



Chapter 4: Routing Concepts



Routing & Switching

Cisco | Networking Academy®
Mind Wide Open™



Chapter 4

- 4.0 Routing Concepts
- 4.1 Initial Configuration of a Router
- 4.2 Routing Decisions
- 4.3 Router Operation
- 4.4 Summary



Chapter 4: Objectives

- Configure a router to route between multiple directly connected networks
- Describe the primary functions and features of a router.
- Explain how routers use information in data packets to make forwarding decisions in a small- to medium-sized business network.
- Explain the encapsulation and de-encapsulation process used by routers when switching packets between interfaces.
- Compare ways in which a router builds a routing table when operating in a small- to medium-sized business network.
- Explain routing table entries for directly connected networks.
- Explain how a router builds a routing table of directly connected networks.



Chapter 4: Objectives (cont.)

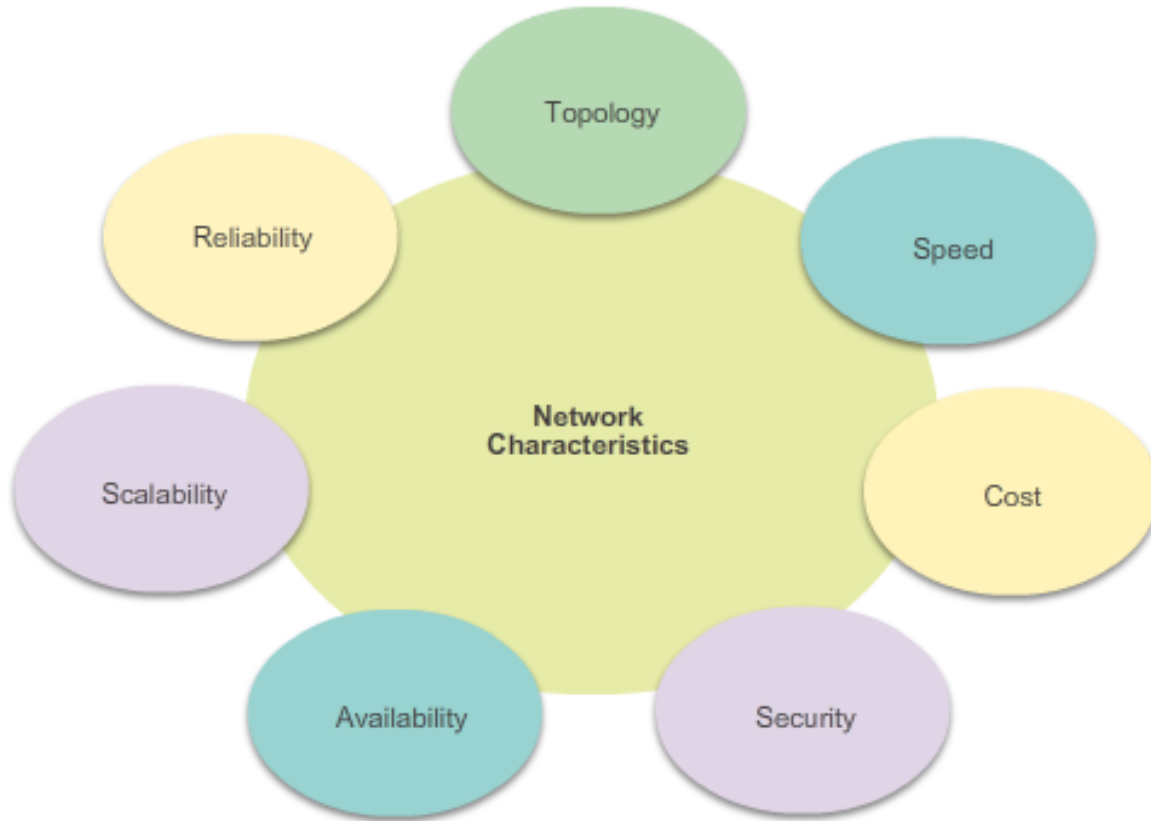
- Explain how a router builds a routing table using static routes.
- Explain how a router builds a routing table using a dynamic routing protocol.



Functions of a Router

Characteristics of a Network

Network Characteristics

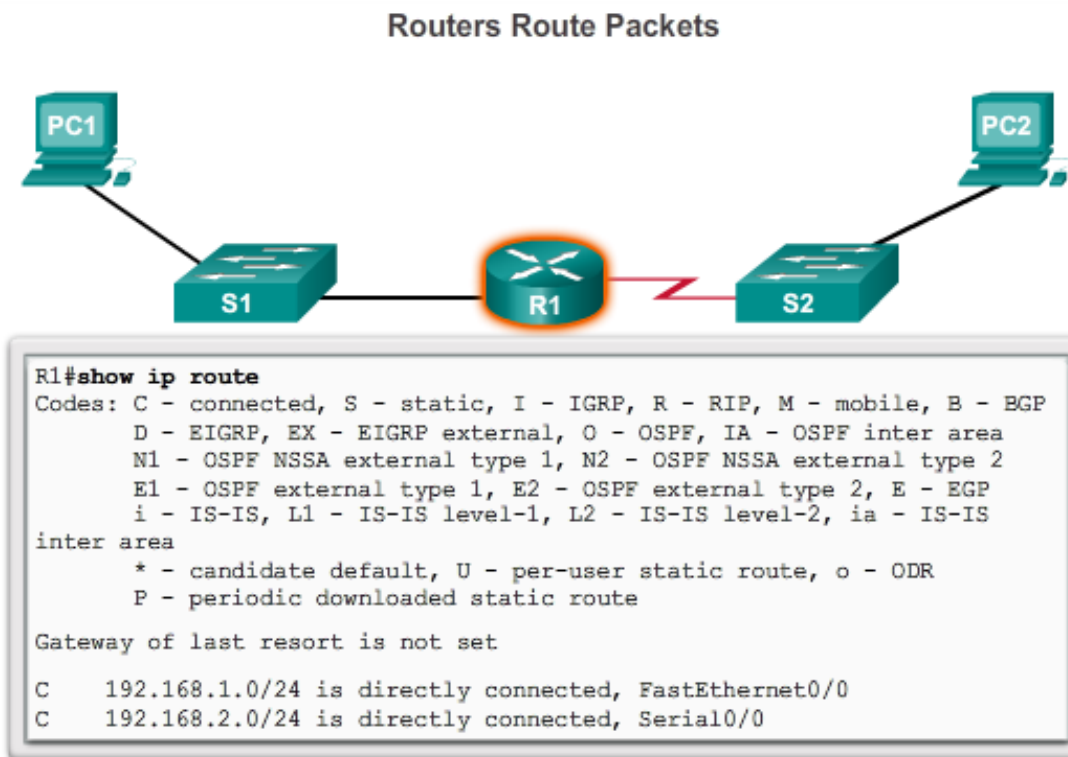




Functions of a Router

Why Routing?

The router is responsible for the routing of traffic between networks.



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)

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

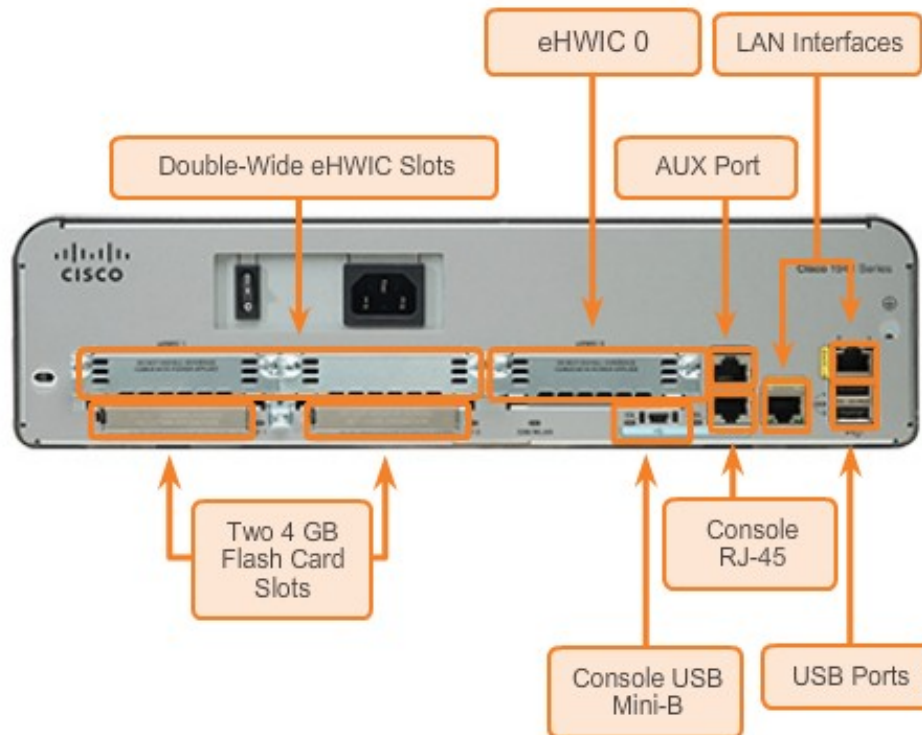


Functions of a Router

Routers are Computers

Routers use specialized ports and network interface cards to interconnect to other networks.

Back Panel of a Router

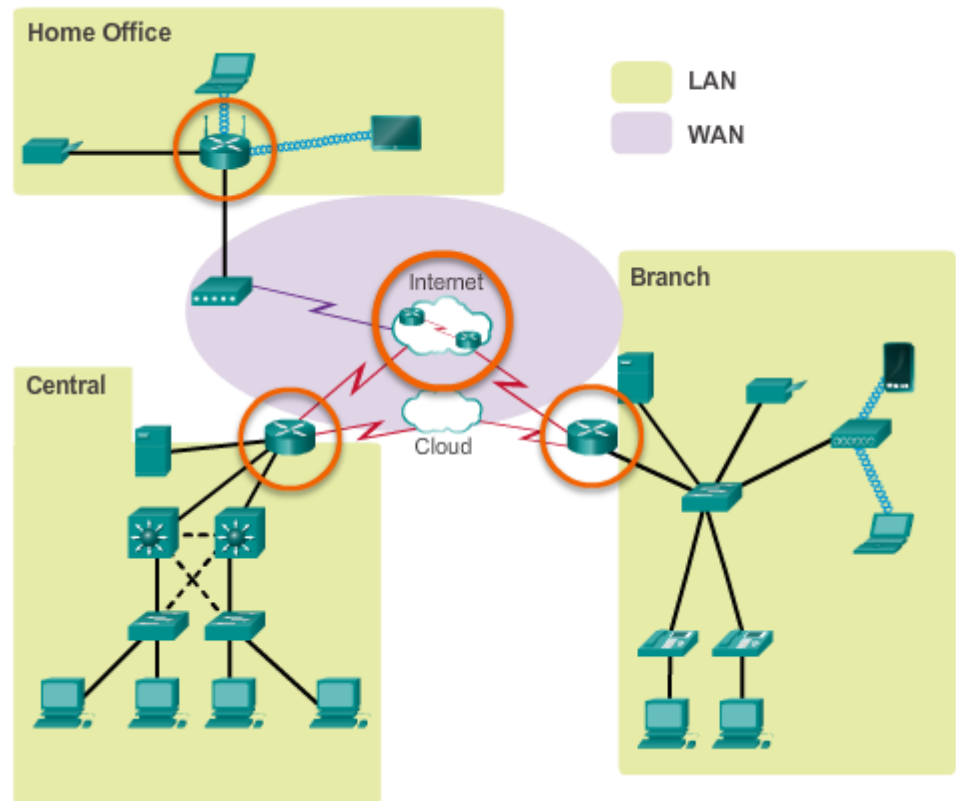




Functions of a Router

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

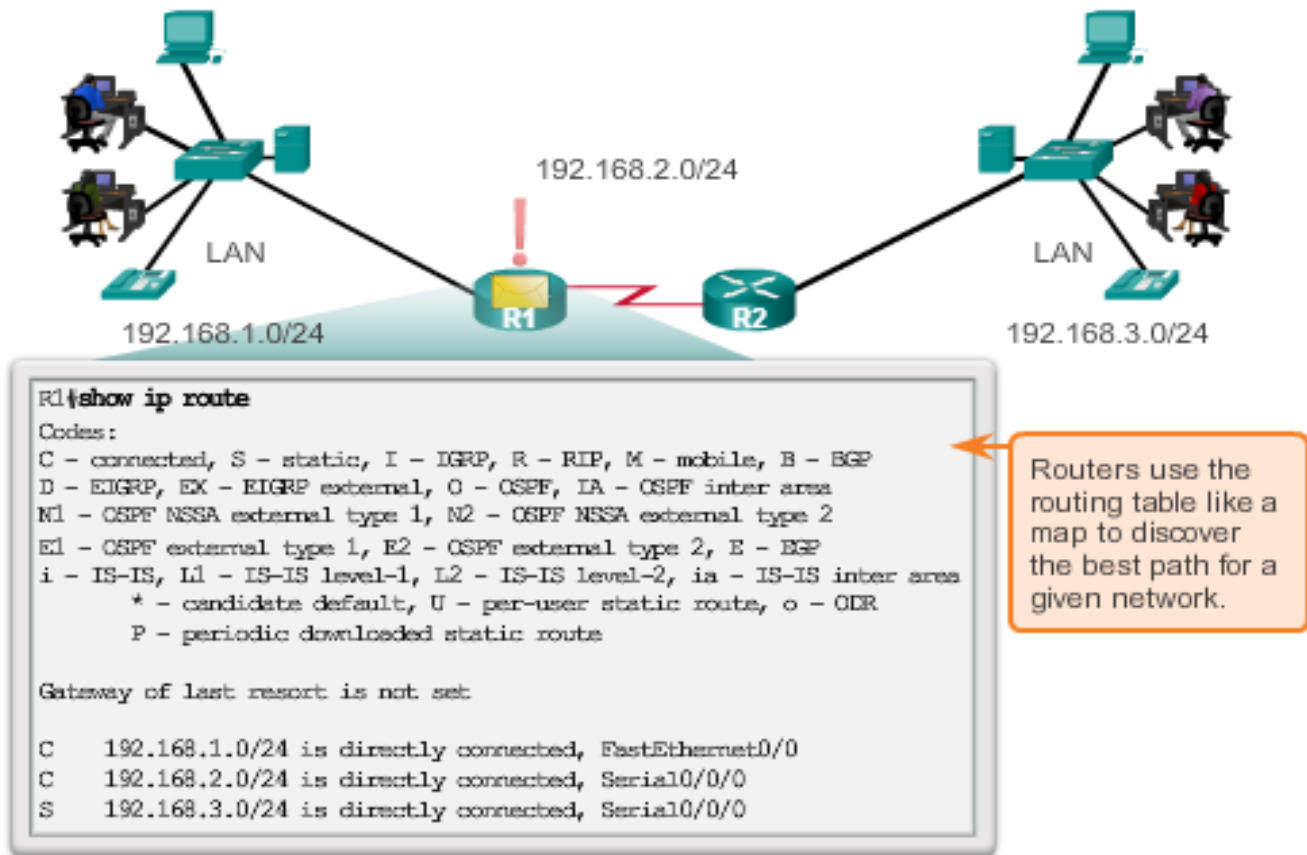
- Routers use static routes and dynamic routing protocols to learn about remote networks and build their routing tables.
- Routers use routing tables to determine the best path to send packets.
- Routers encapsulate the packet and forward it to the interface indicated in routing table.



Functions of a Router

Routers Choose Best Paths

How the Router Works

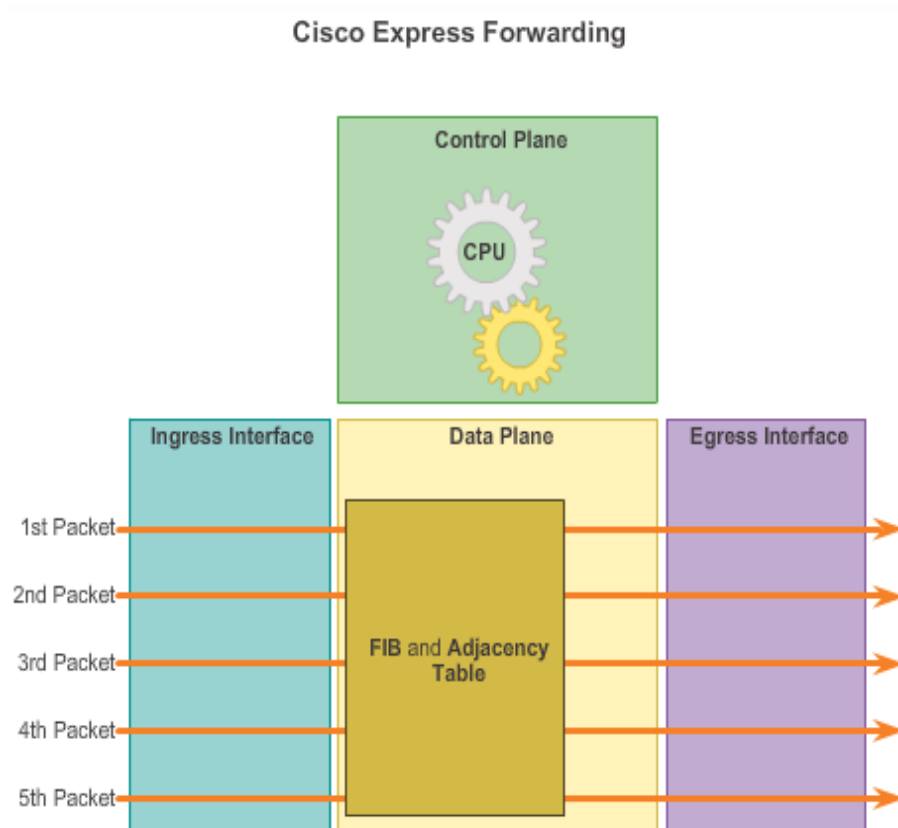




Functions of a Router

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.

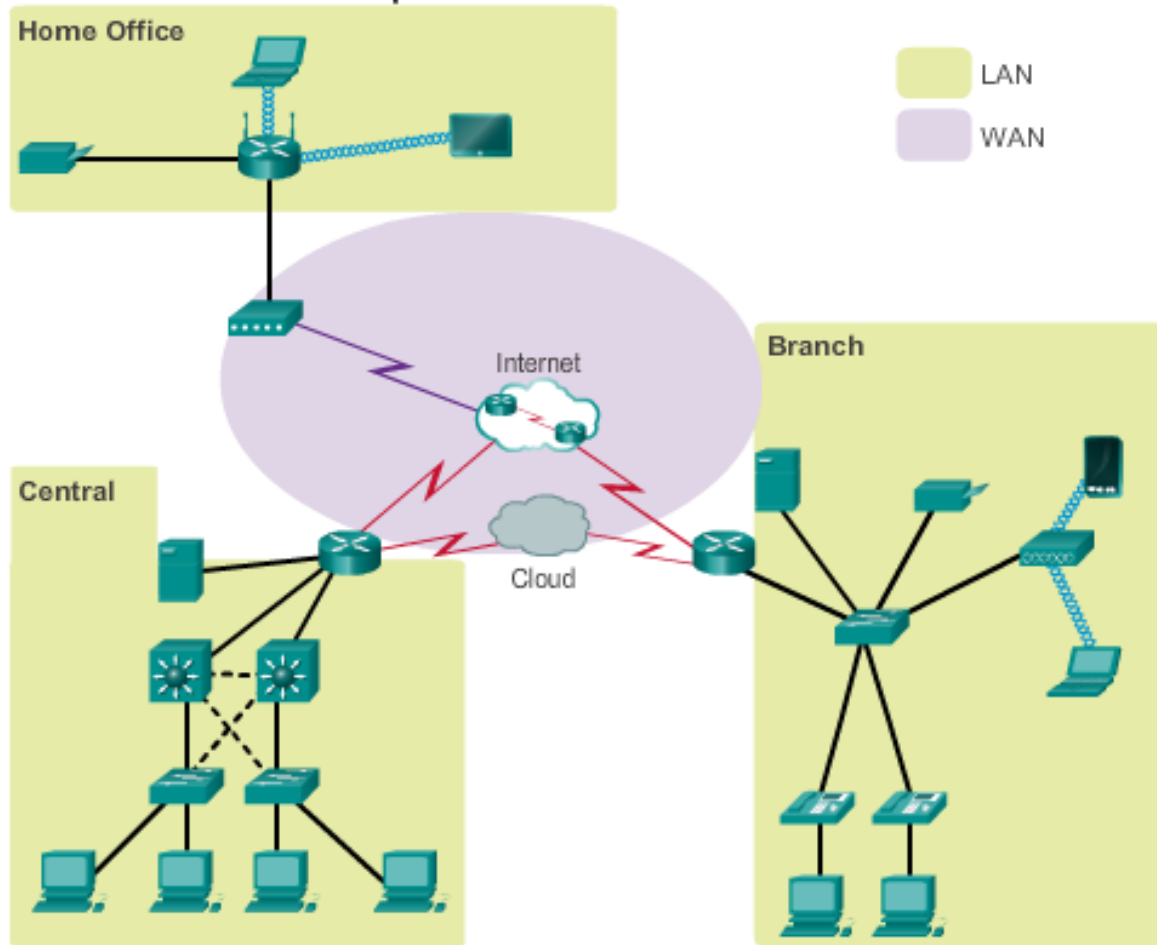




Connect Devices

Connect to a Network

Sample LAN and WAN Connections





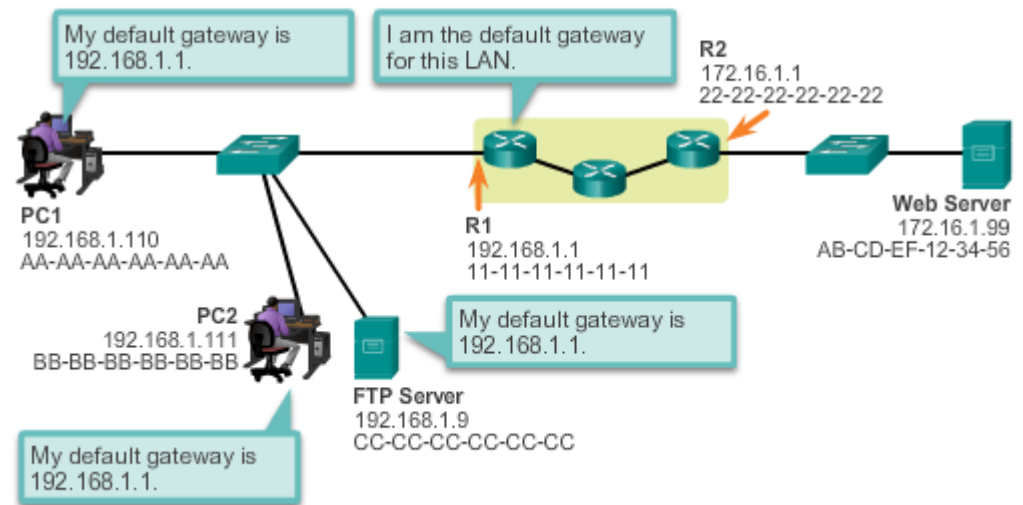
Connect Devices

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 IP Address	Data
11-11-11-11-11-11	AA-AA-AA-AA-AA-AA	192.168.1.110	172.16.1.99	



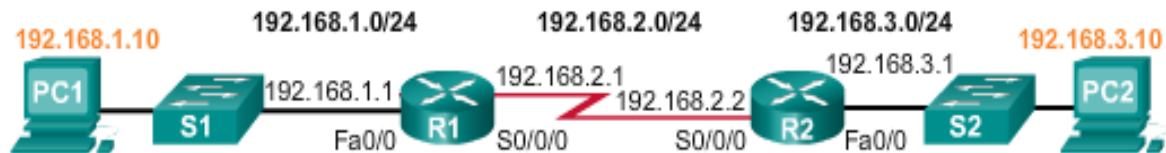


Connect Devices

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



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	192.168.3.1	255.255.255.0	N/A
	S0/0/0	192.168.2.2	255.255.255.0	N/A
PC1	N/A	192.168.1.10	255.255.255.0	192.168.1.1
PC2	N/A	192.168.3.10	255.255.255.0	192.168.3.1



Connect Devices

Enable IP on a Host

Statically Assigned IP address – The host is manually assigned an IP address, subnet mask and default gateway. A 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).

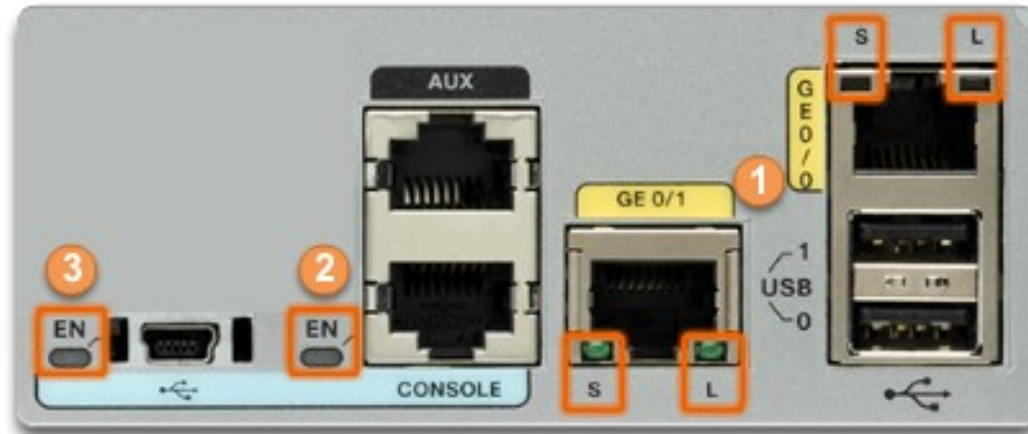
- Most hosts acquire their IP address information through DHCP.
- DHCP services can be provided by Cisco routers.



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



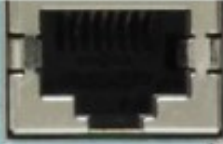









Connect Devices

Console Access

Console access requires:

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

Port on Computer	Cable Required	Port on ISR	Terminal Emulation
 Serial Port	 Console Cable	 CONSOLE RJ45 Console Port	 Tera Term
 USB Type-A Port	 USB-to-RS-232 Serial Port Adapter	 CONSOLE RJ45 Console Port	 PuTTY
	 USB Type-A to USB Type-B (Mini-B) Cable	 EN USB Type-B (Mini-B USB) Console Port	

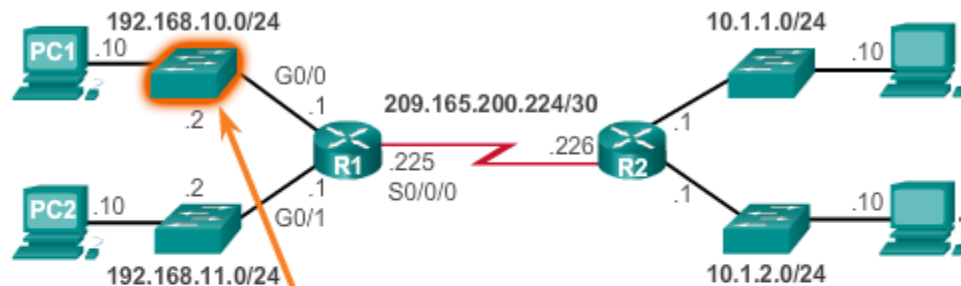


Connect Devices

Enable IP on a Switch

- Network infrastructure devices require IP addresses to enable remote management.
- On a switch, the management IP address is assigned on a virtual interface.

Configure the Switch Management Interface



```

S1(config)#interface vlan 1
S1(config-if)#ip address 192.168.10.2 255.255.255.0
S1(config-if)#no shutdown
%LINK-5-CHANGED: Interface Vlan1, changed state to up
S1(config-if)#exit
S1(config)#
S1(config)#ip default-gateway 192.168.10.1
S1(config)#
  
```



Basic Settings on a Router

Configure Basic Router Settings

Basics tasks that should be first configured on a Cisco Router and Cisco Switch:

- **Name the device** – Distinguishes it from other routers
- **Secure management access** – Secures privileged EXEC, user EXEC, and Telnet access, and encrypts passwords to their highest level

```
R1(config)#enable secret class
R1(config)#
R1(config)#line console 0
R1(config-line)#password cisco
R1(config-line)#login
R1(config-line)#exit
R1(config)#
R1(config)#line vty 0 4
R1(config-line)#password cisco
R1(config-line)#login
R1(config-line)#exit
R1(config)#
R1(config)#service password-encryption
R1(config)#
```

- **Configure a banner** – Provides legal notification of unauthorized access.
- **Save the Configuration**



Basic Settings on a Router

Configure an IPv4 Router Interface

To be available, a router interface must be:

- Configured with an address and subnet mask .
- Must be activated using no shutdown command. By default LAN and WAN interfaces are not activated.
- Serial cable end labeled DCE must be configured with the clock rate command.
- Optional description can be included.

Configure the G0/0 Interface

```

R1(config)#interface gigabitethernet 0/0
R1(config-if)#description Link to LAN 1
R1(config-if)#ip address 192.168.10.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#exit
R1(config)#
*Jan 30 22:04:47.551: %LINK-3-UPDOWN: Interface
GigabitEthernet0/0, changed state to down
R1(config)#
*Jan 30 22:04:50.899: %LINK-3-UPDOWN: Interface
GigabitEthernet0/0, changed state to up
*Jan 30 22:04:51.899: %LINEPROTO-5-UPDOWN: Line protocol on
Interface GigabitEthernet0/0, changed state to up
R1(config)#
  
```



Basic Settings on a Router

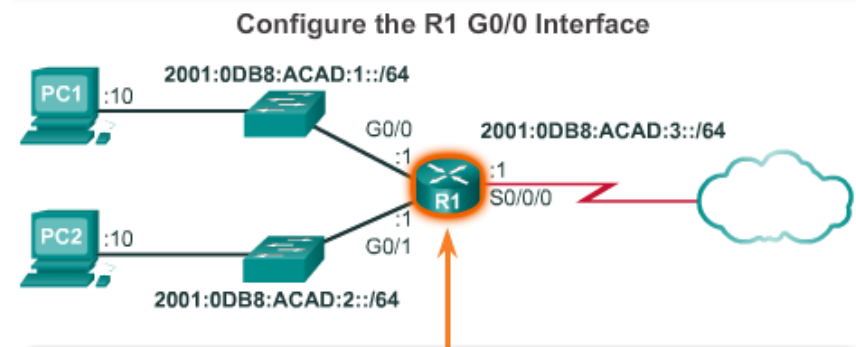
Configure an IPv6 Router Interface

To configure interface with IPv6 address and subnet mask:

- Use the ipv6 address *ipv6-address/ipv6-length* [link-local | eui-64] interface configuration command.
- Activate using the no shutdown command.

IPv6 interfaces can support more than one address:

- Configure a specified global unicast - *ipv6-address /ipv6-length*
- Configure a global IPv6 address with an interface identifier (ID) in the low-order 64 bits - *ipv6-address /ipv6-length eui-64*
- Configure a link-local address - *ipv6-address /ipv6-length link-local*



```

R1 (config)#interface gigabitethernet 0/0
R1 (config-if)#description Link to LAN 1
R1 (config-if)#ipv6 address 2001:db8:acad:1::1/64
R1 (config-if)#no shutdown
R1 (config-if)#exit
R1 (config)#
*Feb 3 21:38:37.279: %LINK-3-UPDOWN: Interface
GigabitEthernet0/0, changed state to down
*Feb 3 21:38:40.967: %LINK-3-UPDOWN: Interface
GigabitEthernet0/0, changed state to up
*Feb 3 21:38:41.967: %LINEPROTO-5-UPDOWN: Line protocol on
Interface GigabitEthernet0/0, changed state to up
R1 (config)#
  
```



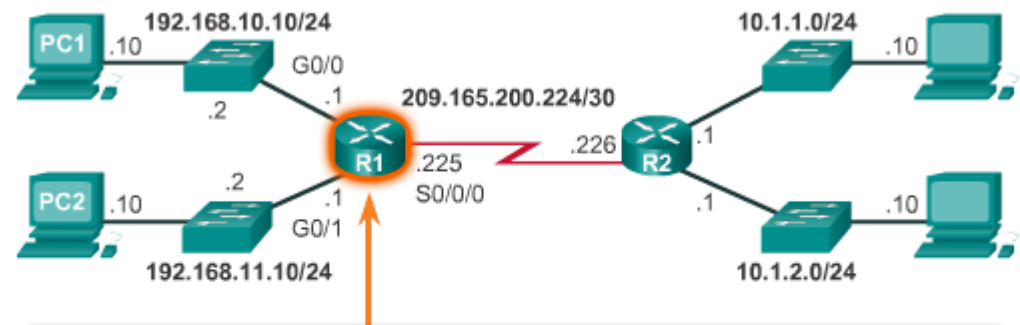
Basic Settings on a Router

Configure a Loopback Interface

A loopback interface is a logical interface that is internal to the router:

- It is not assigned to a physical port, it is considered a software interface that is automatically in an UP state.
- A loopback interface is useful for testing.
- It is important in the OSPF routing process.

Configure the Loopback0 Interface



```
R2 (config)#interface loopback 0
R2 (config-if)#ip address 10.0.0.1 255.255.255.0
R2 (config-if)#exit
R1 (config)#
*Jan 30 22:04:50.899: %LINK-3-UPDOWN: Interface loopback0,
changed state to up
*Jan 30 22:04:51.899: %LINEPROTO-5-UPDOWN: Line protocol on
Interface loopback0, changed state to up
```



Verify Connectivity of Directly Connected Networks

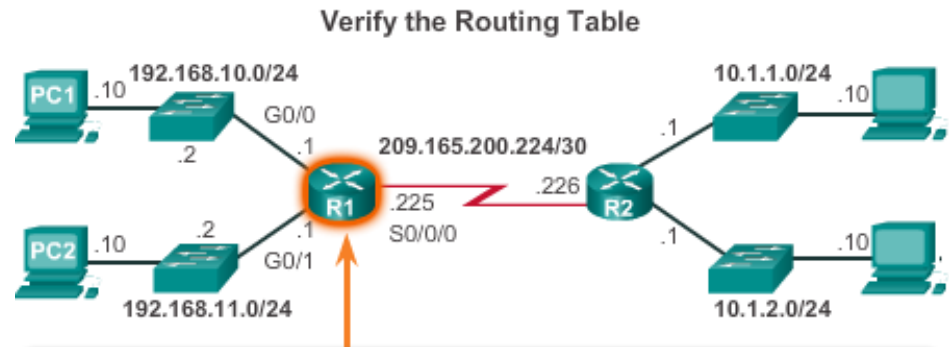
Verify Interface Settings

Show commands are used to verify operation and configuration of interface:

- **show ip interfaces brief**
- **show ip route**
- **show running-config**

Show commands are used to gather more detailed interface information:

- **show interfaces**
- **show ip interfaces**



```

R1#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - m
<output omitted.
Gateway of last resort is not set

    192.168.10.0/24 is variably subnetted, 2 subnets, 2 ma
C    192.168.10.0/24 is directly connected, GigabitEther
L    192.168.10.1/32 is directly connected, GigabitEther
    192.168.11.0/24 is variably subnetted, 2 subnets, 2 ma
C    192.168.11.0/24 is directly connected, GigabitEther
L    192.168.11.1/32 is directly connected, GigabitEther
    209.165.200.0/24 is variably subnetted, 2 subnets, 2 m
  
```

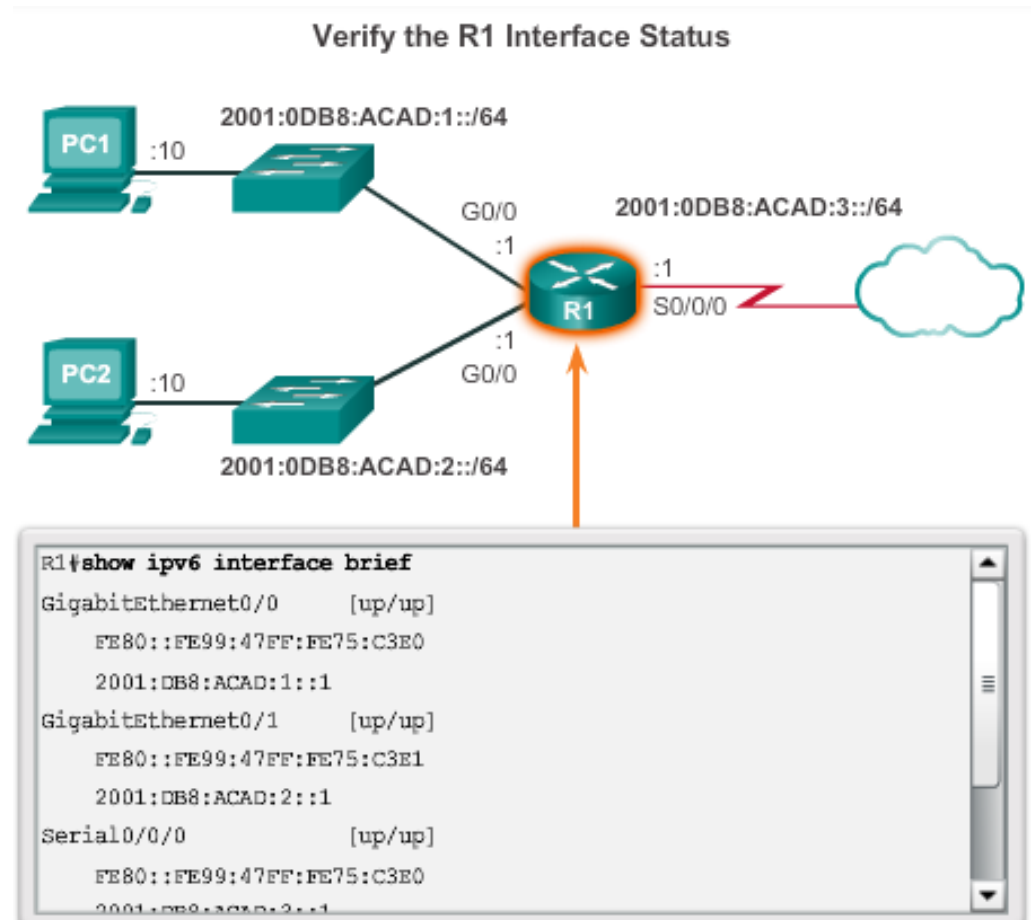



Verify Connectivity of Directly Connected Networks

Verify Interface Settings

Some of the common commands to verify the IPv6 interface configuration are:

- **show ipv6 interface brief** - displays a summary for each of the interfaces.
- **show ipv6 interface gigabitethernet 0/0** - displays the interface status and all the IPv6 addresses for this interface.
- **show ipv6 route** - verifies that IPv6 networks and specific IPv6 interface addresses have been installed in the IPv6 routing table.





Verify Connectivity of Directly Connected Networks

Filter Show Command Output

Show command output can be managed using the following command and filters:

- Use the **terminal length *number*** 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  administrat
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  administrat

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  administrat
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  administrat
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#
```



Verify Connectivity of Directly Connected Networks

Command History Feature

The command history feature temporarily stores a list of executed commands for access:

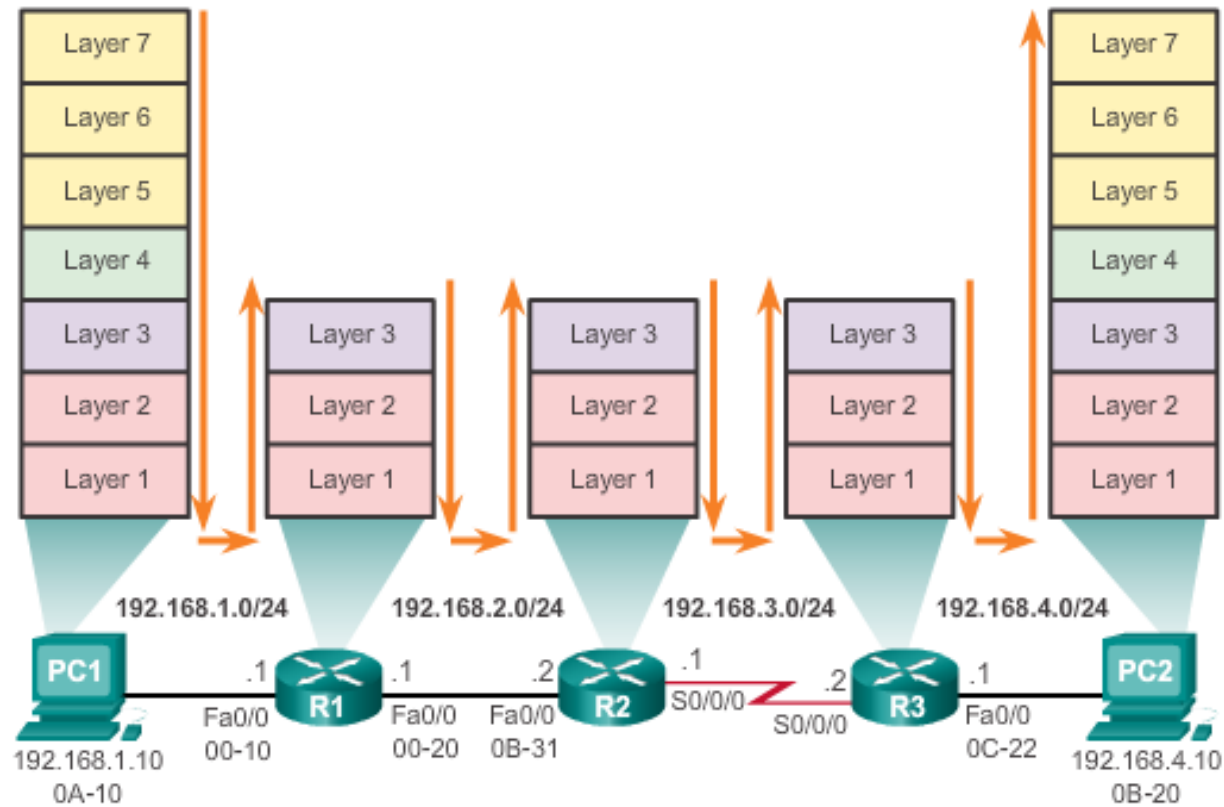
- To recall commands press **Ctrl+P** or the **UP Arrow**.
- To return to more recent commands press **Ctrl+N** or the **Down Arrow**.
- By default, command history is enabled and the system captures the last 10 commands in the buffer. Use the **show history** privileged EXEC command to display the buffer contents.
- Use the **terminal history size** user EXEC command to increase or decrease size of the buffer.



Switching Packets between Networks

Router Switching Functions

Encapsulating and De-Encapsulating Packets



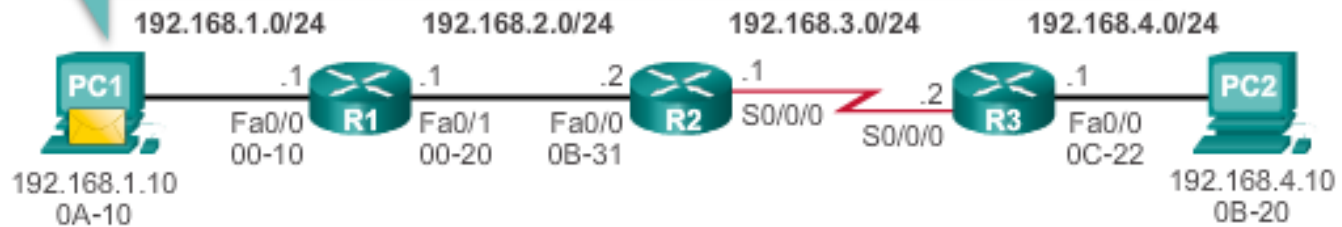


Switching Packets between Networks

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
--------------------	---------------------	----------	---------------------------	--------------------------	-----------	------	---------

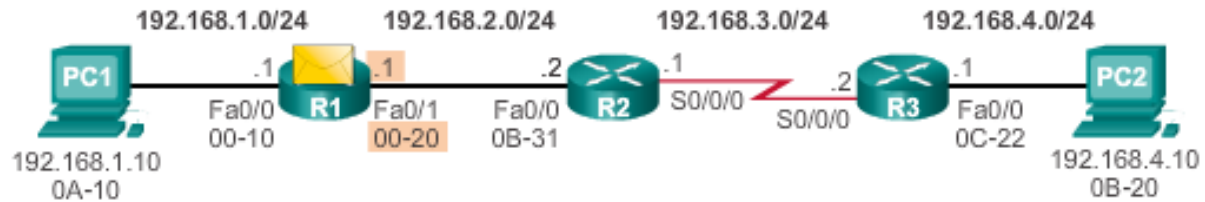
PC1's ARP Cache for R1

IP Address	MAC Address
192.168.1.1	00-10



Switching Packets between Networks Forward to the Next Hop

R3 Forwards the Packet to PC2



Layer 2 Data Link Frame

Packet's Layer 3 data

Dest. MAC 0B-31	Source MAC 00-20	Type 800	Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer
--------------------	---------------------	----------	---------------------------	--------------------------	-----------	------	---------

R1's Routing Table

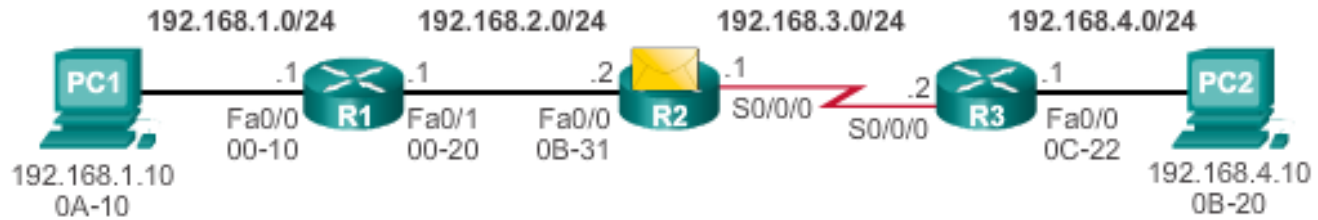
Network	Hops	Next-hop-IP	Exit Interface
192.168.1.0/24	0	Dir. Connect.	Fa0/0
192.168.2.0/24	0	Dir. Connect.	Fa0/1
192.168.3.0/24	1	192.168.2.2	Fa0/1
192.168.4.0/24	2	192.168.2.2	Fa0/1



Switching Packets between Networks

Packet Routing

R2 Forwards the Packet to R3



Layer 2 Data Link Frame

Packet's Layer 3 data

Address 0x8F	Control 0x00	Type 800	Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer
-----------------	-----------------	----------	---------------------------	--------------------------	-----------	------	---------

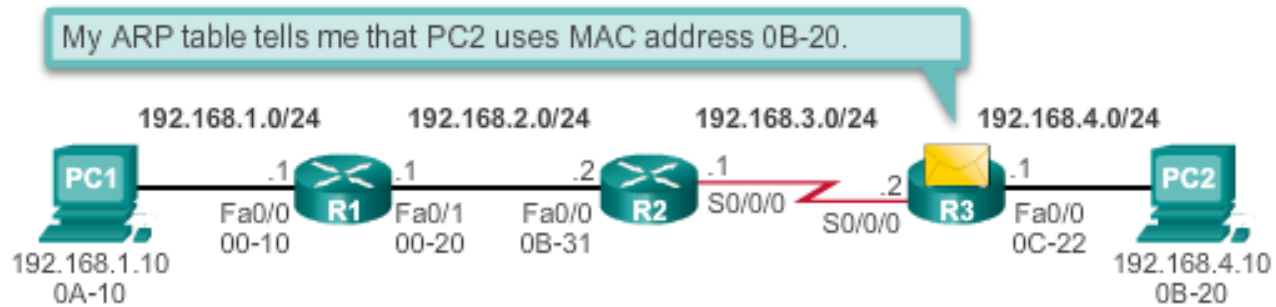
R2's Routing Table

Network	Hops	Next-hop-IP	Exit Interface
192.168.1.0/24	1	192.168.3.1	Fa0/0
192.168.2.0/24	0	Dir. Connect.	Fa0/0
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
---------------------------	----------------------------	----------	----------------------------------	---------------------------------	-----------	------	---------

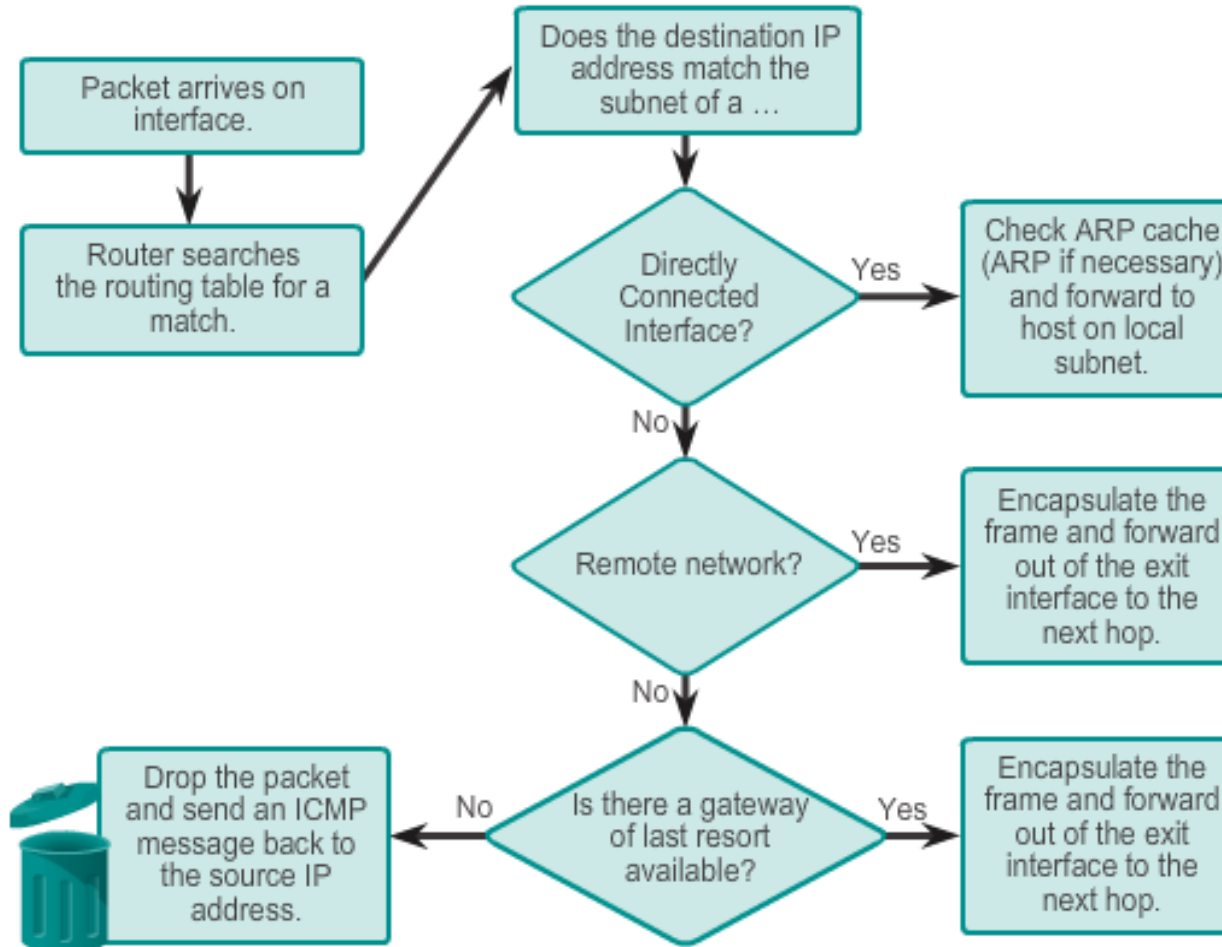
IP Address	MAC Address
192.168.4.10	0B-20

Network	Hops	Next-hop-IP	Exit Interface
192.168.1.0/24	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 Routing Decisions

Packet Forwarding Decision Process





Path Determination

Best Path

Best path is selected by a routing protocol based on the value or metric it uses to determine the distance to reach a network:

- A metric is the value used to measure the distance to a given network.
- Best path to a network is the path with the lowest metric.

Dynamic routing protocols use their own rules and metrics to build and update routing tables:

- 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:

- Equal cost load balancing can improve network performance.
- Equal cost load balancing can be configured to use both dynamic routing protocols and static routes.
- RIP, OSPF and EIGRP support equal cost load balancing.



Path Determination of the route

Administrative Distance

If multiple paths to a destination are configured on a router, the path installed in the routing table is the one with the lowest Administrative Distance (AD):

- A static route with an AD of 1 is more reliable than an EIGRP-discovered route with an AD of 90.
- A directly connected route with an AD of 0 is more reliable than a static route with an AD of 1.

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

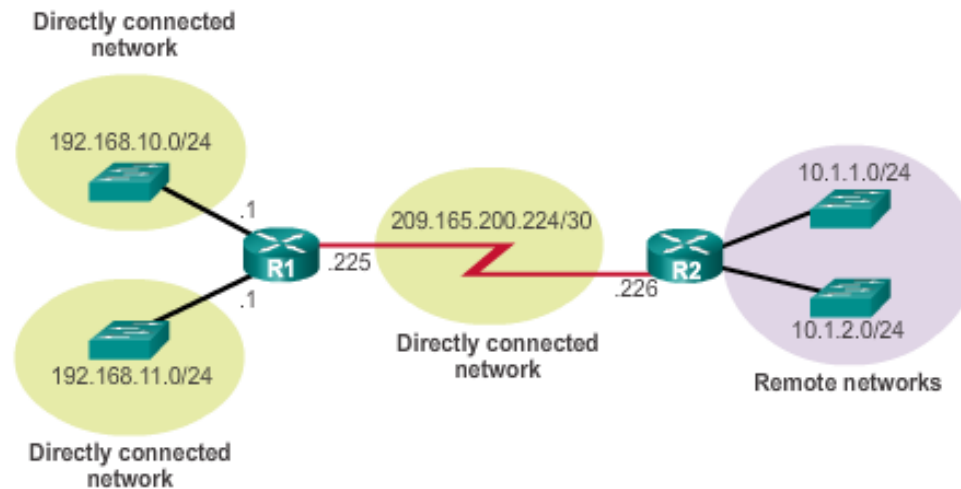


The Routing Table

The Routing Table

A 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

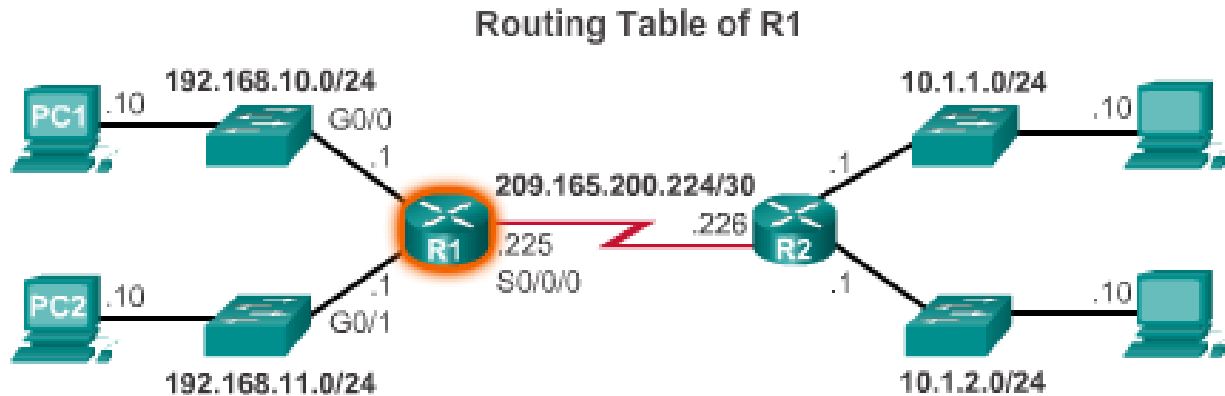
The **show ip route** command is used to display the contents of the routing table:

- **Local route 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

Routing Table Sources



```

R1#show ip route
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
 10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
D    10.1.1.0/24 [90/2170112] via 209.165.200.226, 00:00:05,

```

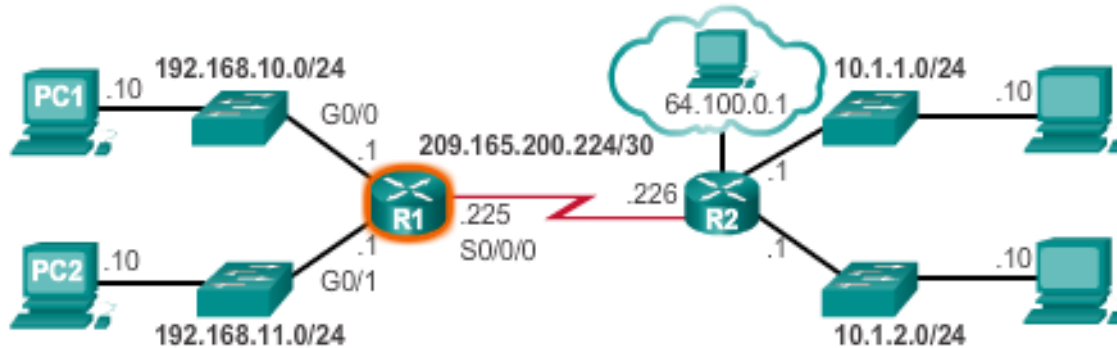


The Routing Table

Remote Network Routing Entries

Interpreting the entries in the routing table.

Remote Network Entry Identifiers



D 10.1.1.0/24 [90/2170112] via 209.165.200.226, 00:00:05, Serial0/0/0

Legend

- Identifies how the network was learned by the router.
- Identifies the destination network.
- Identifies the administrative distance (trustworthiness) of the route source.
- Identifies the metric to reach the remote network.
- Identifies the next-hop IP address to reach the remote network.
- Identifies the amount of elapsed time since the network was discovered.
- Identifies the outgoing interface on the router to reach the destination network.



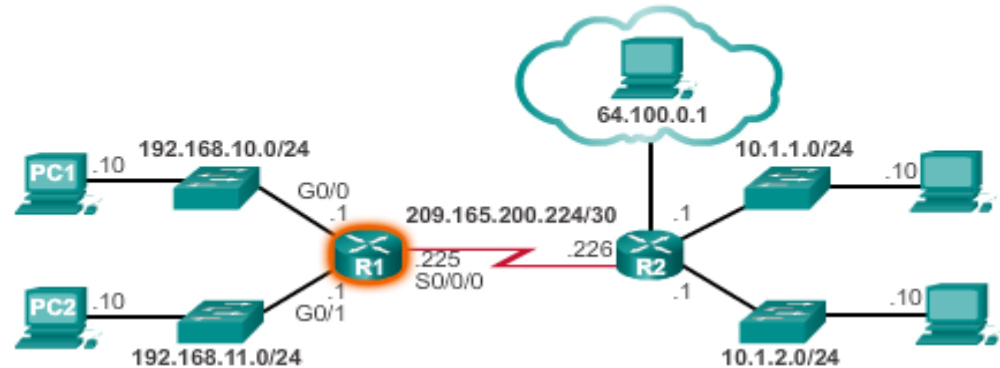
Directly Connected Routes

Directly Connected Interfaces

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)

Directly Connected Network Entry Identifiers



A	B	C
C	192.168.10.0/24 is directly connected,	GigabitEthernet0/0
L	192.168.10.1/32 is directly connected,	GigabitEthernet0/0

Legend

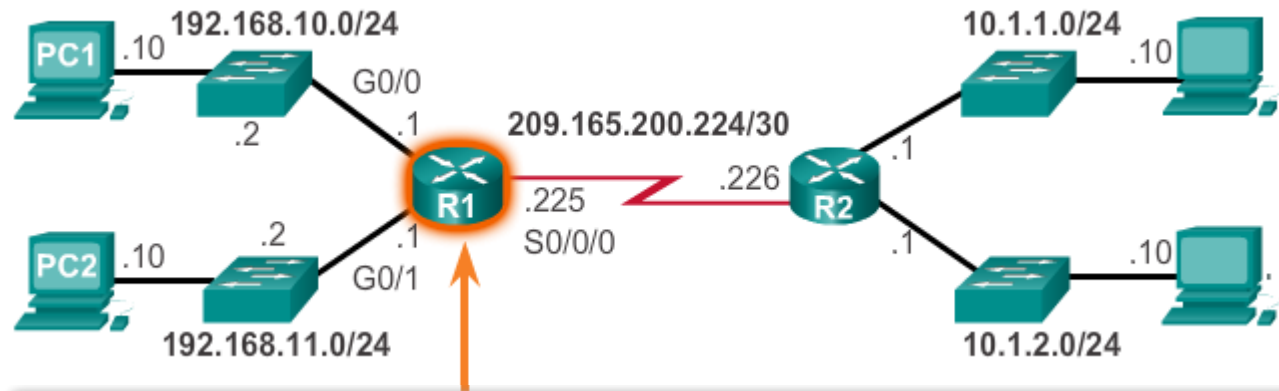
- Identifies how the network was learned by the router.
- Identifies the destination network and how it is connected.
- Identifies the interface on the router connected to the destination network.



Directly Connected Routes

Directly Connected Example

A routing table with the directly connected interfaces of R1 configured and activated.



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

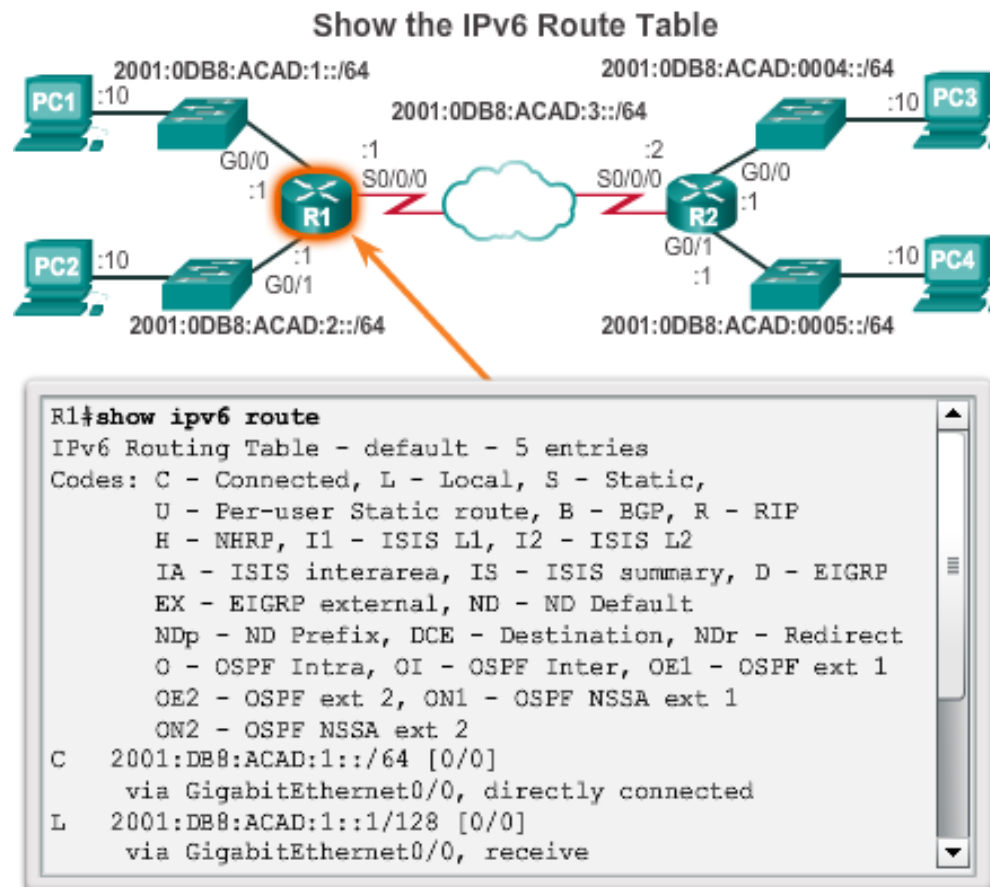
      192.168.10.0/24 is variably subnetted, 2 subnets, 2
masks
C       192.168.10.0/24 is directly connected,
GigabitEthernet0/0
L       192.168.10.1/32 is directly connected,
GigabitEthernet0/0
      192.168.11.0/24 is variably subnetted, 2 subnets, 2
masks
C       192.168.11.0/24 is directly connected,
GigabitEthernet0/1
L       192.168.11.1/32 is directly connected,
GigabitEthernet0/1
```



Directly Connected Routes

Directly Connected IPv6 Example

The **show ipv6 route** command shows the ipv6 networks and routes installed in the routing table.





Statically Learned Routes

Static Routes

Static routes and default static routes can be implemented after directly connected interfaces are added to the routing table:

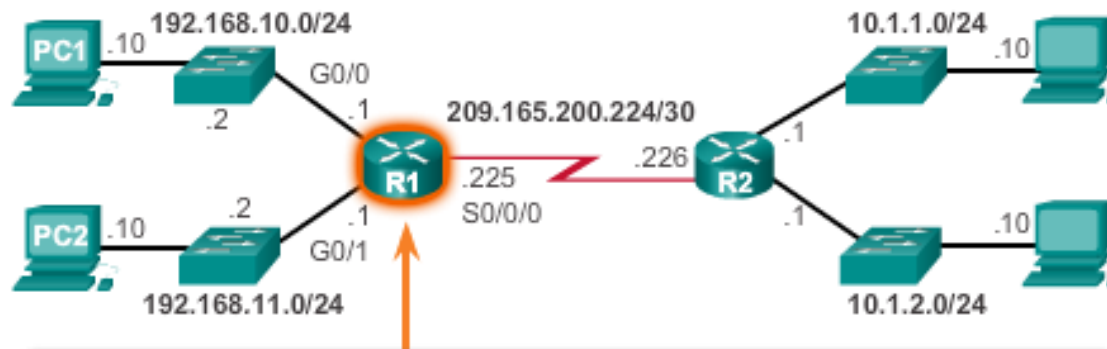
- Static routes are manually configured
- They define an explicit path between two networking devices.
- Static routes must be manually updated if the topology changes.
- Their benefits include improved security and control of resources.
- Configure a static route to a specific network using the **ip route *network mask {next-hop-ip | exit-intf}*** command.
- A default static route is used when the routing table does not contain a path for a destination network.
- Configure a default static route using the **ip route 0.0.0.0 0.0.0.0 {exit-intf | next-hop-ip}** command.



Statically Learned Routes

Default Static Routes Example

Entering and Verifying a Static Default Route



```

R1(config)#ip route 0.0.0.0 0.0.0.0 Serial0/0/0
R1(config)#exit
R1#
*Feb 1 10:19:34.483: %SYS-5-CONFIG_I: Configured from console
by console

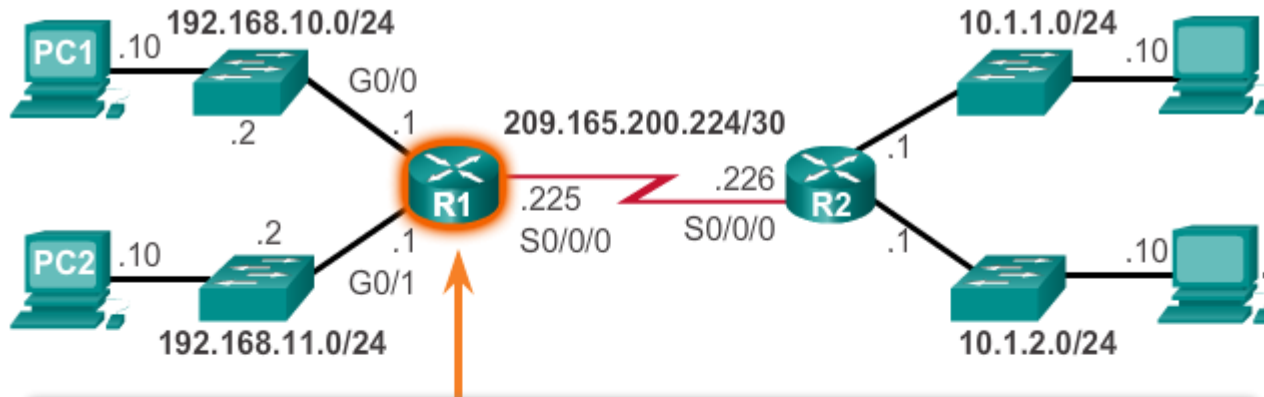
R1#show ip route | begin Gateway
Gateway of last resort is 0.0.0.0 to network 0.0.0.0

S* 0.0.0.0/0 is directly connected, 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
  
```



Statically Learned Routes

Static Routes Example



```

R1(config)# ip route 0.0.0.0 0.0.0.0 Serial0/0/0
R1(config)# exit
R1#
*Feb 1 10:19:34.483: %SYS-5-CONFIG_I: Configured from console
by console

R1# show ip route | begin Gateway
Gateway of last resort is 0.0.0.0 to network 0.0.0.0

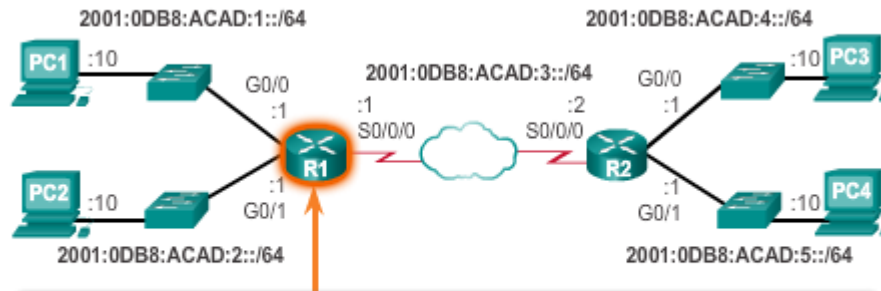
S* 0.0.0.0/0 is directly connected, Serial0/0/0
  192.168.10.0/24 is variably subnetted, 2 subnets, 2 masks
C   192.168.10.0/24 is directly connected, GigabitEthernet0/0
L   192.168.10.1/32 is directly connected, GigabitEthernet0/0
  192.168.11.0/24 is variably subnetted, 2 subnets, 2 masks
C   192.168.11.0/24 is directly connected, GigabitEthernet0/1
L   192.168.11.1/32 is directly connected, GigabitEthernet0/1
  
```



Statically Learned Routes

Static IPv6 Routes Example

Entering and Verifying an IPv6 Static Default Route



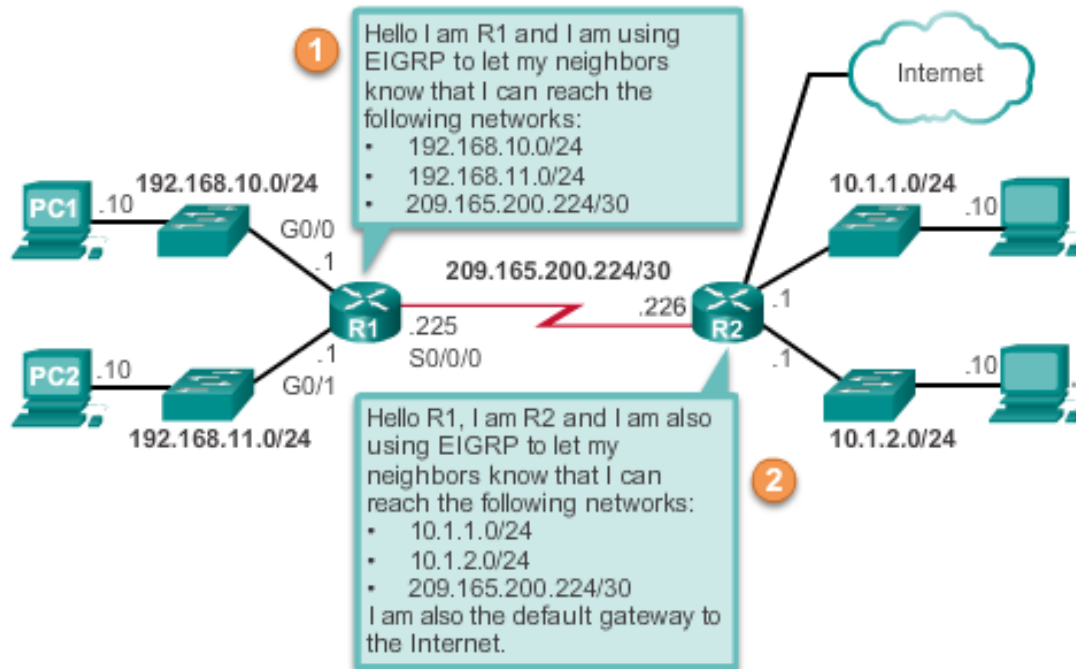
```
R1(config)#ipv6 route ::/0 s0/0/0
R1(config)#exit
R1#
```

```
R1#show ipv6 route
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static,
       U - Per-user Static route
       B - BGP, R - RIP, H - NHRP, I1 - ISIS L1
       I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary,
       D - EIGRP
       EX - EIGRP external, ND - ND Default, NDP - ND Prefix,
       DCE - Destination
       NDR - Redirect, O - OSPF Intra, OI - OSPF Inter,
       OE1 - OSPF ext 1
       OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1,
       ON2 - OSPF NSSA ext 2
S ::/0 [1/0]
   via Serial0/0/0, directly connected
C 2001:DB8:ACAD:1::/64 [0/0]
   via GigabitEthernet0/0, directly connected
```

Dynamic Routing Protocols

Dynamic Routing

Dynamic routing is used by routers to share information about the reachability and status of remote networks. It performs network discovery and maintains routing tables.





Dynamic Routing Protocols

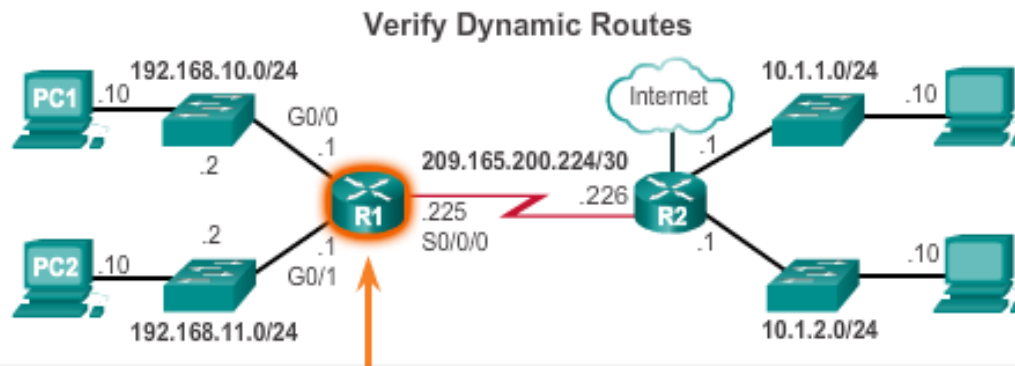
IPv4 Routing Protocols

Cisco ISR routers can support a variety of dynamic IPv4 routing protocols including:

- **EIGRP** – Enhanced Interior Gateway Routing Protocol
- **OSPF** – Open Shortest Path First
- **IS-IS** – Intermediate System-to-Intermediate System
- **RIP** – Routing Information Protocol

Dynamic Routing Protocols

IPv4 Routing Protocols



```

R1#show ip route | begin Gateway
Gateway of last resort is 209.165.200.226 to network 0.0.0.0

D*EX 0.0.0.0/0 [170/2297856] via 209.165.200.226, 00:07:29, Serial0/0/0
    10.0.0.0/24 is subnetted, 2 subnets
D    10.1.1.0 [90/2172416] via 209.165.200.226, 00:07:29, Serial0/0/0
D    10.1.2.0 [90/2172416] via 209.165.200.226, 00:07:29, 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
R1#
  
```



Dynamic Routing Protocols

IPv6 Routing Protocols

Cisco ISR routers can support a variety of dynamic IPv6 routing protocols including:

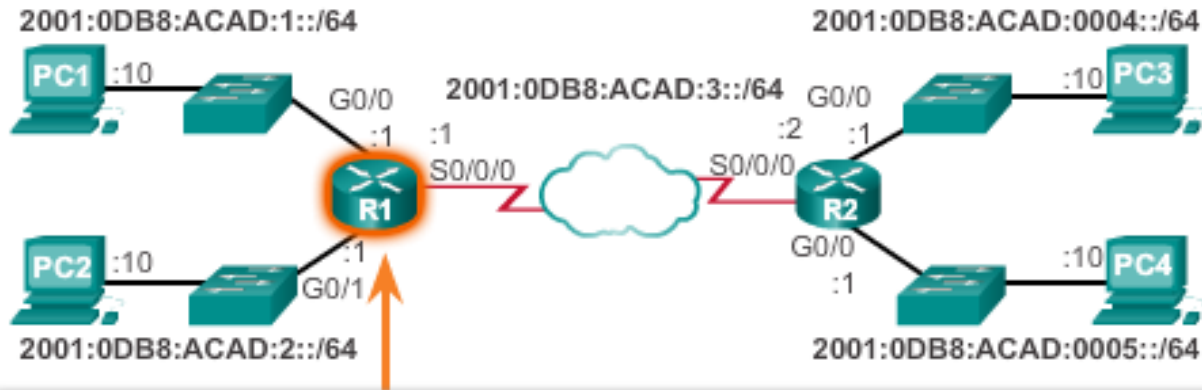
- **RIPng** - RIP next generation
- **OSPFv3**
- **EIGRP** for IPv6
- **MP-BGP4** - Multicast Protocol-Border Gateway Protocol



Dynamic Routing Protocols

IPv6 Routing Protocols

Verify Dynamic Routes



```

R1#show ipv6 route
IPv6 Routing Table - default - 9 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, H - NHRP, I1 - ISIS L1
       I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary, D - EIGRP
       EX - EIGRP external, ND - ND Default, NDp - ND Prefix, DCE -
Destination
       NDR - Redirect, O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1
       OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C   2001:DB8:ACAD:1::/64 [0/0]
    via GigabitEthernet0/0, directly connected
L   2001:DB8:ACAD:1::1/128 [0/0]
    via GigabitEthernet0/0, receive
C   2001:DB8:ACAD:2::/64 [0/0]
    via GigabitEthernet0/1, directly connected
L   2001:DB8:ACAD:2::1/128 [0/0]
  
```



Chapter 4: Summary

- There are many key structures and performance-related characteristics referred to when discussing networks: topology, speed, cost, security, availability, scalability, and reliability.
- Cisco routers and Cisco switches have many similarities. They support a similar modal operating system, similar command structures, and many of the same commands.
- One distinguishing feature between switches and routers is the type of interfaces supported by each.
- The main purpose of a router is to connect multiple networks and forward packets from one network to the next. This means that a router typically has multiple interfaces. Each interface is a member or host on a different IP network.



Chapter 4: Summary (cont.)

- The routing table is a list of networks known by the router.
- A remote network is a network that can only be reached by forwarding the packet to another router.
- Remote networks are added to the routing table in two ways: either by the network administrator manually configuring static routes or by implementing a dynamic routing protocol.
- Static routes do not have as much overhead as dynamic routing protocols; however, static routes can require more maintenance if the topology is constantly changing or is unstable.
- Dynamic routing protocols automatically adjust to changes without any intervention from the network administrator. Dynamic routing protocols require more CPU processing and also use a certain amount of link capacity for routing updates and messages.



Chapter 4: Summary (cont.)

- Routers make their primary forwarding decision at Layer 3, the Network layer. However, router interfaces participate in Layers 1, 2, and 3. Layer 3 IP packets are encapsulated into a Layer 2 data link frame and encoded into bits at Layer 1.
- Router interfaces participate in Layer 2 processes associated with their encapsulation. For example, an Ethernet interface on a router participates in the ARP process like other hosts on that LAN.
- Components of the IPv6 routing table are very similar to the IPv4 routing table. For instance, it is populated using directly connected interfaces, static routes and dynamically learned routes.

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