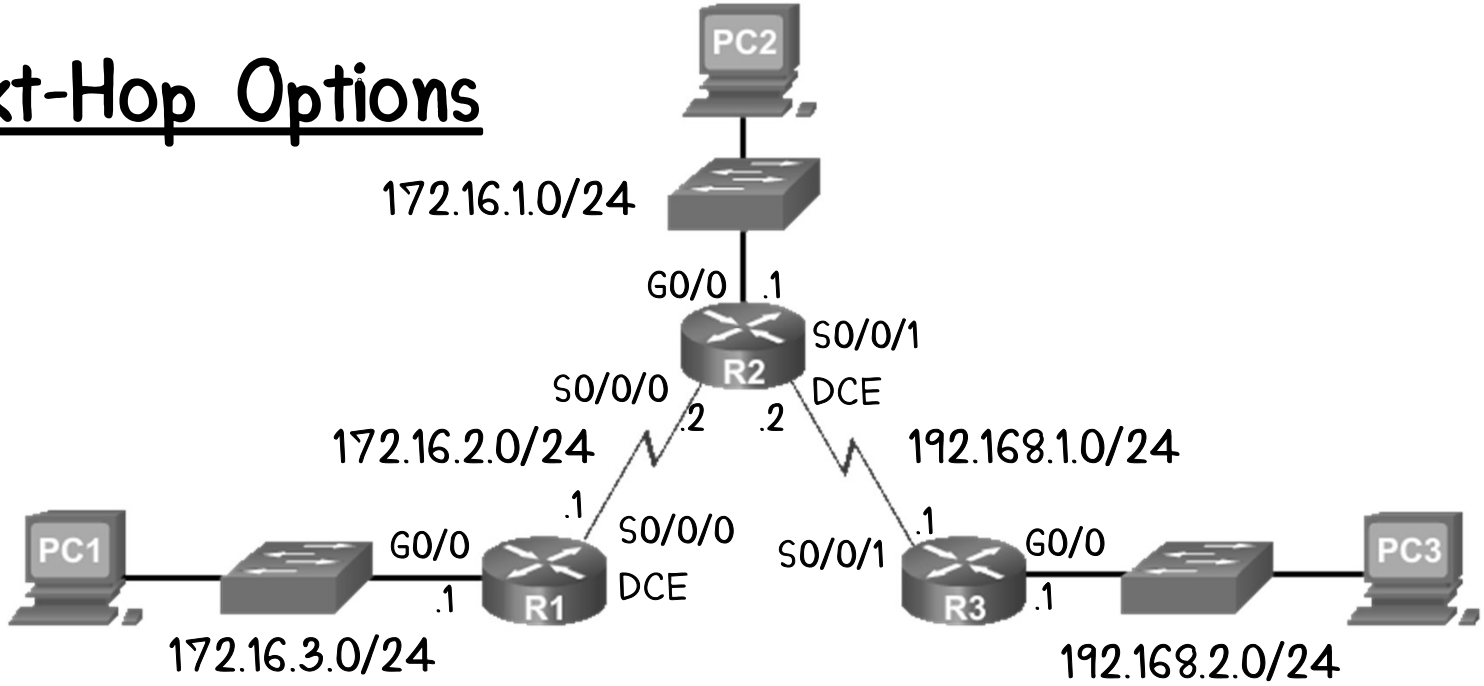
Parameter	Description
network-address	Destination network address of the remote network to be added to the routing table.
subnet-mask	• Subnet mask of the remote network to be added to the routing table. • The subnet mask can be modified to summarize a group of networks.
ip-address	• Commonly referred to as the next-hop router's IP address. • Typically used when connecting to a broadcast media (i.e., Ethernet). • Commonly creates a recursive lookup.
exit-intf	• Use the outgoing interface to forward packets to the destination network. • Also referred to as a directly attached static route. • Typically used when connecting in a point-to-point configuration.

Configure IPv4 Static Routes

- Next-Hop Options : The next hop can be identified by an IP address, exit interface, or both. How the destination is specified creates one of the three following route types:
  - Next-hop route - Only the next-hop IP address is specified.
  - Directly connected static route - Only the router exit interface is specified.
  - Fully specified static route - The next-hop IP address and exit interface are specified.

Configure IPv4 Static Routes

- **Next-Hop Options**



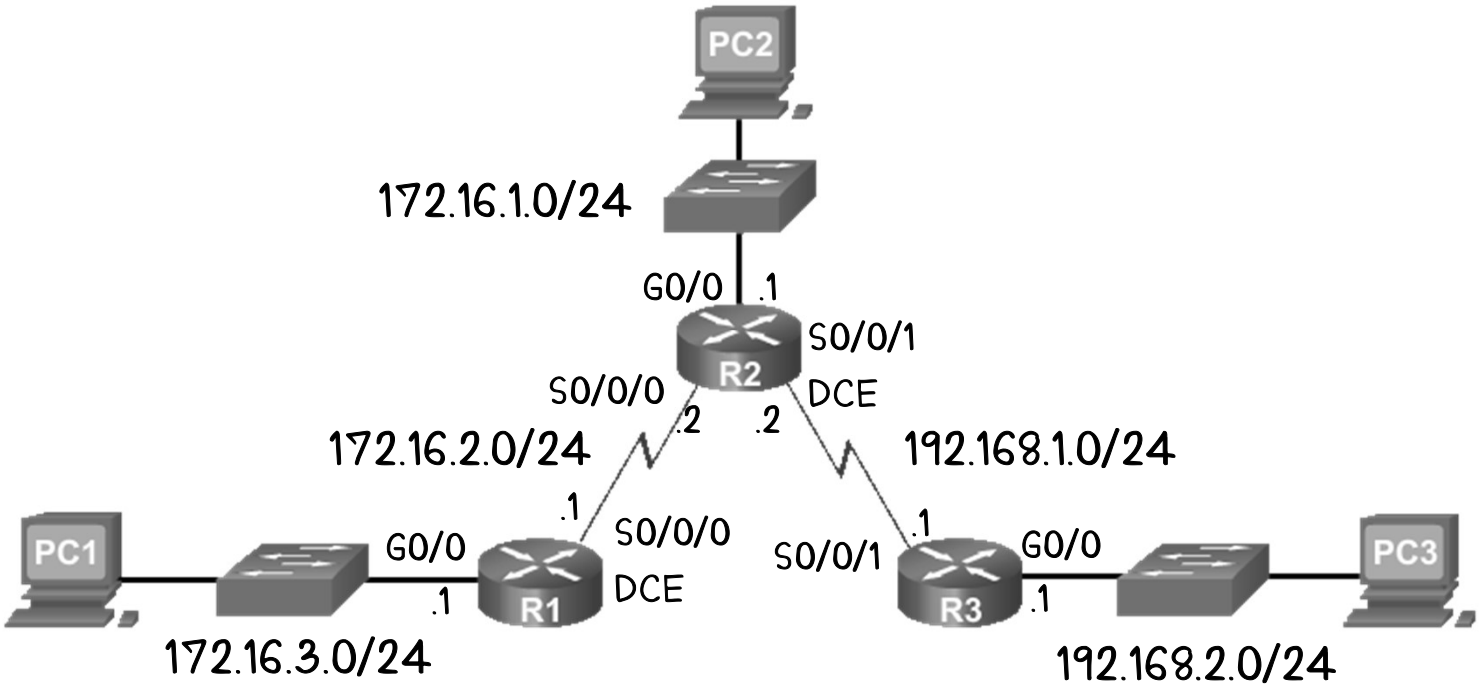

```
R1#show ip route | begin Gateway
Gateway of last resort is not set
   172.16.0.0/16 is varibly subnet, 4 subnets, 2 masks
C     172.16.2.0/24 is directly connected, Serial0/0/0
L     172.16.2.1/32 is directly connected, Serial0/0/0
C     172.16.3.0/24 is directly connected, GigabitEthernet0/0
L     172.16.3.1/32 is directly connected, GigabitEthernet0/0
```

```
R2#show ip route | begin Gateway
Gateway of last resort is not set
   172.16.0.0/16 is varibly subnet, 4 subnets, 2 masks
C     172.16.1.0/24 is directly connected, GigabitEthernet0/0
L     172.16.1.1/32 is directly connected, GigabitEthernet0/0
C     172.16.2.0/24 is directly connected, Serial0/0/0
L     172.16.2.2/32 is directly connected, Serial0/0/0
   192.168.1.0/24 is varibly subnet, 2 subnets, 2 masks
C     192.168.1.0/24 is directly connected, Serial0/0/1
L     192.168.1.2/32 is directly connected, Serial0/0/1
```

```
R3#show ip route | begin Gateway
Gateway of last resort is not set
   192.168.1.0/24 is varibly subnet, 4 subnets, 2 masks
C     192.168.1.0/24 is directly connected, Serial0/0/1
L     192.168.1.1/32 is directly connected, Serial0/0/1
   192.168.2.0/24 is varibly subnet, 4 subnets, 2 masks
C     192.168.2.0/24 is directly connected, GigabitEthernet0/0
L     192.168.2.1/32 is directly connected, GigabitEthernet0/0
```

```
R3#show ip route | include C
Code:L - local, C - connected, S - static, R - RIP, . . .
C  192.168.1.0/24 is directly connected, Serial0/0/1
C  192.168.2.0/24 is directly connected, GigabitEthernet0/0
```

Configure IPv4 Static Routes



Configure a Next-Hop Static Route

```
R1(config)#ip route 172.16.1.0 255.255.255.0 172.16.2.2
R1(config)#ip route 192.168.1.0 255.255.255.0 172.16.2.2
R1(config)#ip route 192.168.2.0 255.255.255.0 172.16.2.2
```

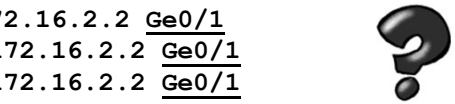
```
R1#show ip route | begin Gateway
Gateway of last resort is not set
   172.16.0.0/16 is varibly subnet, 5 subnets, 2 masks
S     172.16.1.0/24 [1/0] via 172.16.2.2
C     172.16.2.0/24 is directly connected, Serial0/0/0
L     172.16.2.1/32 is directly connected, Serial0/0/0
C     172.16.3.0/24 is directly connected, GigabitEthernet0/0
L     172.16.3.1/32 is directly connected, GigabitEthernet0/0
S  192.16.1.0/24 [1/0] via 172.16.2.2
S  192.16.2.0/24 [1/0] via 172.16.2.2
```

Configure a Directly Connected Static Route

```
R1(config)#ip route 172.16.1.0 255.255.255.0 s0/0/0
R1(config)#ip route 192.168.1.0 255.255.255.0 s0/0/0
R1(config)#ip route 192.168.2.0 255.255.255.0 s0/0/0
```

Configure a Fully Specified Static Route

```
R1(config)#ip route 172.16.1.0 255.255.255.0 172.16.2.2 Ge0/1
R1(config)#ip route 192.168.1.0 255.255.255.0 172.16.2.2 Ge0/1
R1(config)#ip route 192.168.2.0 255.255.255.0 172.16.2.2 Ge0/1
```



Configure IPv4 Static Routes

- Verify a Static Route
  - Along with ping and traceroute, useful commands to verify static routes include:

```
show ip route
show ip route static
show ip route network
Show running-config
```

```
R1# show ip route static | begin Gateway
Gateway of last resort is not set

      172.16.0.0/16 is variably subnetted, 5 subnets, 2 masks
S        172.16.1.0/24 [1/0] via 172.16.2.2
S     192.168.1.0/24 [1/0] via 172.16.2.2
S     192.168.2.0/24 [1/0] via 172.16.2.2
R1#
```

```
R1# show running-config | section ip route
ip route 172.16.1.0 255.255.255.0 172.16.2.2
ip route 192.168.1.0 255.255.255.0 172.16.2.2
ip route 192.168.2.0 255.255.255.0 172.16.2.2
```

```
R1# show ip route 192.168.2.1
Routing entry for 192.168.2.0/24
  Known via "static", distance 1, metric 0
  Routing Descriptor Blocks:
    * 172.16.2.2
      Route metric is 0, traffic share count is 1
R1#
```

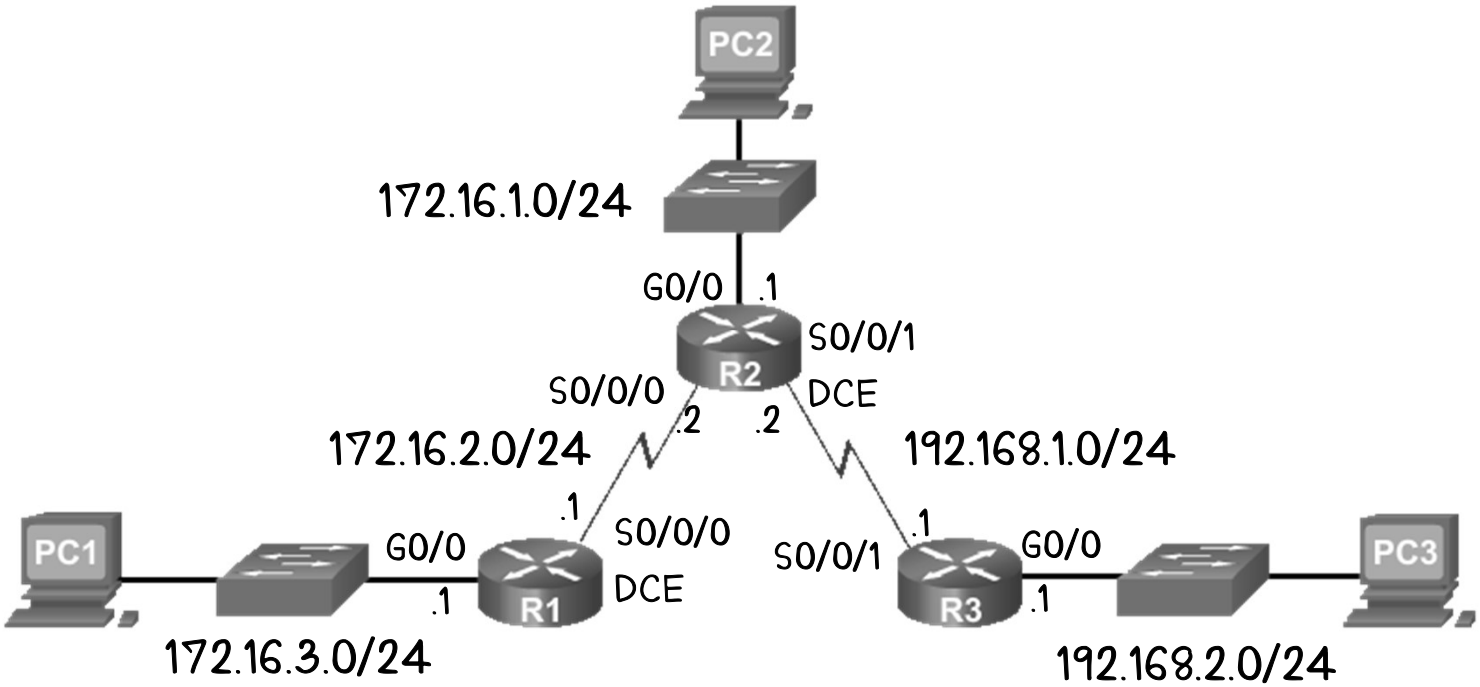
Configure IPv4 Static Routes

Default Static Route Syntax

```
Router(config)#ip route 0.0.0.0 0.0.0.0 {ip-address | exit-intf}
```

Parameter	Description
0.0.0.0	Matches any network address.
0.0.0.0	Matches any subnet mask.
ip-address	• Commonly referred to as the next-hop router's IP address. • Typically used when connecting to a broadcast media (i.e., Ethernet). • Commonly creates a recursive lookup.
exit-intf	• Use the outgoing interface to forward packets to the destination network. • Also referred to as a directly attached static route. • Typically used when connecting in a point-to-point configuration.

Configure IPv4 Static Routes



Default Static Route

```
R3(config)#ip route 0.0.0.0 0.0.0.0 172.16.2.2
```

```
R1#show ip route | begin Gateway
Gateway of last resort is not set
S* 0.0.0.0/0 [1/0] via 172.16.2.2
   172.16.0.0/16 is varibly subnet, 5 subnets, 2 masks
C      172.16.2.0/24 is directly connected, Serial0/0/0
L      172.16.2.1/32 is directly connected, Serial0/0/0
C      172.16.3.0/24 is directly connected, GigabitEthernet0/0
L      172.16.3.1/32 is directly connected, GigabitEthernet0/0
```

```
R1#show ip route static
Gateway of last resort is 172.16.2.2 to network 0.0.0.0

S* 0.0.0.0/0 [1/0] via 172.16.2.2
```

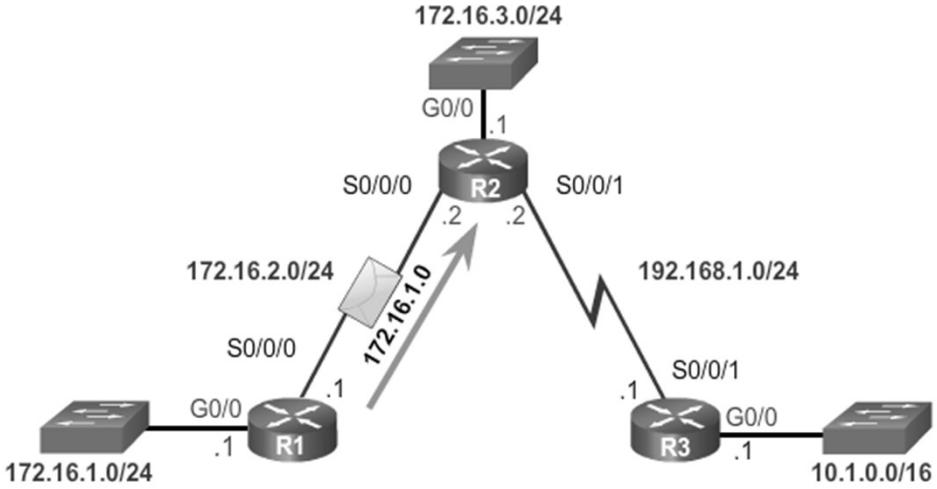
Classful Addressing

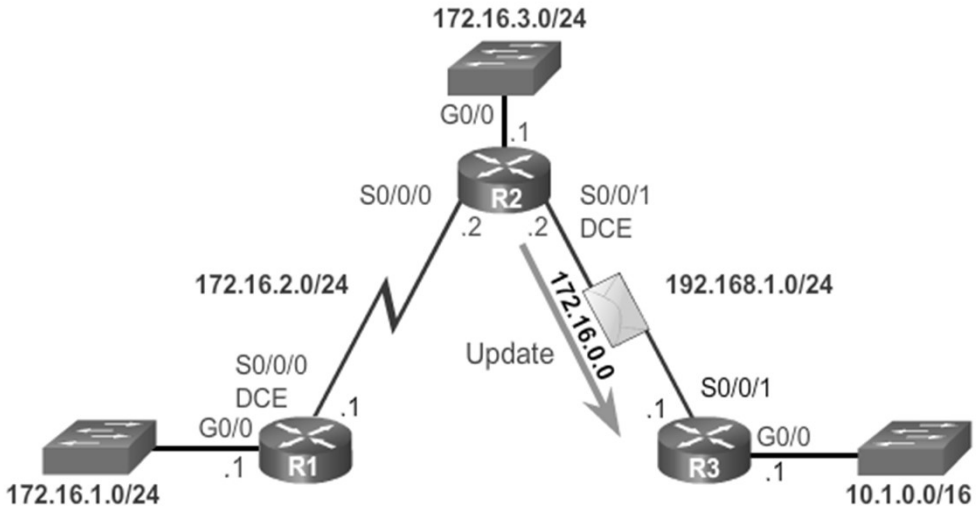
- Classful Network Addressing

Class	High Order Bits	Start	End
Class A	0xxxxxxx	0.0.0.0	127.255.255.255
Class B	10xxxxxx	128.0.0.0	191.255.255.255
Class C	110xxxxx	192.0.0.0	223.255.255.255
Multicast	1110xxxx	224.0.0.0	239.255.255.255
Reserved	1111xxxx	240.0.0.0	255.255.255.255

Classful Addressing

- Classful Routing Protocol Example





Classful Addressing

- Classful Addressing Waste

Classfull IP Address Allocation = Inefficient

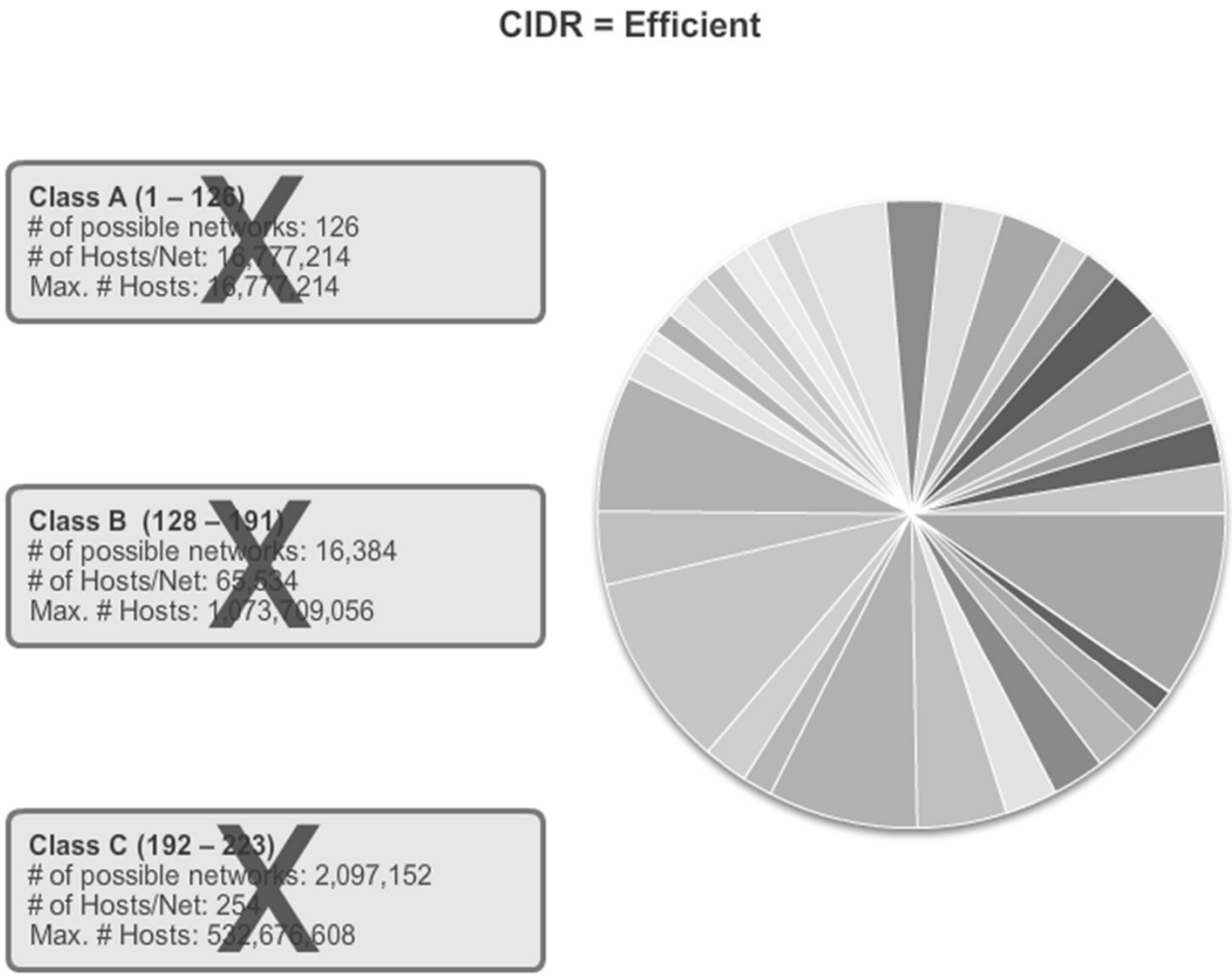
Class A (1 - 126)
# of possible networks: 126
# of Hosts/Net: 16,777,214
Max. # Hosts: 2,113,928,964

Class B (128 – 191)
# of possible networks: 16,384
# of Hosts/Net: 65,534
Max. # Hosts: 1,073,709,056

Class C (192 – 223)
# of possible networks: 2,097,152
# of Hosts/Net: 254
Max. # Hosts: 532,676,608

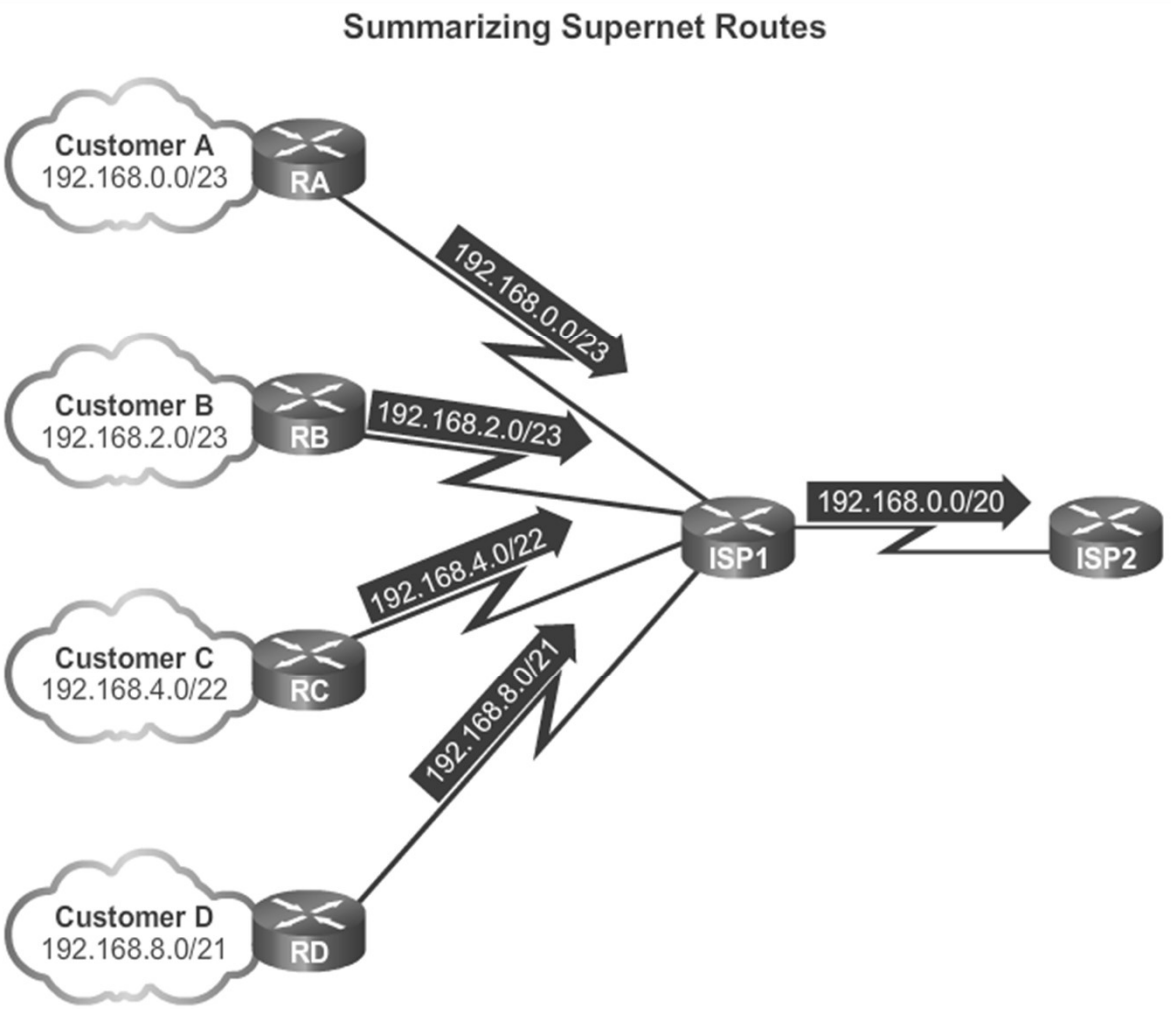
CIDR

- Classless Inter-Domain Routing



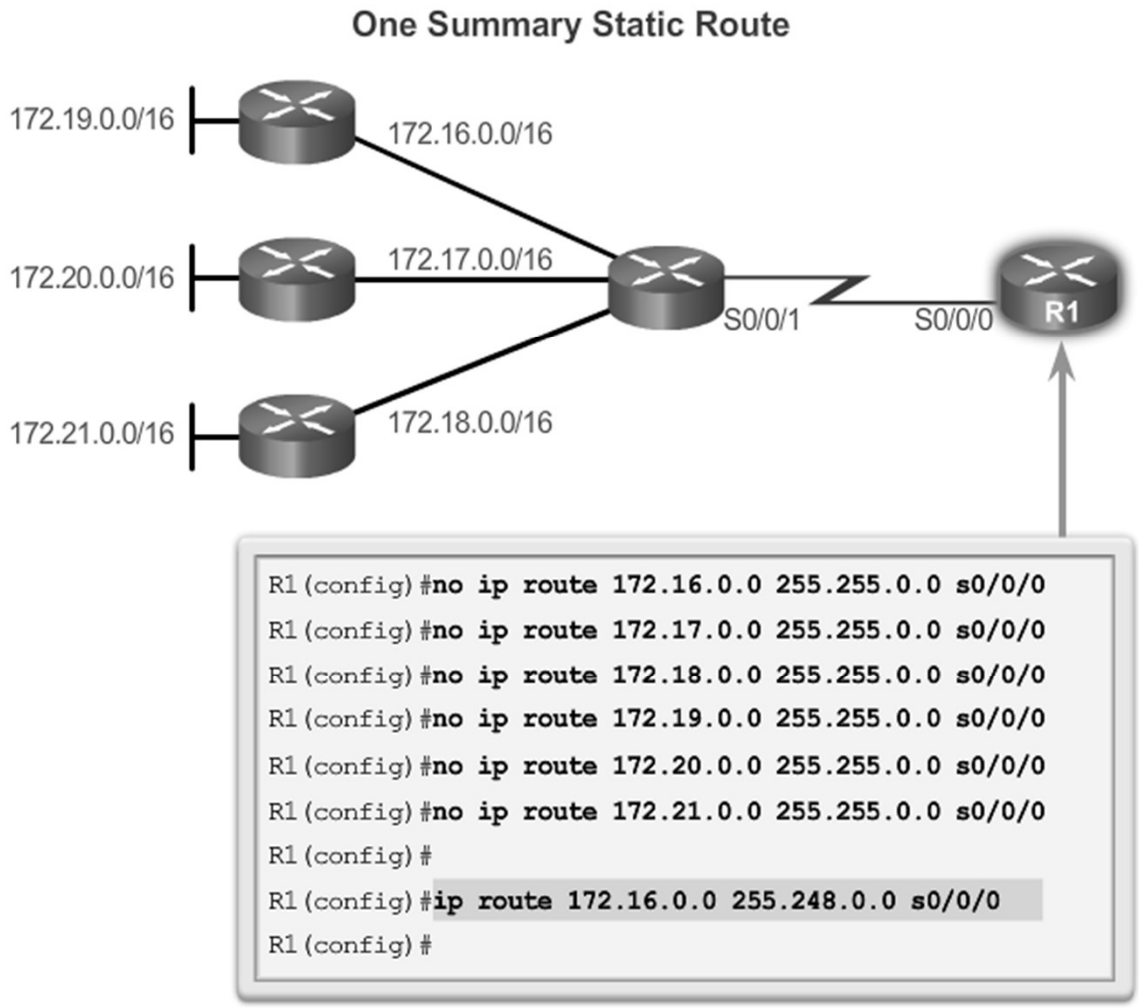
CIDR

- CIDR and Route Summarization



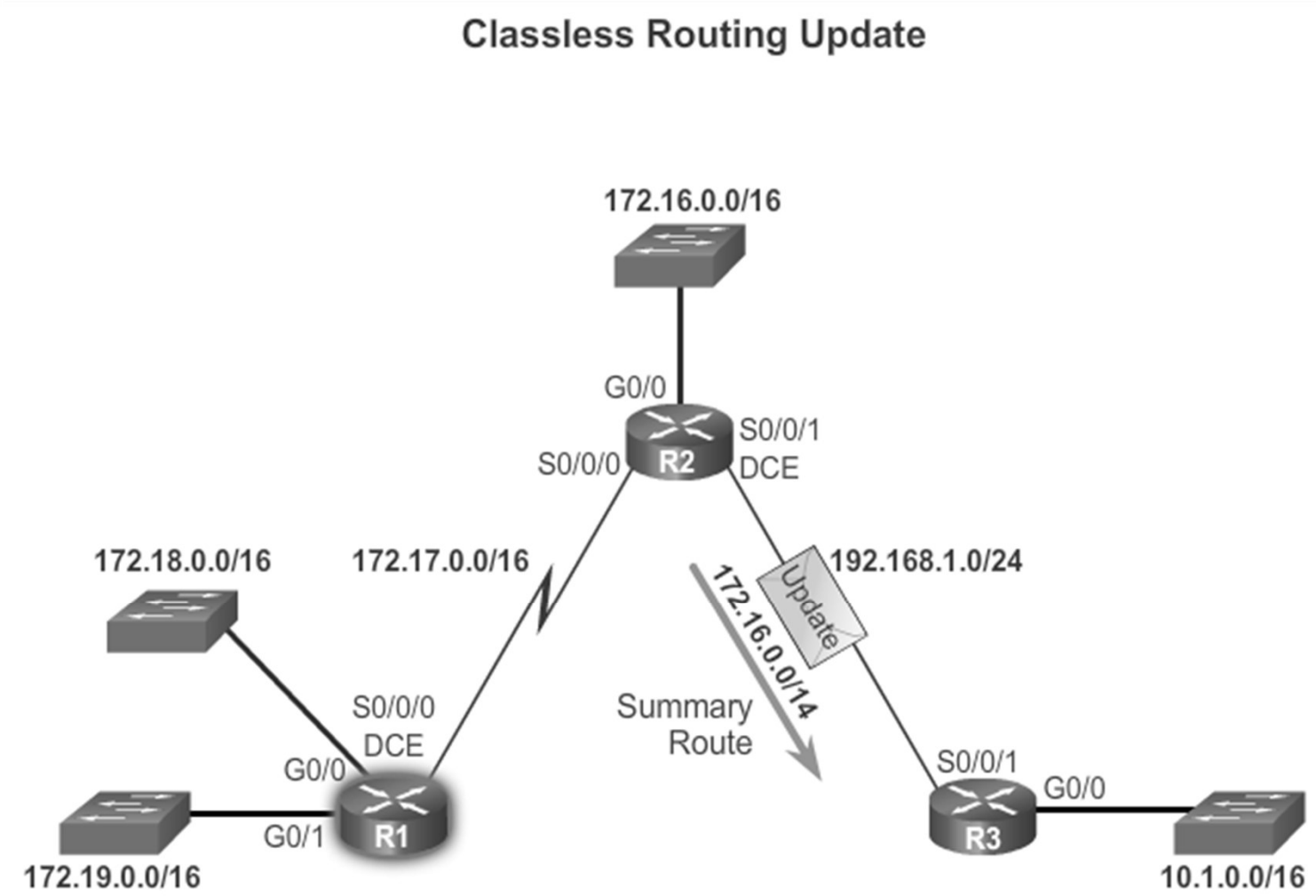
CIDR

- Static Routing CIDR Example



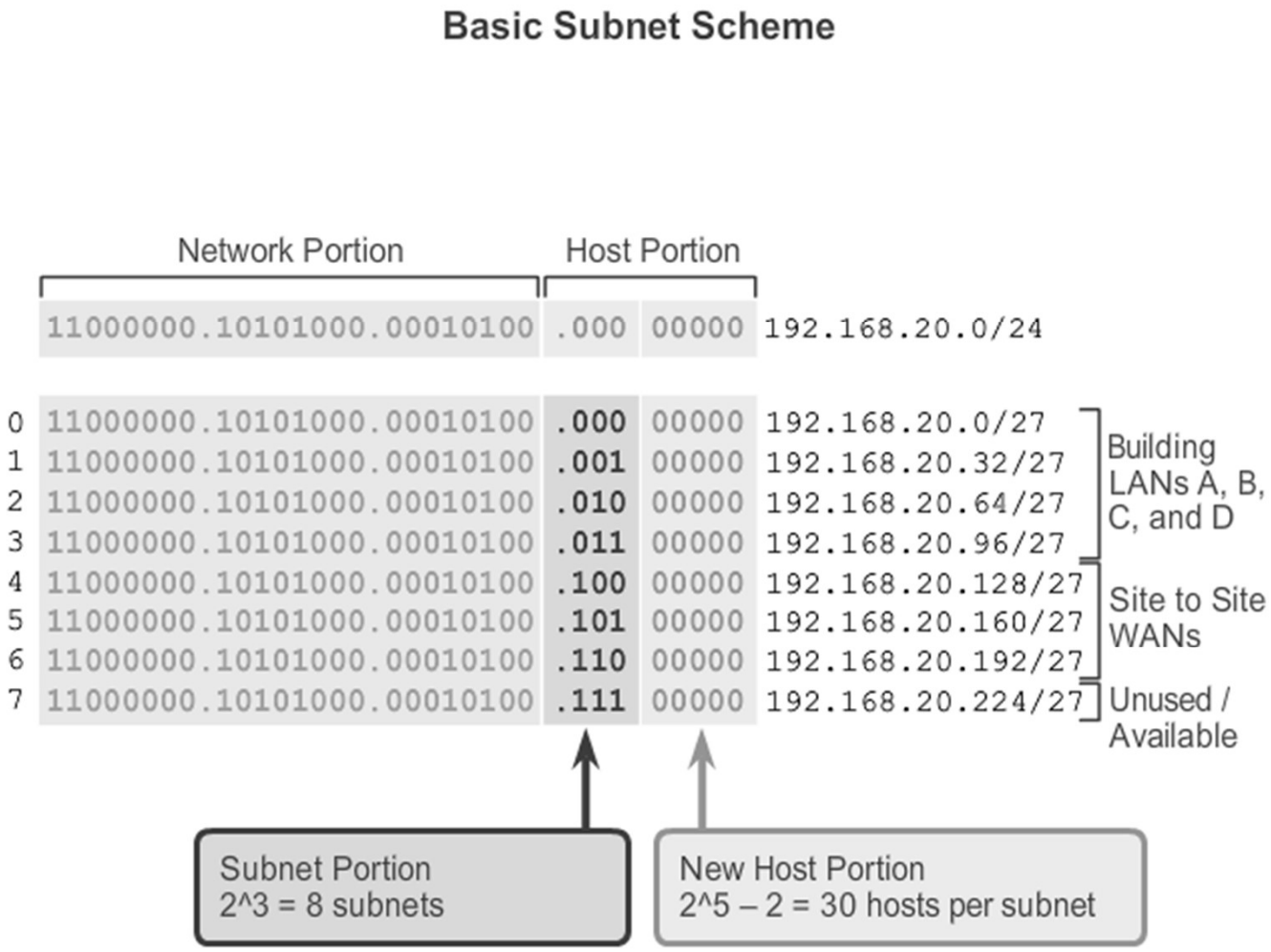
CIDR

- Classless Routing Protocol Example



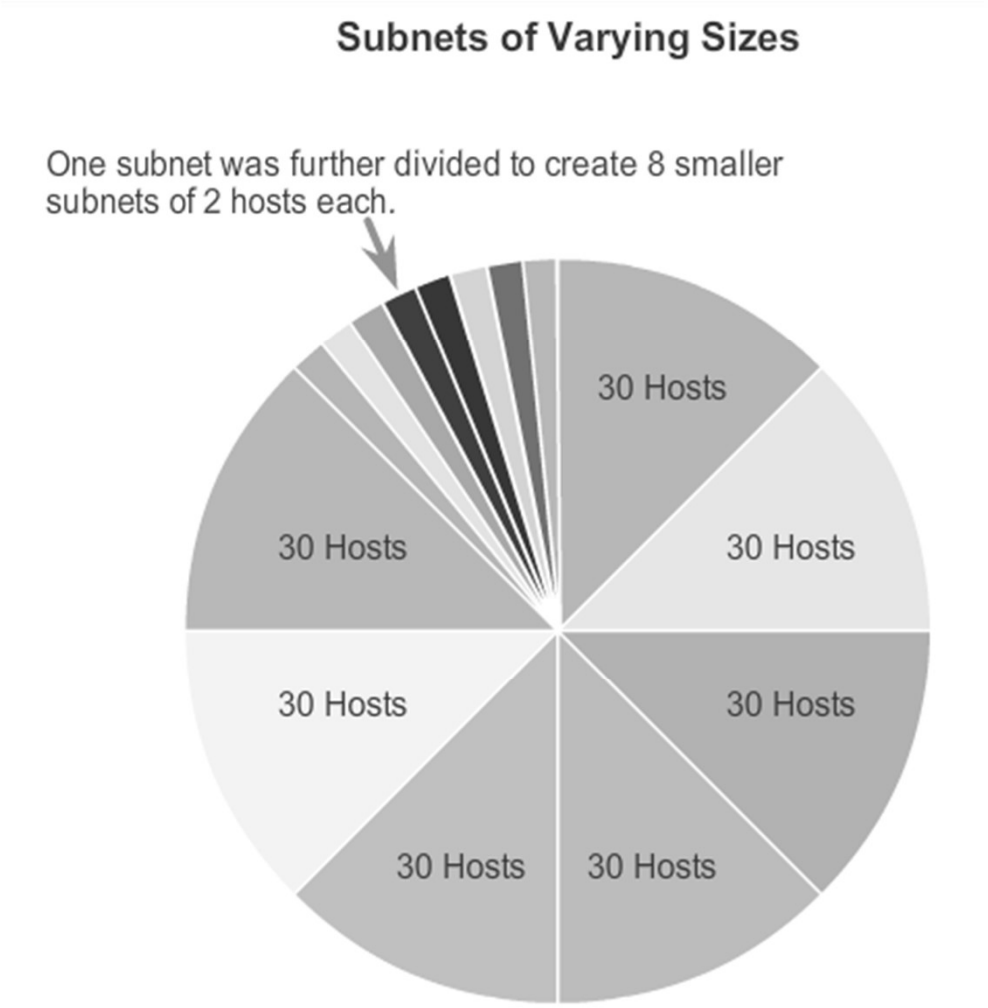
VLSM

- Fixed Length Subnet Masking



VLSM

- Variable Length Subnet Masking



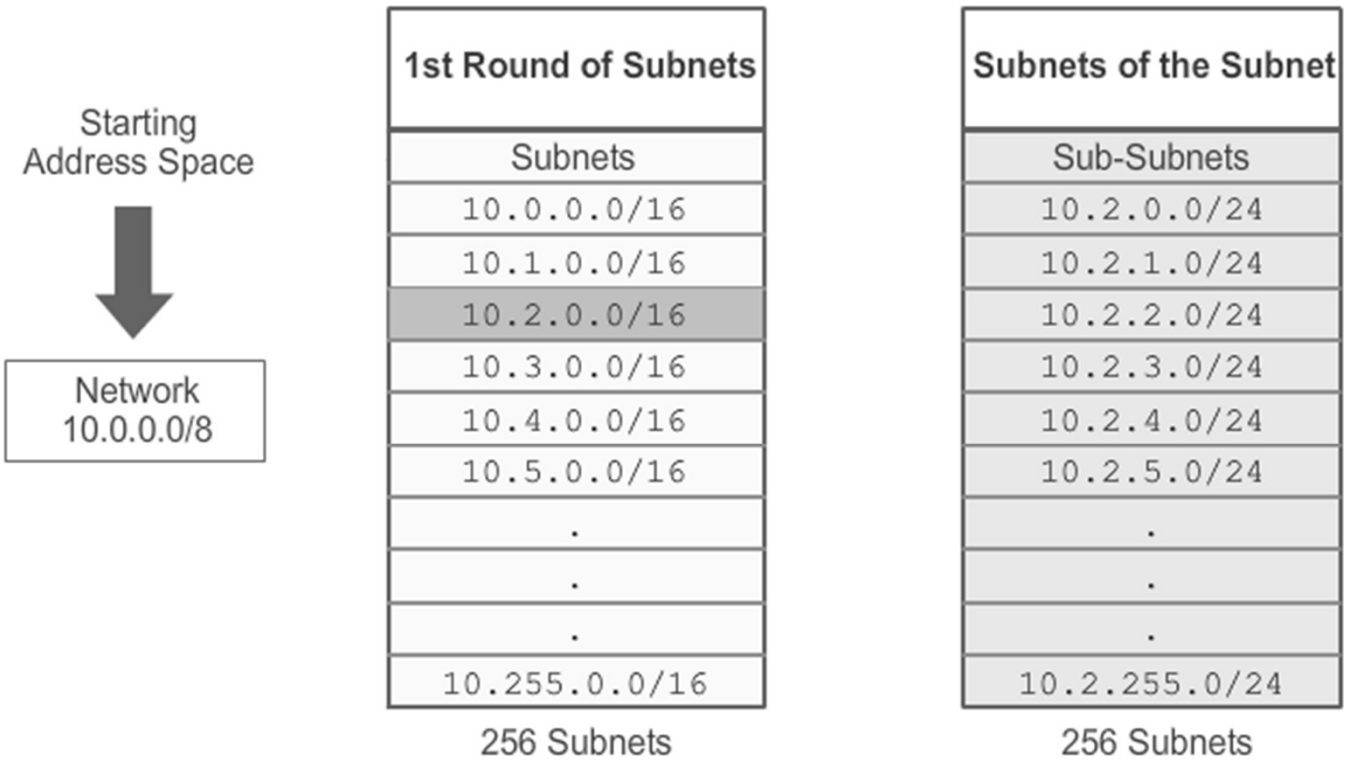
VLSM

- VLSM in Action
  - VLSM allows the use of different masks for each subnet.
  - After a network address is subnetted, those subnets can be further subnetted.
  - VLSM is simply subnetting a subnet. VLSM can be thought of as sub-subnetting.
  - Individual host addresses are assigned from the addresses of "sub-subnets".

VLSM

- Subnetting Subnets

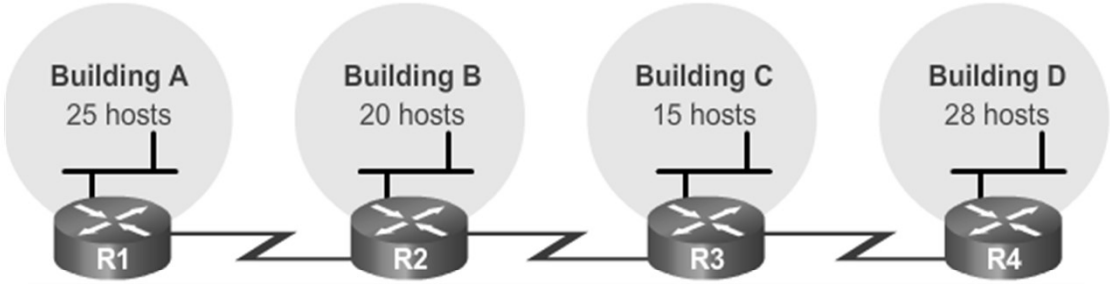
Subnetting the Subnet 10.2.0.0/16 to 10.2.0.0/24



VLSM

- VLSM Example

Subnetting Subnet 192.168.20.224/27 to 192.168.20.224/30



	/27 Network	Hosts
Bldg A	.0	.1 - .30
Bldg B	.32	.33 - .62
Bldg C	.64	.65 - .94
Bldg D	.96	.97 - .126
Unused	.128	.129 - .158
Unused	.160	.161 - .190
Unused	.192	.193 - .222
	.224	.225 - .254

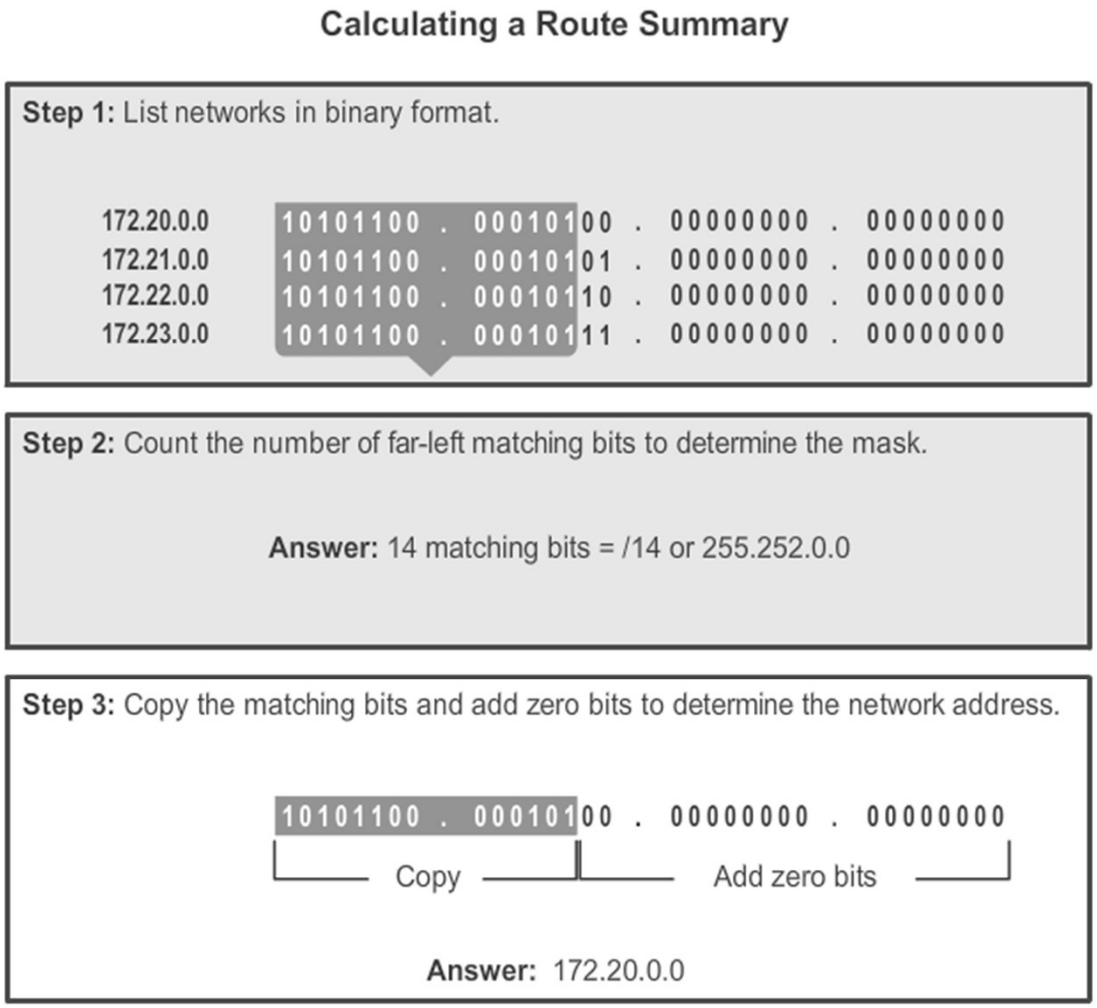
	/30 Network	Hosts
WAN R1–R2	.224	.225 - .226
WAN R2–R3	.228	.229 - .230
WAN R3–R4	.232	.233 - .234

Configure IPv4 Summary Routes

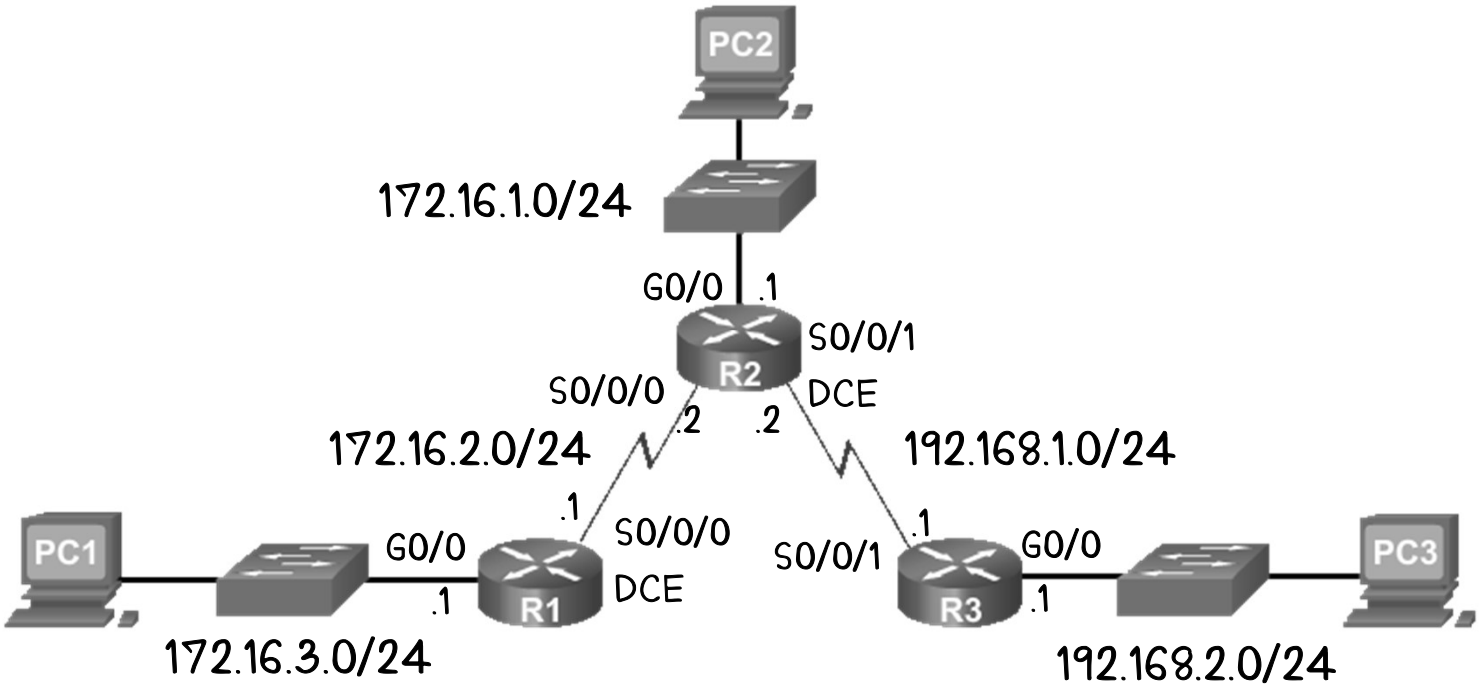
- Route summarization, also known as route aggregation, is the process of advertising a contiguous set of addresses as a single address with a less-specific, shorter subnet mask.
- CIDR is a form of route summarization and is synonymous with the term supernetting.
- CIDR ignores the limitation of classful boundaries, and allows summarization with masks that are smaller than that of the default classful mask.
- This type of summarization helps reduce the number of entries in routing updates and lowers the number of entries in local routing tables.

Configure IPv4 Summary Routes

- Calculate a Summary Route



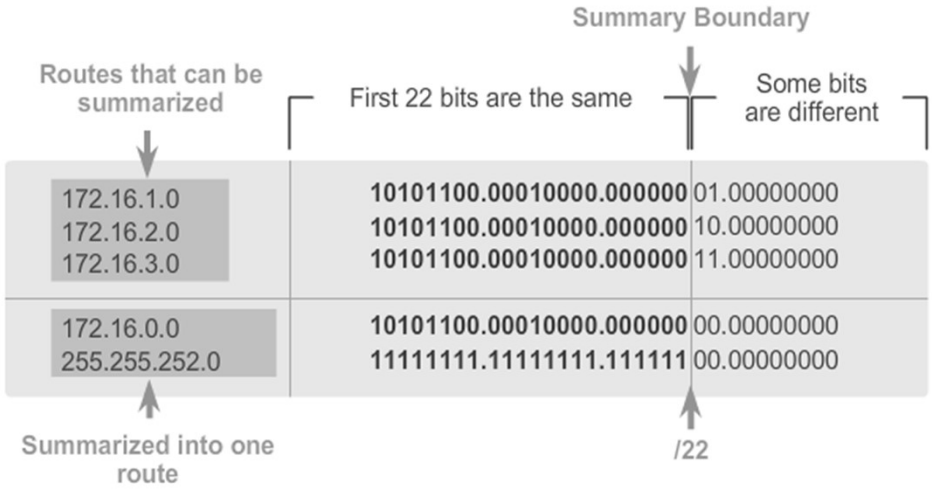
Configure IPv4 Summary Routes




```
R3#show ip route static | begin Gateway
Gateway of last resort is not set
   172.16.0.0/24 is subnet, 3 subnets
S      172.16.1.0/24 [1/0] via 192.168.1.2
S      172.16.2.0/24 [1/0] via 192.168.1.2
S      172.16.3.0/24 [1/0] via 192.168.1.2
```

```
R3(config)#no ip route 172.16.1.0 255.255.255.0 192.168.1.2
R3(config)#no ip route 172.16.2.0 255.255.255.0 192.168.1.2
R3(config)#no ip route 172.16.3.0 255.255.255.0 192.168.1.2
R3(config)#ip route 172.16.0.0 255.255.252.0 192.168.1.2
```

```
R3#show ip route static | begin Gateway
Gateway of last resort is not set
   172.16.0.0/22 is subnet, 1 subnets
S      172.16.1.0 [1/0] via 192.168.1.2
```

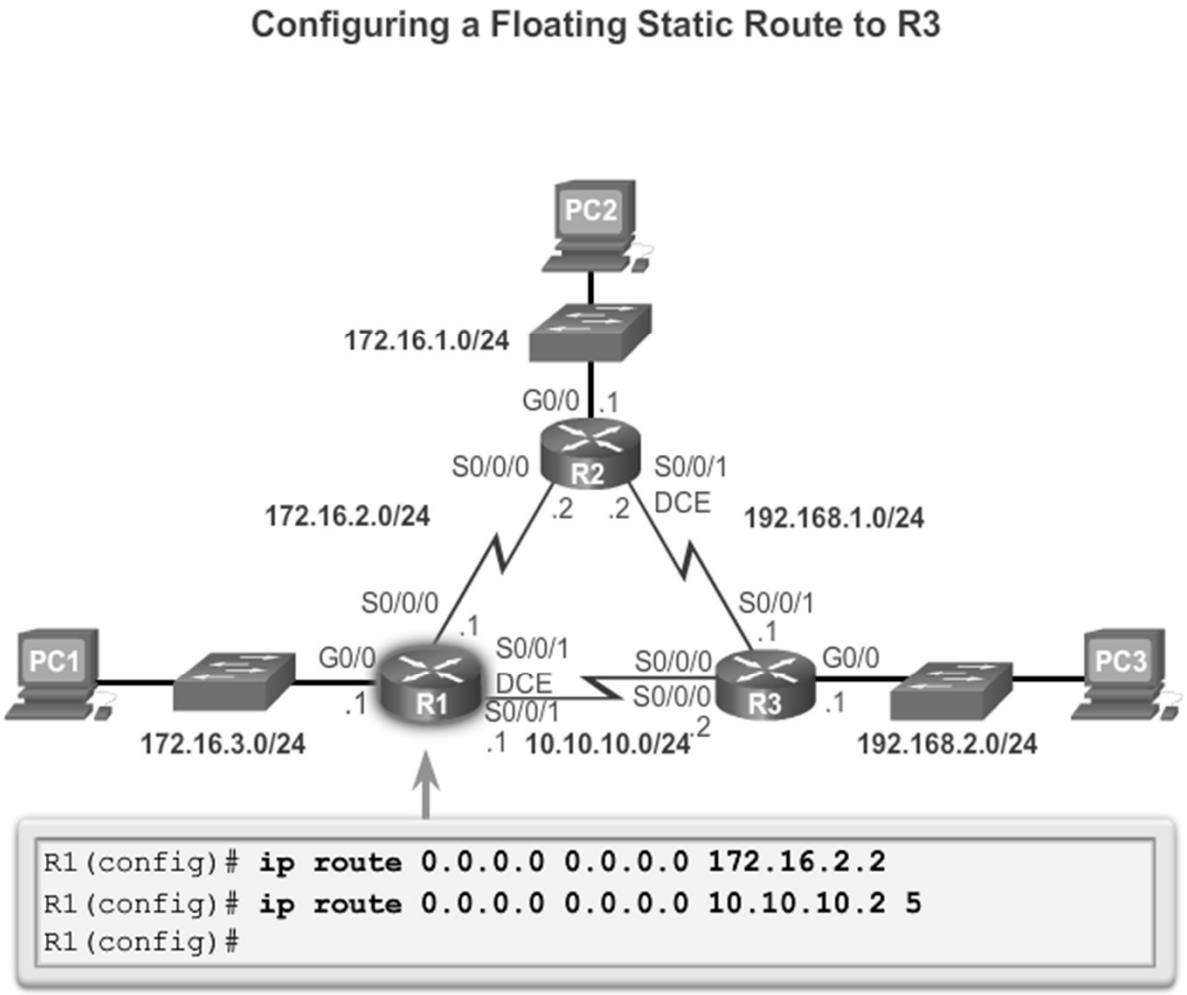


Configure Floating Static Routes

- Floating static routes are static routes that have an administrative distance greater than the administrative distance of another static route or dynamic routes.
- The administrative distance of a static route can be increased to make the route less desirable than that of another static route or a route learned through a dynamic routing protocol.
- In this way, the static route "floats" and is not used when the route with the better administrative distance is active.
- However, if the preferred route is lost, the floating static route can take over, and traffic can be sent through this alternate route.

Configure Floating Static Routes

- Configure a Floating Static Route



Configure Floating Static Routes

- Test the Floating Static Route
  - Use a show ip route command to verify that the routing table is using the default static route.
  - Use a traceroute command to follow the traffic flow out the primary route.
  - Disconnect the primary link or shutdown the primary exit interface.
  - Use a show ip route command to verify that the routing table is using the floating static route.
  - Use a traceroute command to follow the traffic flow out the backup route.

Troubleshoot IPv4 Static and Default Route Configuration

- Troubleshoot a Missing Route

```
ping
traceroute
show ip route
show ip interface brief
show cdp neighbors detail
```

Questions and Answers