



# 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

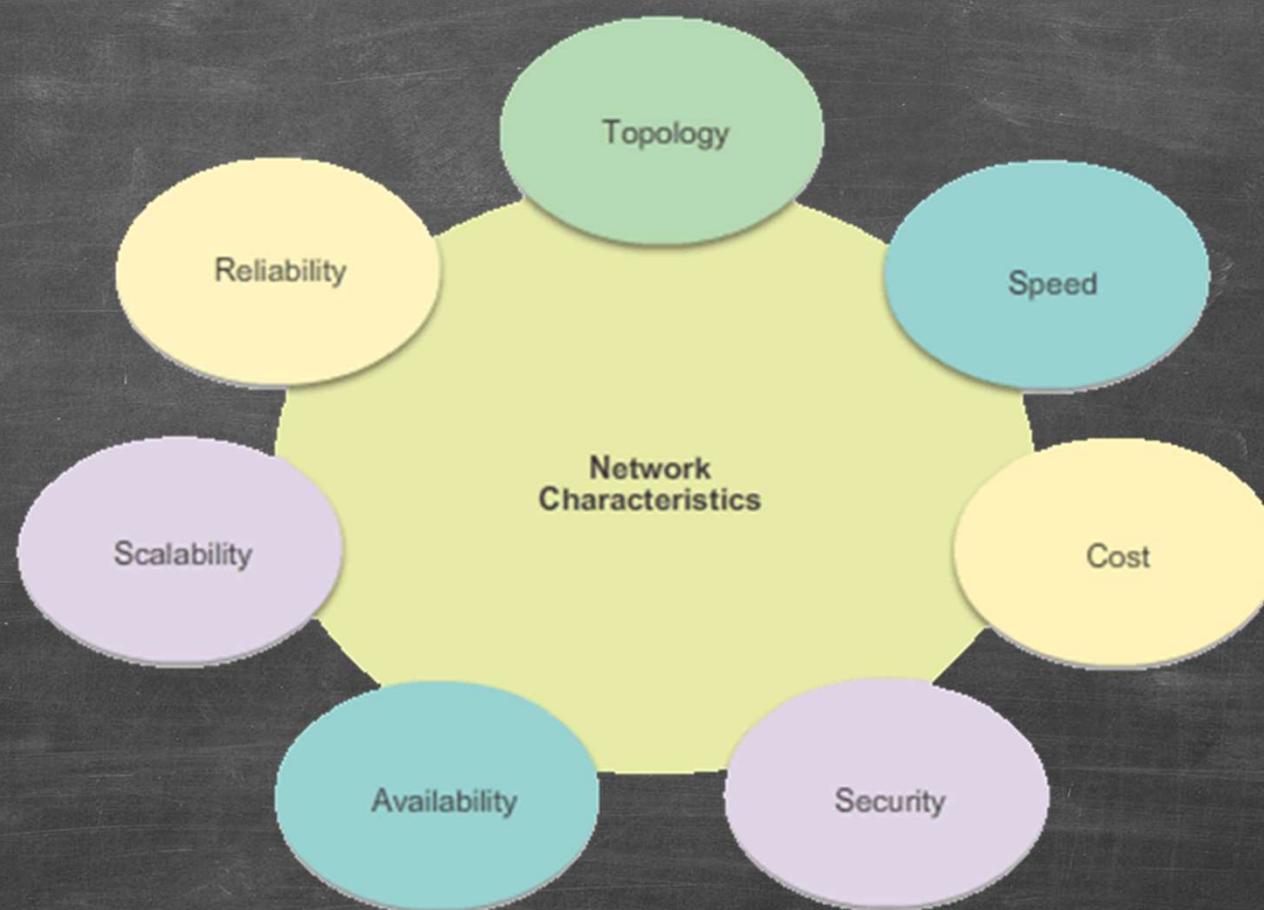
Review of CIDR and VLSM

Summary and Floating Static Routes

Troubleshoot Static and Default Route Issues

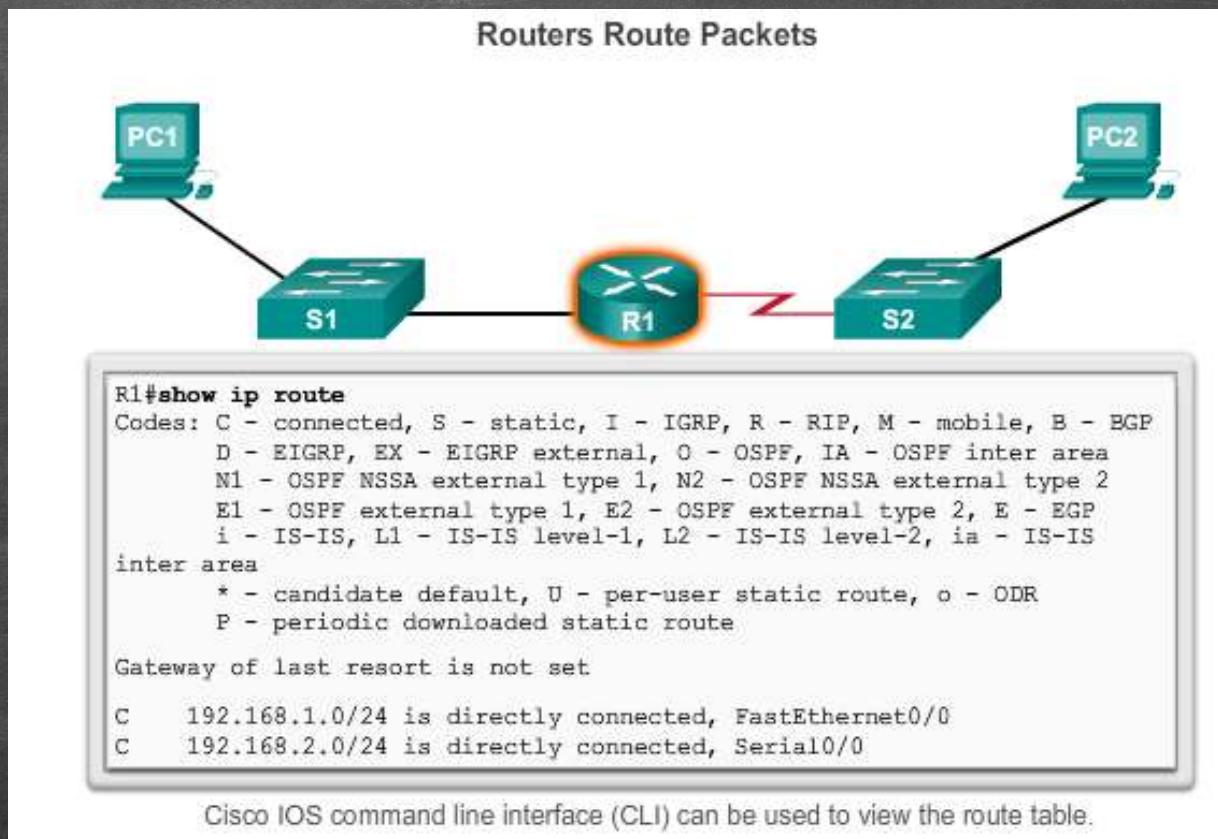
# Functions of a Router

- Characteristics of a Network



# Functions of a Router

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



# 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	<ul style="list-style-type: none"><li>• Running IOS</li><li>• Running configuration file</li><li>• IP routing and ARP tables</li><li>• Packet buffer</li></ul>
ROM	Non-Volatile	<ul style="list-style-type: none"><li>• Bootup instructions</li><li>• Basic diagnostic software</li><li>• Limited IOS</li></ul>
NVRAM	Non-Volatile	<ul style="list-style-type: none"><li>• Startup configuration file</li></ul>
Flash	Non-Volatile	<ul style="list-style-type: none"><li>• IOS</li><li>• Other system files</li></ul>

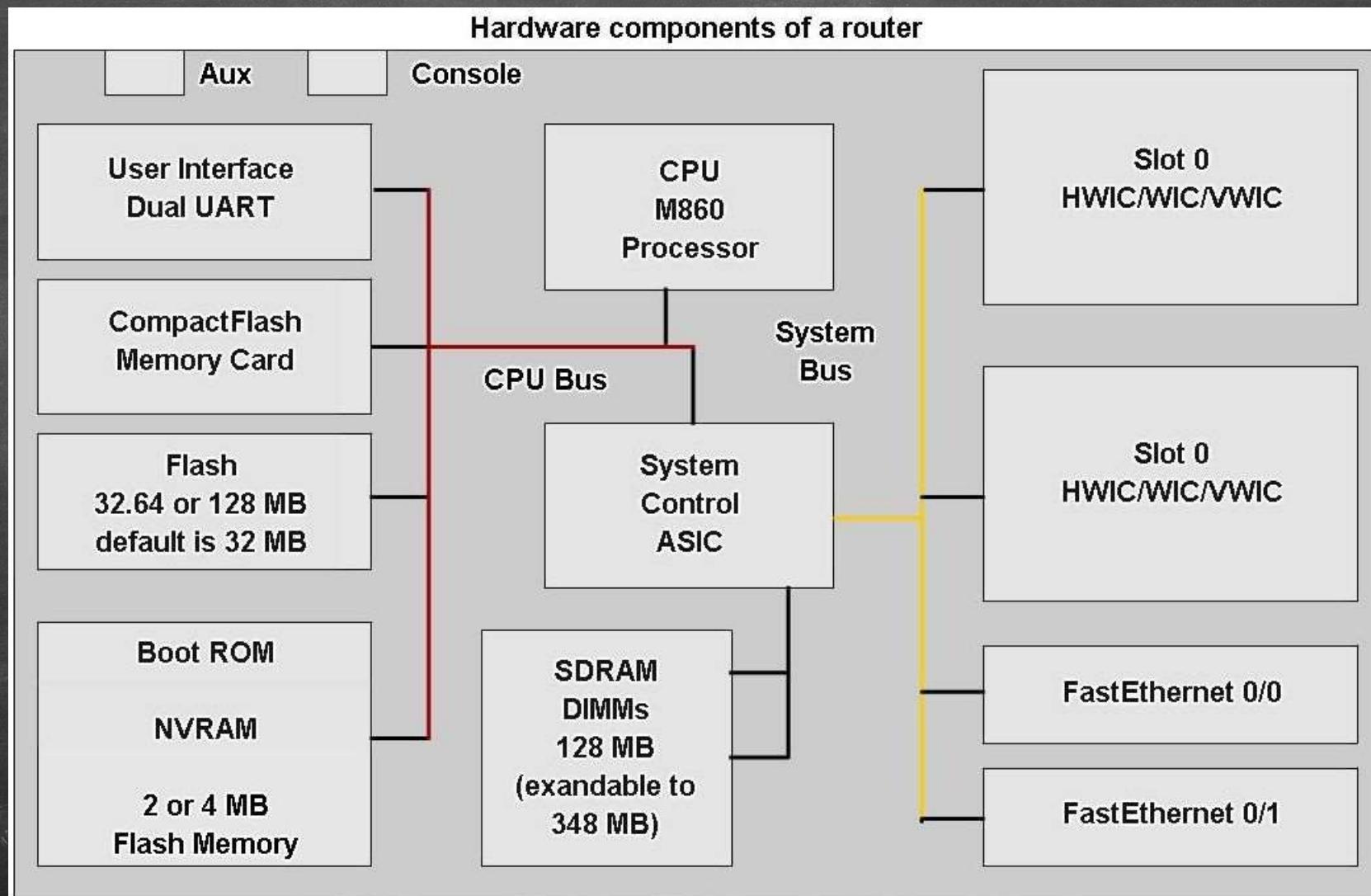
# Functions of a Router

- 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



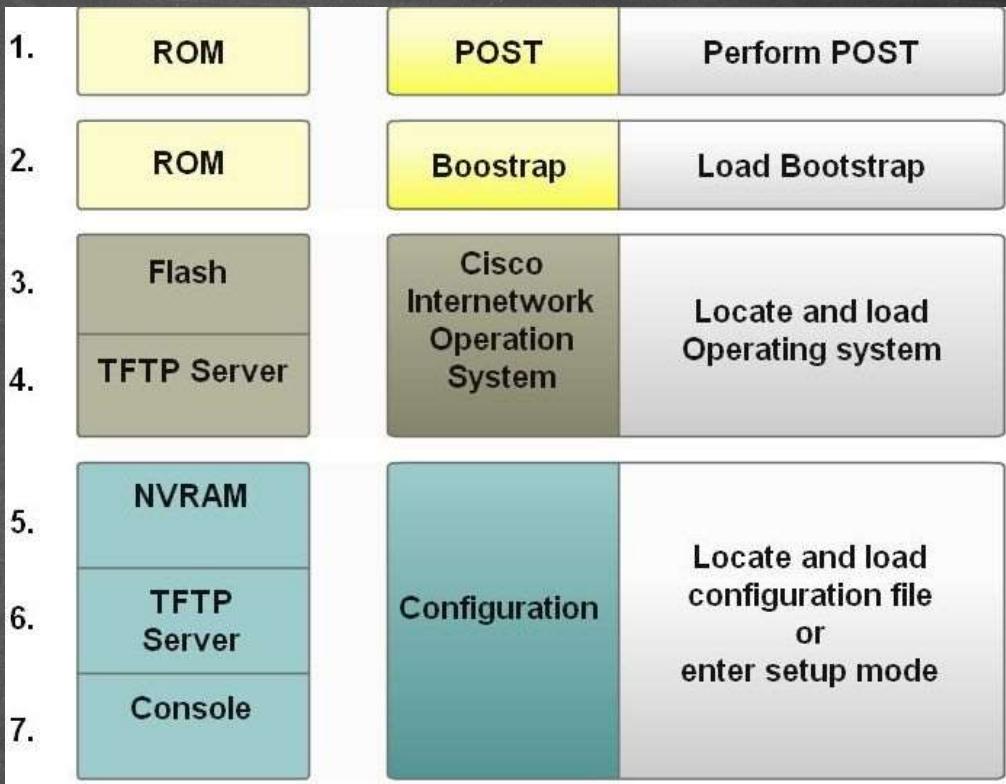
# Functions of a Router

- 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 5.01 with 114688K/16384K bytes of memory.

Self decompressing the image :

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### --- System Configuration Dialog ---

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

# Functions of a Router

```
Router#show version
Cisco Internetwork Operating System Software
IOS (tm) C2600 Software (C2600-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2005 by cisco Systems, Inc.
Compiled Wed 27-Apr-04 19:01 by miwang
Image text-base: 0x8000808C, data-base: 0x80A1FECC

Bootstrap version
ROM: System Bootstrap, Version 12.1(3z)T2, RELEASE SOFTWARE (fc1)
CDATA[Copyright (c) 2000 by cisco Systems, Inc.
ROM: C2600 Software (C2600-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)
System returned to ROM by reload
System image file is "flash:c2600-i-mz.122-28.bin"

Model and CPU
cisco 2621 (MPC860) processor (revision 0x200) with 60416K/5120K bytes of memory.

Amount of RAM
Processor board ID JAD05190MTZ (4292891495)
M860 processor: part number 0, mask 49
Bridging software.
X.25 software, Version 3.0.0.

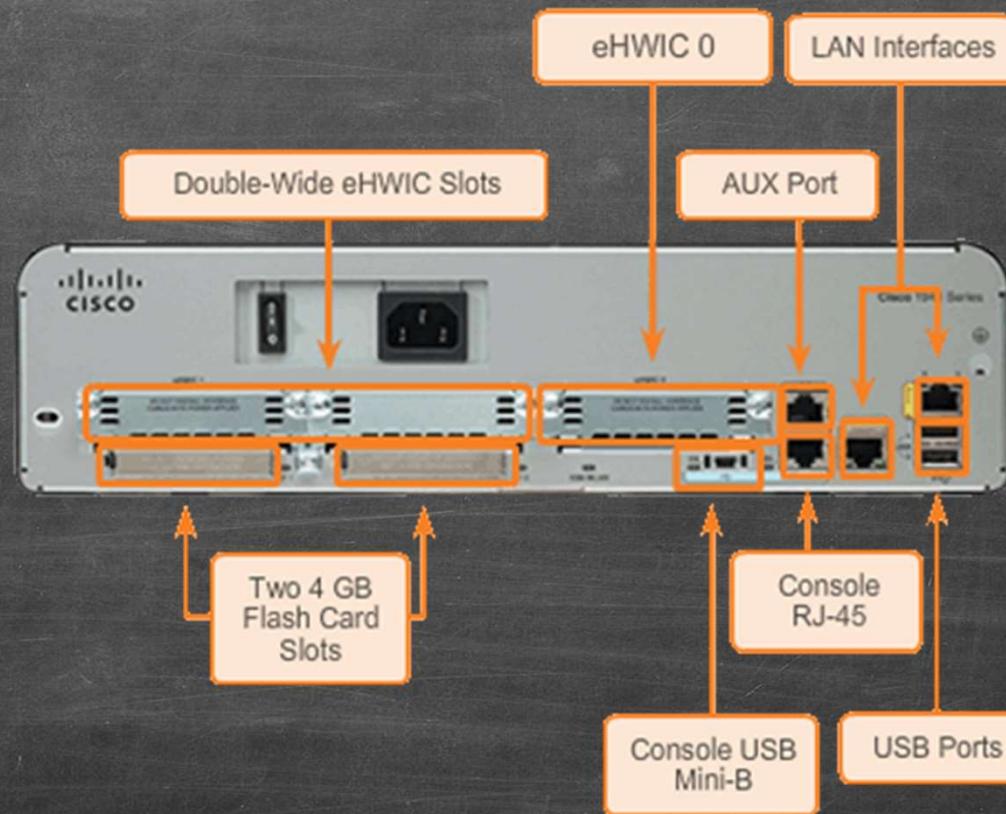
Number and type of interfaces
2 FastEthernet/IEEE 802.3 interface(s)
2 Low-speed serial(sync/async) network interface(s)

Amount of NVRAM
32K bytes of non-volatile configuration memory.

Amount of Flash
16384K bytes of processor board System flash (Read/Write)
Configuration register is 0x2102
Router#
```

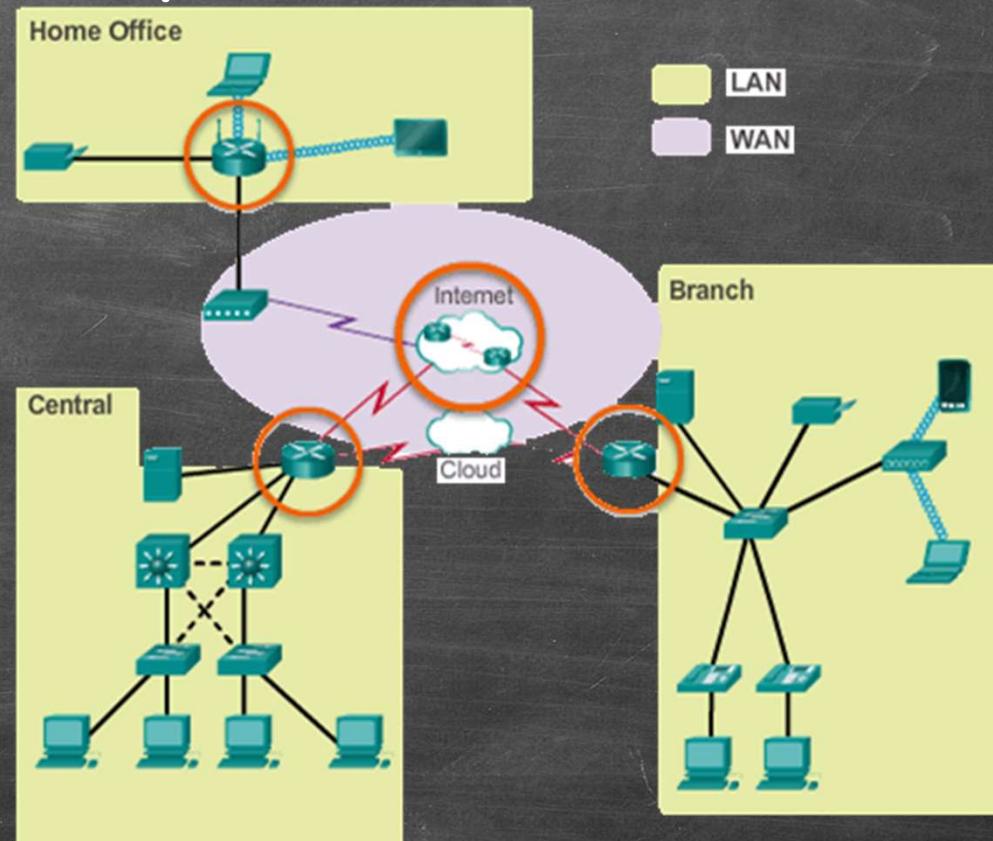
# Functions of a Router

- 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.

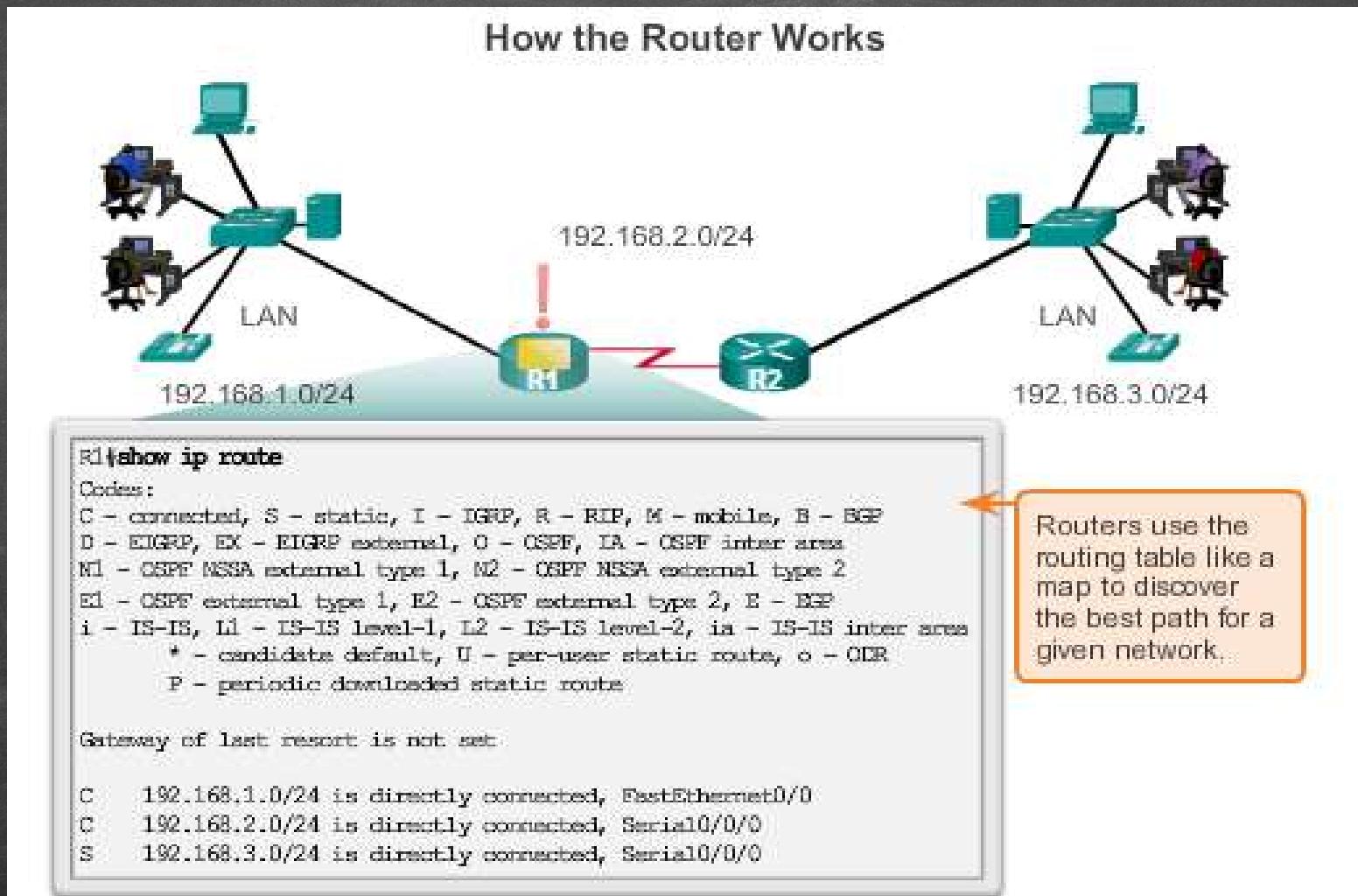


# Functions of a Router

- 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.

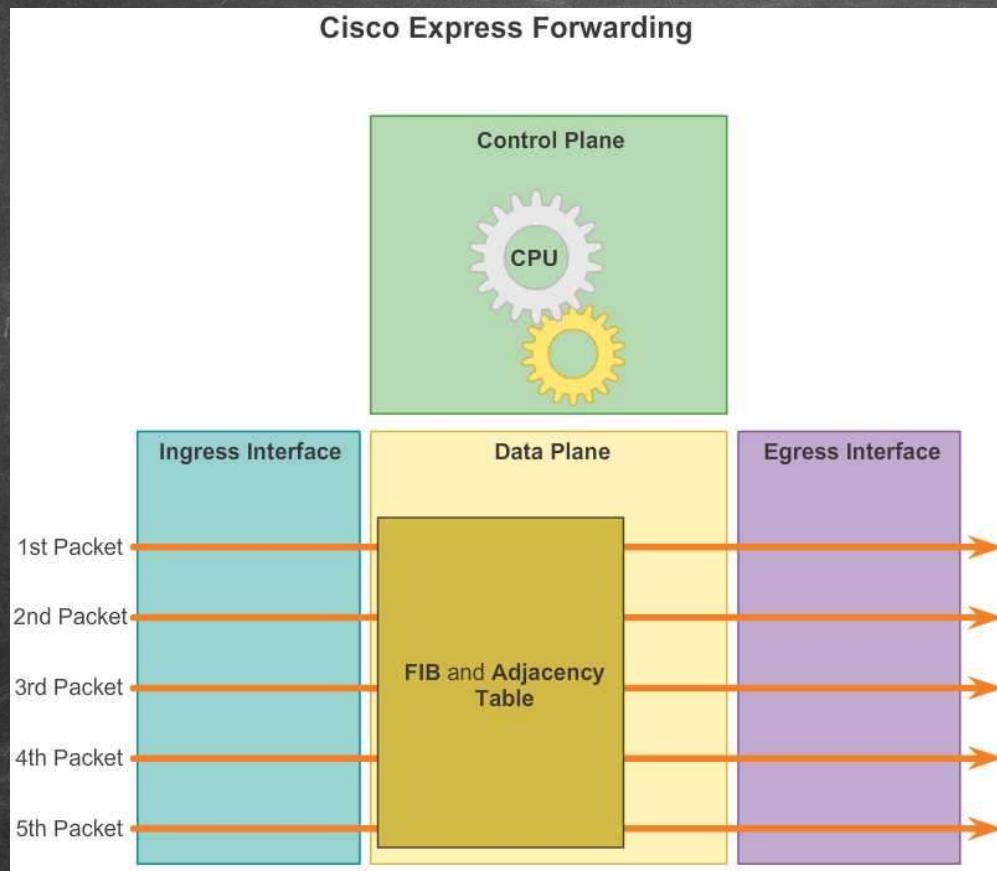
# Functions of a Router

- Routers Choose Best Paths



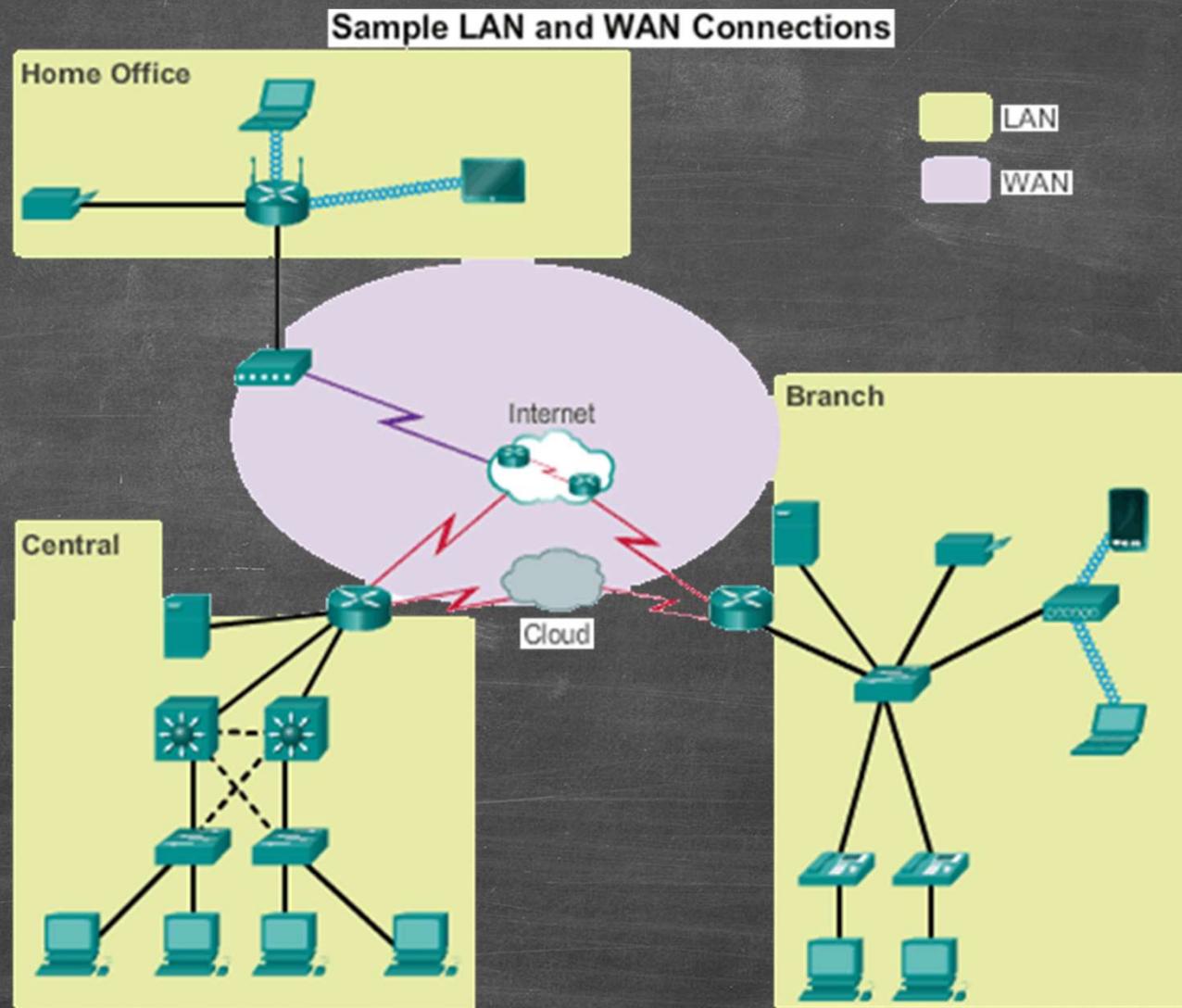
# Functions of a Router

- Packet Forwarding Methods



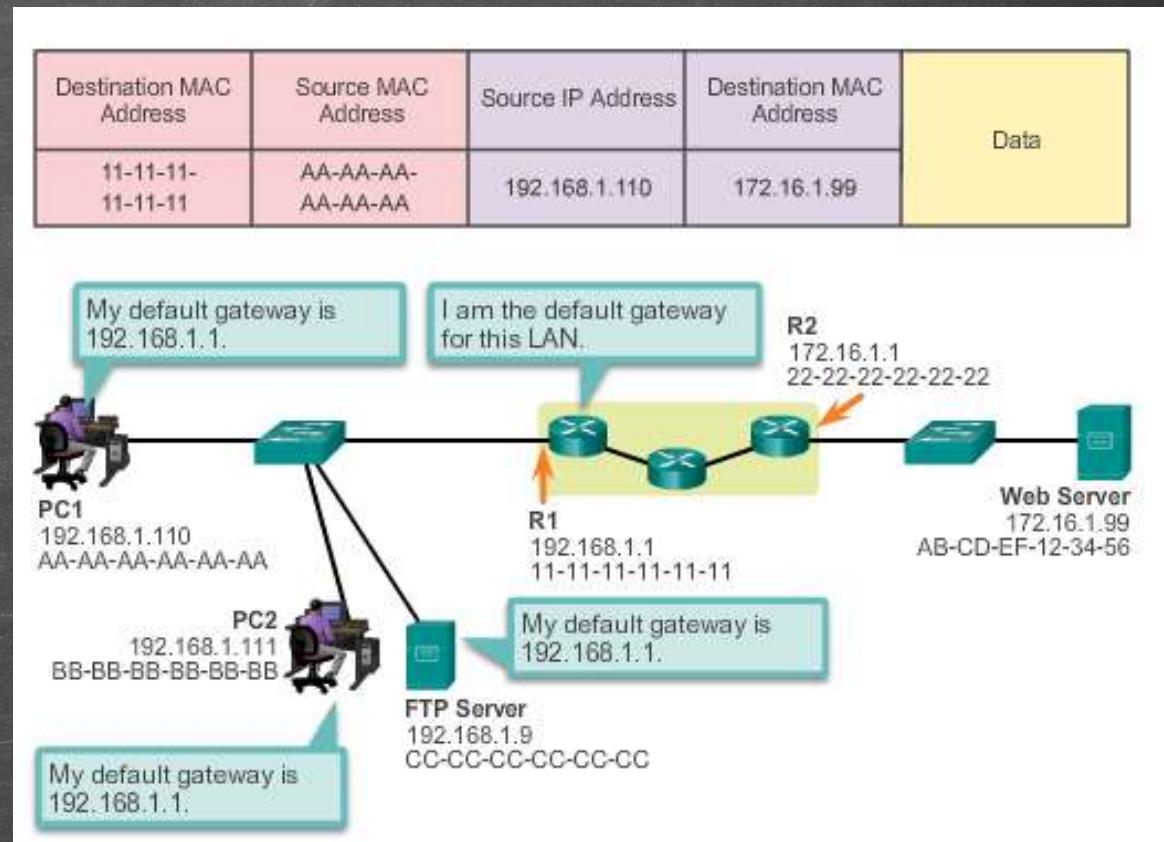
- **Process switching** - An older packet forwarding mechanism still available for Cisco routers.
- **Fast switching** - A common packet forwarding mechanism which uses a fast-switching cache to store next hop information.
- **Cisco Express Forwarding (CEF)** - The most recent, fastest, and preferred 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.

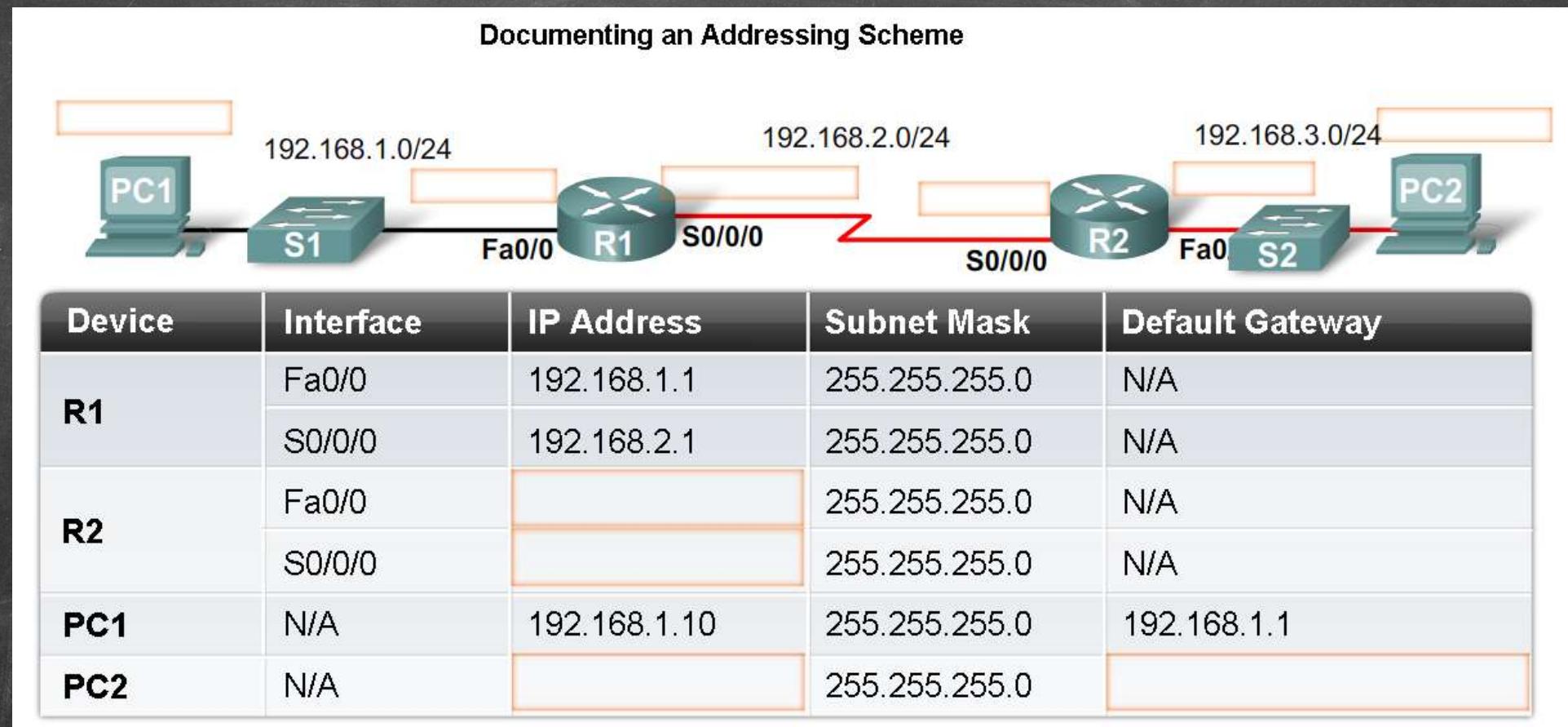


# Connect Devices

- 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



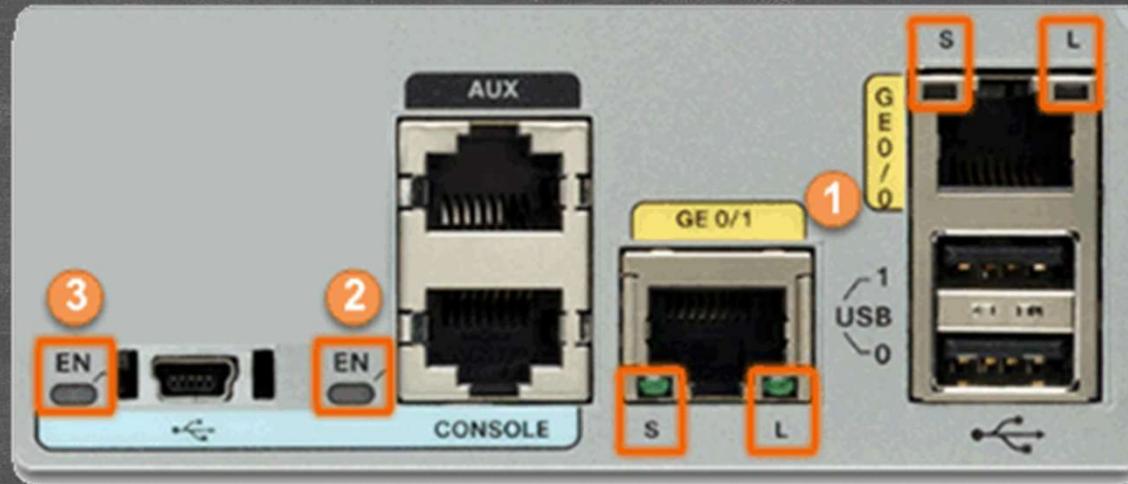
# Connect Devices

- 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

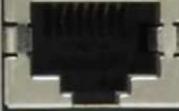
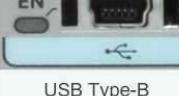
# Connect Devices

- Console Access

- Console access requires:

- Console cable - RJ-45-to-DB-9 console cable
    - Terminal emulation software - Tera Term, PuTTY,

HyperTerminal

Ports and Cables			
Port on Computer	Cable Required	Port on ISR	Terminal Emulation
	 Console Cable		 Tera Term
	USB-to-RS-232 Serial Port Adapter  Console Cable	RJ-45 Console Port	 PuTTY
			

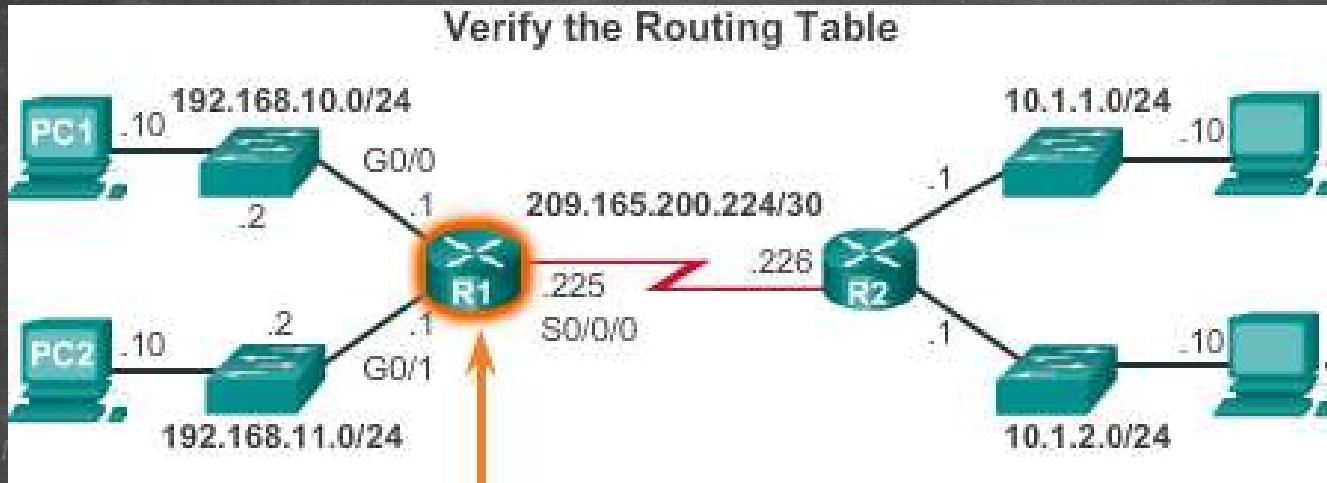
# Basic Settings on a Router

- 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

```
C 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
!
```

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

# Verify Connectivity of Directly Connected Networks

- Filter Show Command Output
  - Use the terminal `lengthnumber` command 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	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#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#
```

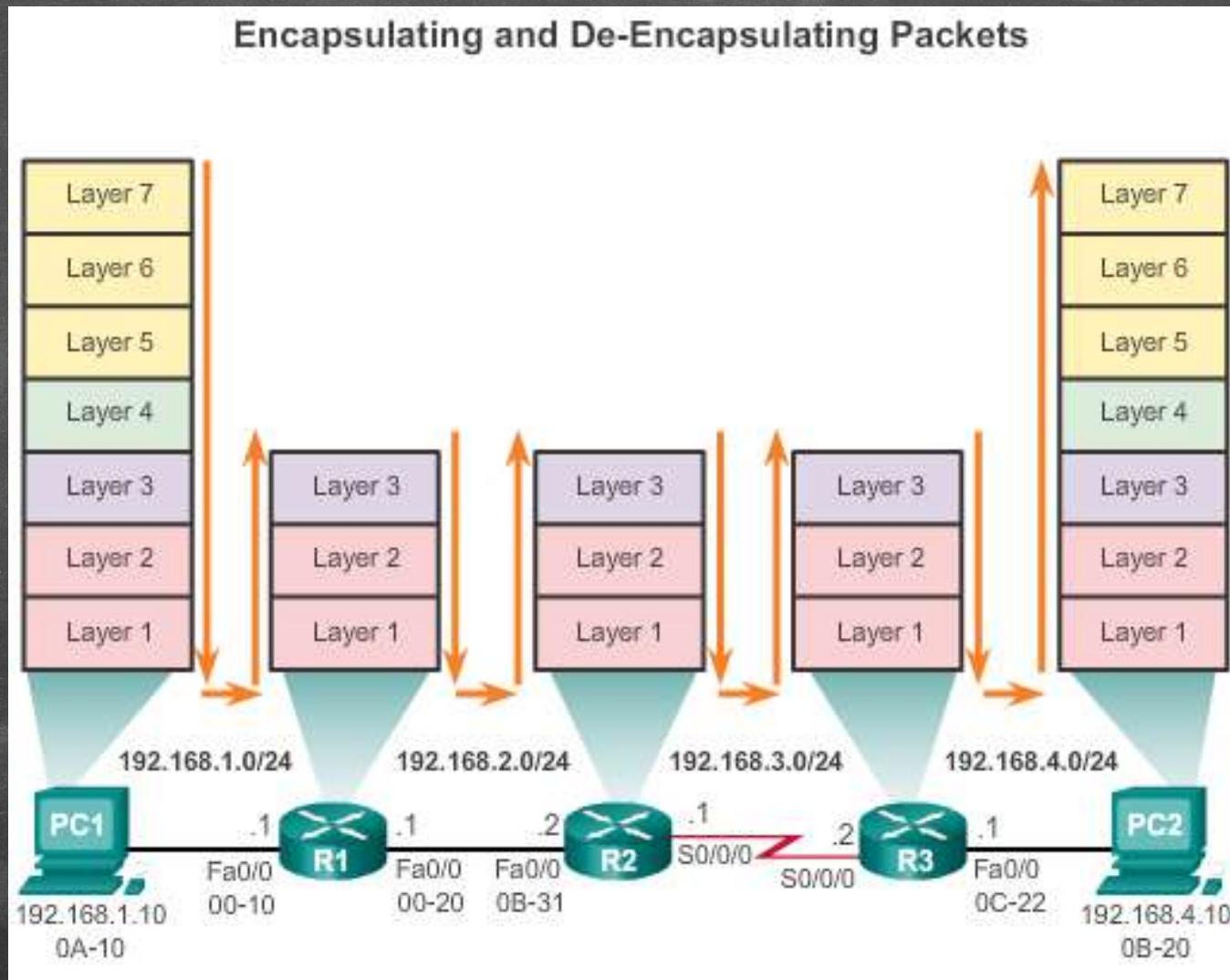
```
R1#show ip interface brief | include up
```

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#
```

# Switching Packets between Networks

- Router Switching Functions



# Switching Packets between Networks

- Send a Packet

## PC1 Sends a Packet to PC2

Because PC2 is on different network, I will encapsulate the packet and send it to the router on MY network. Let me find that MAC address....



Layer 2 Data Link Frame

Packet's Layer 3 data

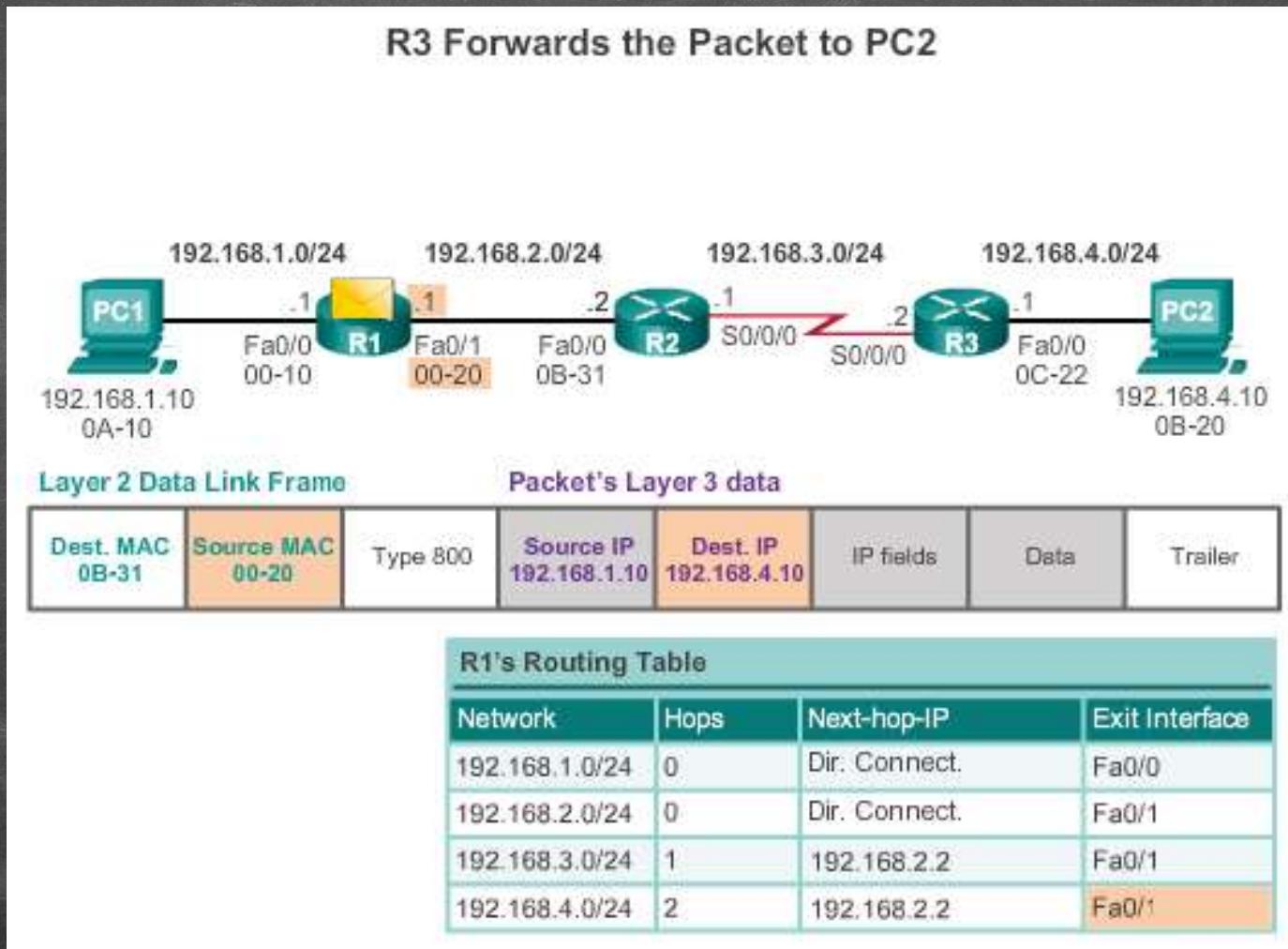
Dest. MAC 00-10	Source MAC 0A-10	Type 800	Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer
--------------------	---------------------	----------	---------------------------	--------------------------	-----------	------	---------

PC1's ARP Cache for R1

IP Address	MAC Address
192.168.1.1	00-10

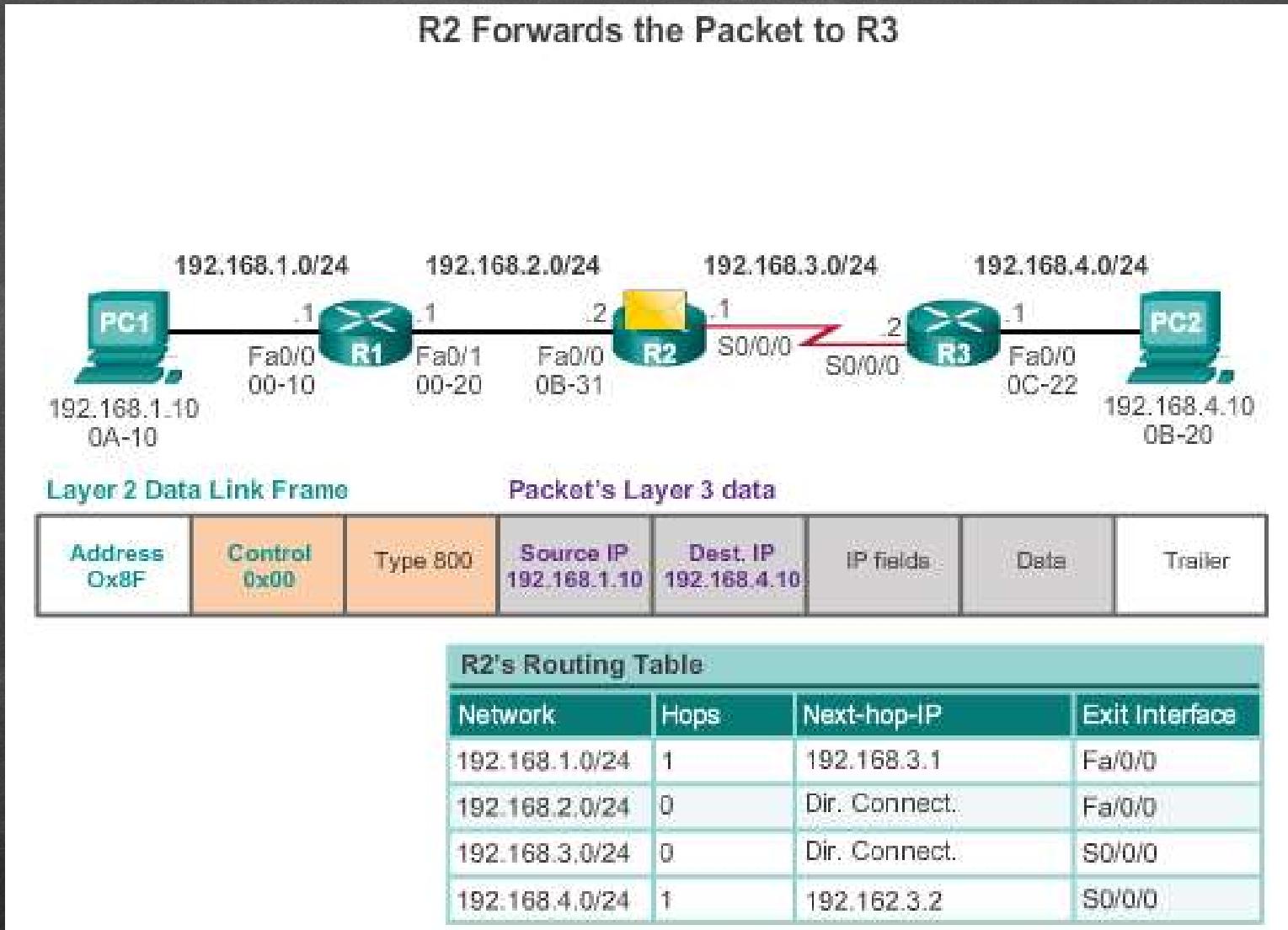
# Switching Packets between Networks

- Forward to the Next Hop



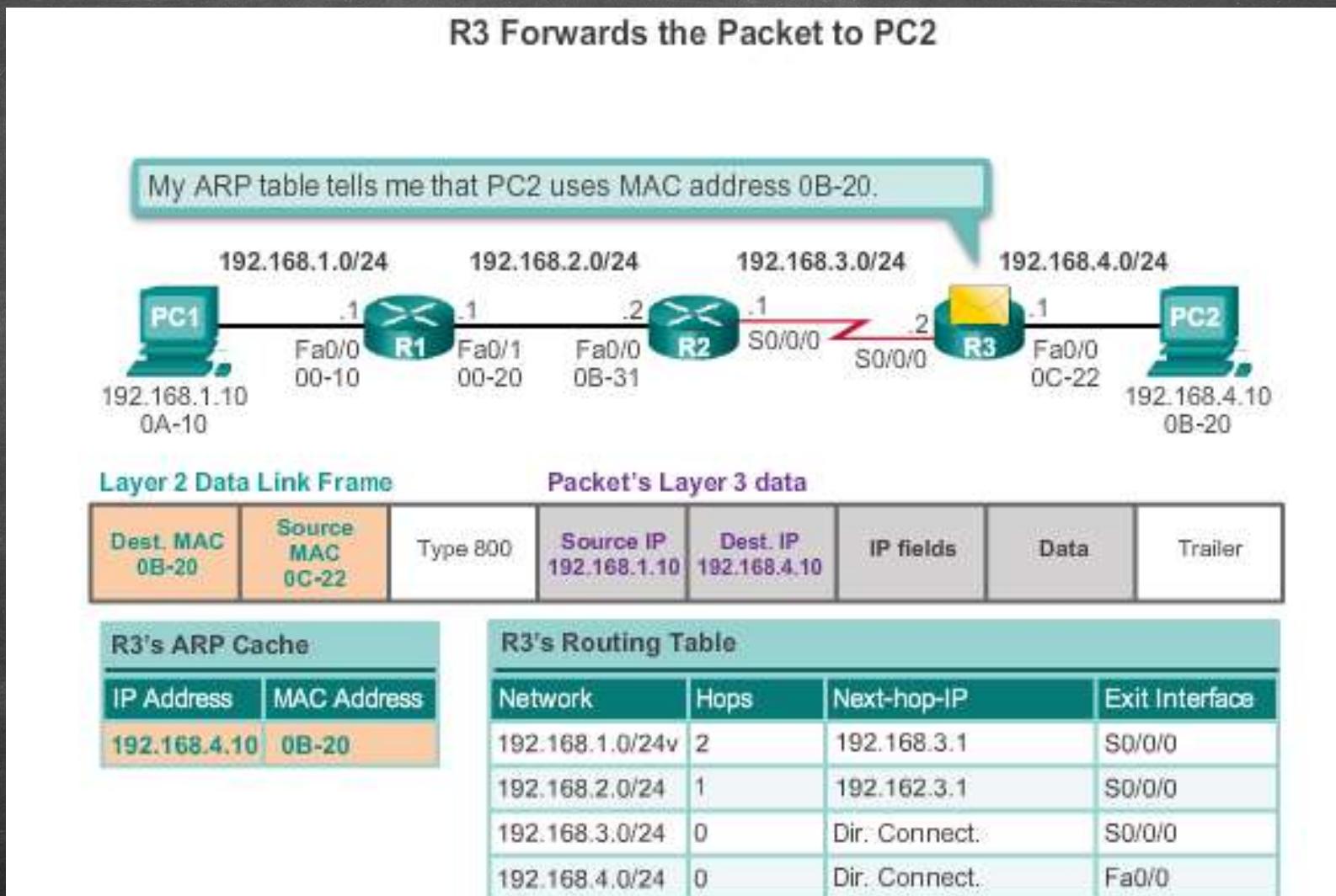
# Switching Packets between Networks

- Packet Routing

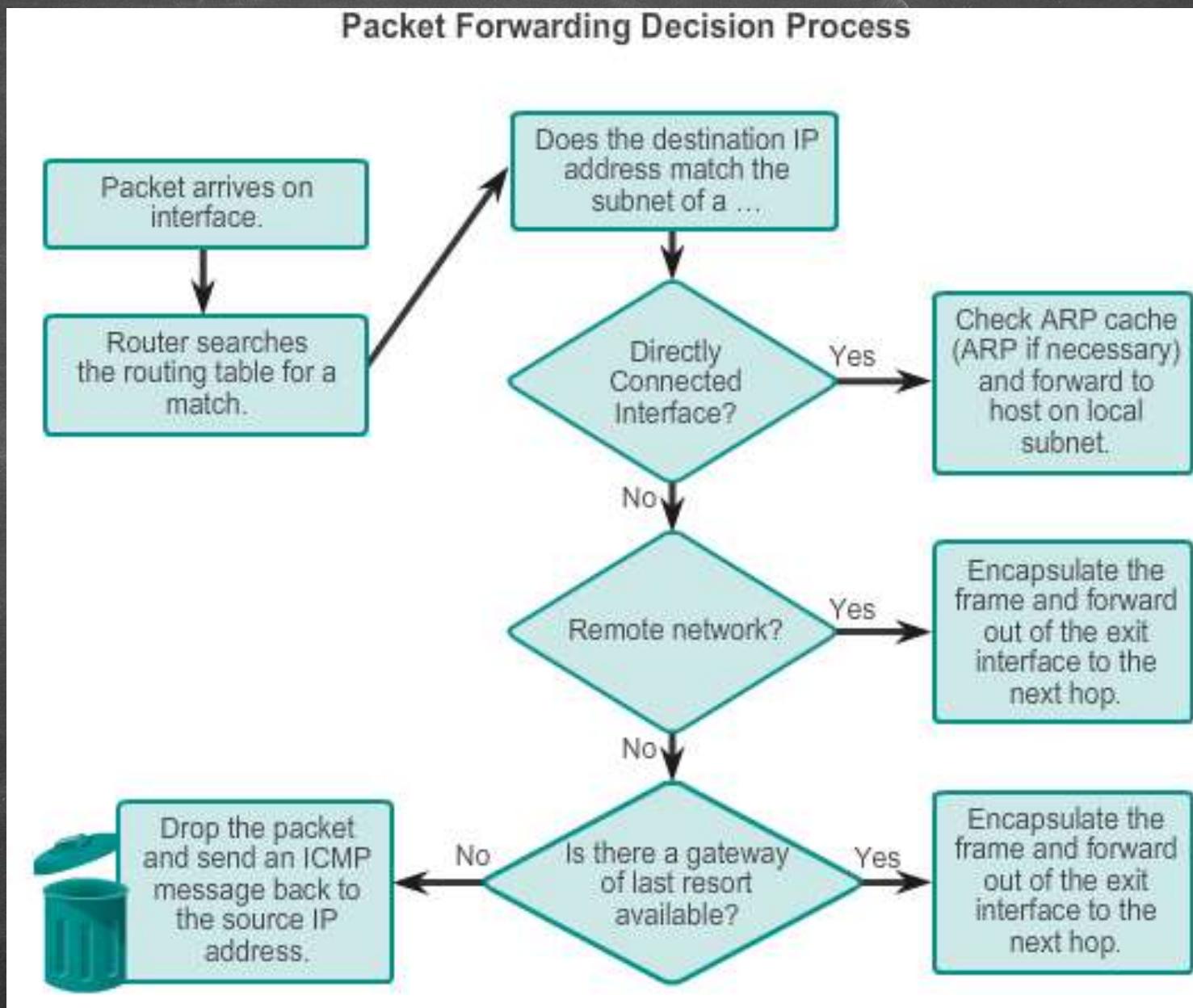


# Switching Packets between Networks

- Reach the Destination

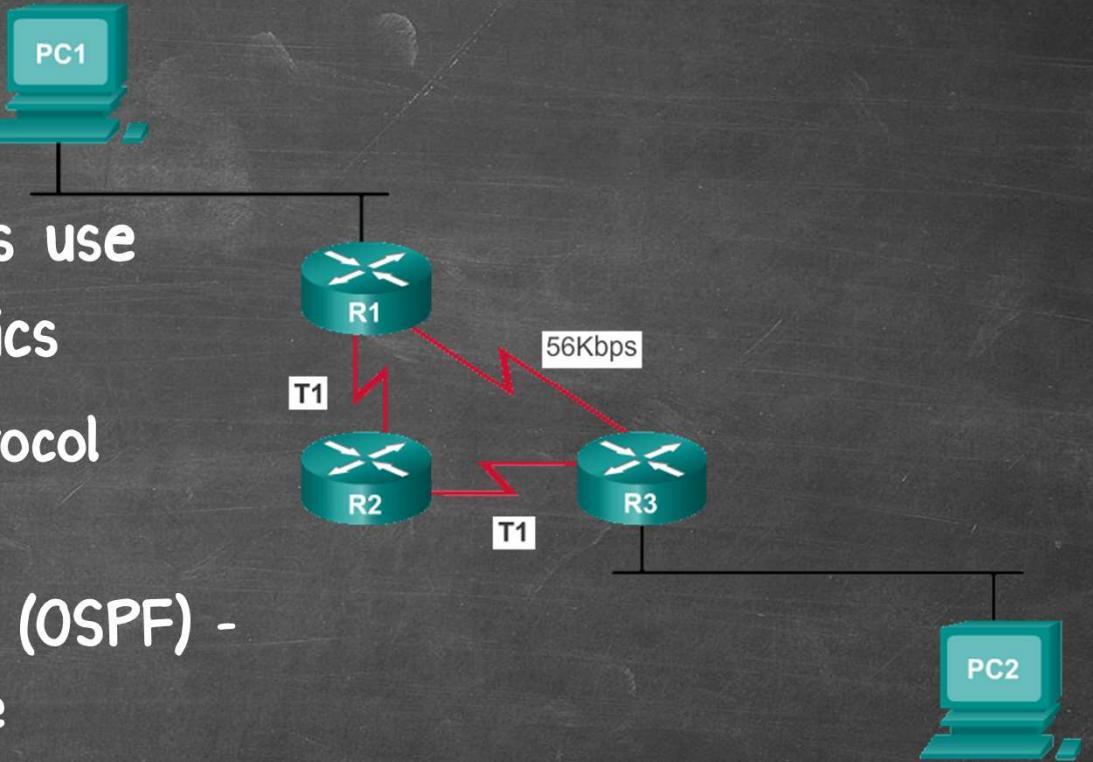


# Path Determination



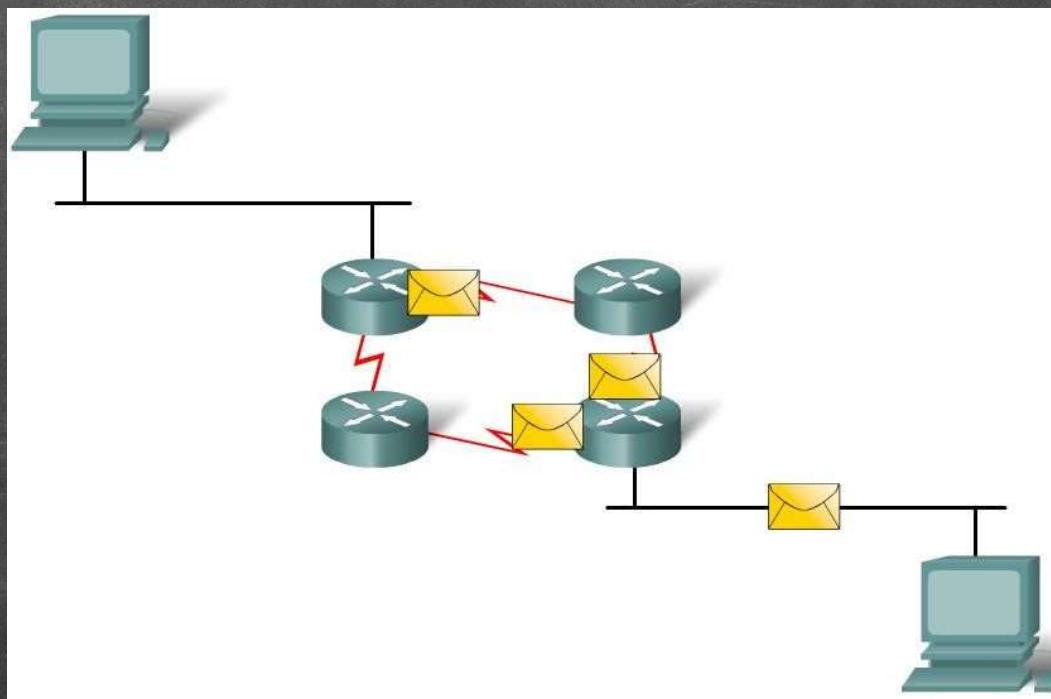
# Path Determination

- 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

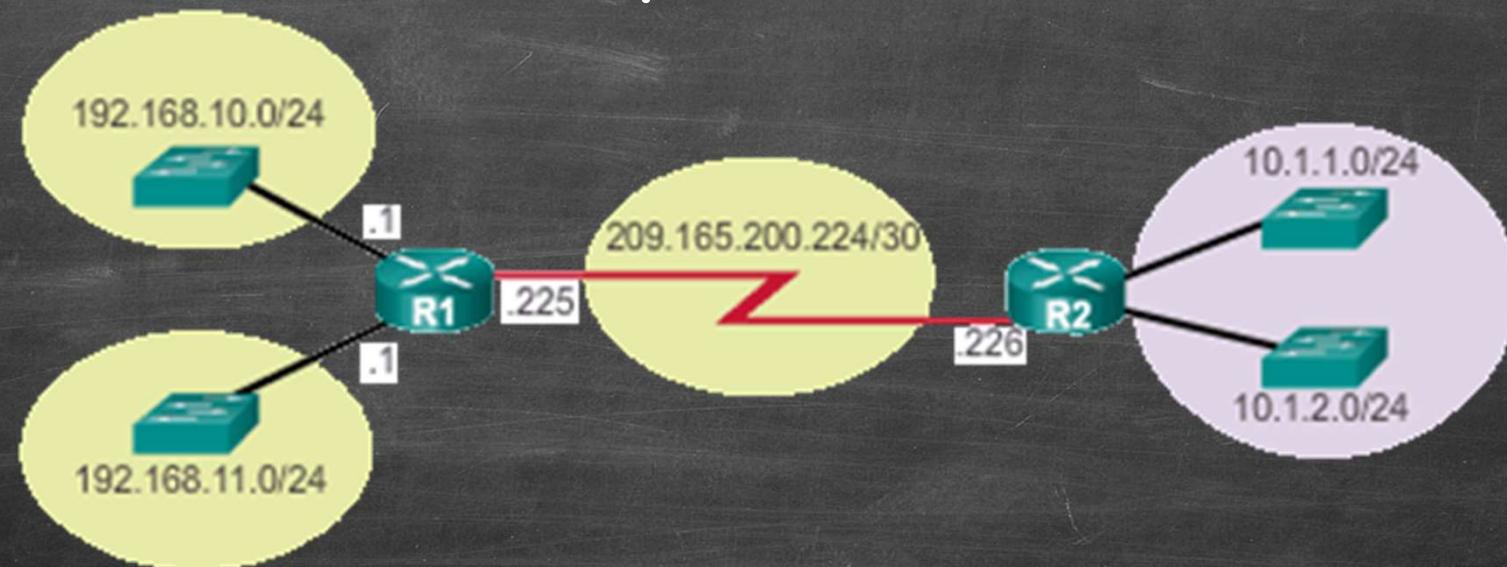
- Administrative Distance (AD) : “trustworthiness”

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

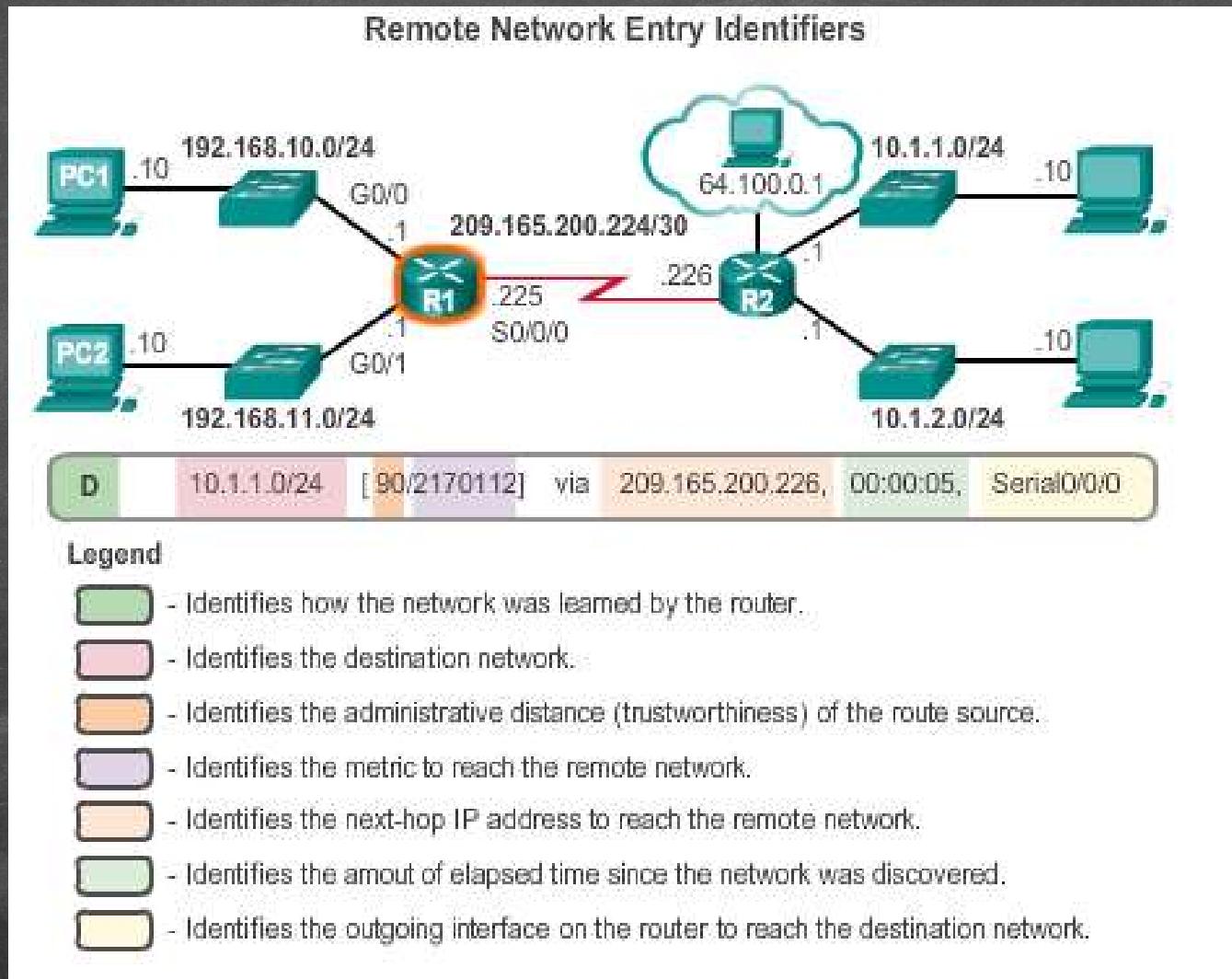
Gateway of last resort is not set

      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#

```

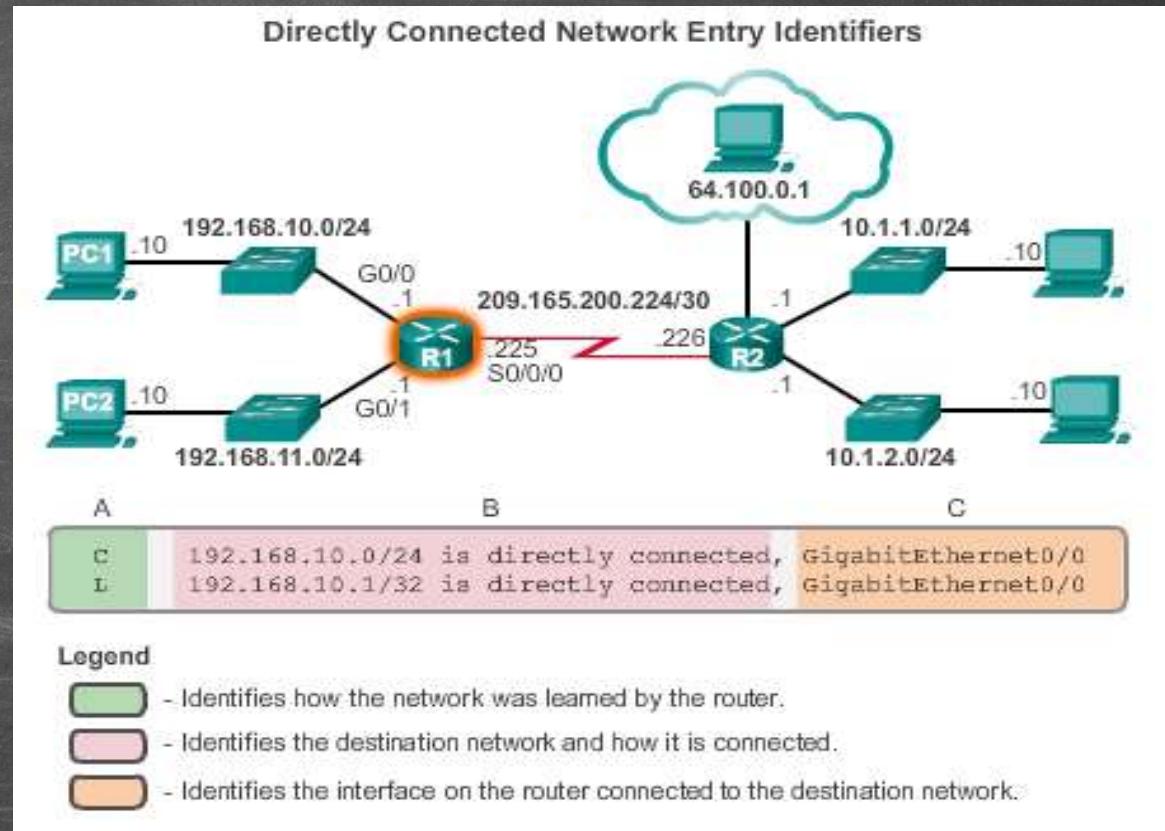
# The Routing Table

- 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

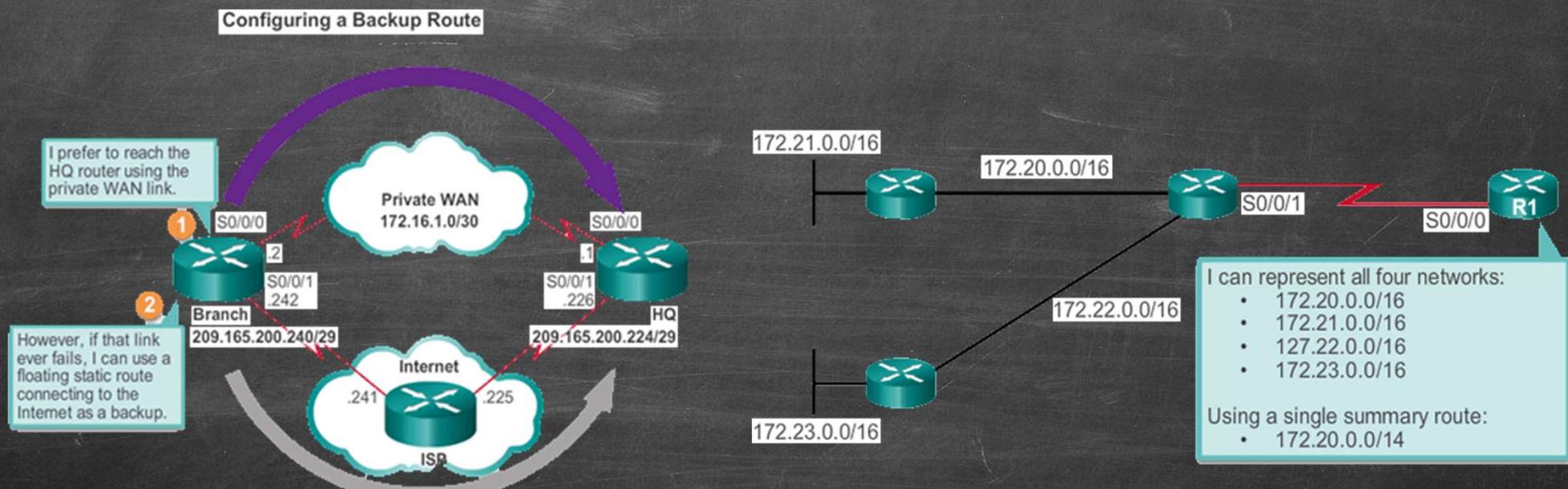
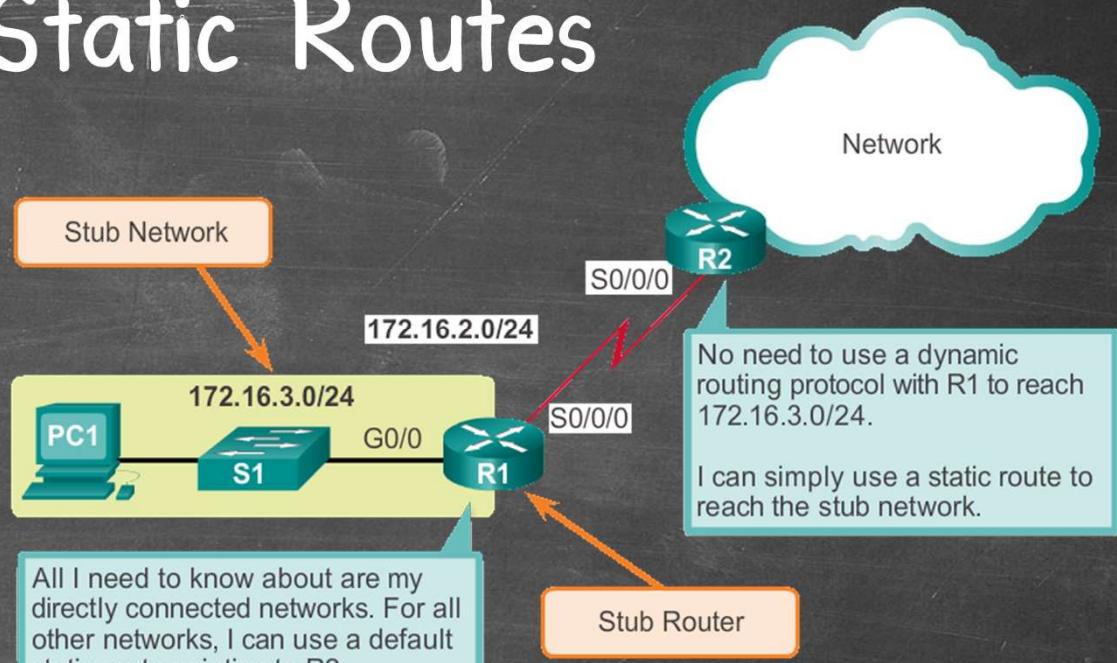
- Advantages
- Disadvantages
- When to Use Static Routes

# 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}
```

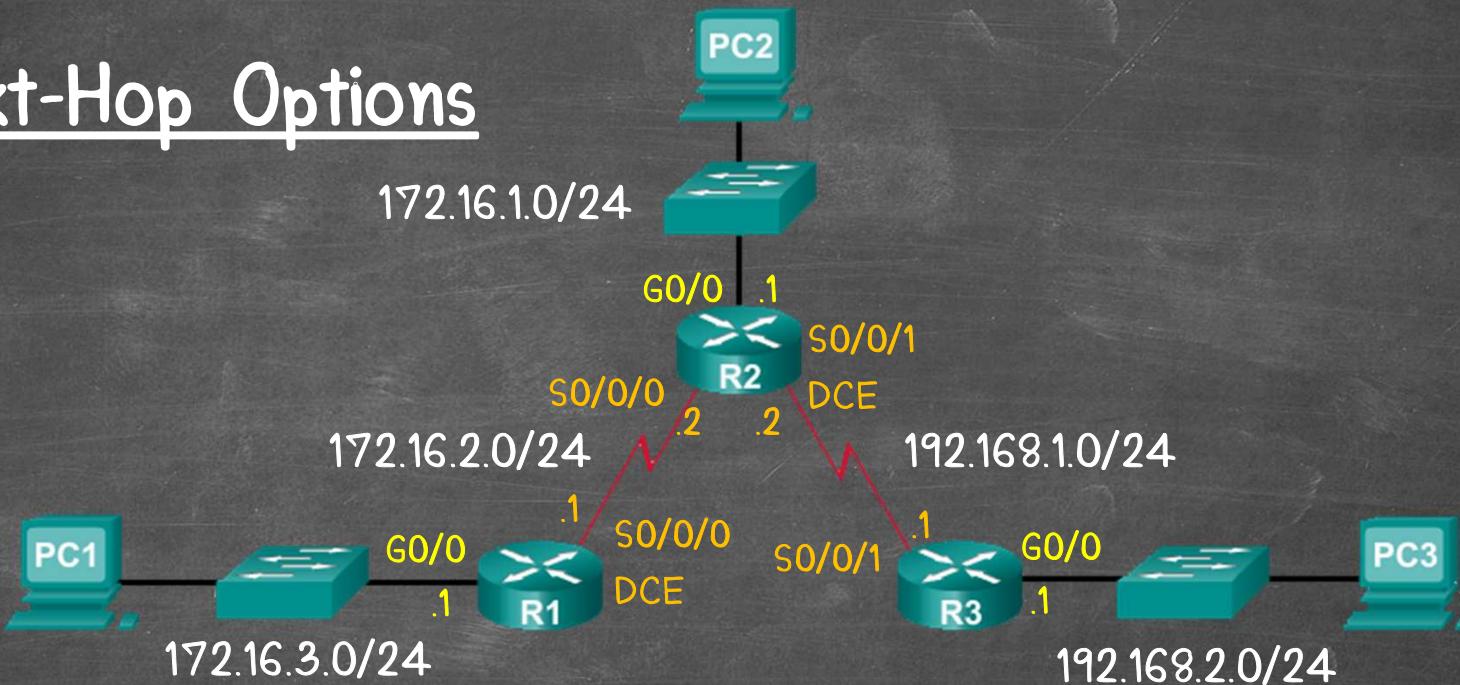
Parameter	Description
network-address	Destination network address of the remote network to be added to the routing table.
subnet-mask	<ul style="list-style-type: none"><li>Subnet mask of the remote network to be added to the routing table.</li><li>The subnet mask can be modified to summarize a group of networks.</li></ul>
ip-address	<ul style="list-style-type: none"><li>Commonly referred to as the next-hop router's IP address.</li><li>Typically used when connecting to a broadcast media (i.e., Ethernet).</li><li>Commonly creates a recursive lookup.</li></ul>
exit-intf	<ul style="list-style-type: none"><li>Use the outgoing interface to forward packets to the destination network.</li><li>Also referred to as a directly attached static route.</li><li>Typically used when connecting in a point-to-point configuration.</li></ul>

# 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



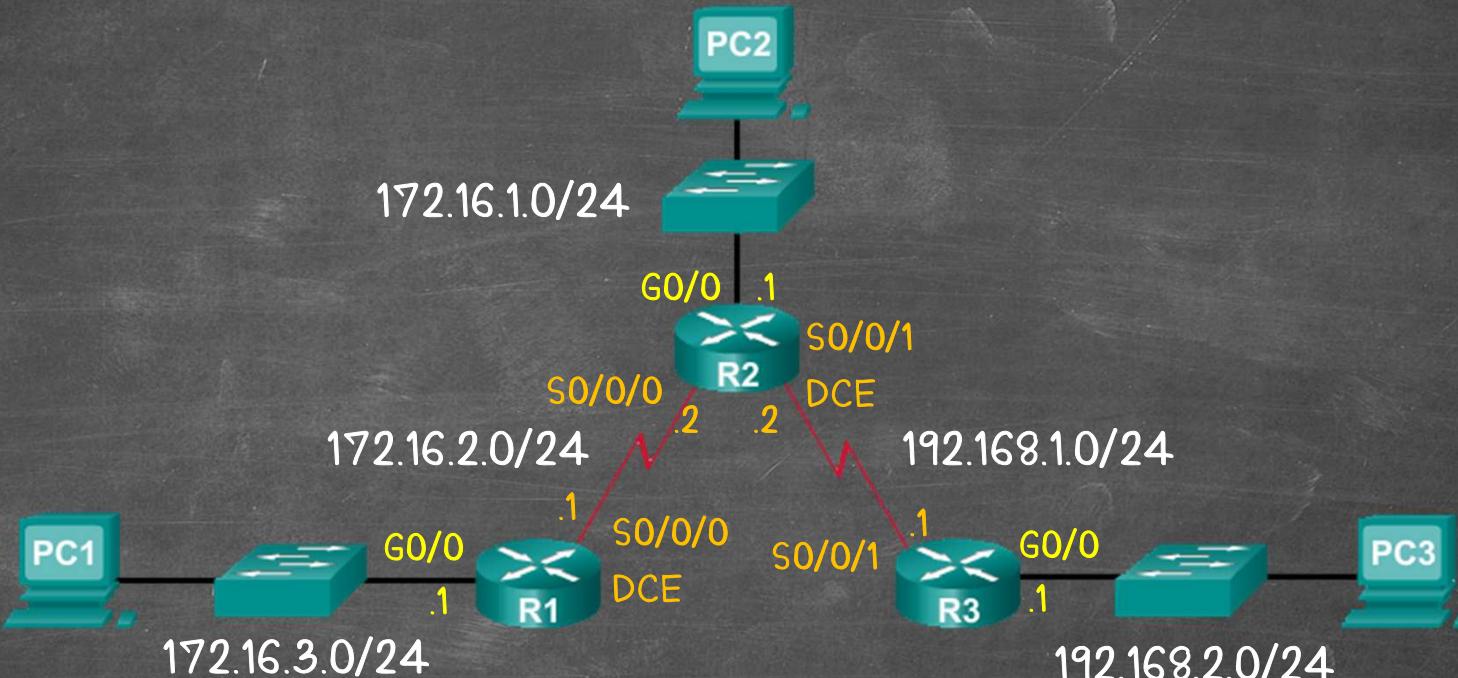
```
R1#show ip route | begin Gateway
Gateway of last resort is not set
  172.16.0.0/16 is variably subnet, 4 subnets, 2 masks
C    172.16.2.0/24 is directly connected, Serial0/0/0
L    172.16.2.1/32 is directly connected, Serial0/0/0
C    172.16.3.0/24 is directly connected, GigabitEthernet0/0
L    172.16.3.1/32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

```
R2#show ip route | begin Gateway
Gateway of last resort is not set
  172.16.0.0/16 is variably 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 variably 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 variably 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 variably 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
```

## 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
```

```
R1#show ip route | 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
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 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#
```

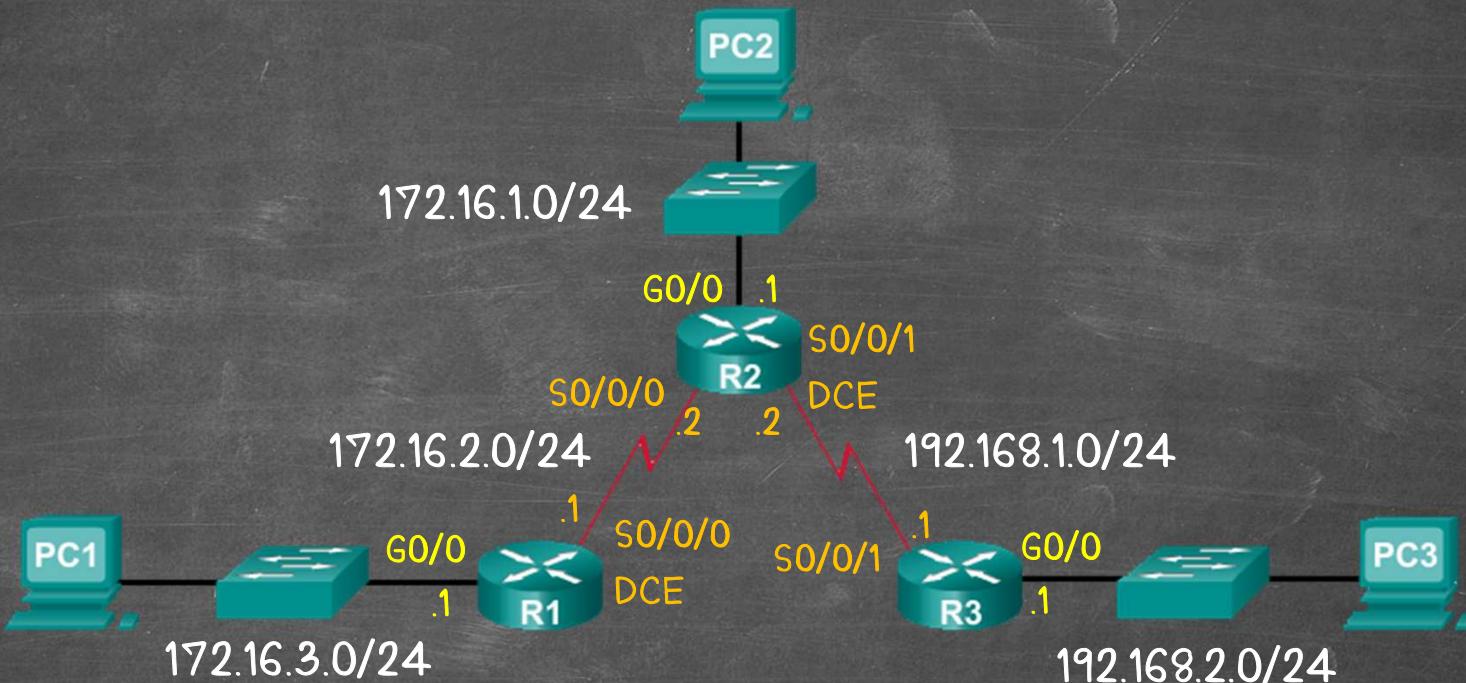
# Configure IPv4 Static Routes

## 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	<ul style="list-style-type: none"><li>Commonly referred to as the next-hop router's IP address.</li><li>Typically used when connecting to a broadcast media (i.e., Ethernet).</li><li>Commonly creates a recursive lookup.</li></ul>
exit-intf	<ul style="list-style-type: none"><li>Use the outgoing interface to forward packets to the destination network.</li><li>Also referred to as a directly attached static route.</li><li>Typically used when connecting in a point-to-point configuration.</li></ul>

# 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
```

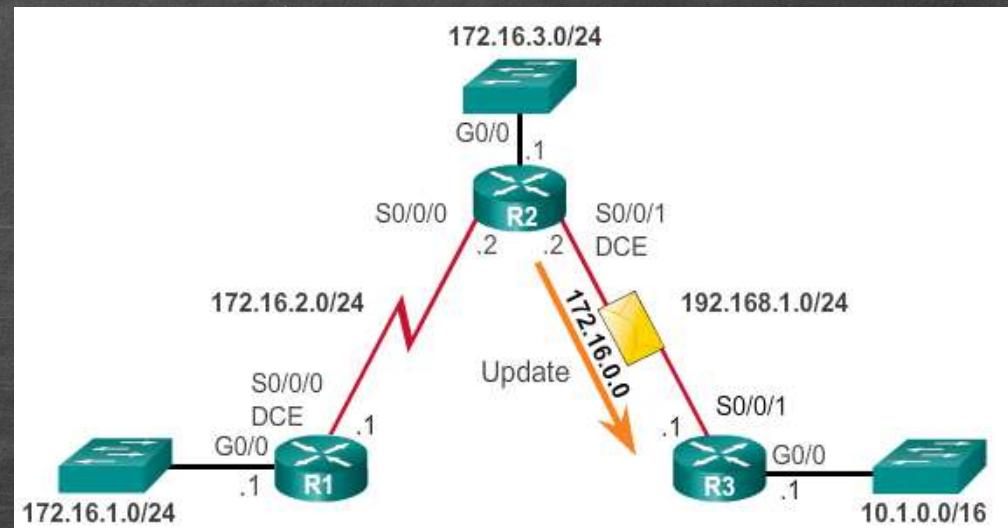
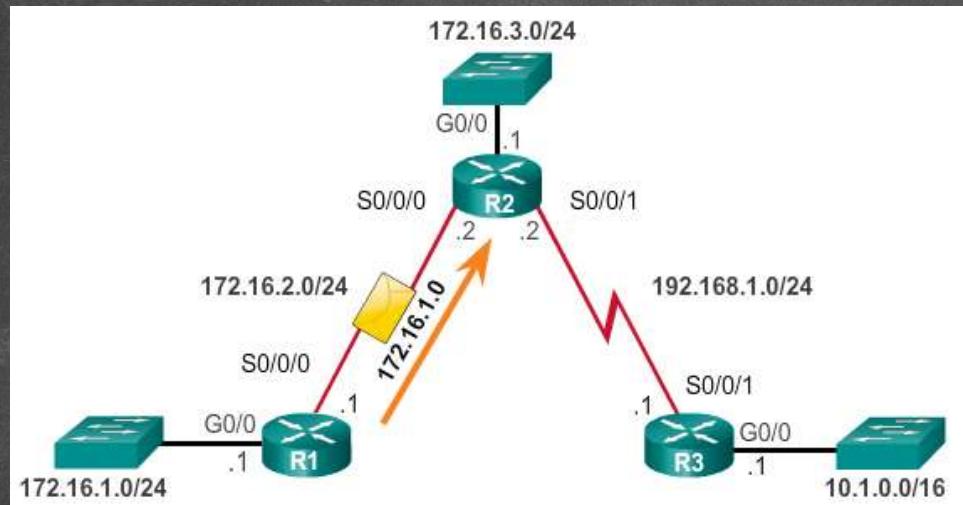
# Classful Addressing

- 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

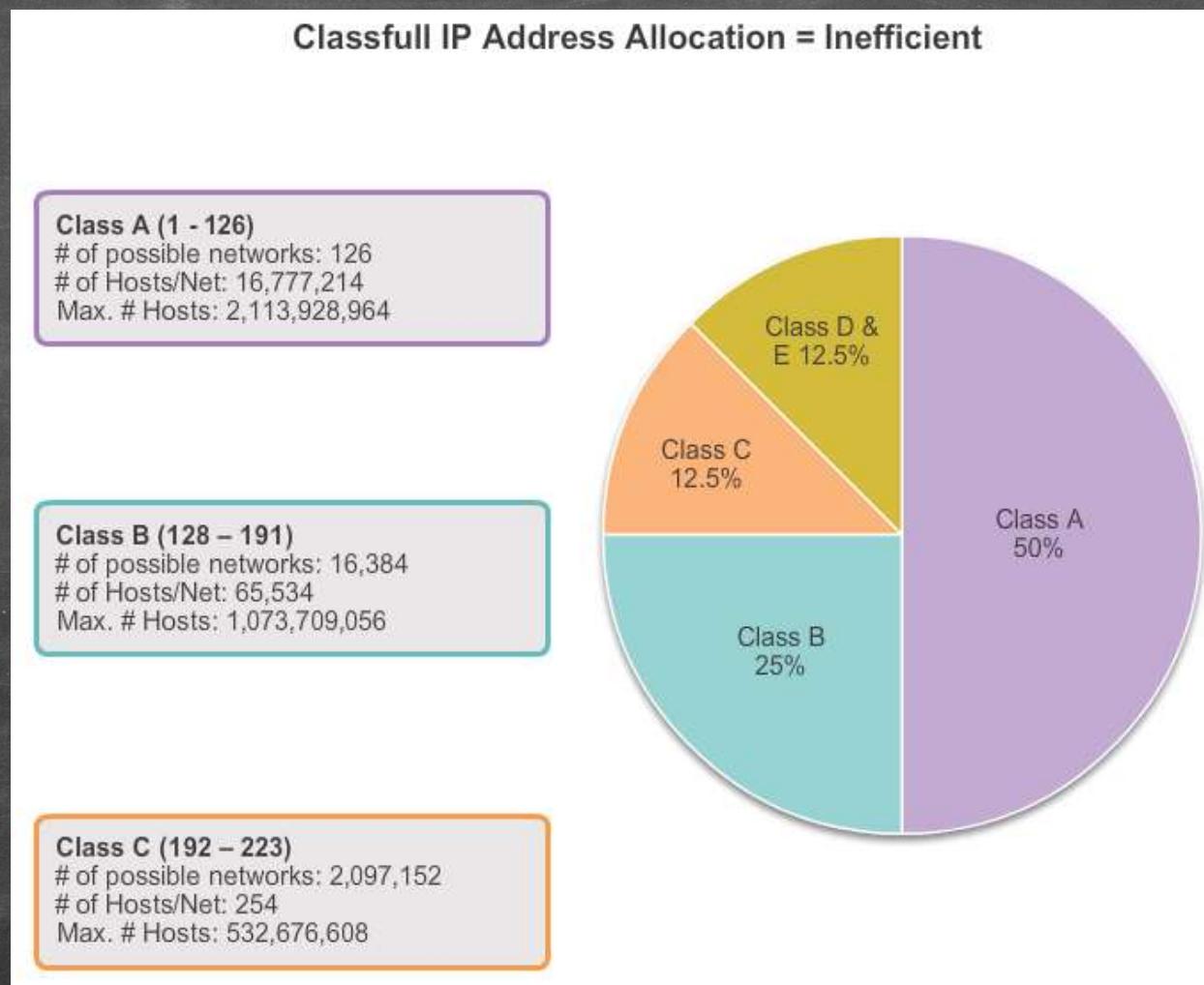
# Classful Addressing

- Classful Routing Protocol Example



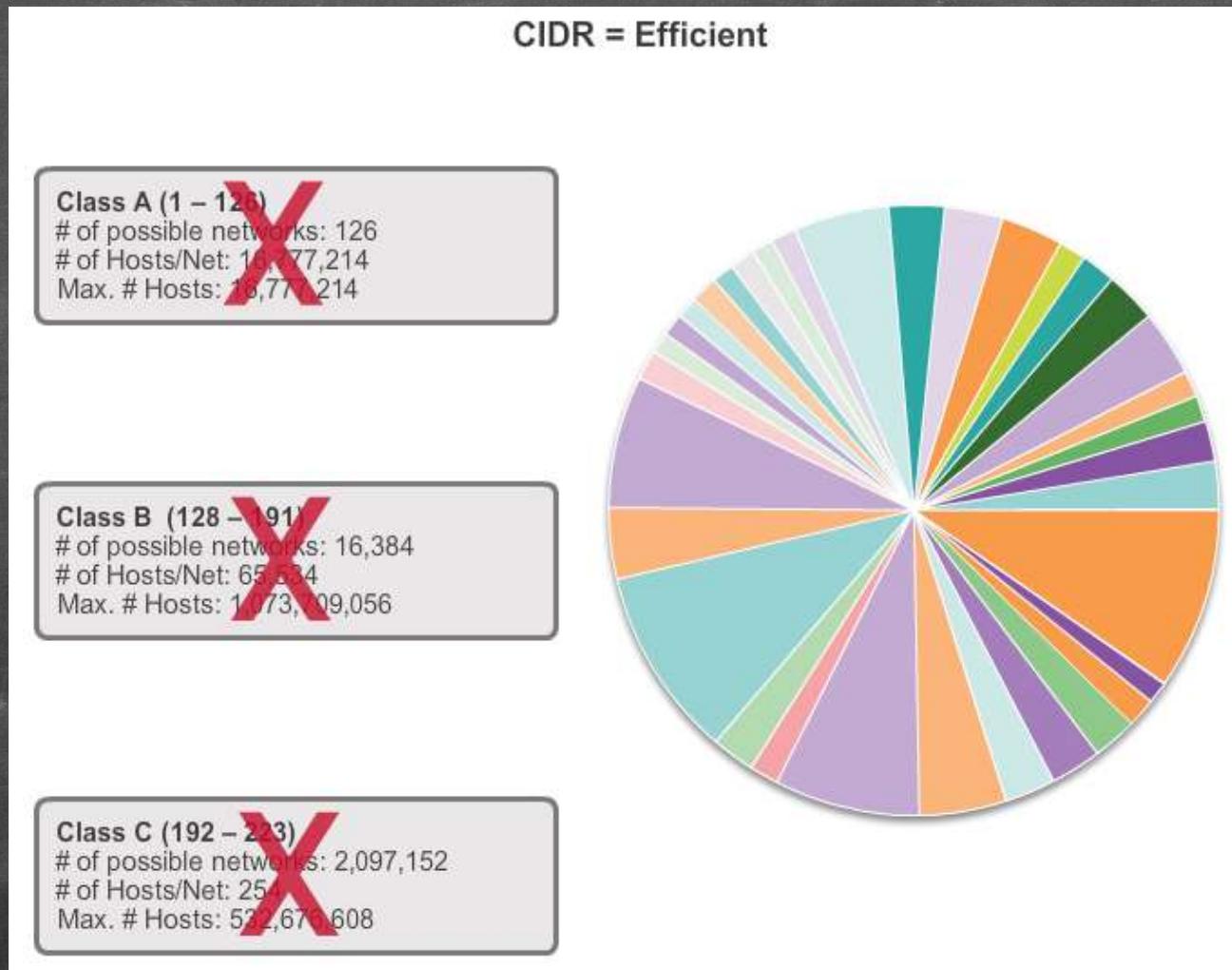
# Classful Addressing

- Classful Addressing Waste



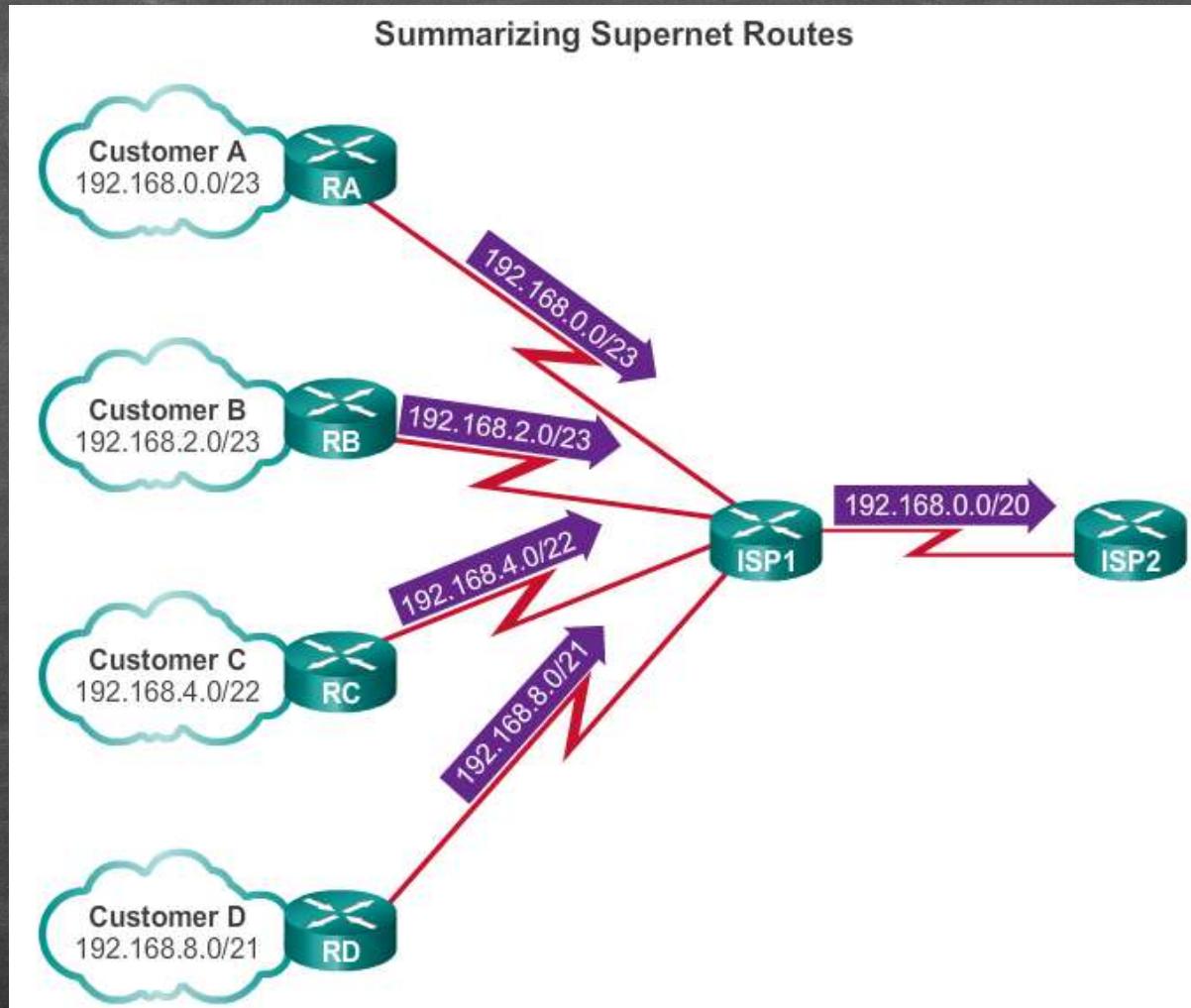
# CIDR

- Classless Inter-Domain Routing



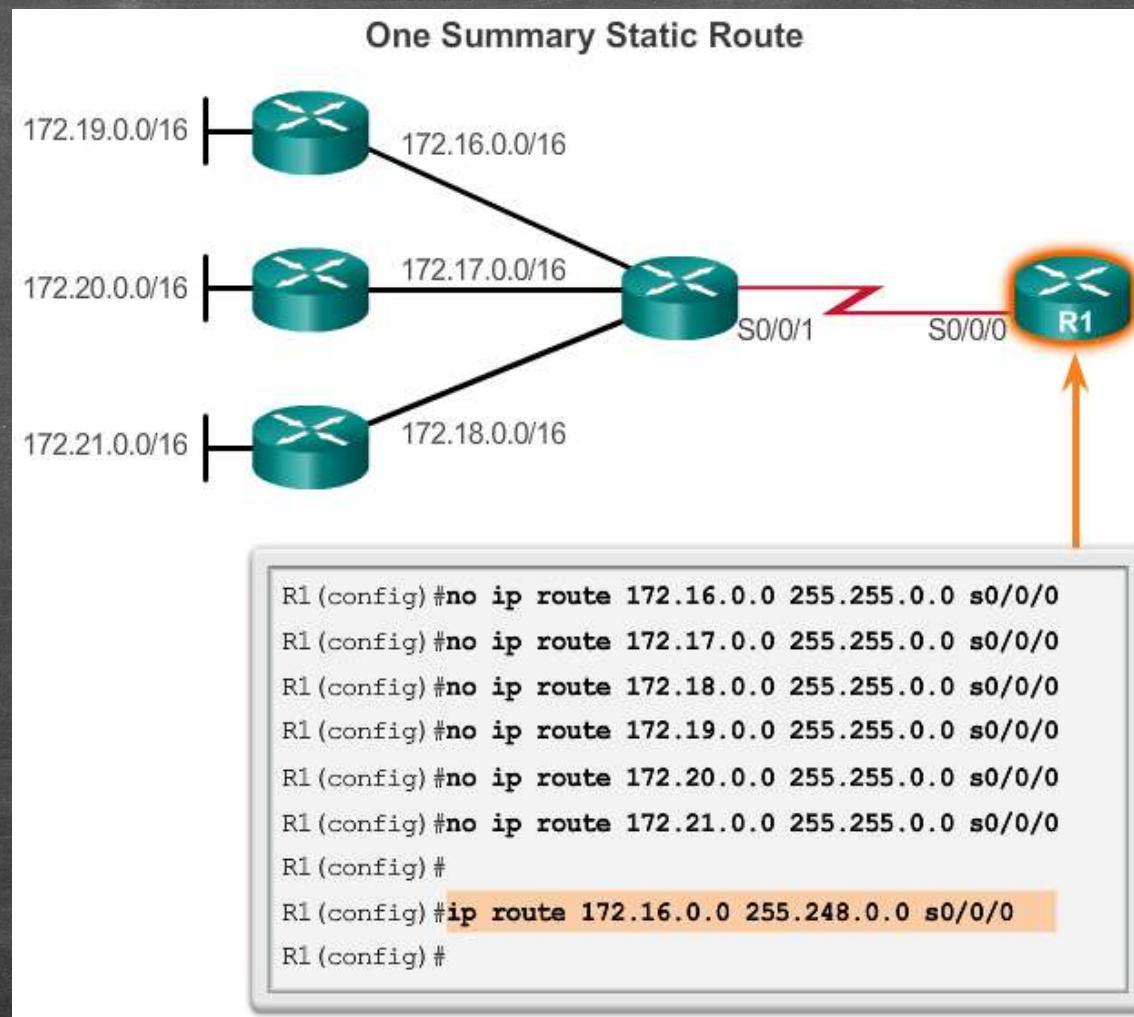
# CIDR

- CIDR and Route Summarization



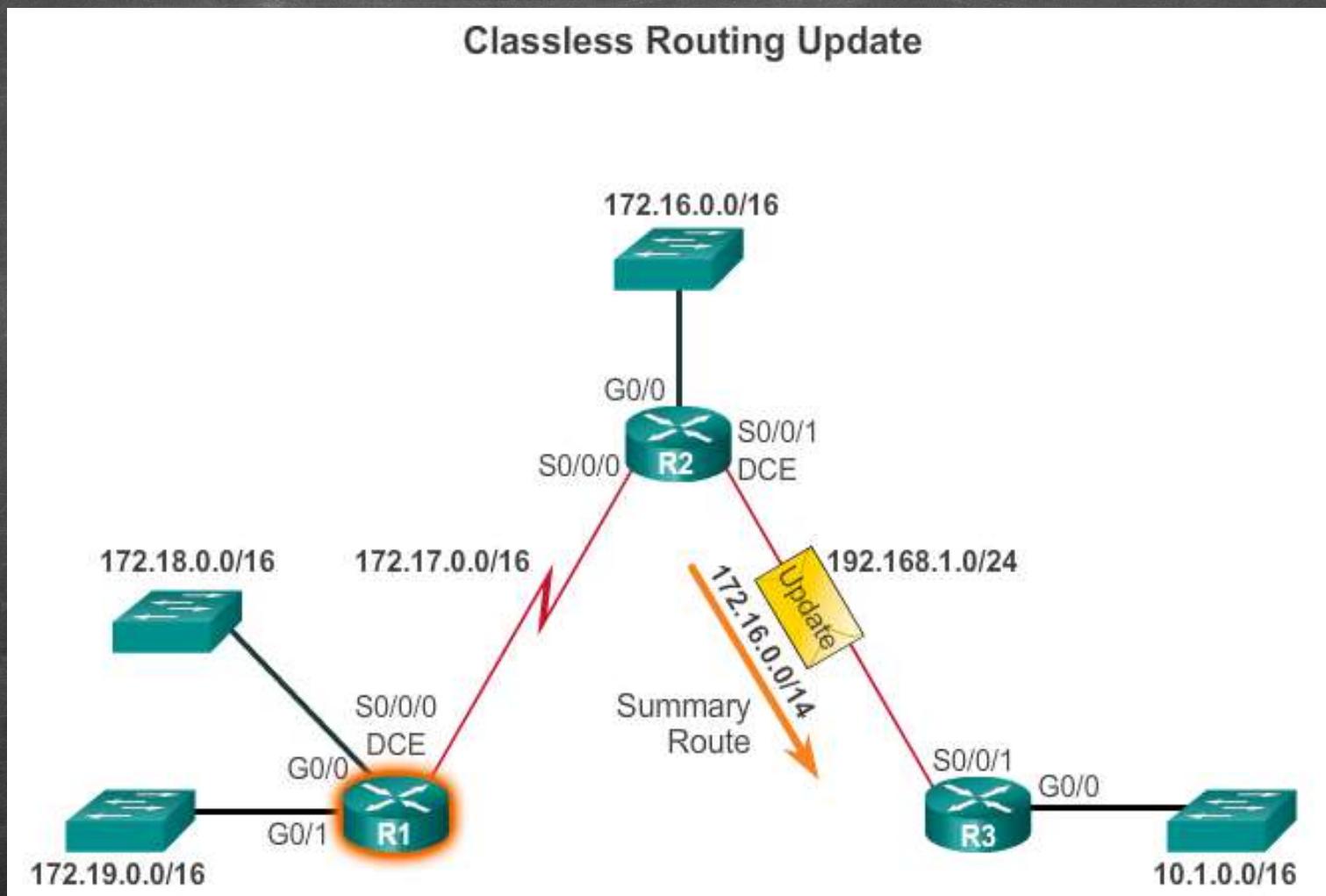
# CIDR

- Static Routing CIDR Example



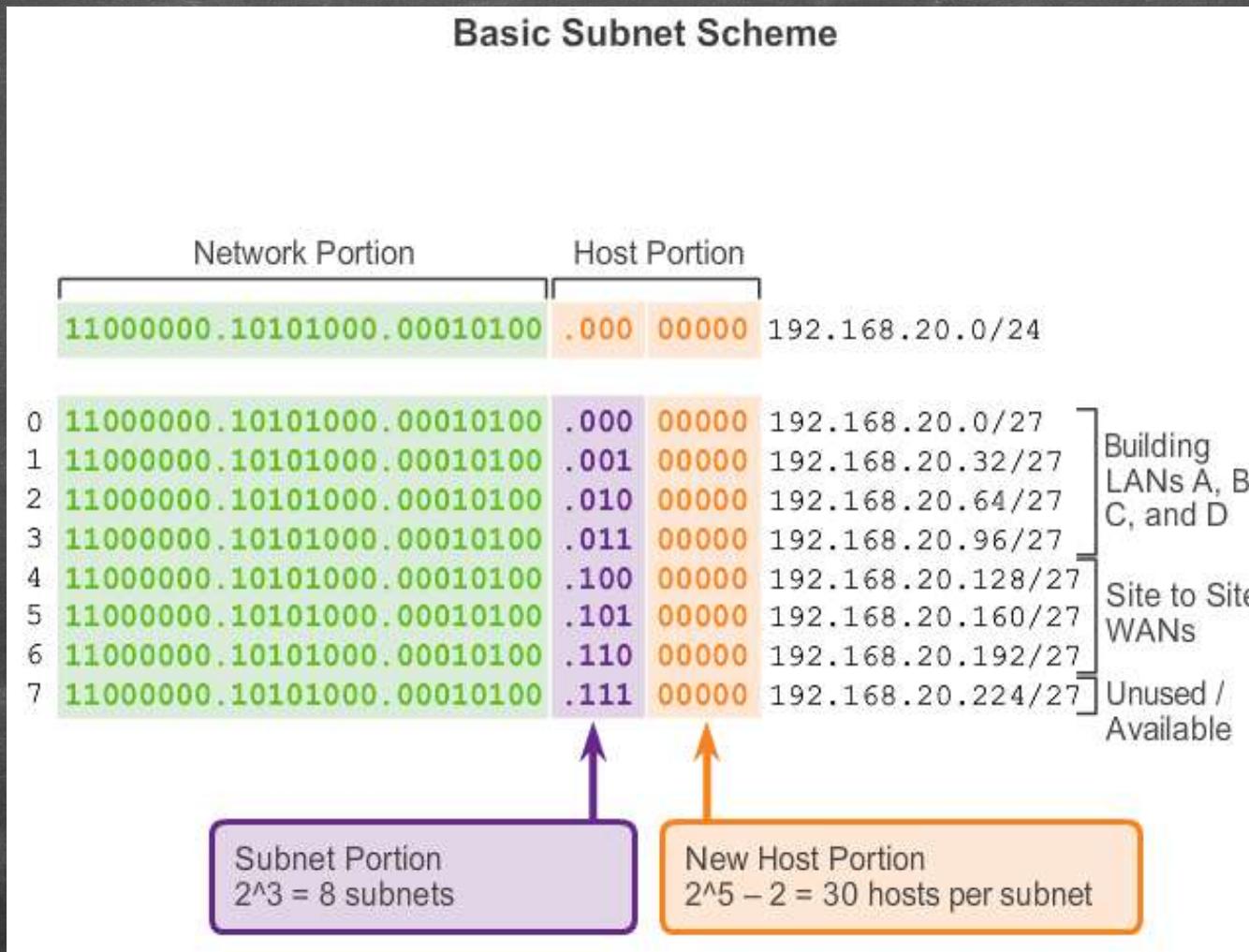
# CIDR

- Classless Routing Protocol Example



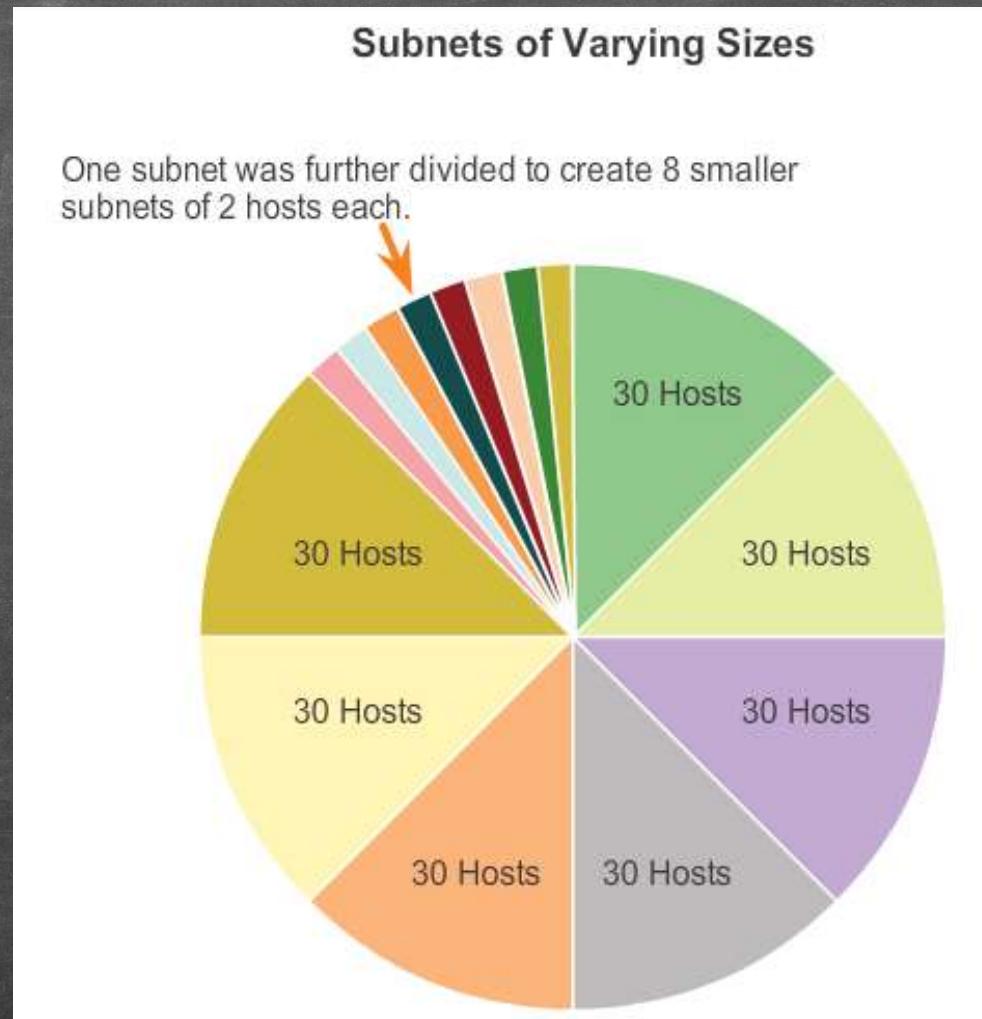
# VLSM

- Fixed Length Subnet Masking



# VLSM

- Variable Length Subnet Masking

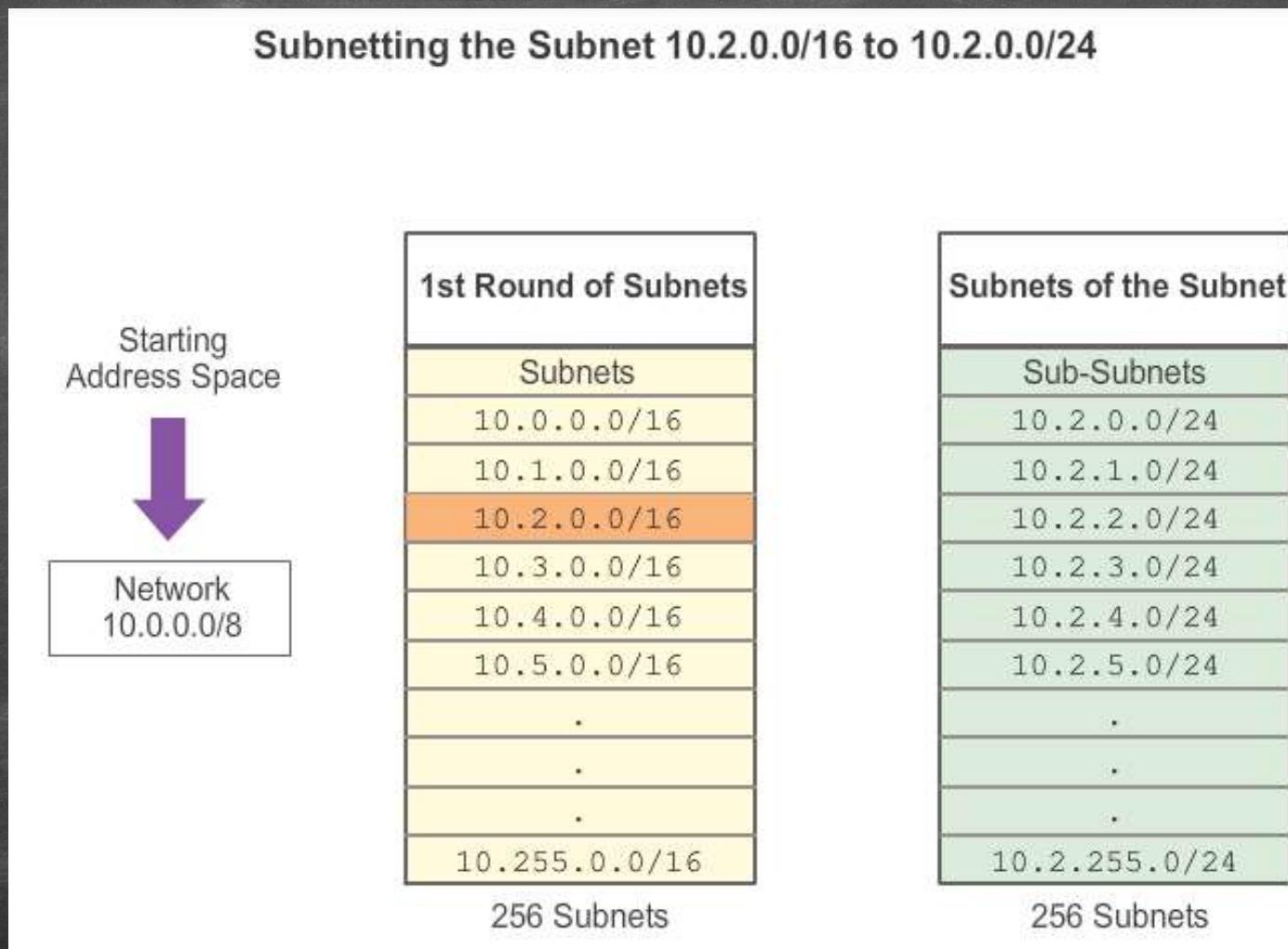


# VLSM

- 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".

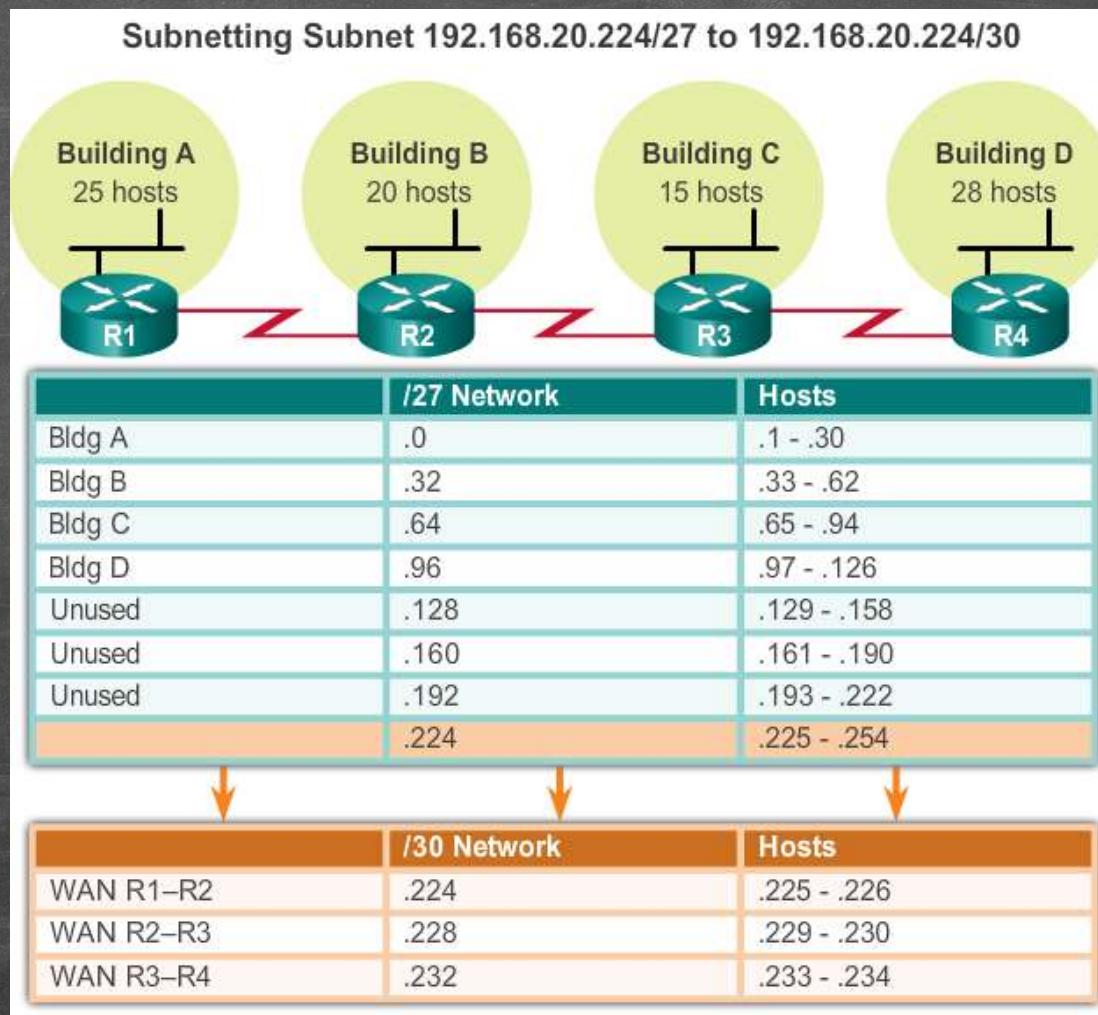
# VLSM

- Subnetting Subnets



# VLSM

- VLSM Example



# 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

## Calculating a Route Summary

Step 1: List networks in binary format.

172.20.0.0	10101100 . 00010100 . 00000000 . 00000000
172.21.0.0	10101100 . 00010101 . 00000000 . 00000000
172.22.0.0	10101100 . 00010110 . 00000000 . 00000000
172.23.0.0	10101100 . 00010111 . 00000000 . 00000000

Step 2: Count the number of far-left matching bits to determine the mask.

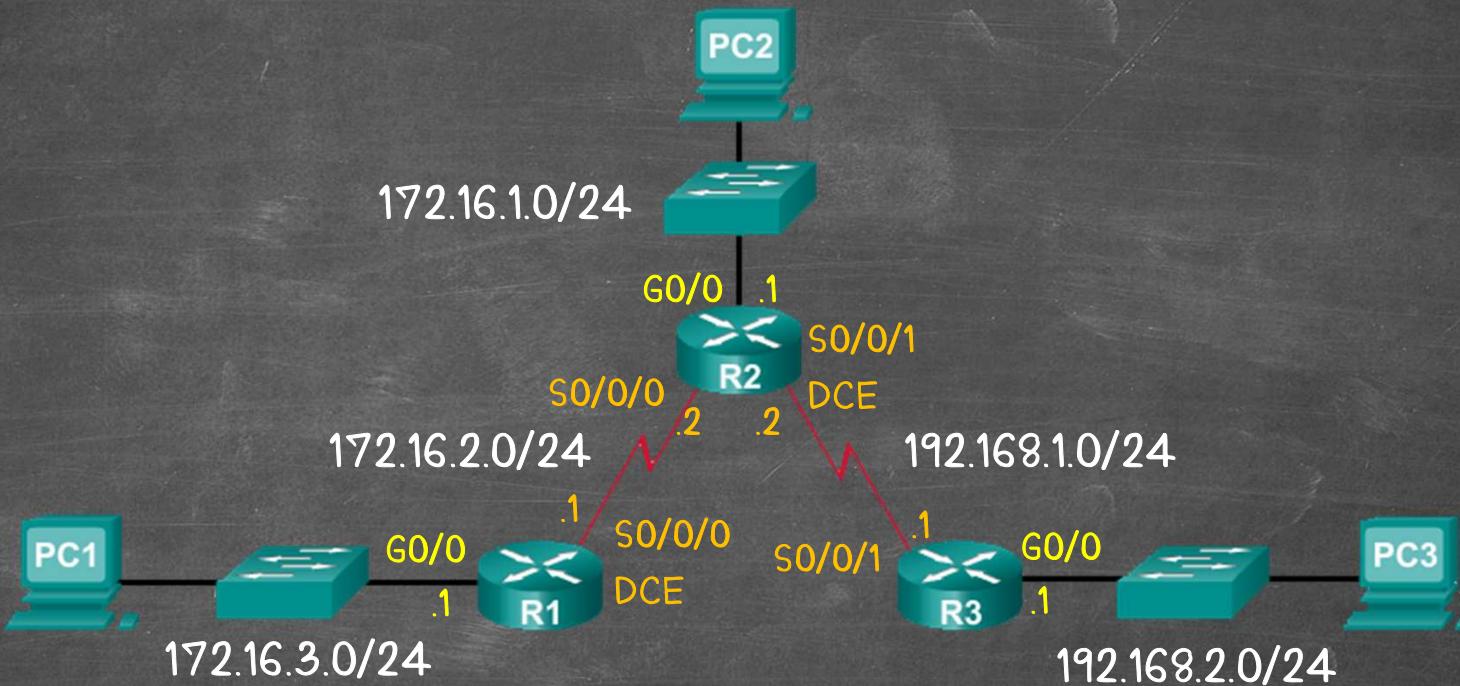
Answer: 14 matching bits = /14 or 255.252.0.0

Step 3: Copy the matching bits and add zero bits to determine the network address.

10101100 . 00010100 . 00000000 . 00000000
----- ----- ----- -----
Copy      Add zero bits

Answer: 172.20.0.0

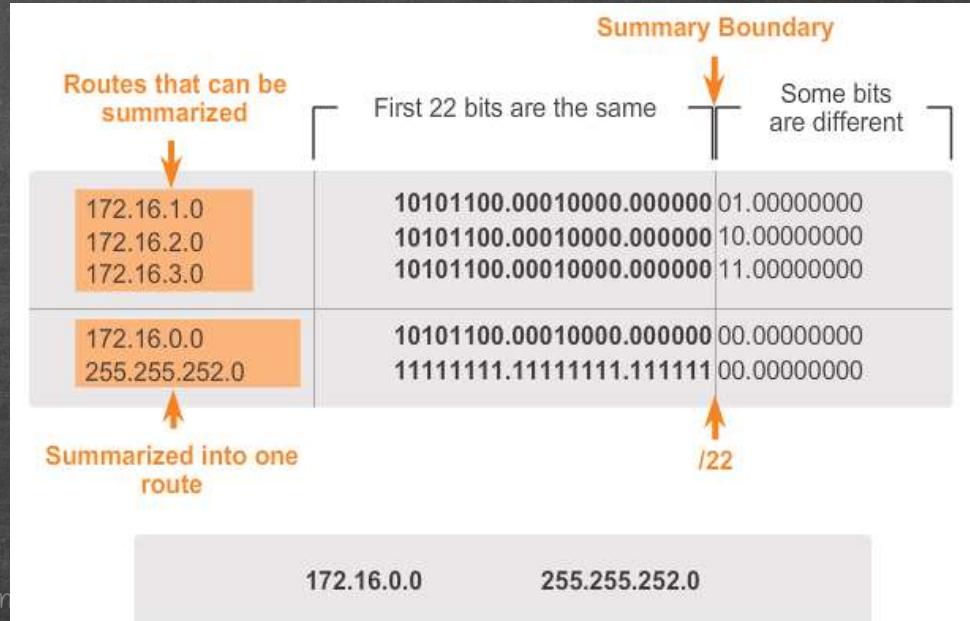
# Configure IPv4 Summary Routes



```
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
```

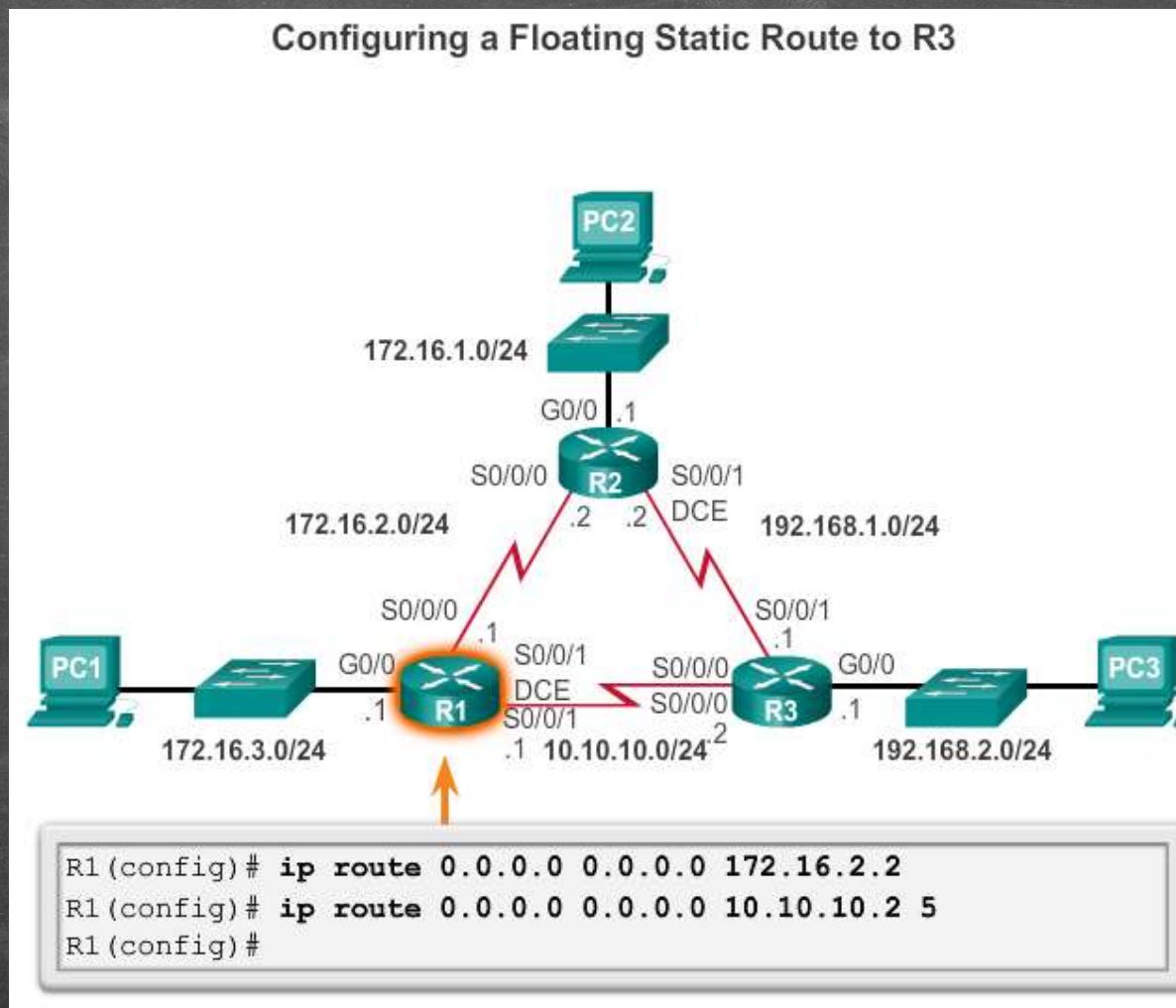


# Configure Floating Static Routes

- 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

