



## Chapter 4: Routing Concepts



## Routing & Switching

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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.)

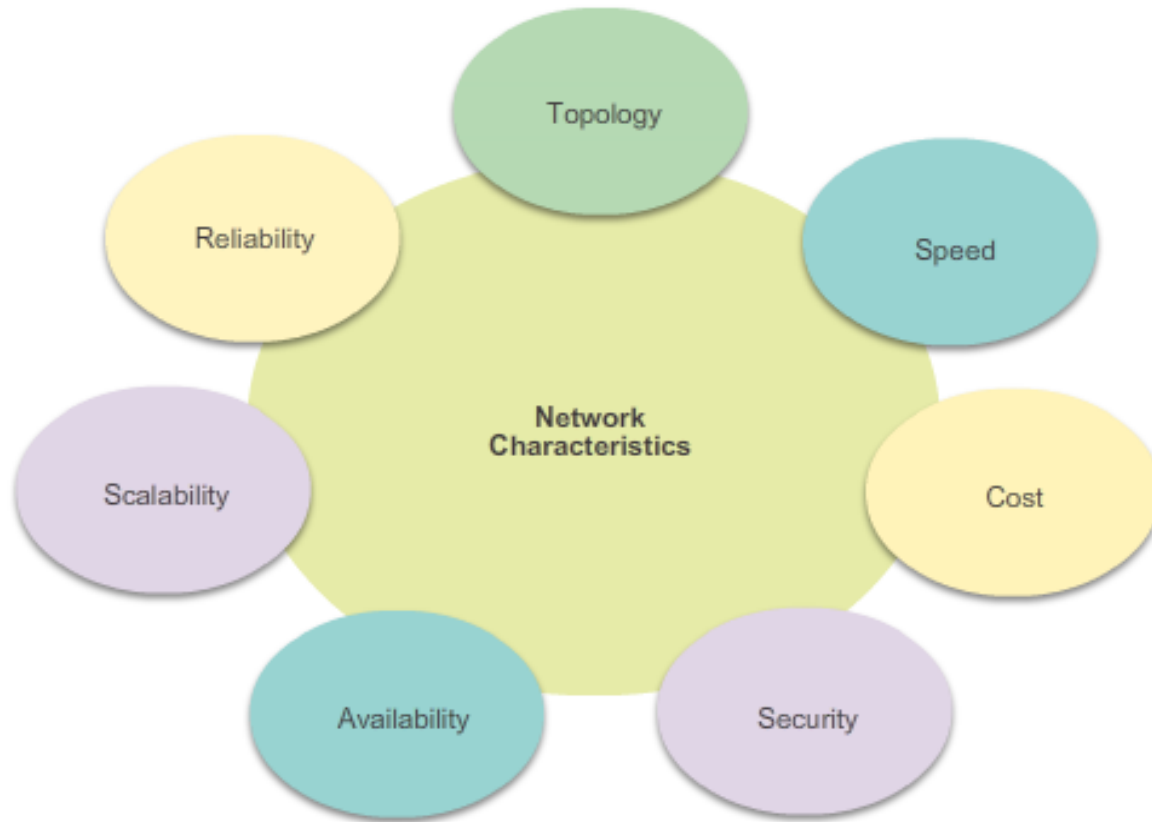
- Explain how a router builds a routing table using static routes.
- Explain how a router builds a routing table using a dynamic routing protocol.



## Functions of a Router

# Characteristics of a Network

### Network Characteristics

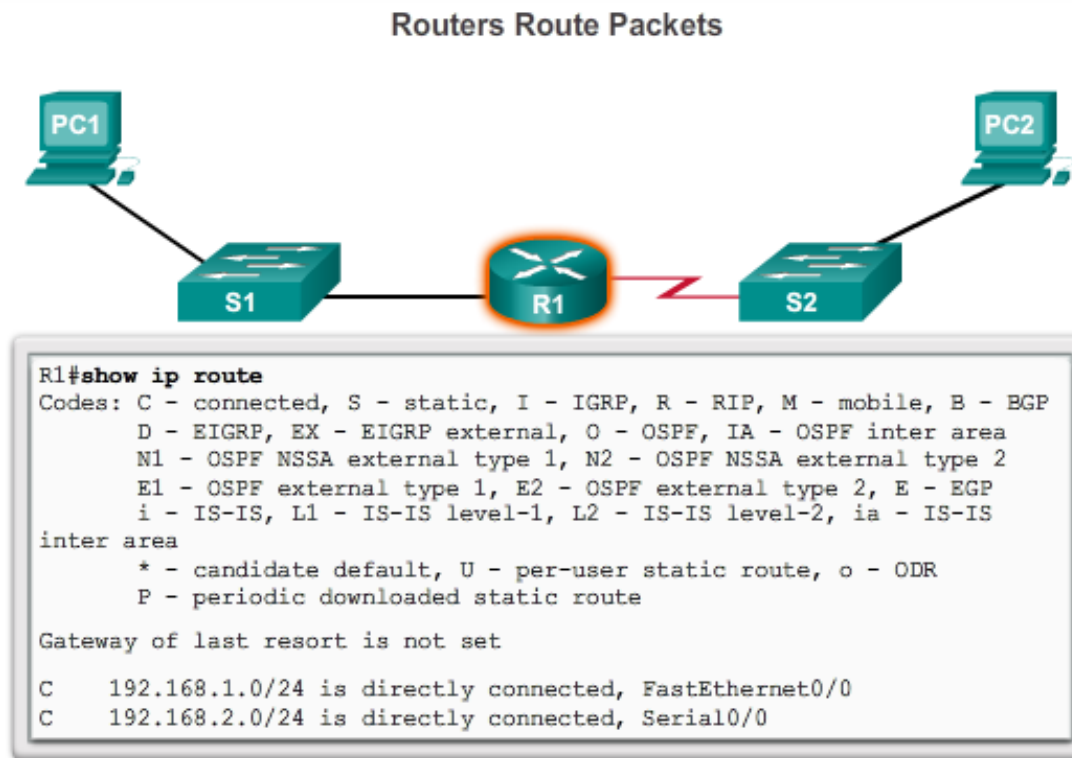




## Functions of a Router

# 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"> <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>

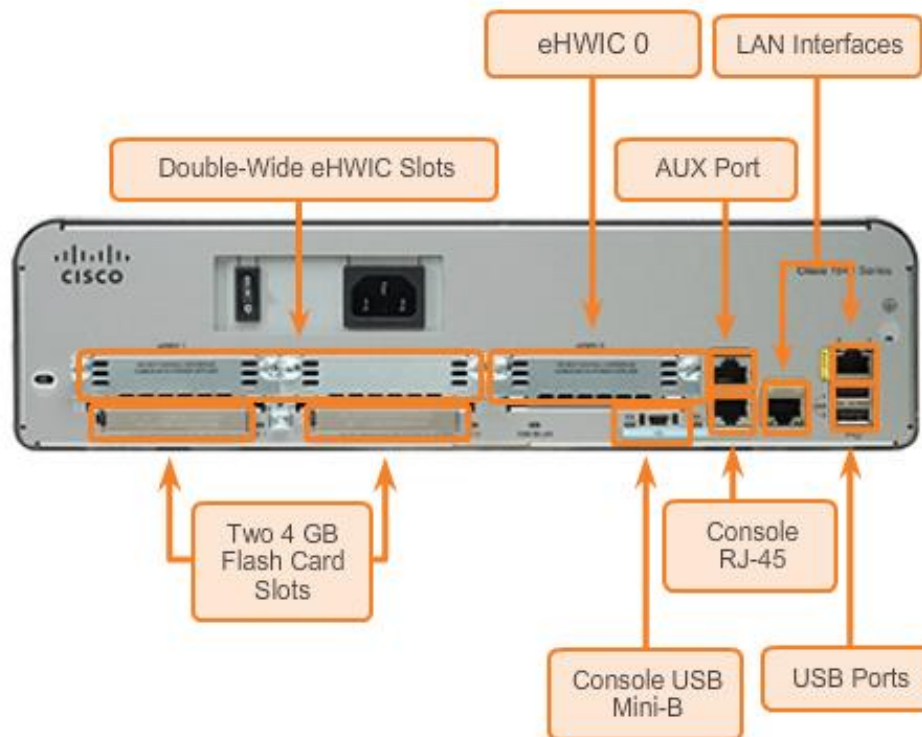


## Functions of a Router

# Routers are Computers

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

Back Panel of a Router



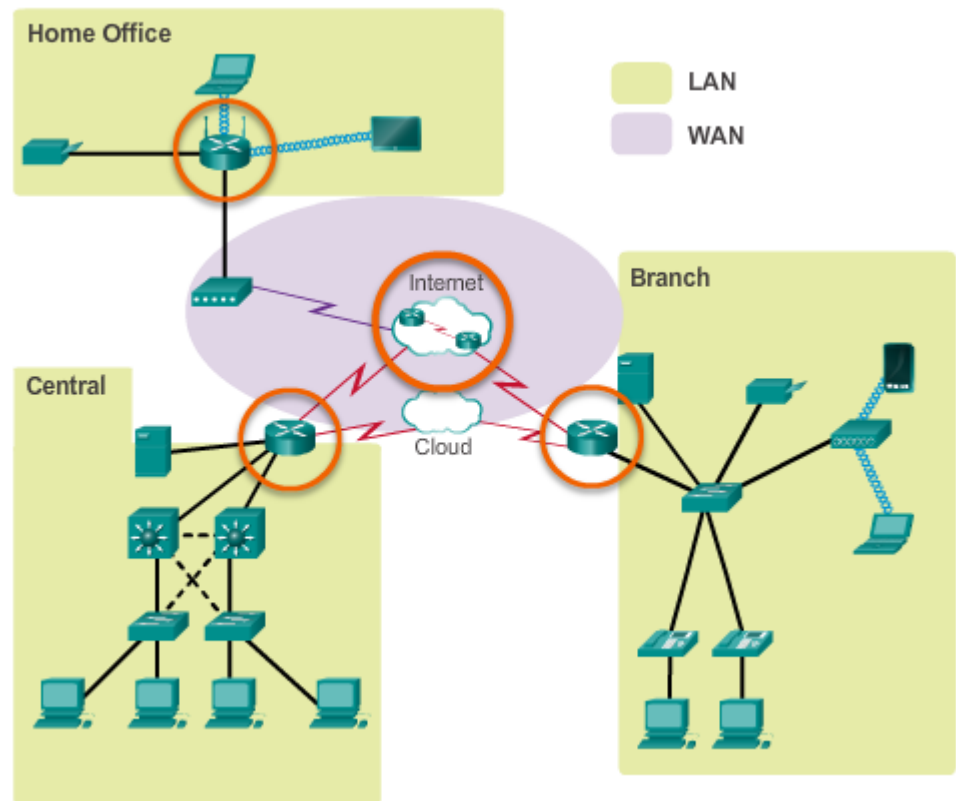




## Functions of a Router

# 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

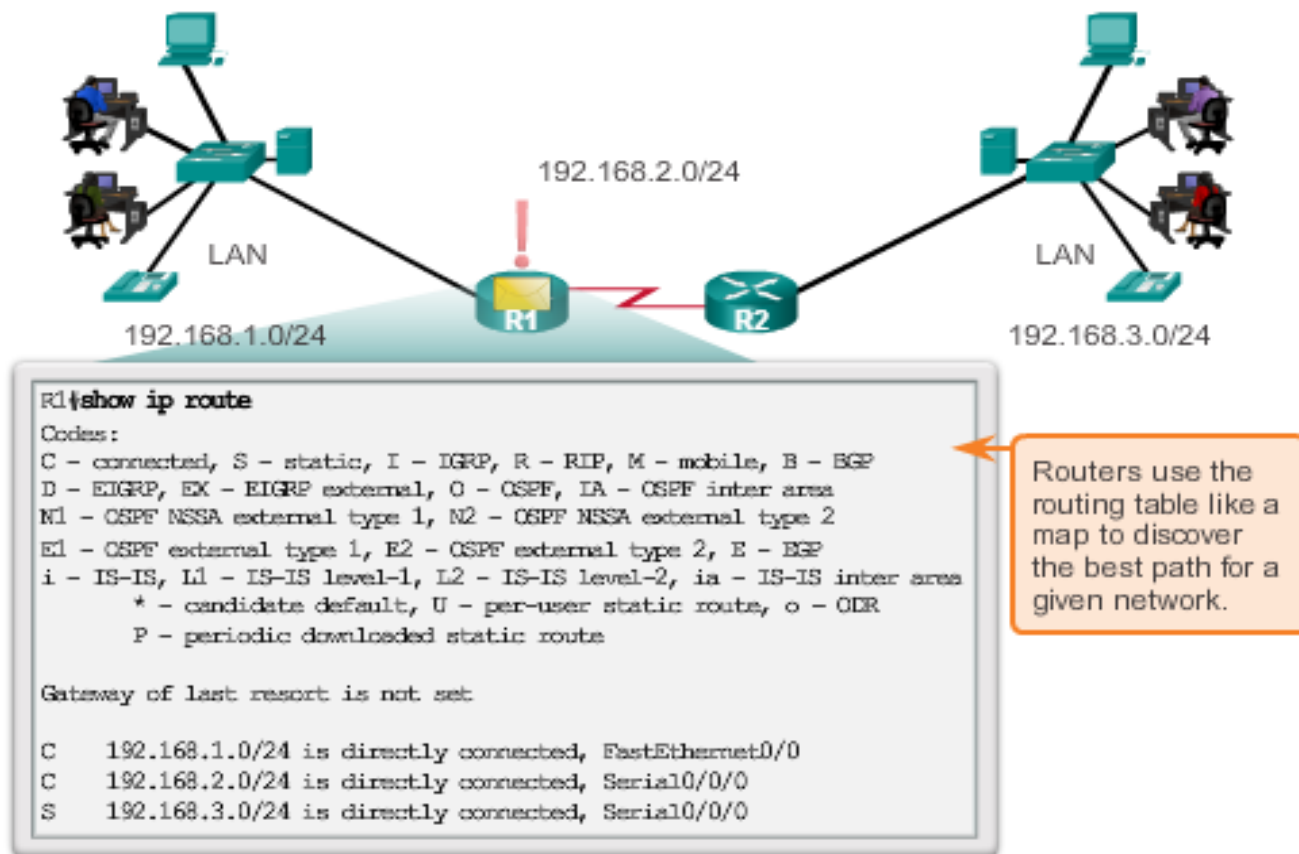
- Routers use static routes and dynamic routing protocols to learn about remote networks and build their routing tables.
- Routers use routing tables to determine the best path to send packets.
- Routers encapsulate the packet and forward it to the interface indicated in routing table.



## Functions of a Router

# Routers Choose Best Paths

### How the Router Works

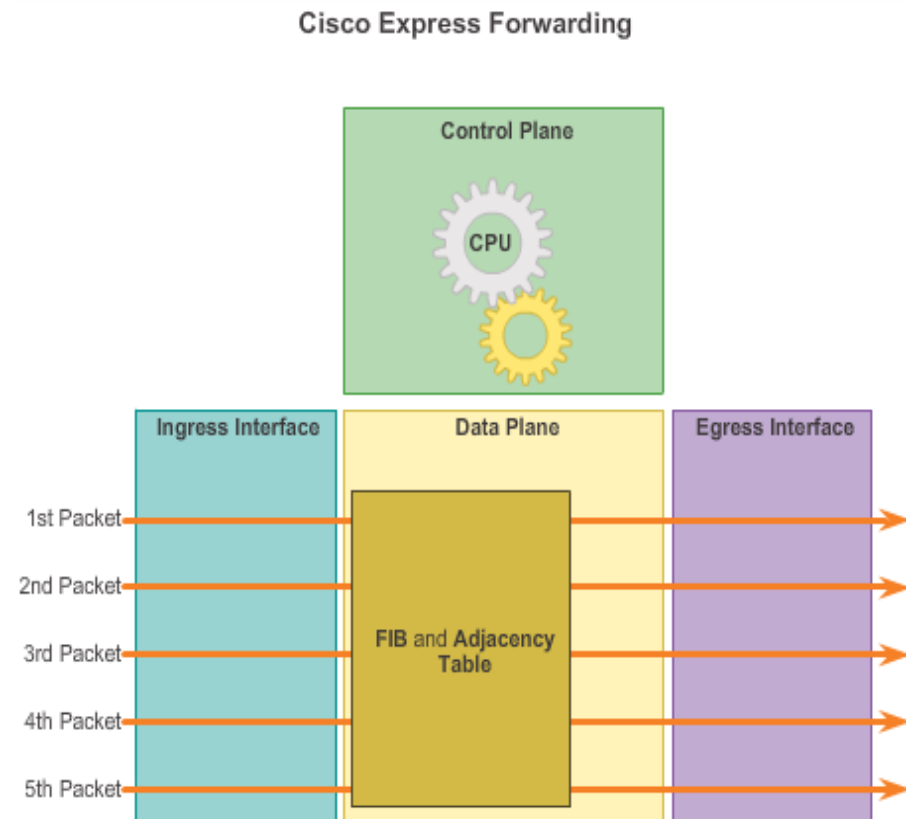




## Functions of a Router

# Packet Forwarding Methods

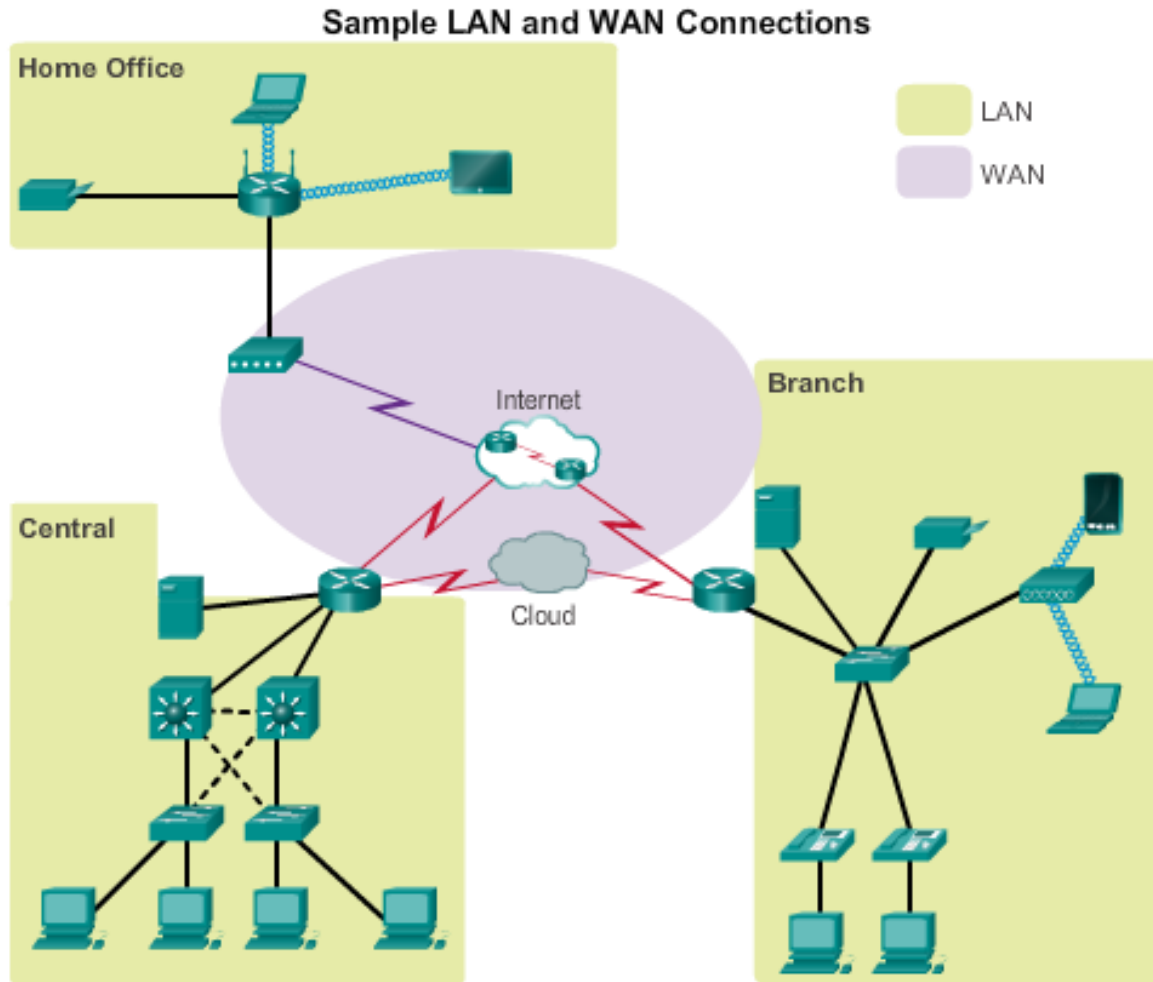
- **Process switching** – An older packet forwarding mechanism still available for Cisco routers.
- **Fast switching** – A common packet forwarding mechanism which uses a fast-switching cache to store next hop information.
- **Cisco Express Forwarding (CEF)** – The most recent, fastest, and preferred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





# Connect Devices

## Connect to a Network



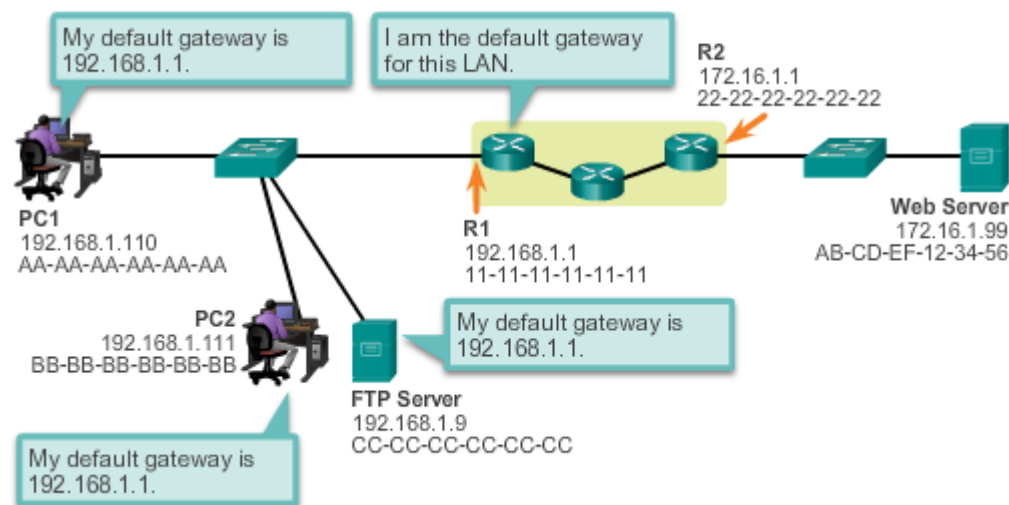
# Connect Devices

## 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	



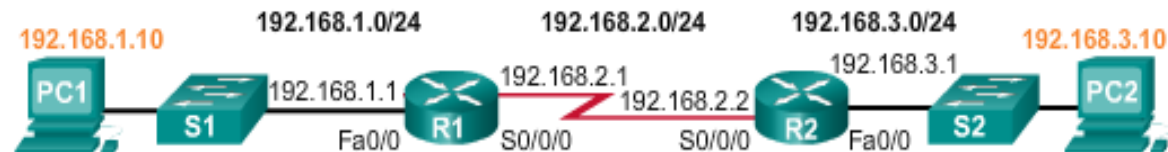


## Connect Devices

# 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



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.

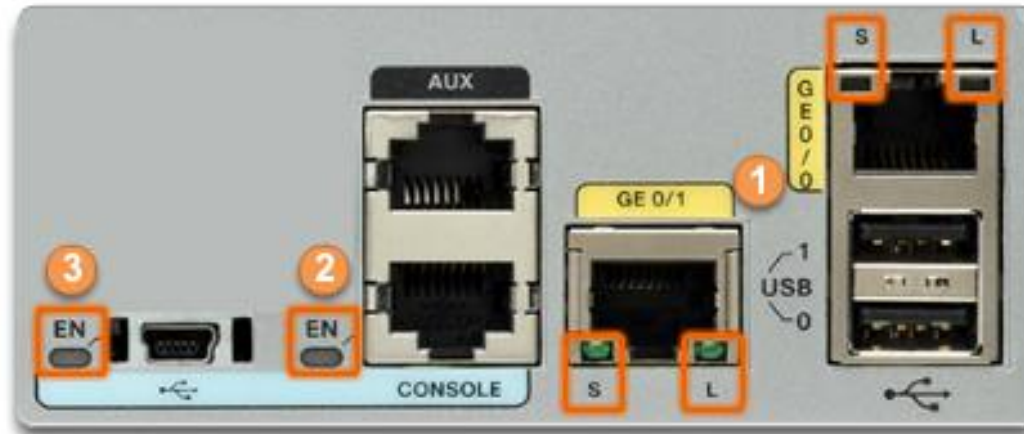




# Connect Devices

## 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	 RJ45 Console Port	 Tera Term
 USB Type-A Port	 USB-to-RS-232 Serial Port Adapter	 RJ45 Console Port	 Tera Term
 USB Type-A Port	 USB Type-A to USB Type-B (Mini-B) Cable	 USB Type-B (Mini-B USB) Console Port	 PuTTY

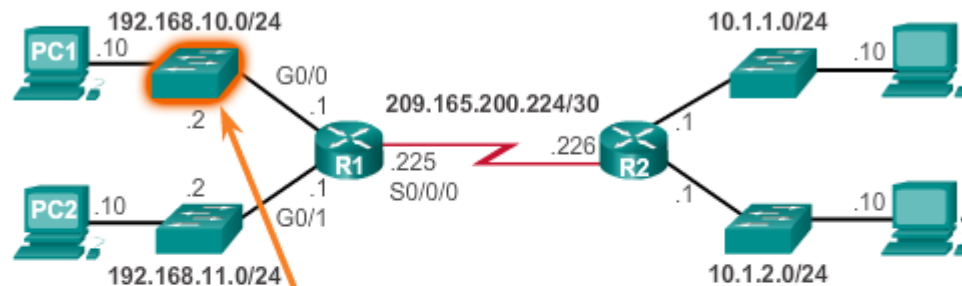


## Connect Devices

# 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**

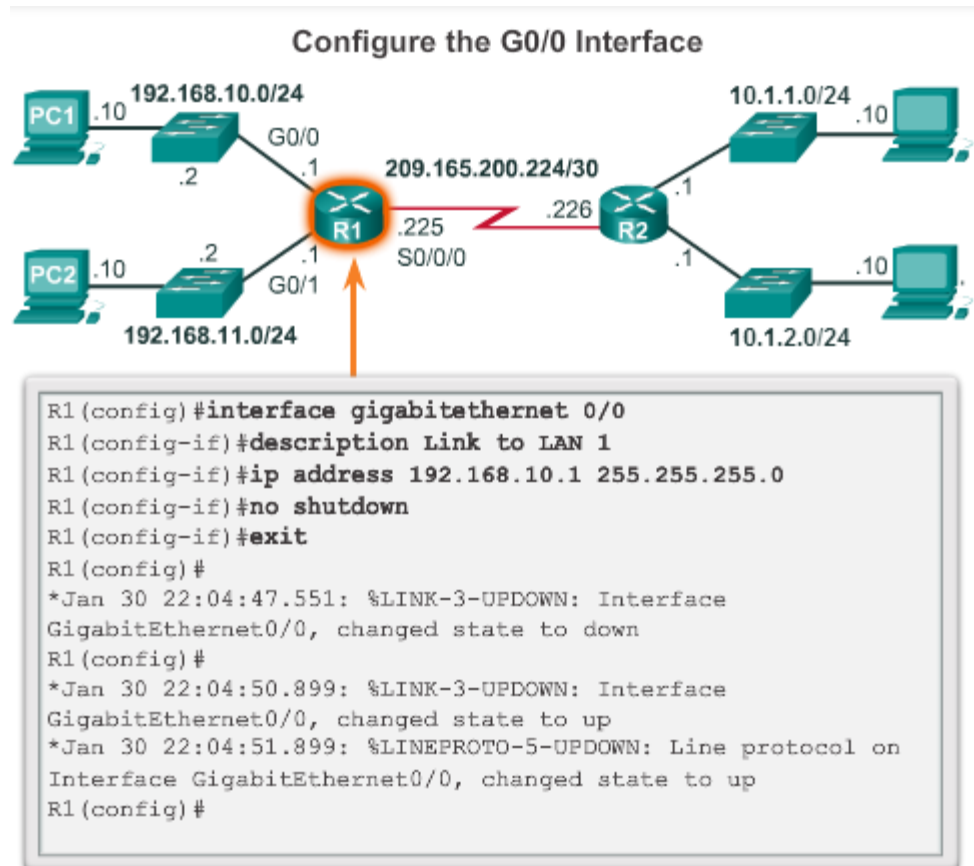


## Basic Settings on a Router

# 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.





## Basic Settings on a Router

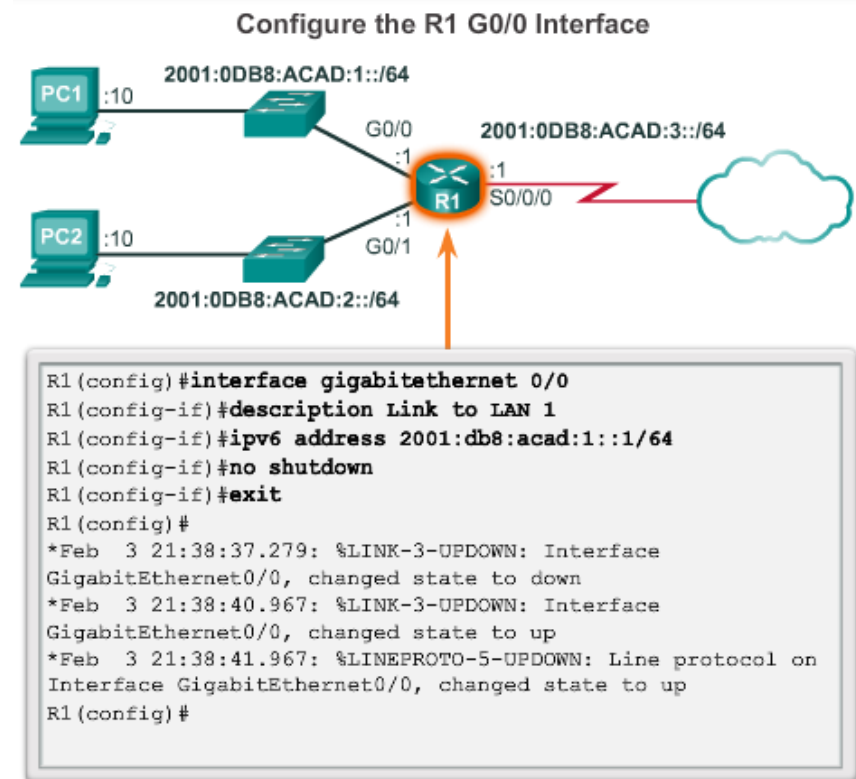
# Configure an IPv6 Router Interface

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*







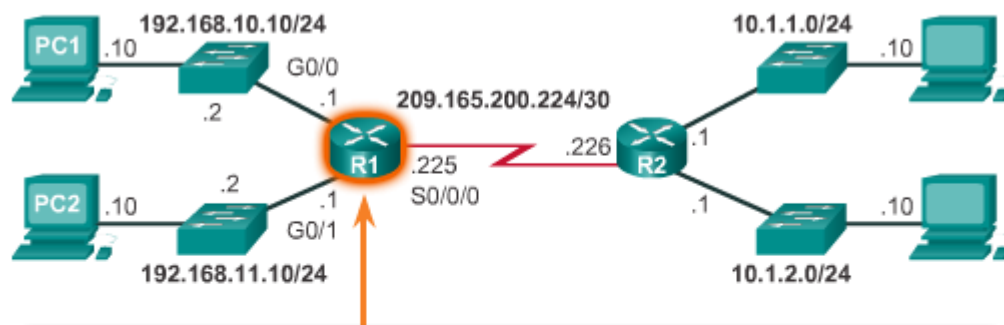
## Basic Settings on a Router

# 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

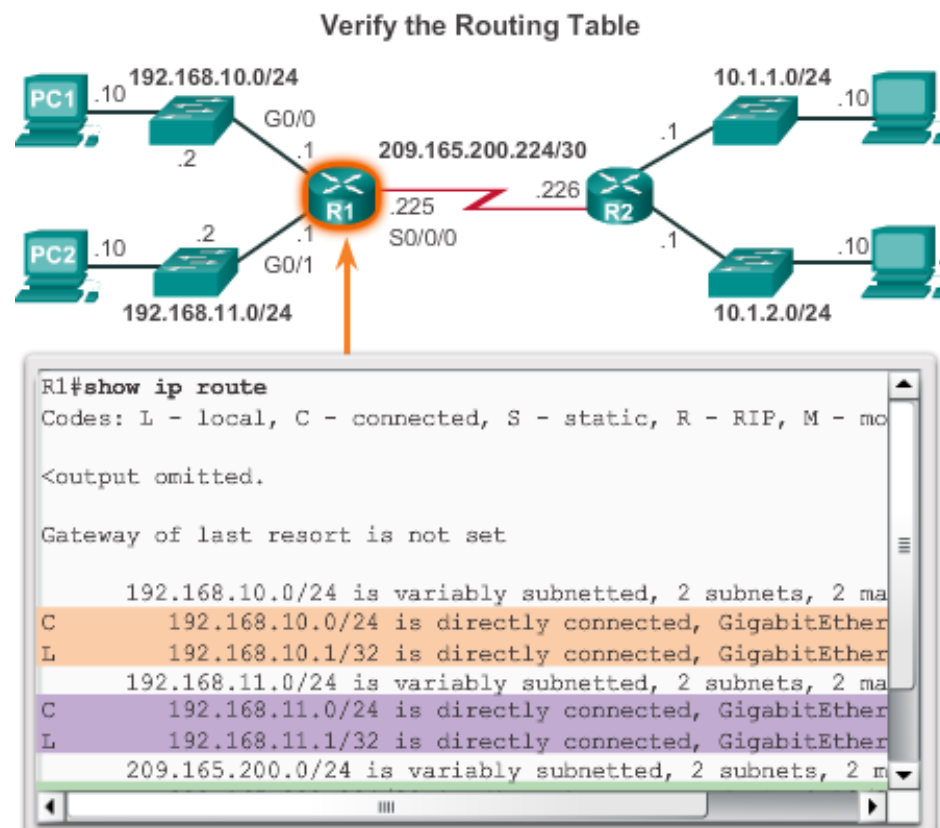
## Verify Interface Settings

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**





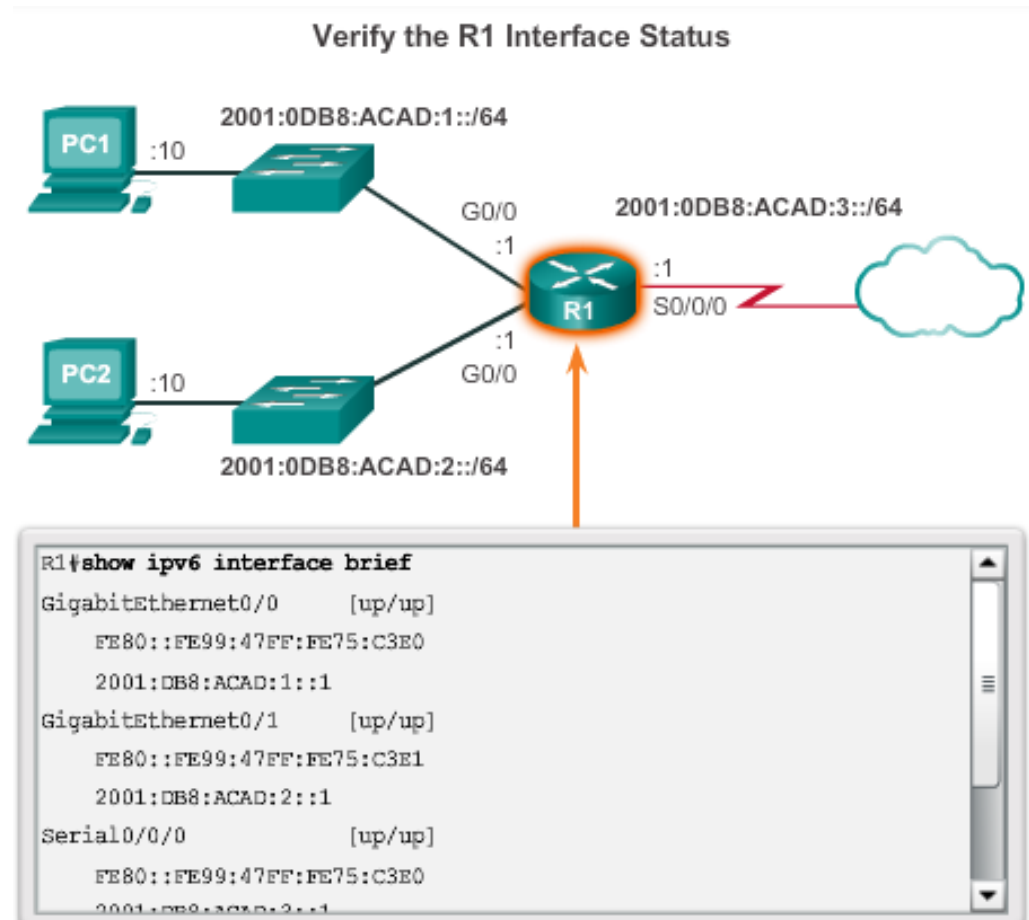


# Verify Connectivity of Directly Connected Networks

## 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  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#
```



## Verify Connectivity of Directly Connected Networks

# Command History Feature

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

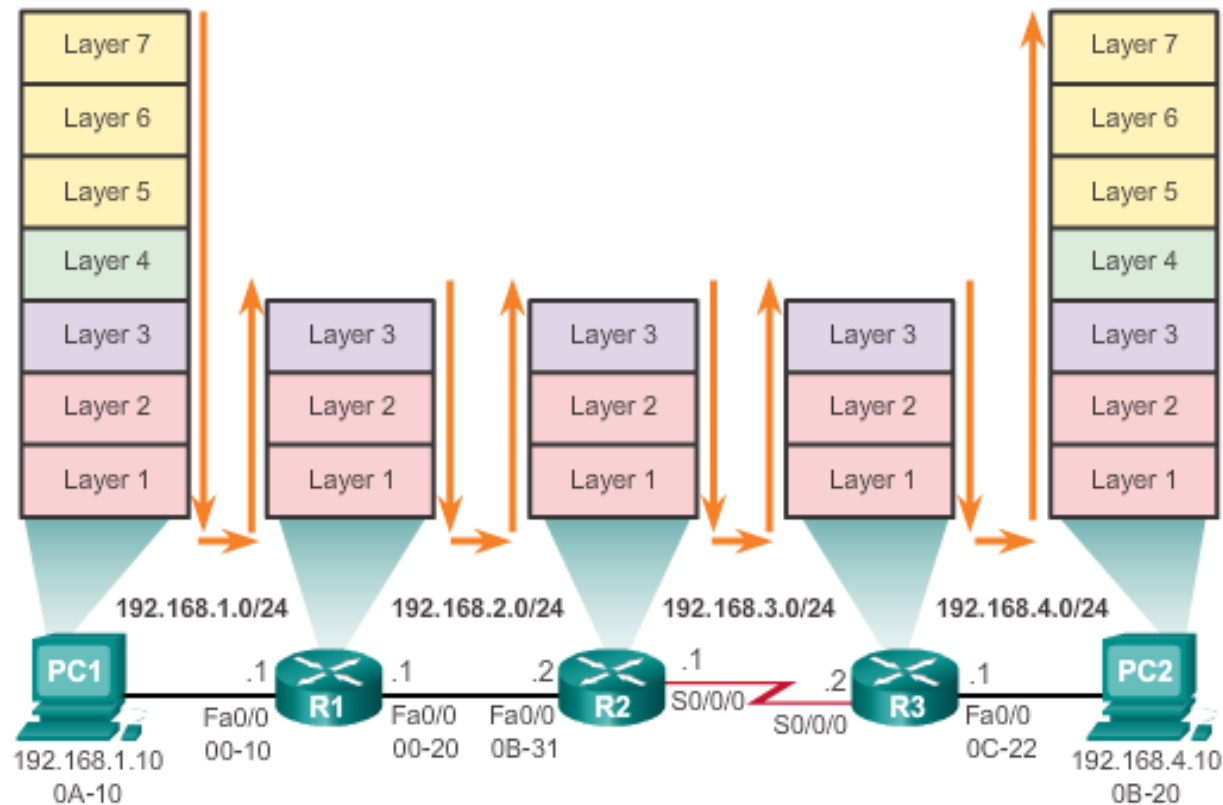
- To recall commands press **Ctrl+P** or the **UP Arrow**.
- To return to more recent commands press **Ctrl+N** or the **Down Arrow**.
- By default, command history is enabled and the system captures the last 10 commands in the buffer. Use the **show history** privileged EXEC command to display the buffer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

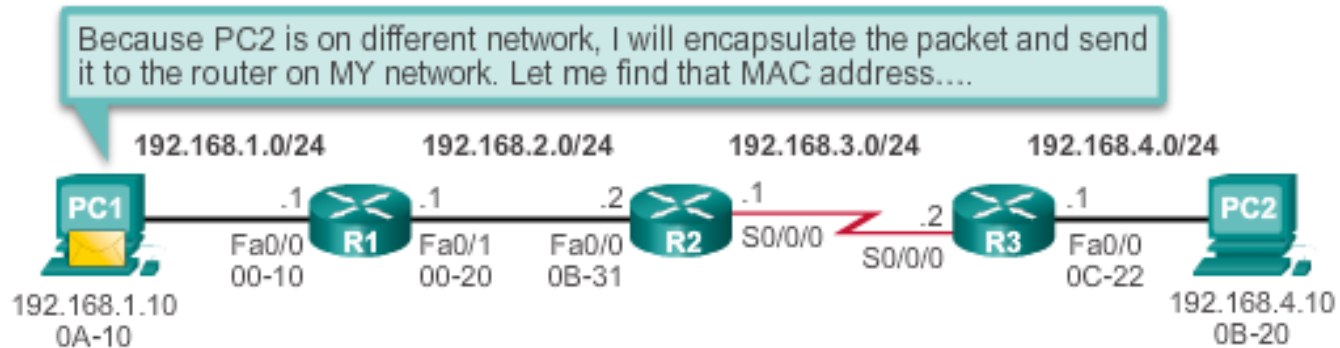




# Switching Packets between Networks

## Send a Packet

### PC1 Sends a Packet to PC2



#### Layer 2 Data Link Frame

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

#### Packet's Layer 3 data

#### PC1's ARP Cache for R1

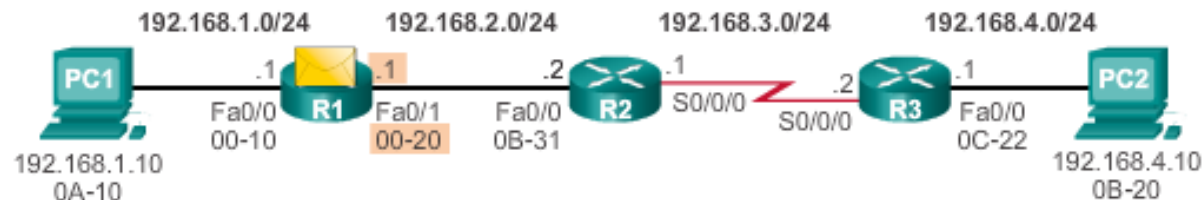
IP Address	MAC Address
192.168.1.1	00-10



# 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
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#### R1's Routing Table

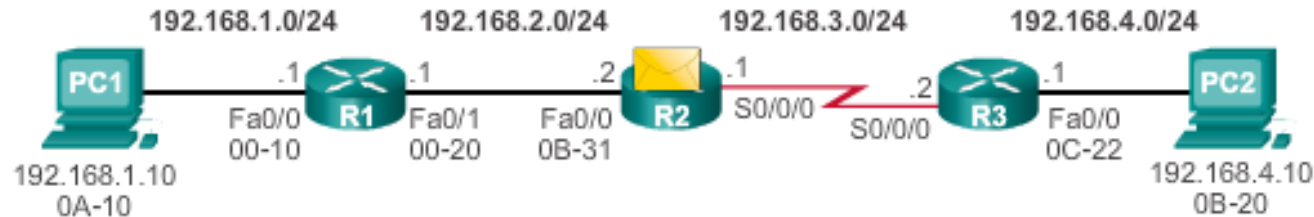
Network	Hops	Next-hop-IP	Exit Interface
192.168.1.0/24	0	Dir. Connect.	Fa0/0
192.168.2.0/24	0	Dir. Connect.	Fa0/1
192.168.3.0/24	1	192.168.2.2	Fa0/1
192.168.4.0/24	2	192.168.2.2	Fa0/1



# 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
-----------------	-----------------	----------	---------------------------	--------------------------	-----------	------	---------

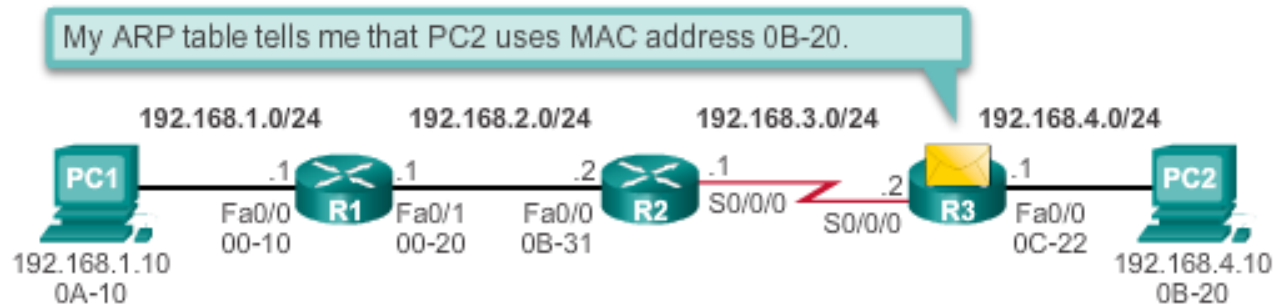
R2's Routing Table

Network	Hops	Next-hop-IP	Exit Interface
192.168.1.0/24	1	192.168.3.1	Fa0/0/0
192.168.2.0/24	0	Dir. Connect.	Fa0/0/0
192.168.3.0/24	0	Dir. Connect.	S0/0/0/0
192.168.4.0/24	1	192.162.3.2	S0/0/0/0



# Switching Packets between Networks Reach the Destination

## R3 Forwards the Packet to PC2



### Layer 2 Data Link Frame

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
192.168.1.0/24	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

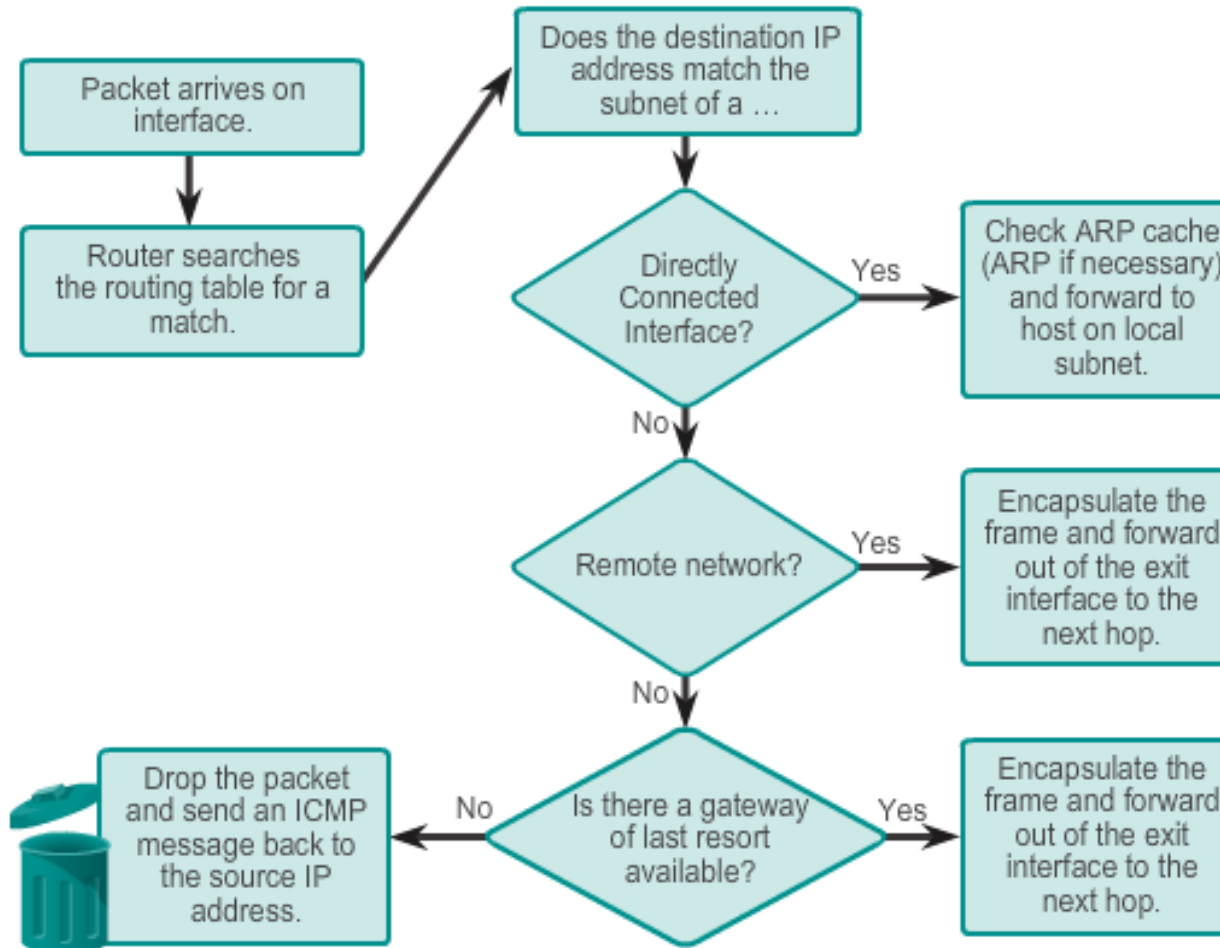




# Path Determination

## 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

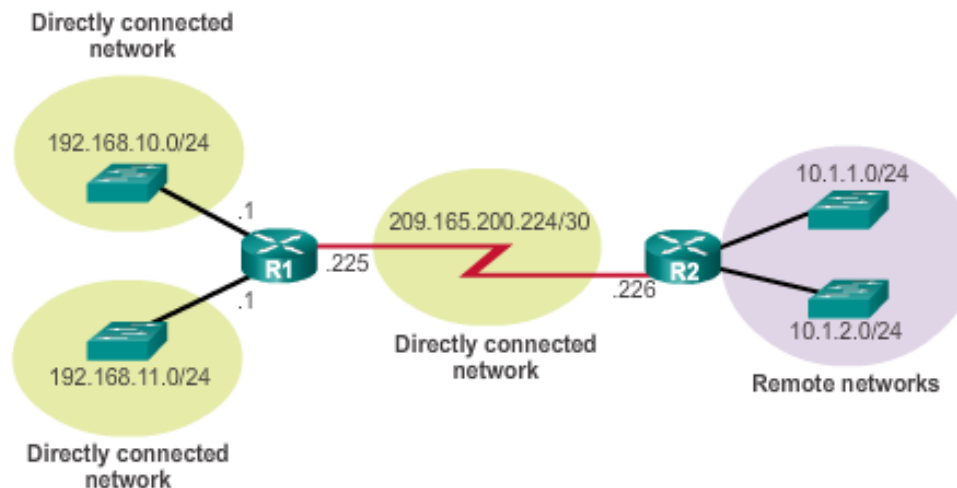


## The Routing Table

# 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:

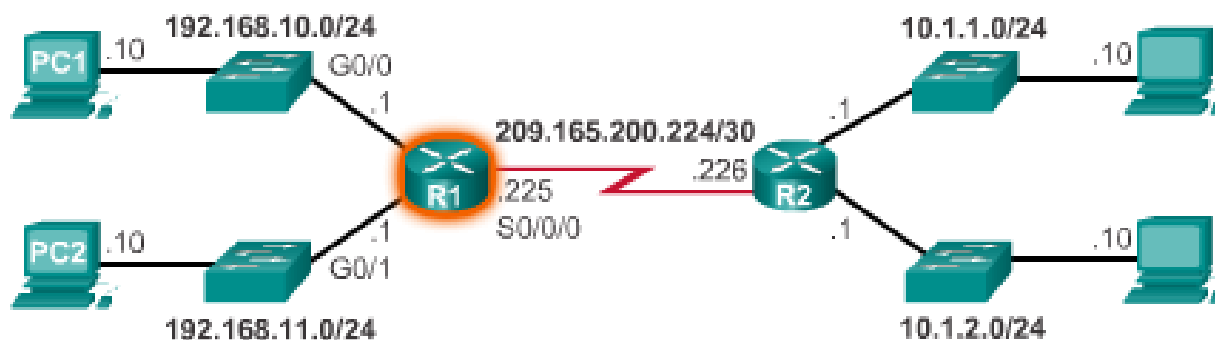
- **Local route interfaces** - Added to the routing table when an interface is configured. (displayed in IOS 15 or newer)
- **Directly connected interfaces** - Added to the routing table when an interface is configured and active.
- **Static routes** - Added when a route is manually configured and the exit interface is active.
- **Dynamic routing protocol** - Added when EIGRP or OSPF are implemented and networks are identified.



# The Routing Table

## Routing Table Sources

Routing Table of R1



```
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,
```

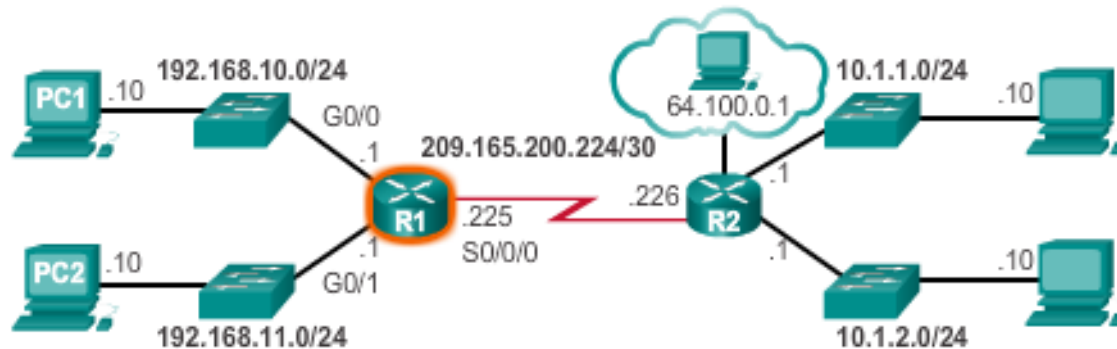


## The Routing Table

# 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.





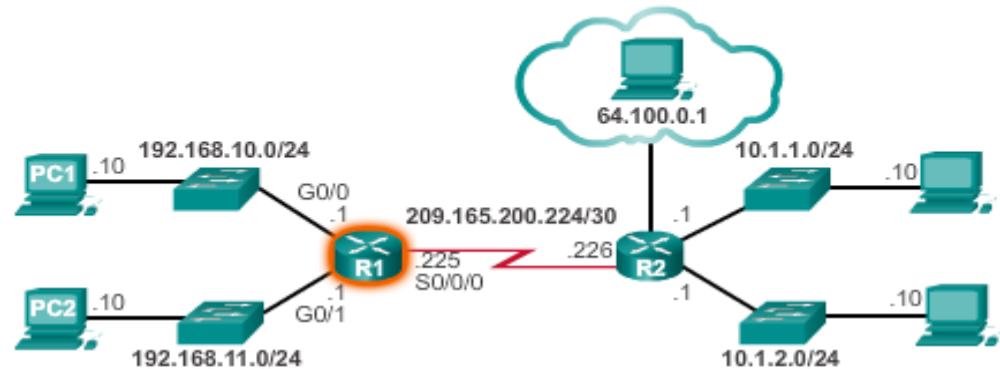
## Directly Connected Routes

# 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

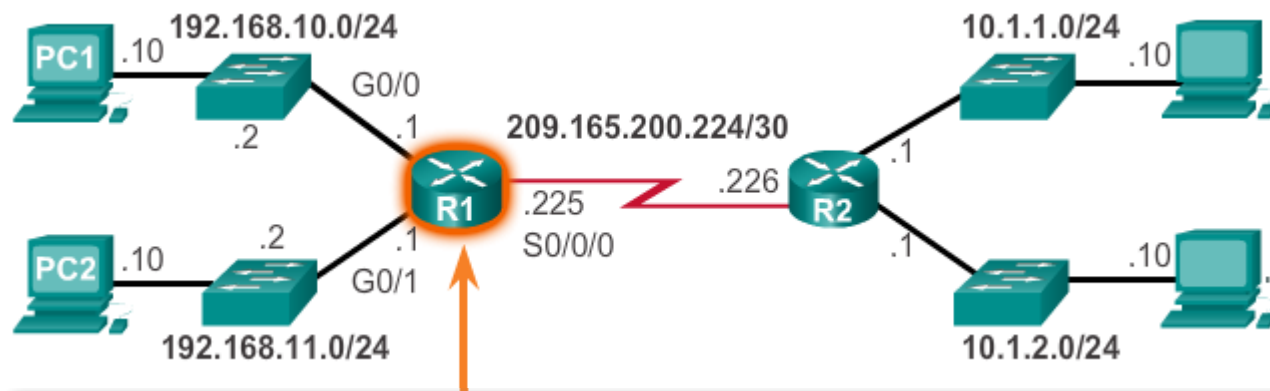
- Identifies how the network was learned by the router.
- Identifies the destination network and how it is connected.
- Identifies the interface on the router connected to the destination network.



## 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

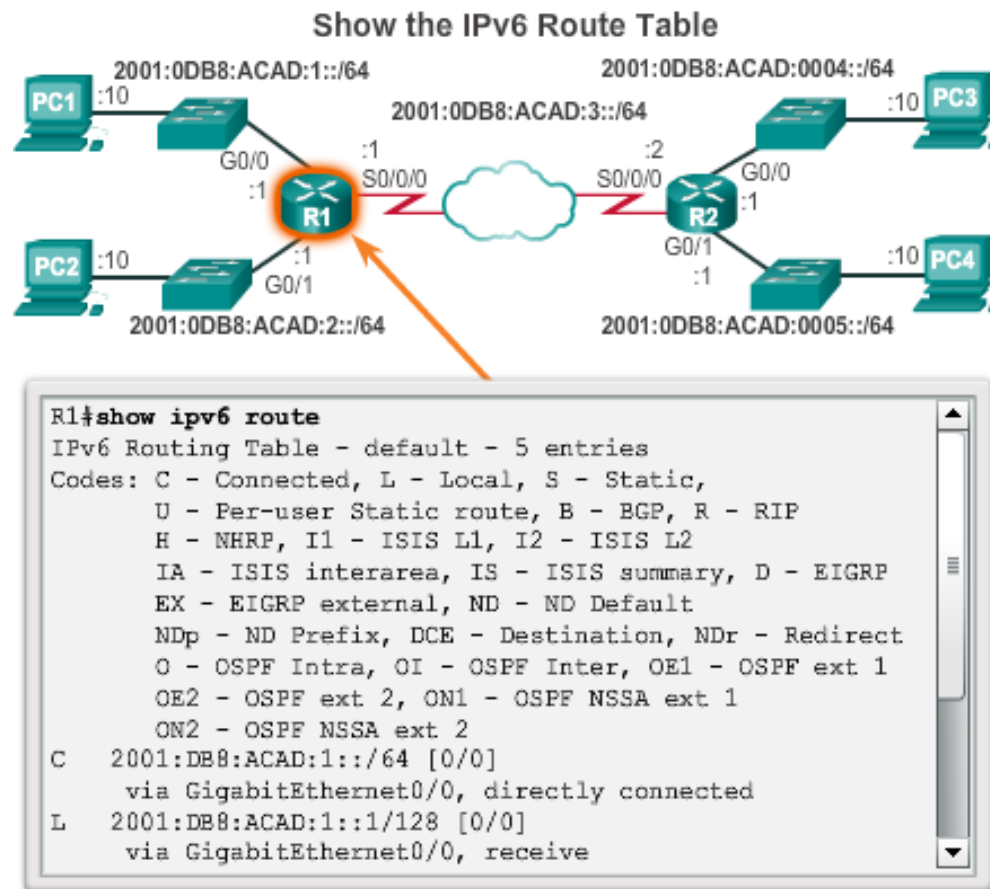
      192.168.10.0/24 is variably subnetted, 2 subnets, 2
masks
C       192.168.10.0/24 is directly connected,
GigabitEthernet0/0
L       192.168.10.1/32 is directly connected,
GigabitEthernet0/0
      192.168.11.0/24 is variably subnetted, 2 subnets, 2
masks
C       192.168.11.0/24 is directly connected,
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:**

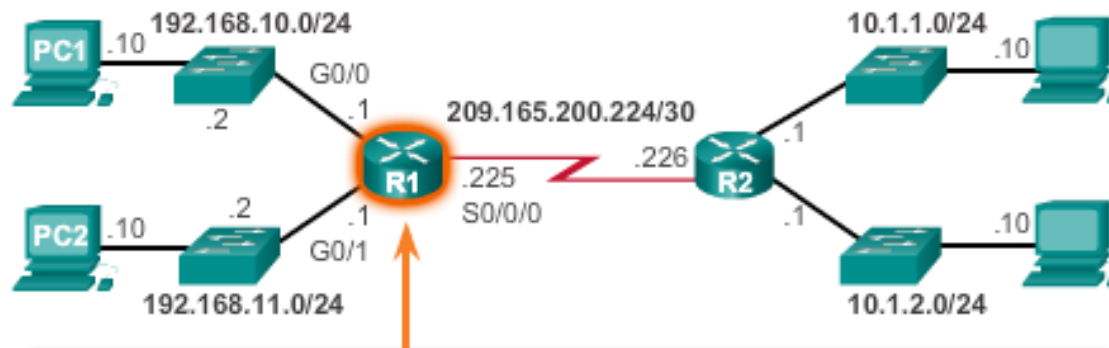
- Static routes are manually configured
- They define an explicit path between two networking devices.
- Static routes must be manually updated if the topology changes.
- Their benefits include improved security and control of resources.
- Configure a static route to a specific network using the **ip 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

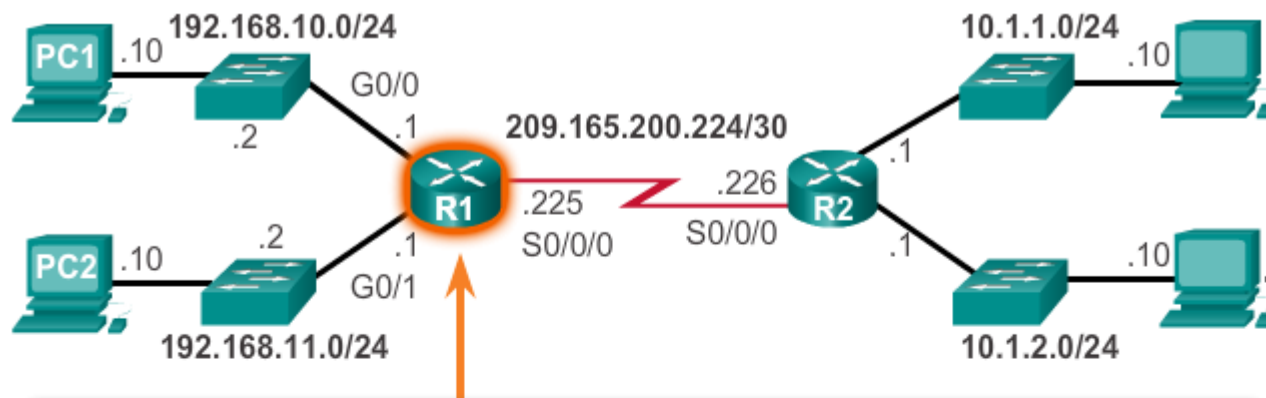
R1#show ip route | begin Gateway
Gateway of last resort is 0.0.0.0 to network 0.0.0.0

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

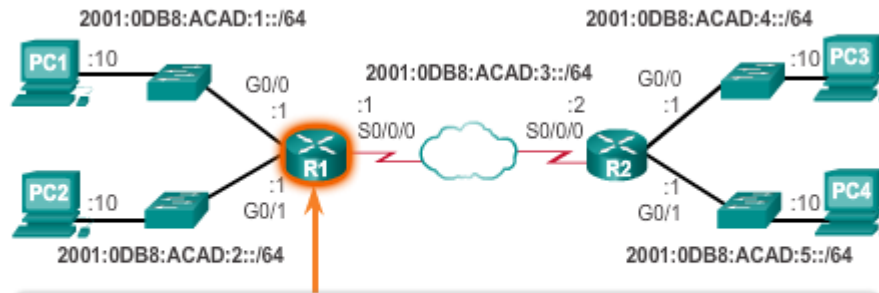
S* 0.0.0.0/0 is directly connected, Serial0/0/0
  192.168.10.0/24 is variably subnetted, 2 subnets, 2 masks
C    192.168.10.0/24 is directly connected, GigabitEthernet0/0
L    192.168.10.1/32 is directly connected, GigabitEthernet0/0
  192.168.11.0/24 is variably subnetted, 2 subnets, 2 masks
C    192.168.11.0/24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

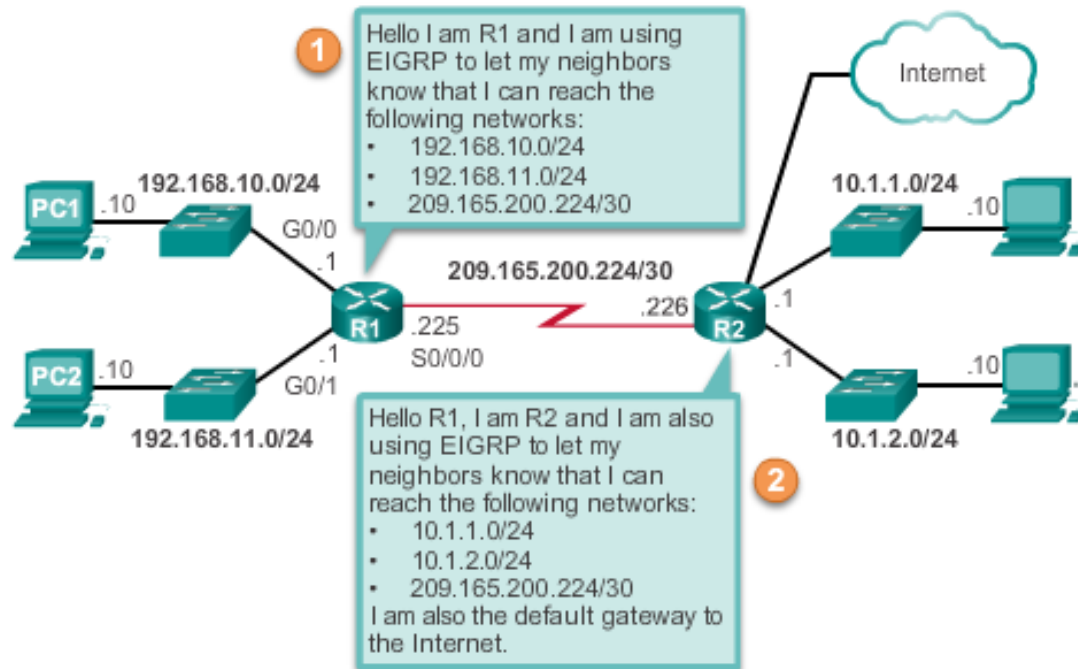




# Dynamic Routing Protocols

## 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

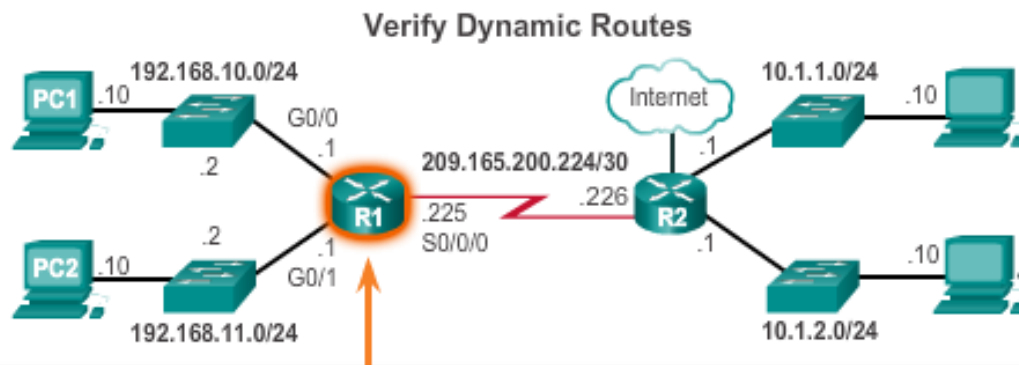
# IPv4 Routing Protocols

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:

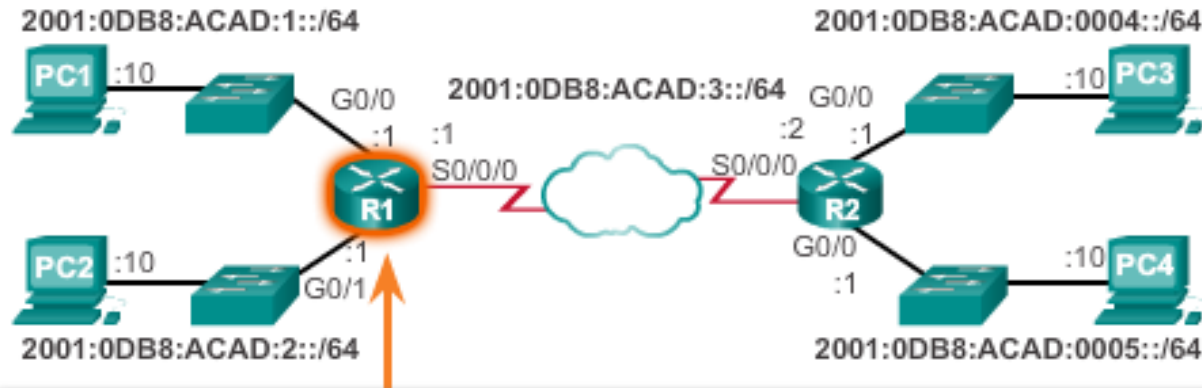
- **RIPng** - RIP next generation
- **OSPFv3**
- **EIGRP** for IPv6
- **MP-BGP4** - Multicast Protocol-Border Gateway Protocol



# 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.

