Routing Concepts and Static Routing

Introduction to Networks v6.0

Chapter 1: Routing Concepts

Pertemuan ke 15

Kompetensi Khusus

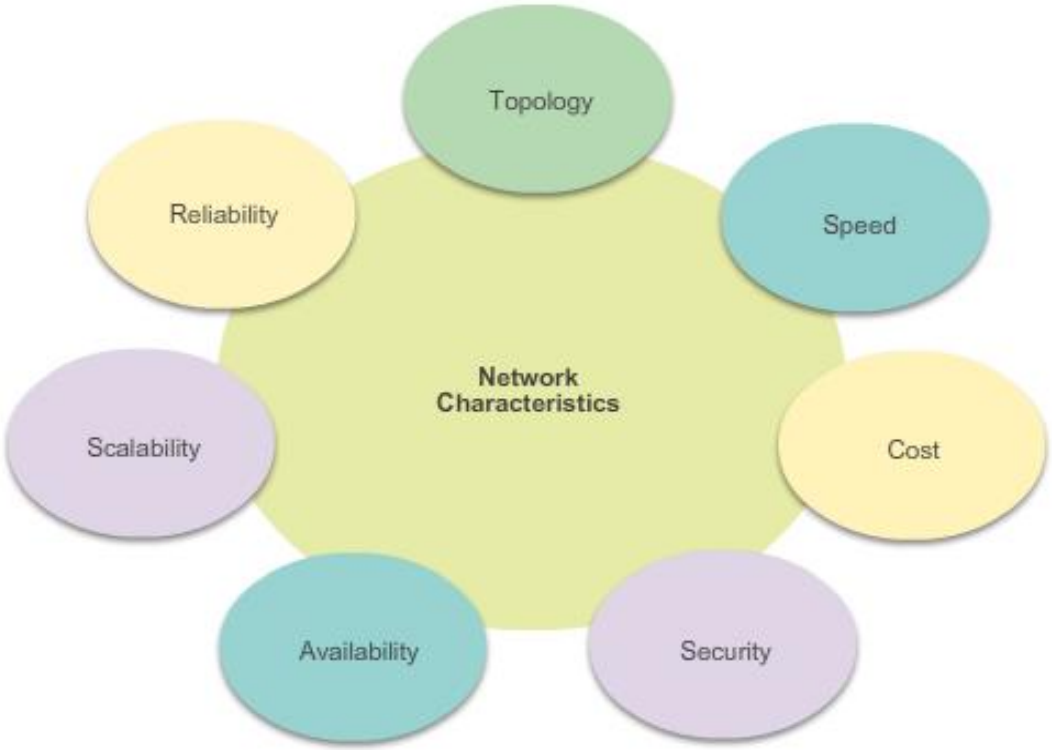
- Mahasiswa dapat melakukan konfigurasi routing statis untuk menghubungkan dua kelompok jaringan yang berbeda (C3)

Materi:

1. Router Initial Configuration
2. Routing Decisions
3. Router Operation
4. Implement Static Routers
5. Configure Static and Default Routers
6. Troubleshoot Static and Default Route

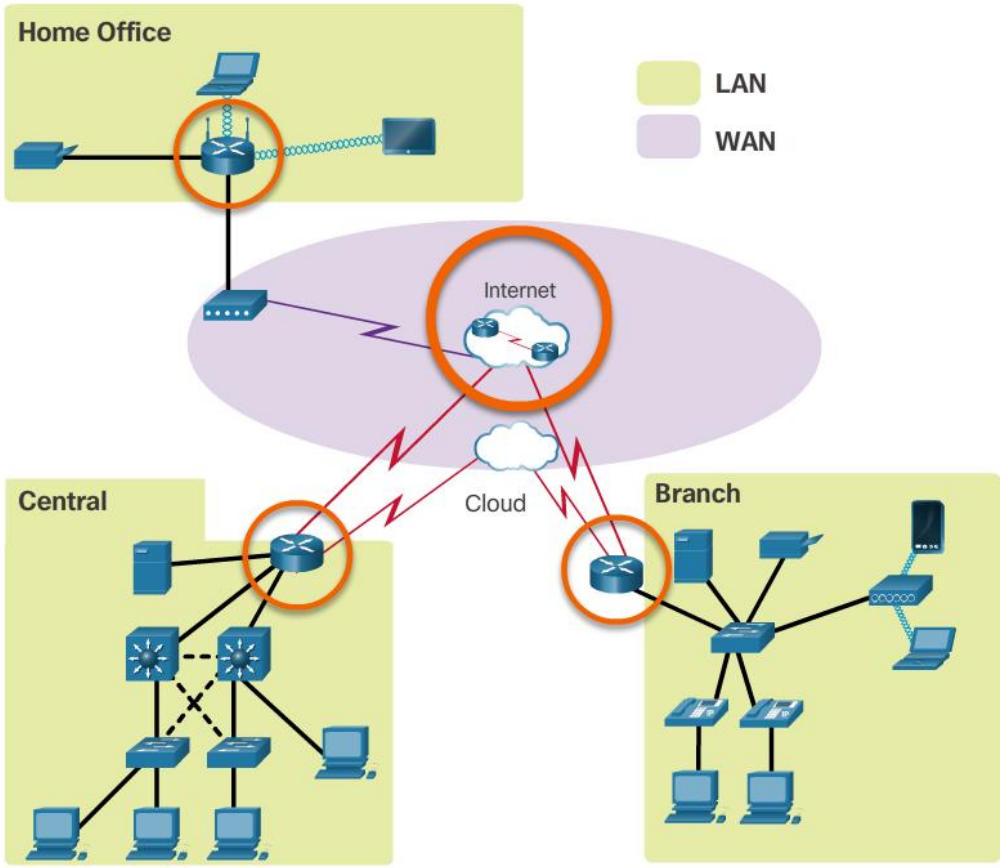
1. Router Initial Configuration

1.1 Characteristics of a Network



1.2 Why Routing?

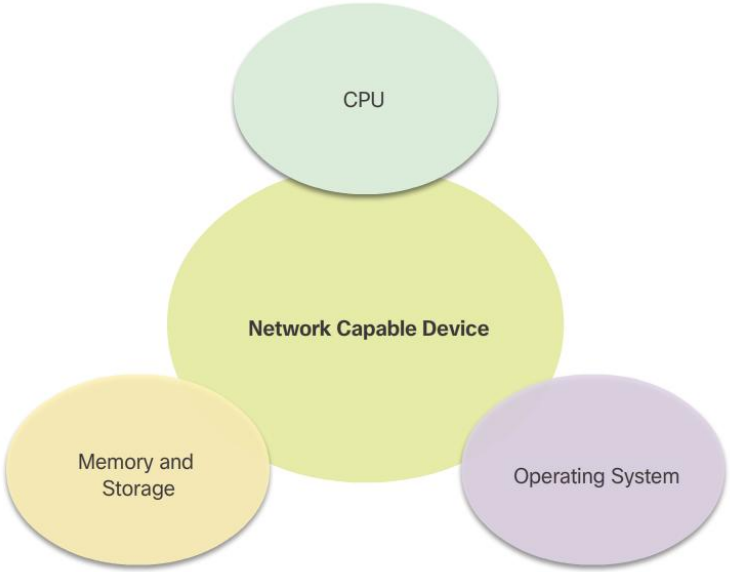
The router is responsible for the routing of traffic between networks.



1.3 Routers are Computers

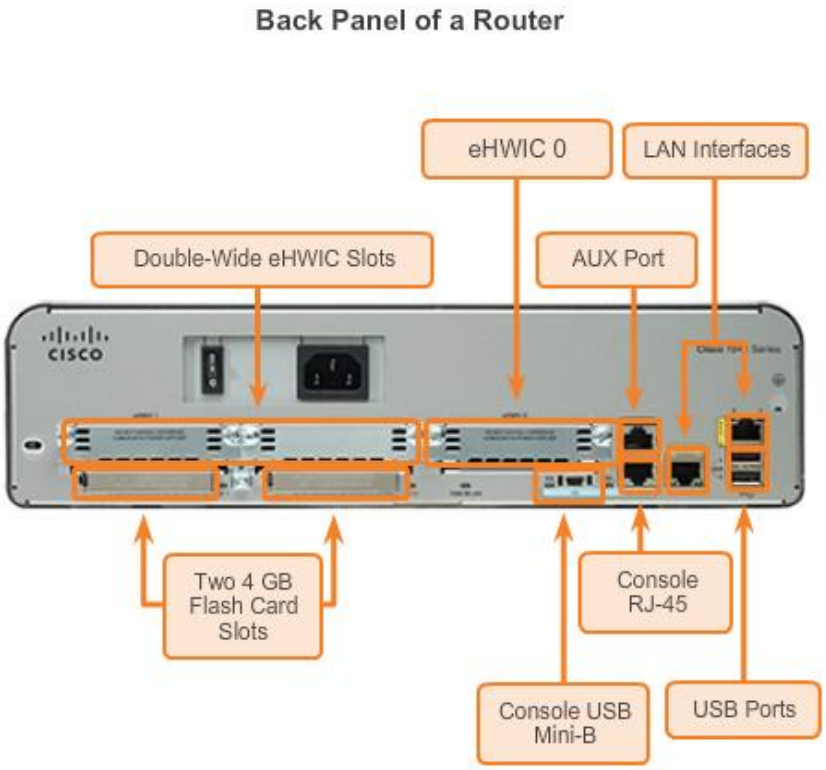
Routers are specialized computers containing the following required components to operate:

- Central processing unit (CPU)
- Operating system (OS) - Routers use Cisco IOS
- Memory and storage (RAM, ROM, NVRAM, Flash, hard drive)



1.3 Routers are Computers

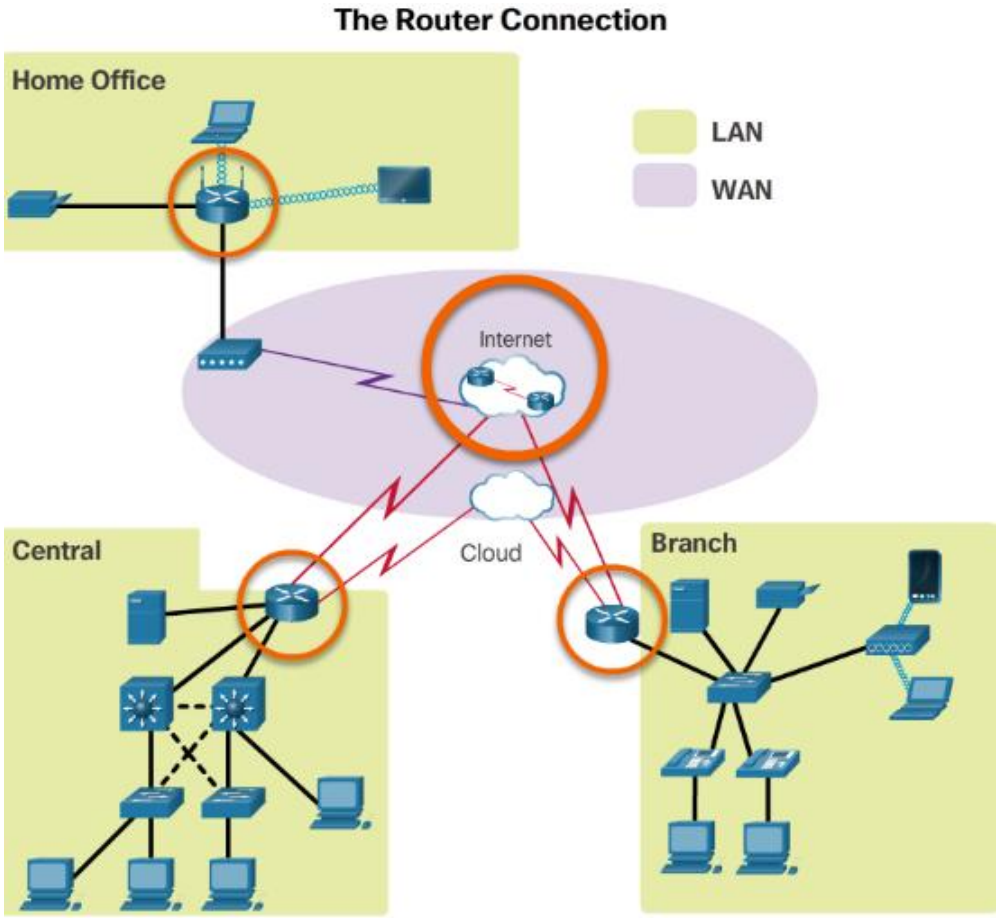
Routers use specialized ports and network interface cards to interconnect to other networks.



1.3 Routers are Computers

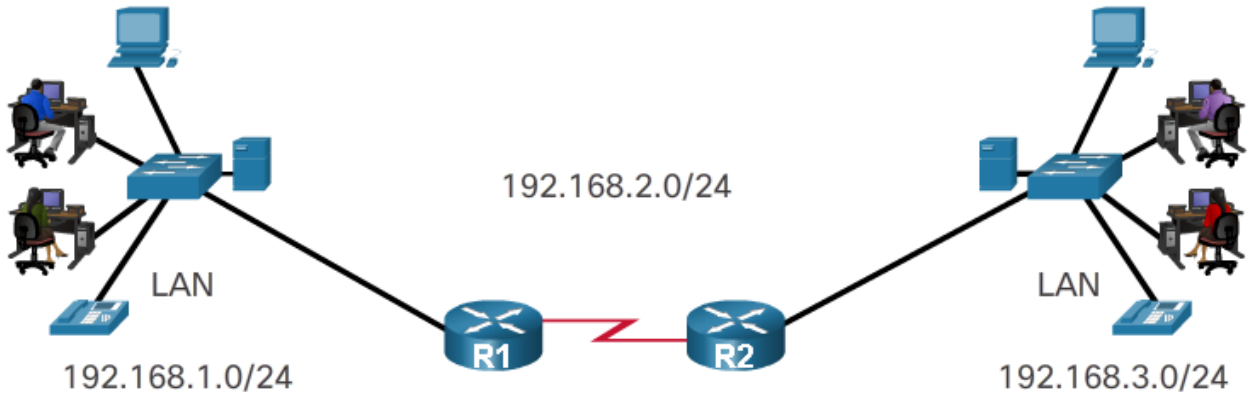
Memory	Description
Random Access Memory (RAM)	Volatile memory that provides temporary storage for various applications and processes including: • Running IOS • Running configuration file • IP routing and ARP tables • Packet buffer
Read-Only Memory (ROM)	Non-volatile memory that provides permanent storage for: • Bootup instructions • Basic diagnostic software • Limited IOS in case the router cannot load the full featured IOS
Non-Volatile Random Access Memory (NVRAM)	Non-volatile memory that provides permanent storage for the: • Startup configuration file
Flash	Non-volatile memory that provides permament storage for: • IOS • Other system-related files

1.4 Routers Interconnect Networks



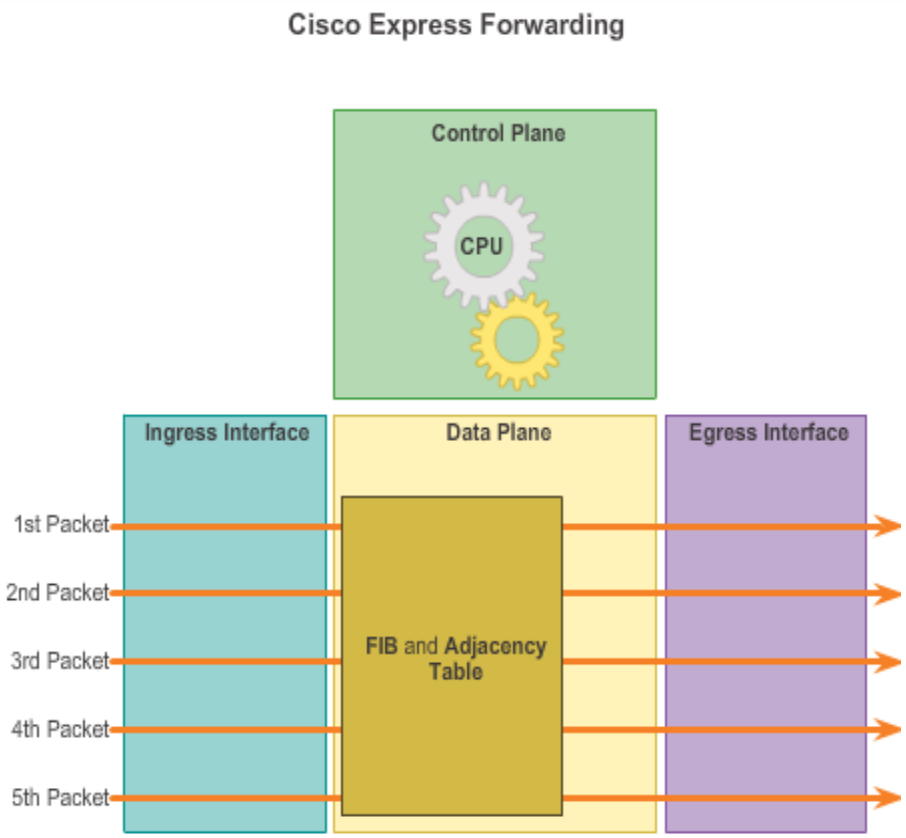
1.5 Routers Choose Best Paths

- 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.

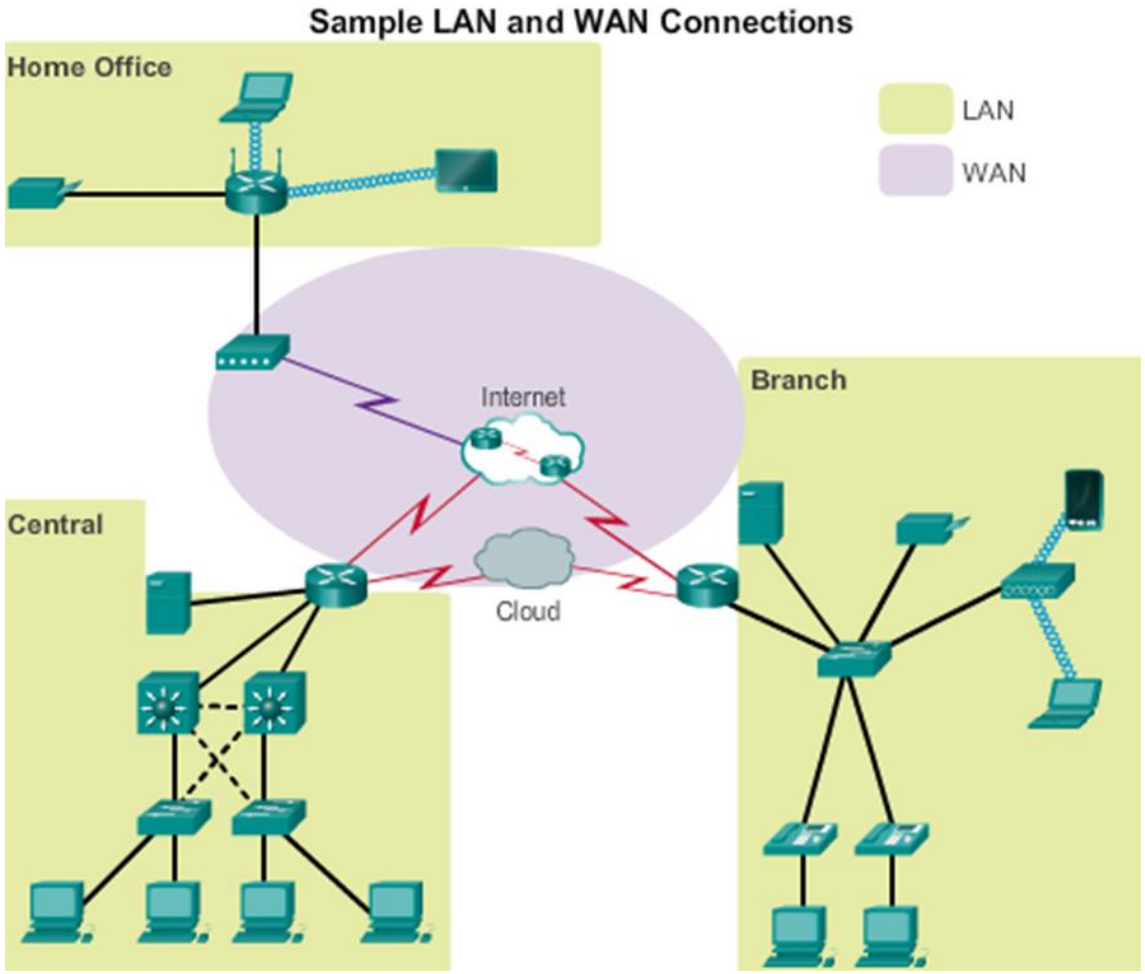


1.6 Packet Forwarding Methods

- **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.

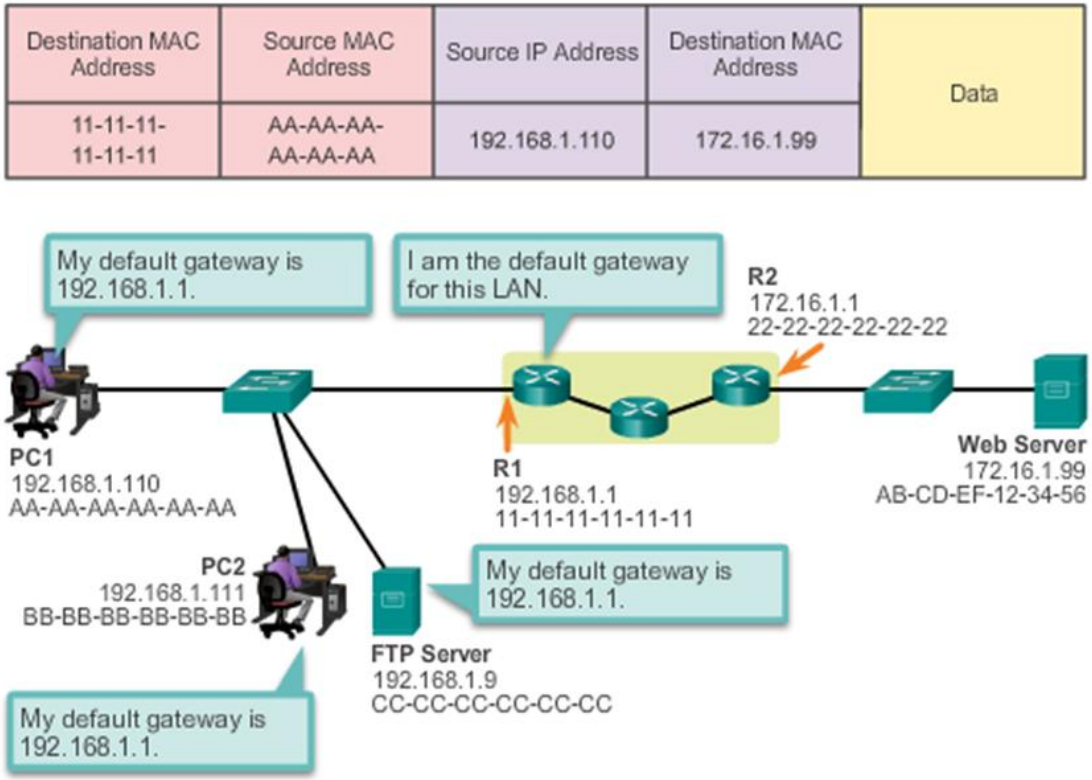


1.7 Connect to a Network



1.8 Default Gateways

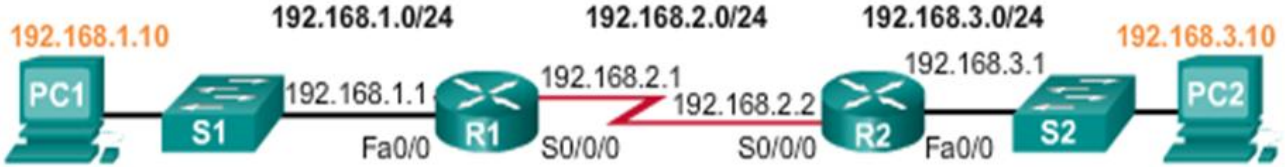
- To enable network access devices, must be configured with the following IP address information:
  - **IP address** - Identifies a unique host on a local network.
  - **Subnet mask** - Identifies the host's network subnet.
  - **Default gateway** - Identifies the router a packet is sent to when the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



1.9 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 masks
- 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

1.10 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.

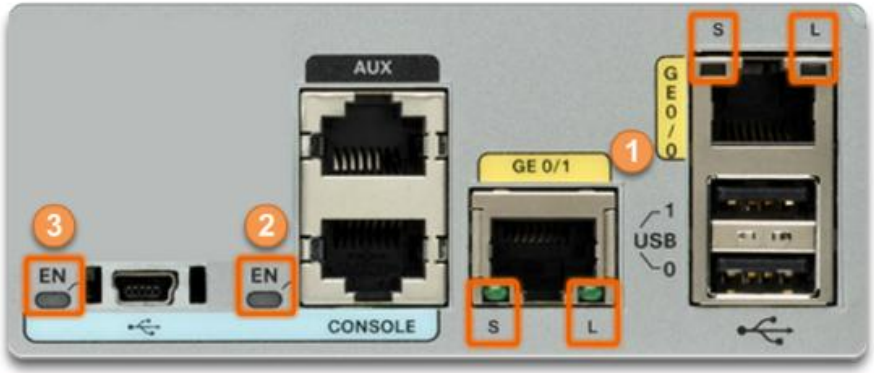
- Used to identify specific network resources such as network servers and printers.
- Can be used in very small networks with few hosts.

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.

1.11 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

1.12 Console Access

Console Connection Requirements

Port on Computer	Cable Required	Port on ISR	Terminal Emulation
Serial Port	RJ-45-to-DB-9 Console Cable	RJ-45 Console Port	 Tera Term
USB Type-A Port	• USB-to-RS-232 compatible serial port adapter • Adapter may require a software driver • RJ-45-to-DB-9 console cable		
	• USB Type-A to USB Type-B (Mini-B USB) • A device driver is required and available from cisco.com.	USB Type-B (Mini-B USB)	 PuTTY

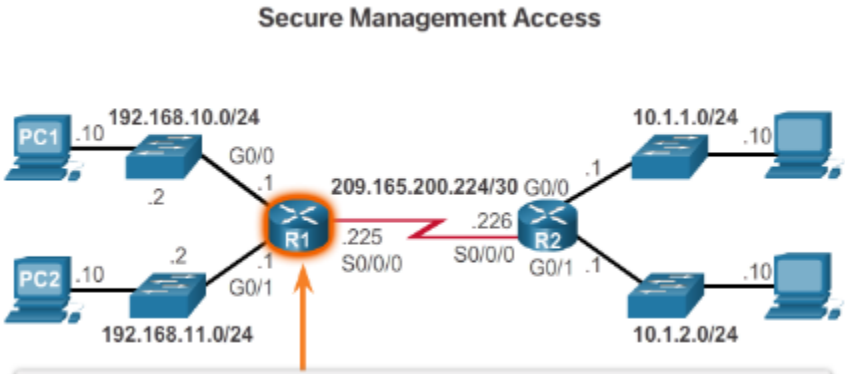
1.13 Enable IP on a Switch

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


```
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)#
```

1.14 Configure Router Basic Settings

- **Name the device –** Distinguishes it from other routers
- **Secure management access –** Secures privileged EXEC, user EXEC, and Telnet access, and encrypts passwords .
- **Configure a banner –** Provides legal notification of unauthorized access.
- **Save the Configuration**




```
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)#
```

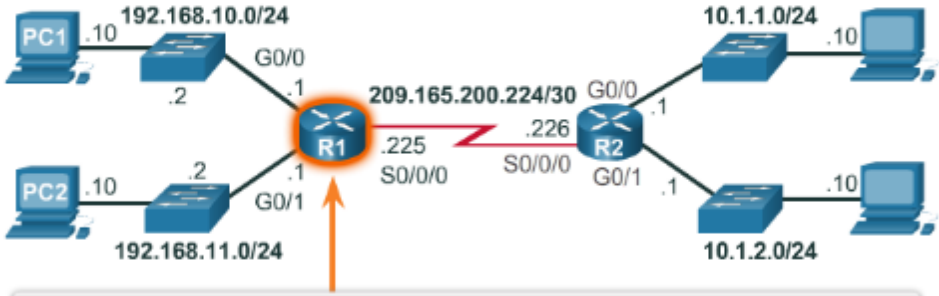
1.15 Configure an IPv4 Router Interface

To be available, a router interface must be:

- Configured with an address and subnet mask.
- Activated using **no shutdown** command. By default LAN and WAN interfaces are not activated.
- Configured with the clock rate command on the Serial cable end labeled DCE.

Optional description can be included.

Configure the G0/0 Interface

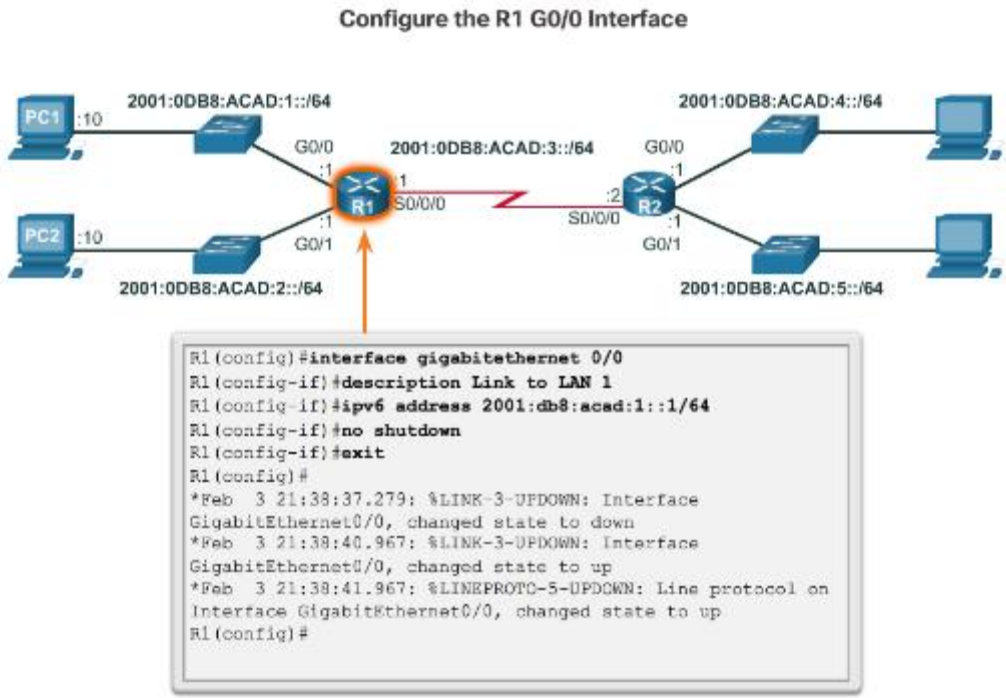



```
R1(config)# interface gigabitethernet 0/0
R1(config-if)# description Link to LAN 1
R1(config-if)# ip address 192.168.10.1 255.255.255.0
R1(config-if)# no shutdown
R1(config-if)# exit
R1(config)#
*Jan 30 22:04:47.551: %LINK-3-UPDOWN: Interface
GigabitEthernet0/0, changed state to down
R1(config)#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

1.16 Configure an IPv6 Router Interface

Configure interface with IPv6 address and subnet mask:

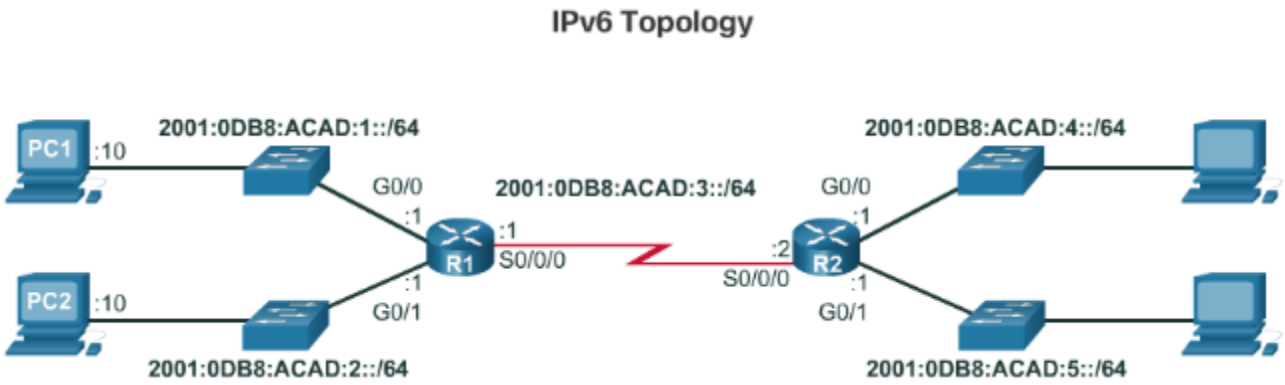
- Use the **ipv6 address** *ipv6-address/ipv6-length* [link-local | eui-64]interface configuration command.
- Activate using the **no shutdown** command.



1.16 Configure an IPv6 Router Interface

IPv6 interfaces can support more than one address:

- Configure a specified global unicast – **ipv6address** *ipv6-address /ipv6-length*
- Configure a global IPv6 address with an interface identifier (ID) in the low-order 64 bits - **ipv6address** *ipv6-address /ipv6-length* eui-64
- Configure a link-local address - **ipv6address** *ipv6-address /ipv6-length* link-local

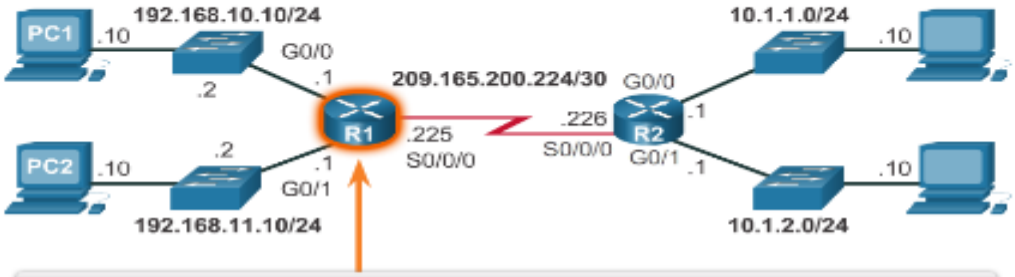


1.17 Configure an IPv4 Loopback Interface

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




```
R1(config)# interface loopback 0
R1(config-if)# ip address 10.0.0.1 255.255.255.0
R1(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
```

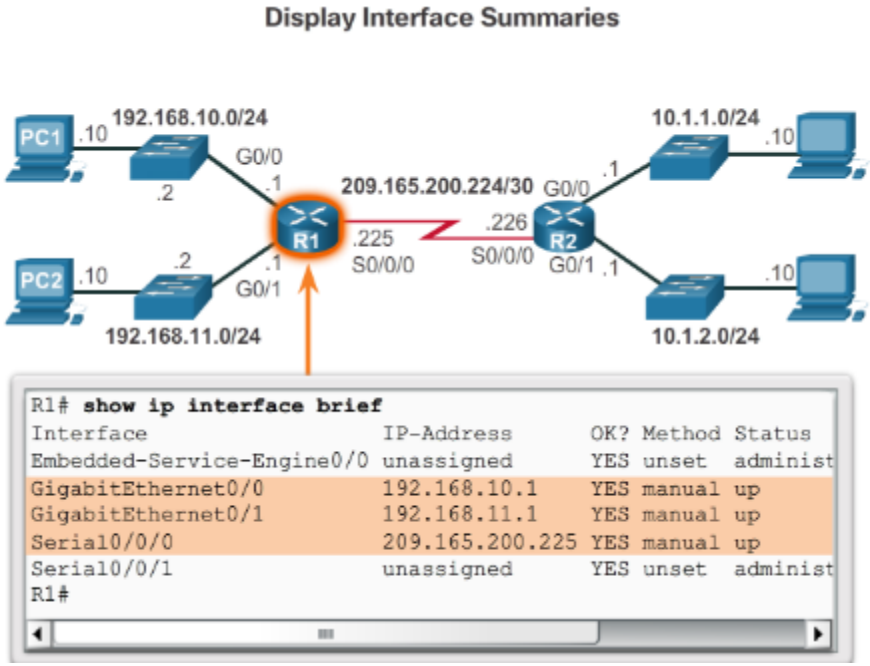
1.18 Verify Interface Settings

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

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

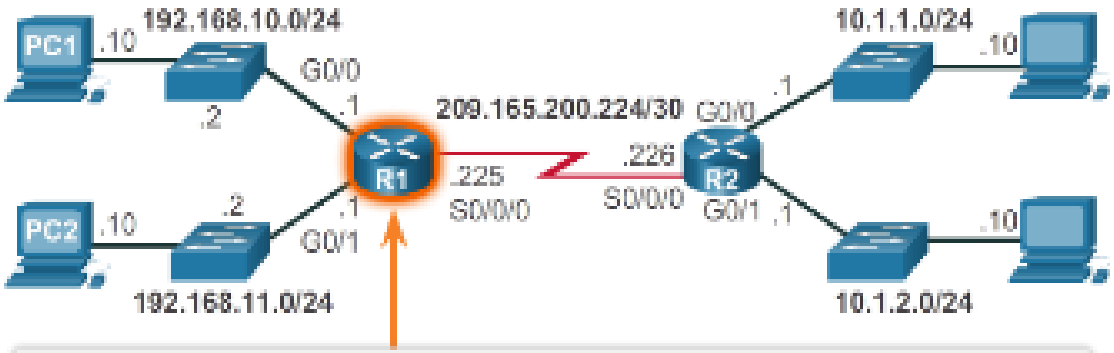
Show commands that are used to gather more detailed interface information:

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



1.18 Verify Interface Settings

Verify the Routing Table

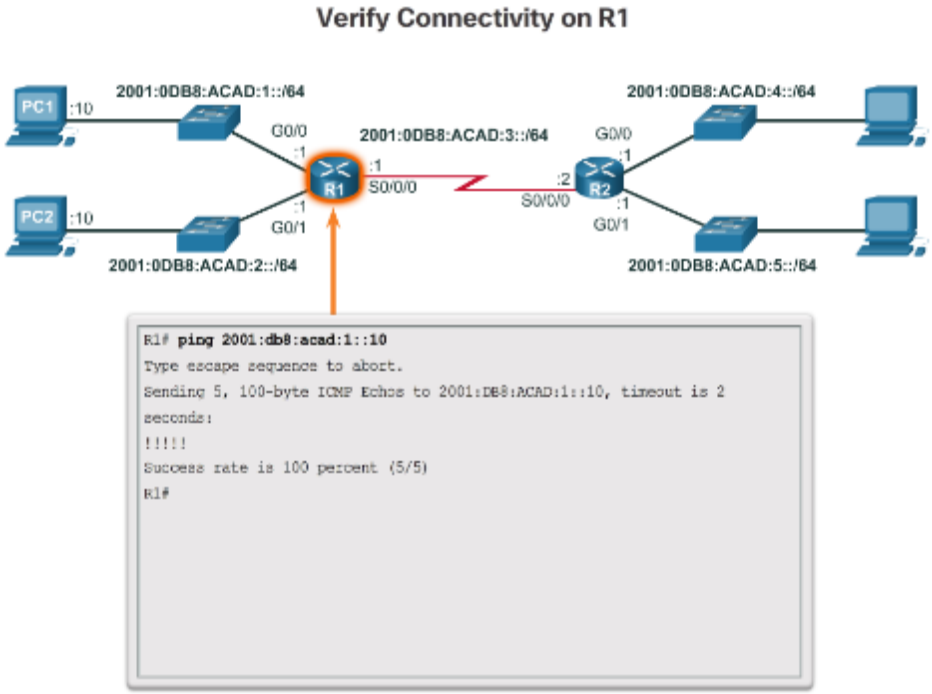



```
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mo

<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
```

1.19 Verify IPv6 Interface Settings

Common commands to verify the IPv6 interface configuration:

- **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.



1.20 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.
- 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**

Filtering Show Commands

```
R1# show running-config | section line vty
line vty 0 4
 password 7 030752180500
 login
 transport input all
R1#
```

Filtering Show Commands

```
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#
```

1.21 Command History Feature

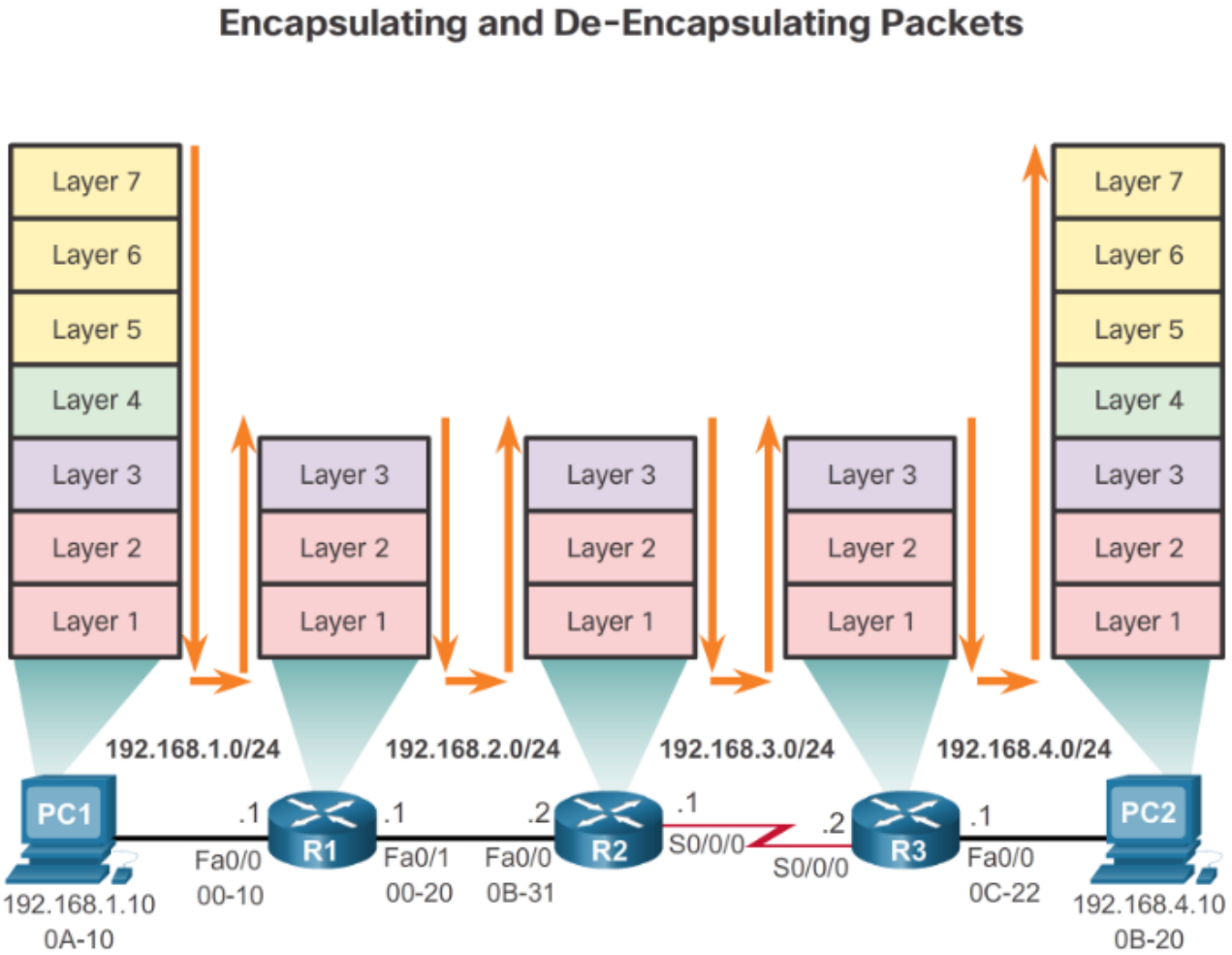
The command history feature temporarily stores a list of executed commands for access:

- 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.

```
R1# terminal history size 200
R1#
R1# show history
  show ip interface brief
  show interface g0/0
  show ip interface g0/1
  show ip route
  show ip route 209.165.200.224
  show running-config interface s0/0/0
  terminal history size 200
  show history
R1#
```

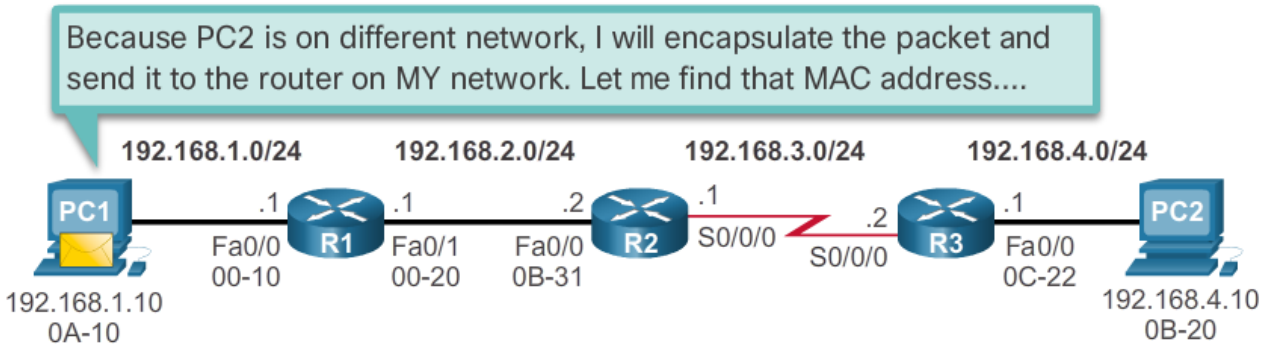
2. Routing Decisions

2.1 Router Switching Function



2.2 Send a Packet

PC1 Sends a Packet to PC2



Layer 2 Data Link Frame | **Packet's Layer 3 data**

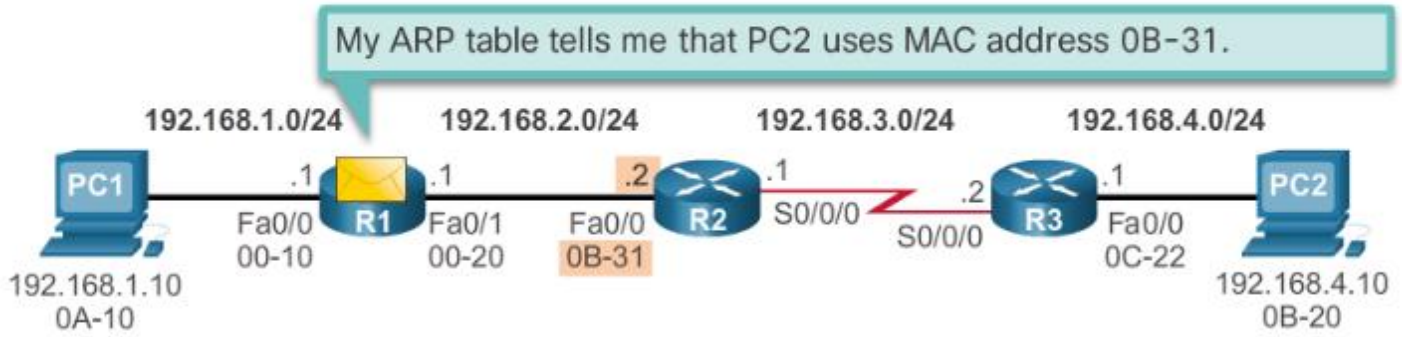
Dest. MAC 00-10	Source MAC 0A-10	Type 0x800	Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer

PC1's ARP Cache for R1

IP Address	MAC Address
192.168.1.1	00-10

2.3 Forward to Next Hop

R1 Forwards the Packet to PC2



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

Dest. MAC 0B-31		Type 0x800	Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer

R1's ARP Cache

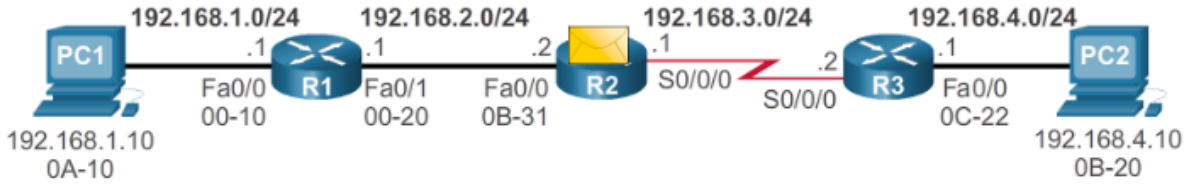
IP Address	MAC Address
192.168.2.2	0B-31

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

2.4 Packet Routing

R2 Forwards the Packet to R3



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

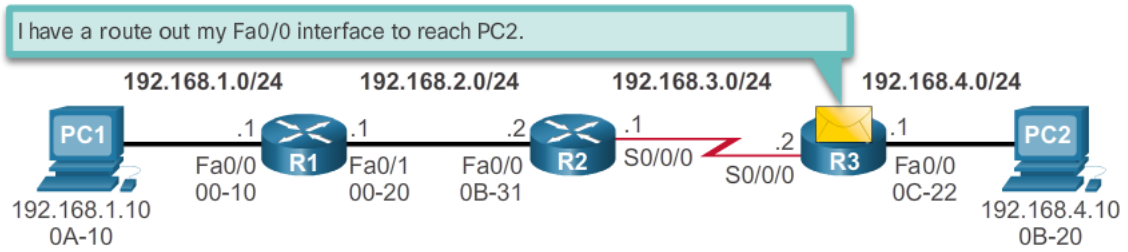
			Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer

R2's Routing Table

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

2.5 Reach the Destination

R3 Forwards the Packet to PC2



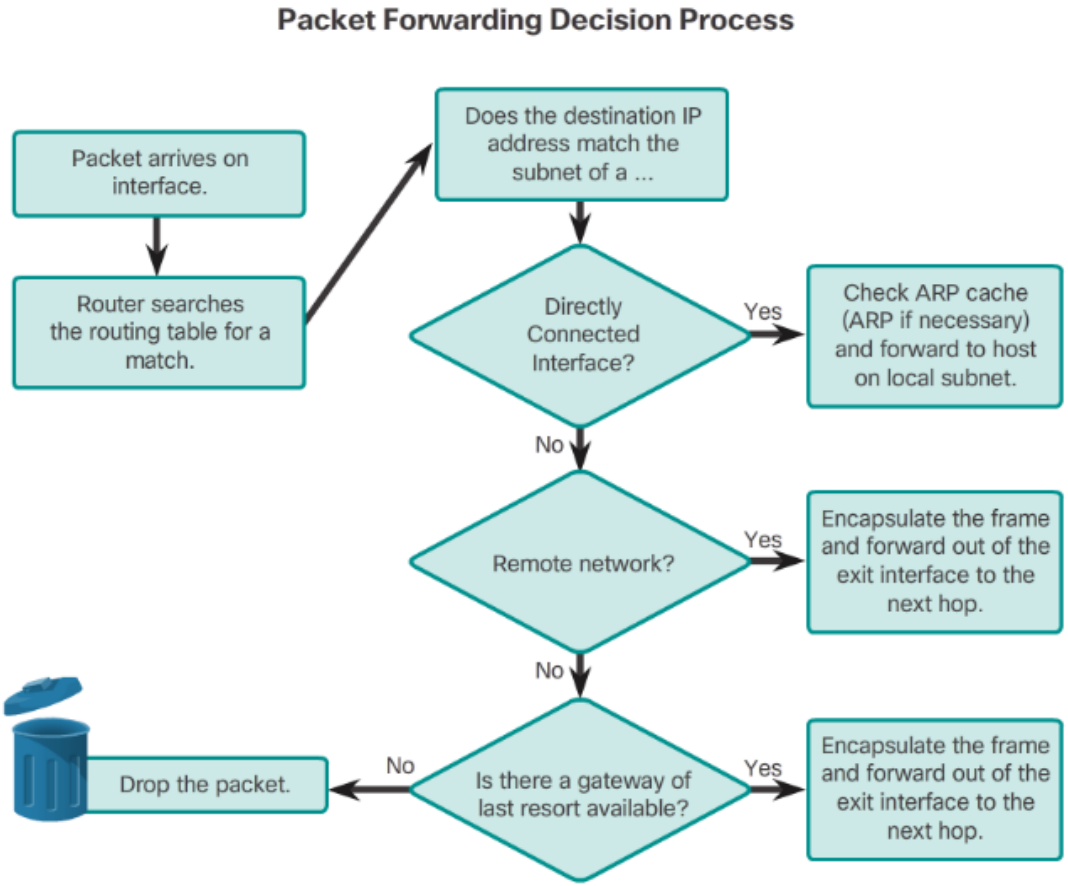
Layer 2 Data Link Frame **Packet's Layer 3 data**

		Type 0x800	Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer

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	192.168.3.1	S0/0/0
192.168.3.0/24	0	Dir. Connect.	S0/0/0
192.168.4.0/24	**0**	Dir. Connect.	**Fa0/0**

2.6 Routing Decisions

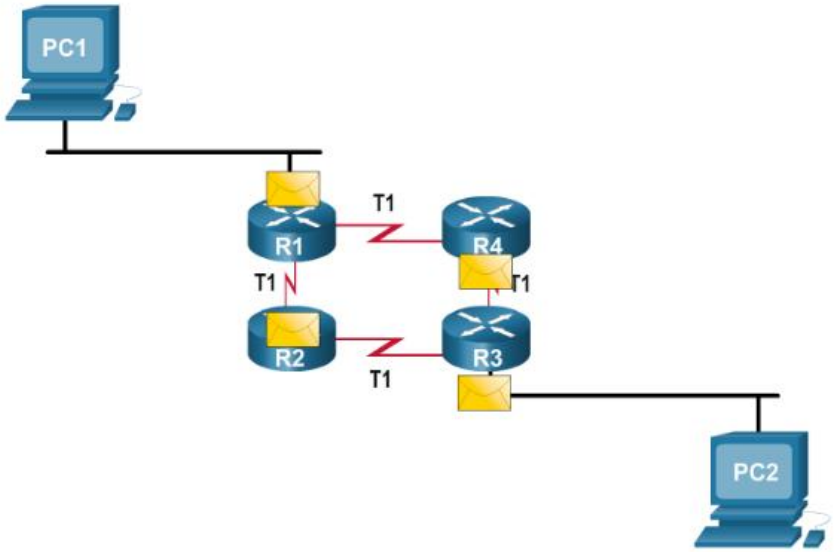


2.7 Best Path

- **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

2.8 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.



2.9 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.

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
RIP	120
External EIGRP	170
Internal BGP	200

Chapter Summary

Summary

- Describe the primary functions and features of a router.
- Configure basic settings on a router to route between two directly-connected networks, using CLI.
- Verify connectivity between two networks that are directly connected to 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.
- Explain the path determination function of a router.
- Explain how a router learns about remote networks when operating in a small to medium-sized business network.
- Explain how a router builds a routing table of directly connected networks.
- Explain how a router builds a routing table using static routes.
- Explain how a router builds a routing table using a dynamic routing protocol.

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