

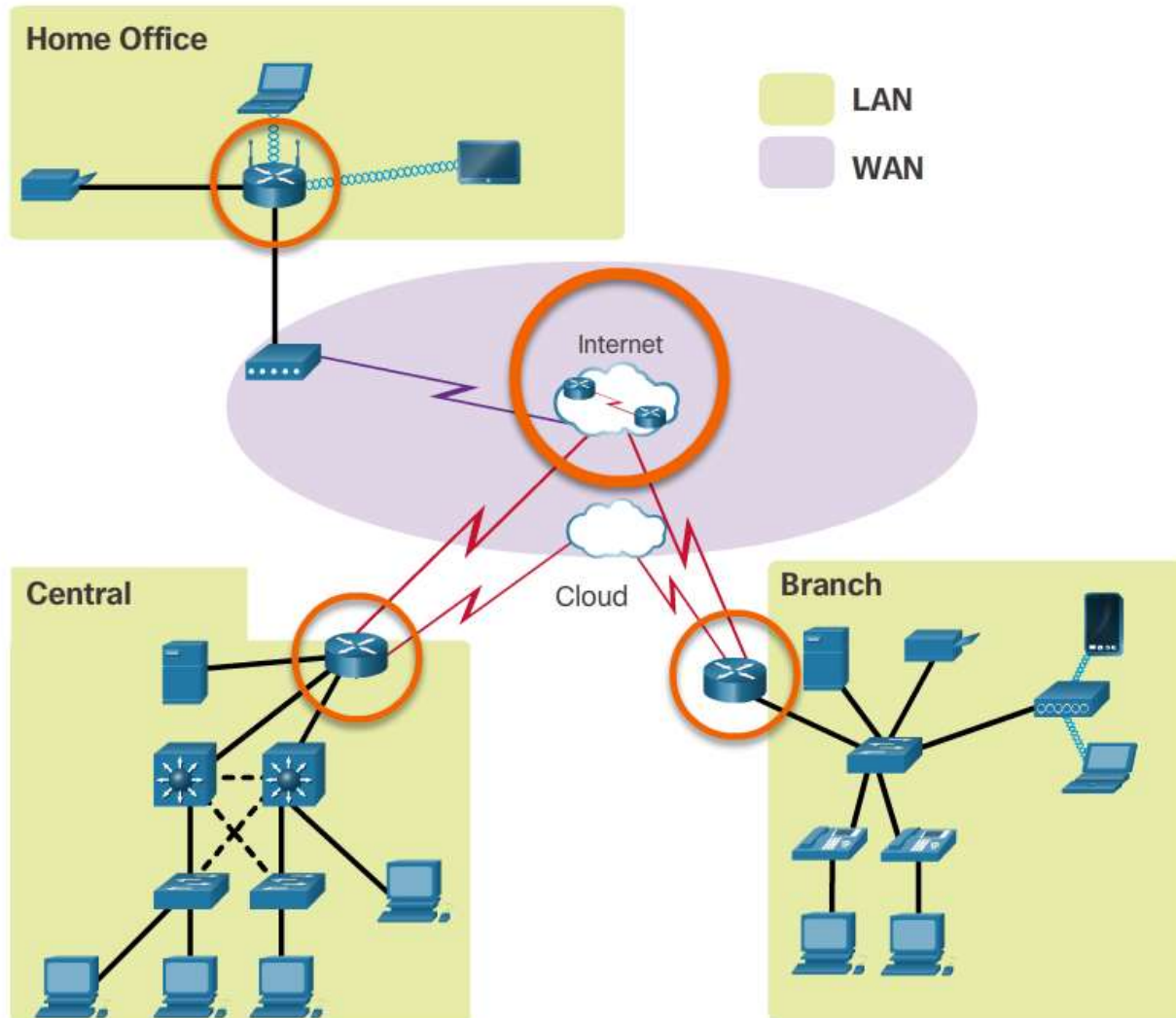
ROUTING CONCEPTS

REDES DE DATOS

ROUTER FUNCTIONS

WHY ROUTING?

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

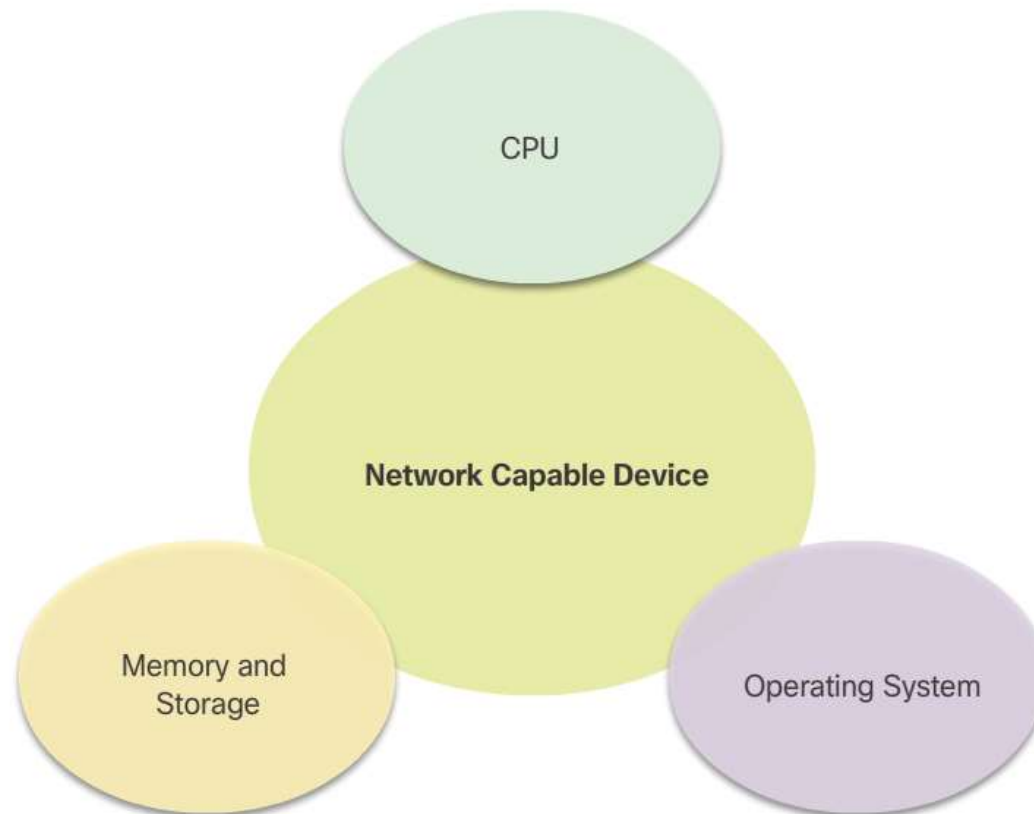


ROUTER FUNCTIONS

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)



ROUTER FUNCTIONS

ROUTERS ARE COMPUTERS

Memory	Description
Random Access Memory (RAM)	Volatile memory that provides temporary storage for various applications and processes including: <ul style="list-style-type: none">• Running IOS• Running configuration file• IP routing and ARP tables• Packet buffer
Read-Only Memory (ROM)	Non-volatile memory that provides permanent storage for: <ul style="list-style-type: none">• 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: <ul style="list-style-type: none">• Startup configuration file
Flash	Non-volatile memory that provides permanent storage for: <ul style="list-style-type: none">• IOS• Other system-related files

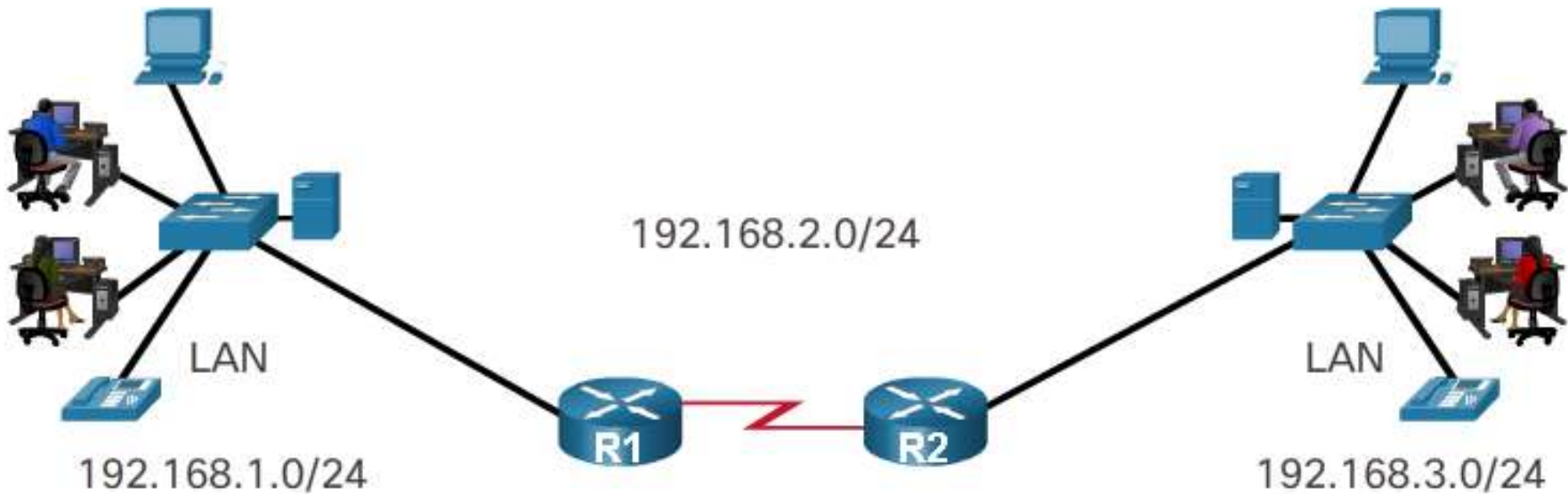
ROUTER FUNCTIONS

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.



ROUTER FUNCTIONS

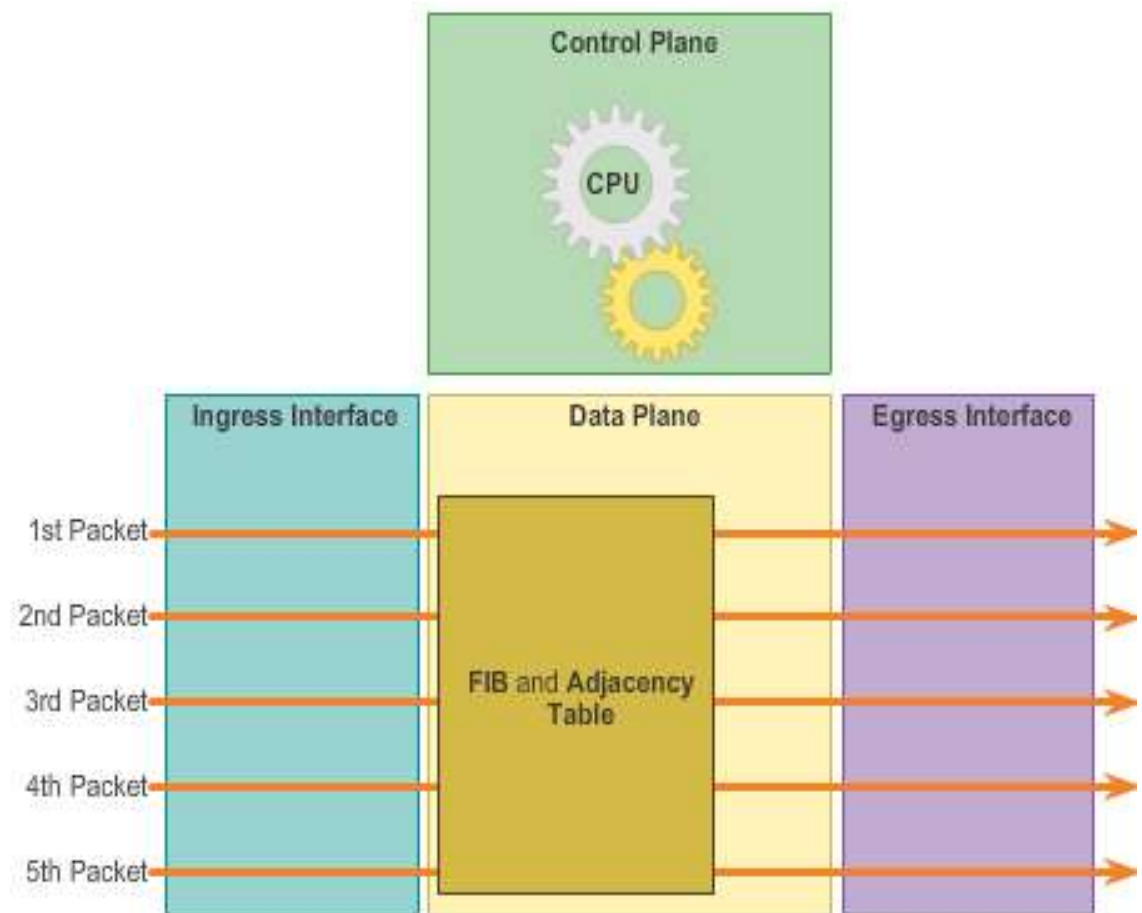
PACKET FORWARDING METHODS

Cisco Express Forwarding

Process switching – An older packet forwarding mechanism still available for Cisco routers.

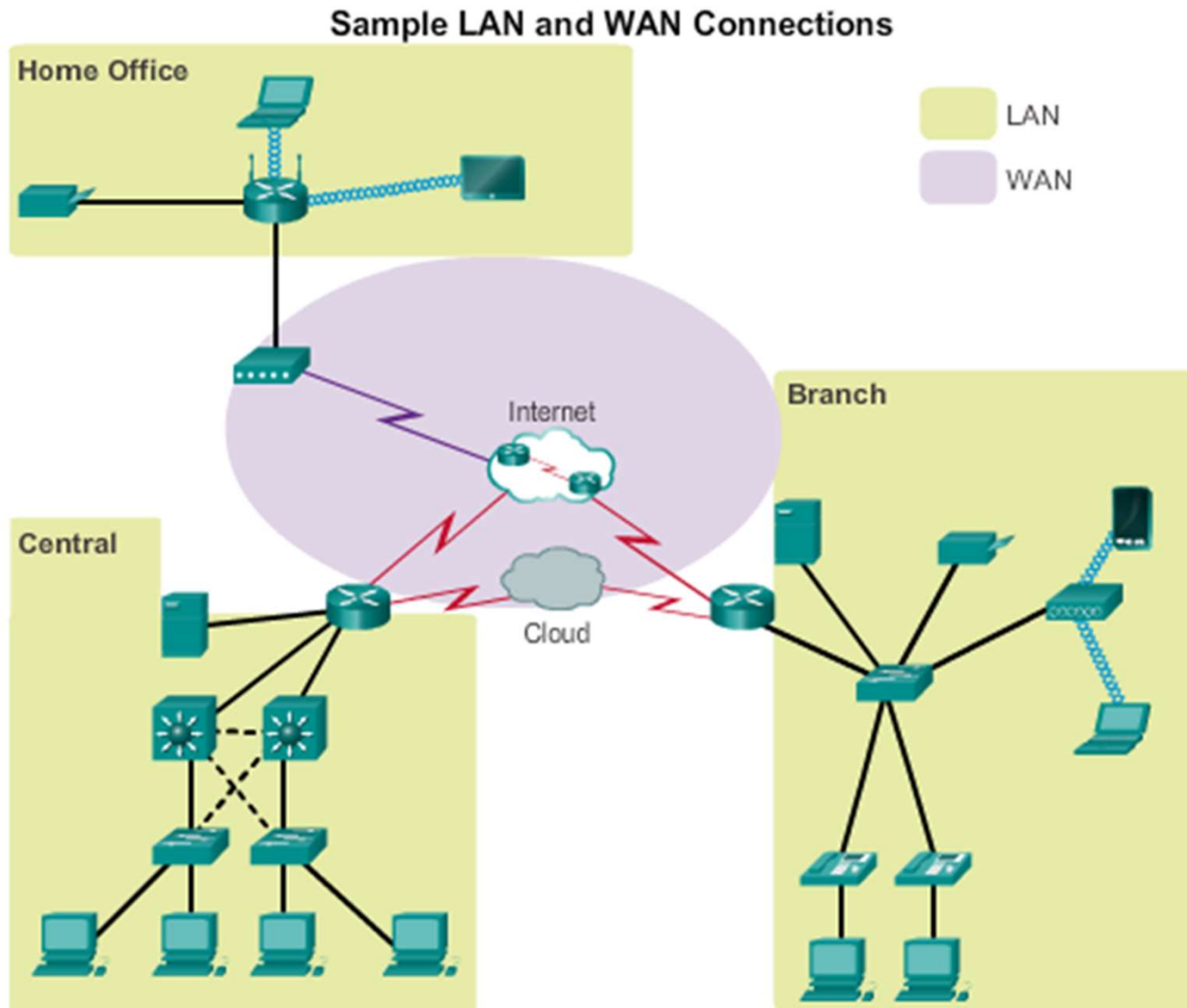
Fast switching – A common packet forwarding mechanism which uses a fast-switching cache to store next hop information.

Cisco Express Forwarding (CEF) – The most recent, fastest, and preferred Cisco IOS packet-forwarding mechanism.



CONNECT DEVICES

CONNECT TO A NETWORK



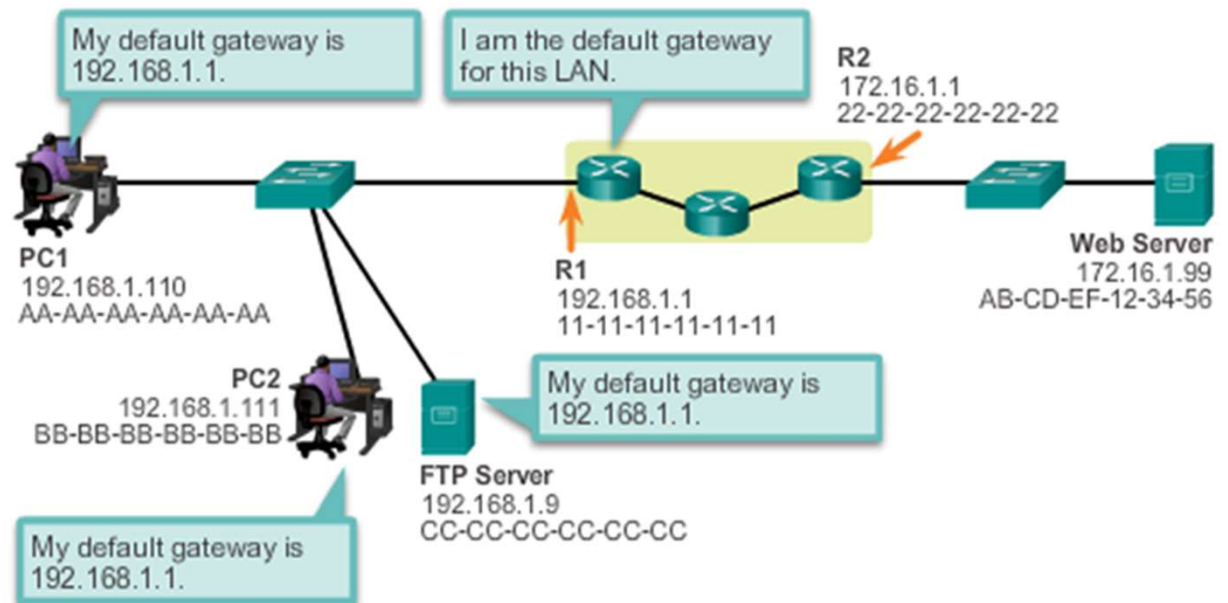
CONNECT DEVICES

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 when the destination is not on the same local network subnet.

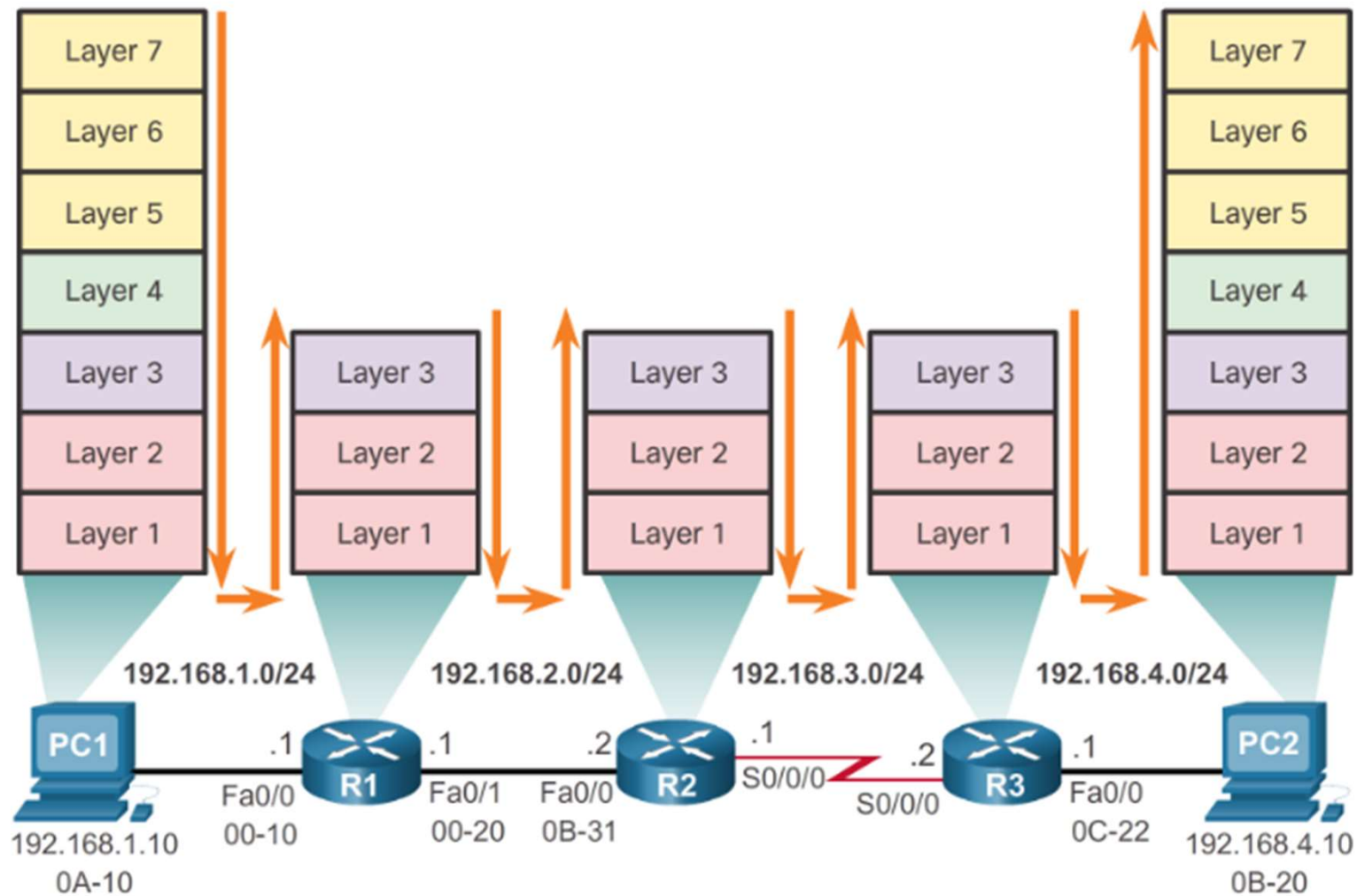
Destination MAC Address	Source MAC Address	Source IP Address	Destination MAC Address	Data
11-11-11-11-11-11	AA-AA-AA-AA-AA-AA	192.168.1.110	172.16.1.99	



SWITCHING PACKETS BETWEEN NETWORKS

ROUTER SWITCHING FUNCTION

Encapsulating and De-Encapsulating Packets

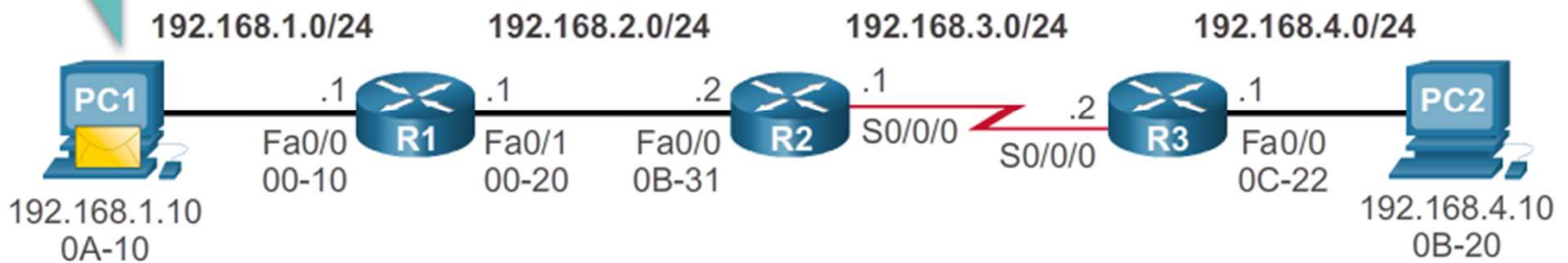


SWITCHING PACKETS BETWEEN NETWORKS

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

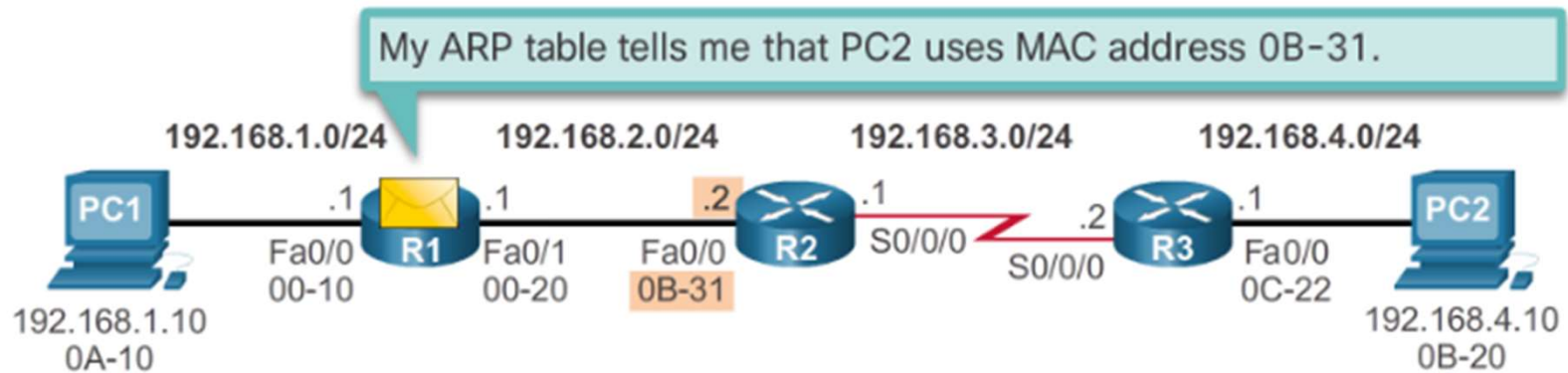
Layer 2 Data Link Frame			Packet's Layer 3 data				
Dest. MAC 00-10	Source MAC 0A-10	Type 0x800	Source IP 192.168.1.10	Dest. IP 192.168.4.10	IP fields	Data	Trailer

PC1's ARP Cache for R1

IP Address	MAC Address
192.168.1.1	00-10

SWITCHING PACKETS BETWEEN NETWORKS 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
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R1's ARP Cache

IP Address	MAC Address
192.168.2.2	0B-31

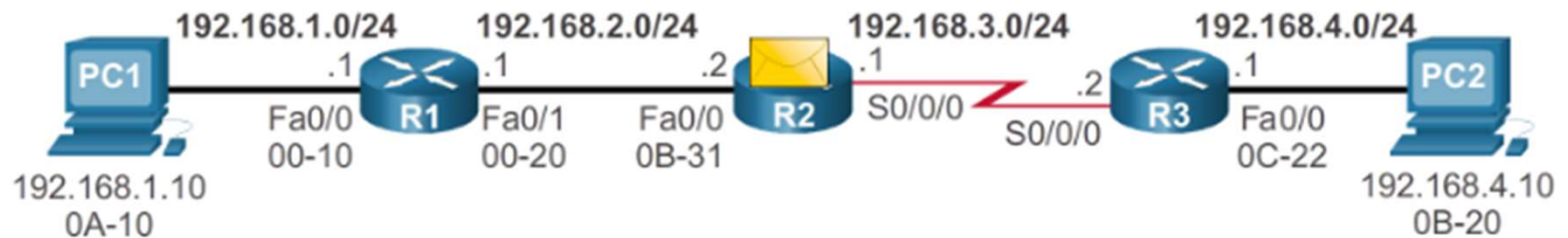
R1's Routing Table

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

SWITCHING PACKETS BETWEEN NETWORKS

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
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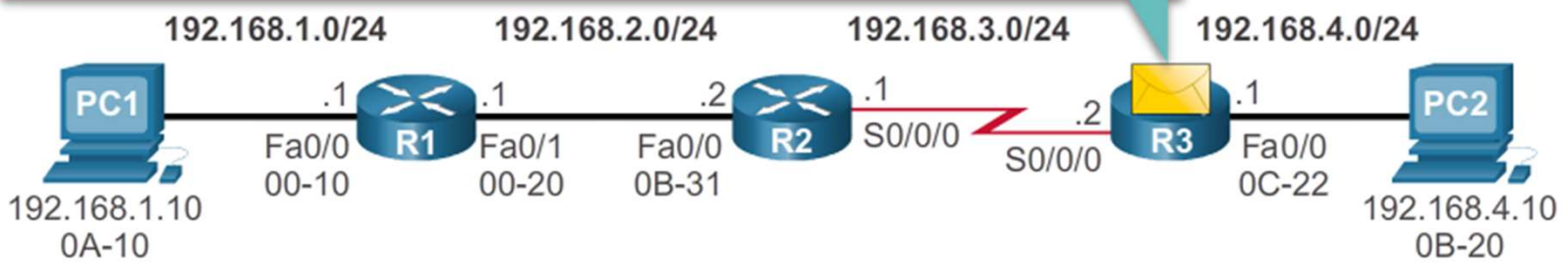
R2's Routing Table

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
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

I have a route out my Fa0/0 interface to reach 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
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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

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:

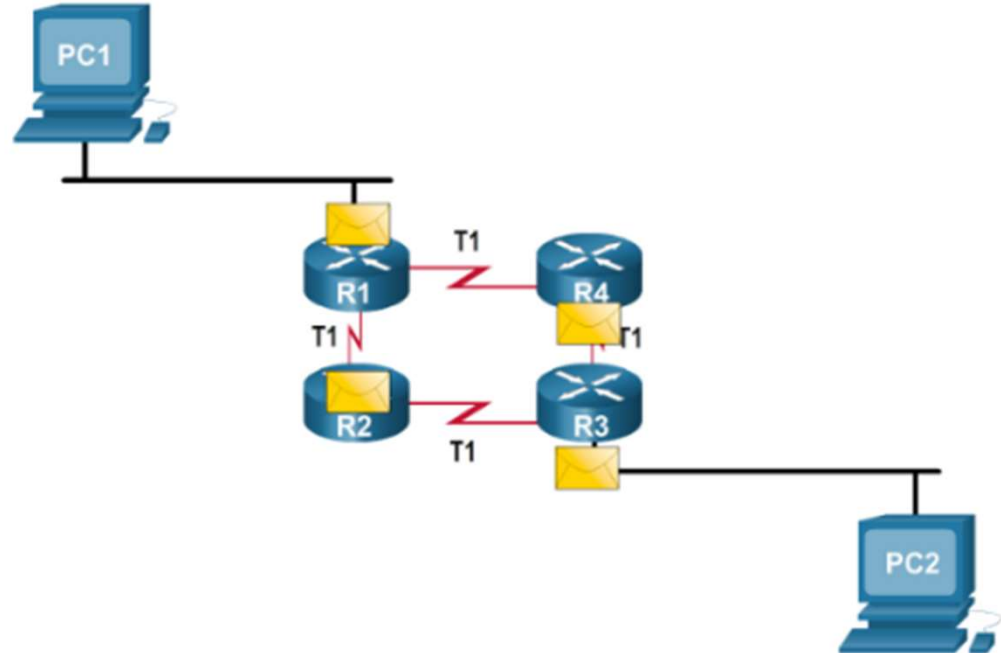
- Routing Information Protocol (RIP) - Hop count
- Open Shortest Path First (OSPF) - Cost based on cumulative bandwidth from source to destination
- Enhanced Interior Gateway Routing Protocol (EIGRP) - Bandwidth, delay, load, reliability

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.

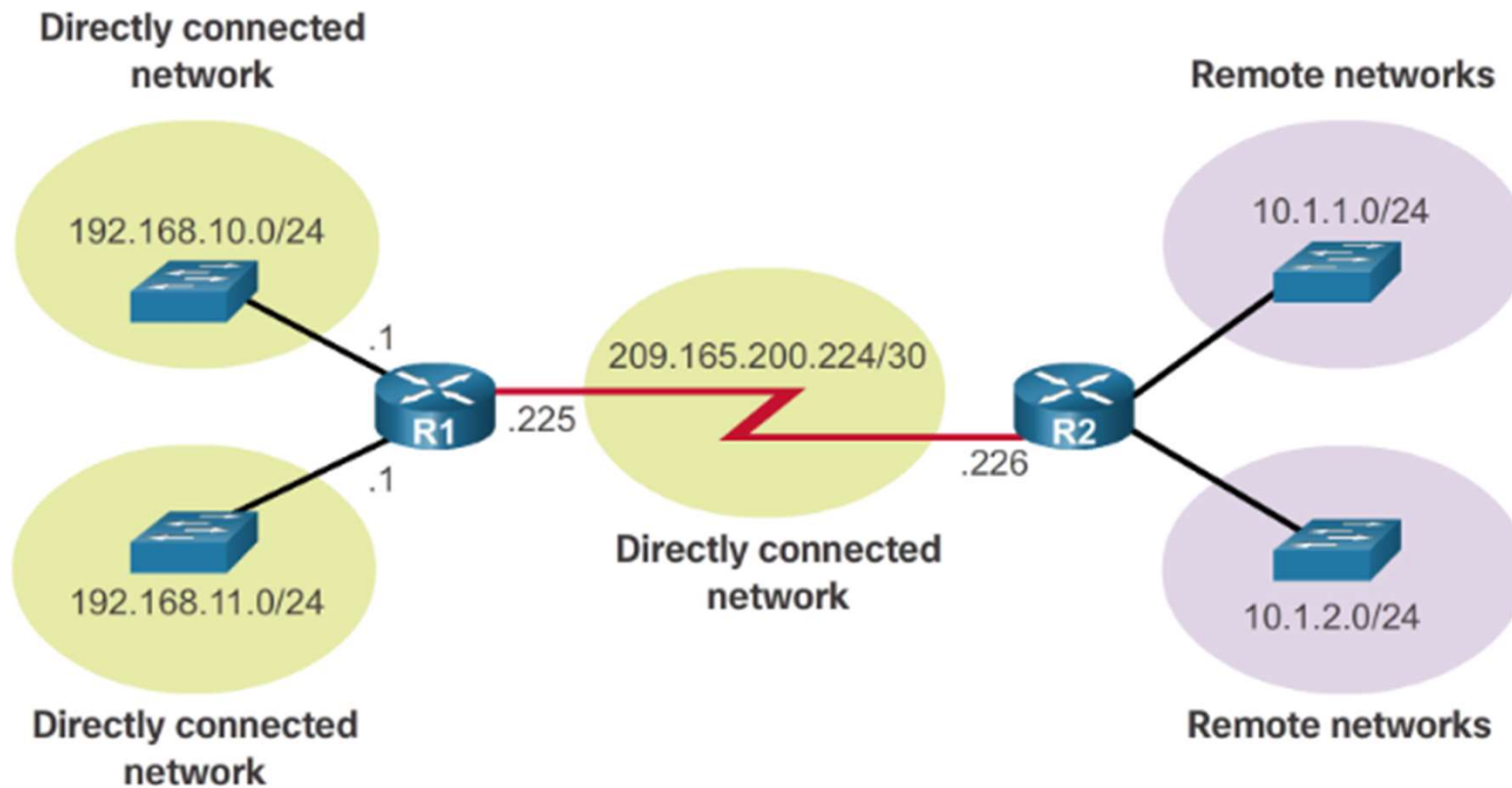


ANALYZE THE ROUTING TABLE

THE ROUTING TABLE

A routing table is a file stored in RAM that contains information about:

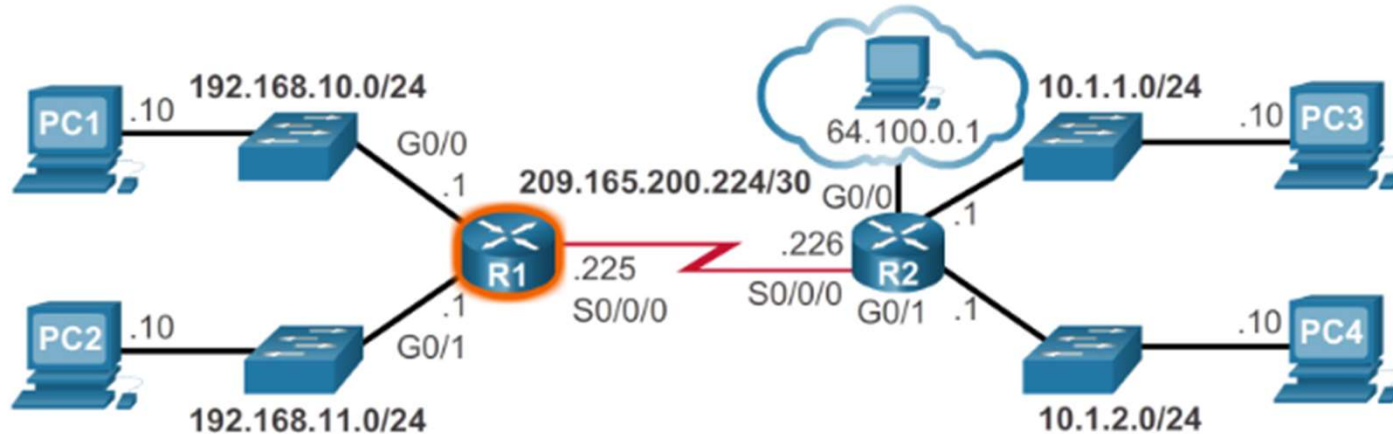
- Directly connected routes
- Remote routes



ANALYZE THE ROUTING TABLE

REMOTE NETWORK ROUTING ENTRIES

Interpreting the entries in the routing table



```
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.

STATIC ROUTING

WHY USE STATIC ROUTING?

Static routing provides some advantages over dynamic routing, including:

Static routes are not advertised over the network, resulting in **better security**.

Static routes **use less bandwidth** than dynamic routing protocols, no CPU cycles are used to calculate and communicate routes.

The path a static route uses to send data is known.

	Dynamic Routing	Static Routing
Configuration Complexity	Generally independent of the network size	Increases with network size
Topology Changes	Automatically adapts to topology changes	Administrator intervention required
Scaling	Suitable for simple and complex topologies	Suitable for simple topologies
Security	Less secure	More secure
Resource Usage	Uses CPU, memory, link bandwidth	No extra resources needed
Predictability	Route depends on the current topology	Route to destination is always the same

STATIC ROUTING

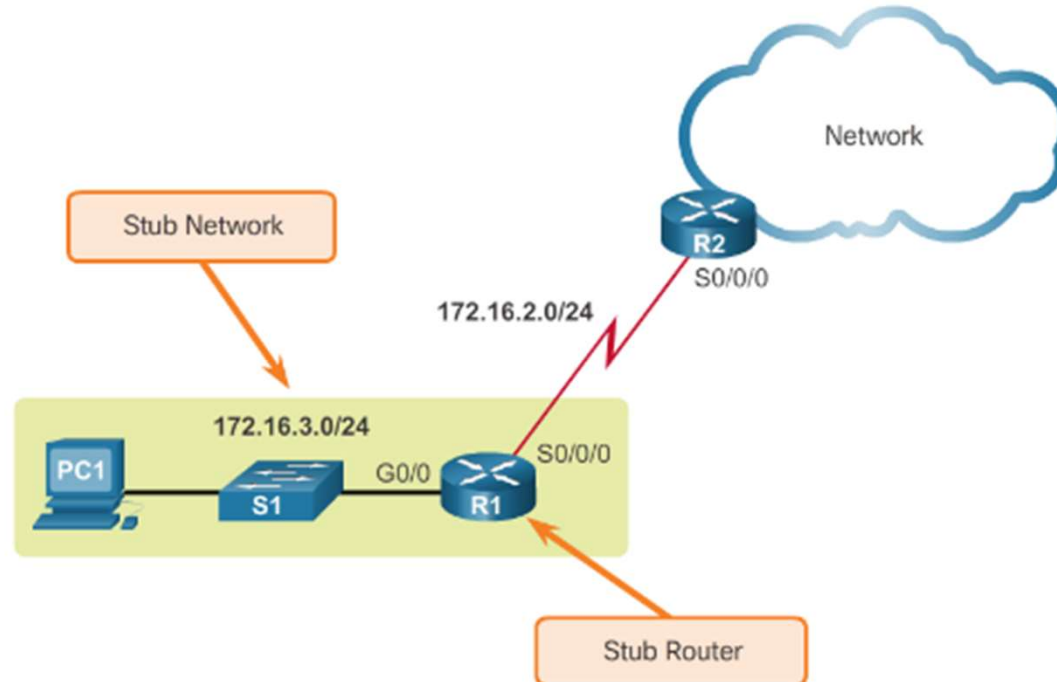
WHEN TO USE STATIC ROUTES

Static routing has three primary uses:

Providing ease of routing table maintenance in **smaller networks**.

Routing to and from **stub networks**. A stub network is a network accessed by a single route, and the router has no other neighbors.

Using a **single default route** to represent a path to any network that does not have a more specific match with another route in the routing table.



DYNAMIC ROUTING PROTOCOL OVERVIEW

DYNAMIC ROUTING PROTOCOL EVOLUTION

Dynamic routing protocols have been used in networks since the late 1980s.

Newer versions support the communication based on IPv6.

Routing Protocols Classification

	Interior Gateway Protocols				Exterior Gateway Protocols
	Distance Vector		Link-State		Path Vector
IPv4	RIPv2	EIGRP	OSPFv2	IS-IS	BGP-4
IPv6	RIPng	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	BGP-MP

DYNAMIC ROUTING PROTOCOL OVERVIEW

DYNAMIC ROUTING PROTOCOLS COMPONENTS

Routing Protocols are used to facilitate the exchange of routing information between routers.

The purpose of dynamic routing protocols includes:

Discovery of remote networks

Maintaining up-to-date routing information

Choosing the best path to destination networks

Ability to find a **new best path** if the current path is no longer available

DYNAMIC ROUTING PROTOCOL OVERVIEW

DYNAMIC ROUTING PROTOCOLS COMPONENTS (CONT.)

Main components of dynamic routing protocols include:

Data structures - Routing protocols typically use tables or databases for its operations. This information is kept in RAM.

Routing protocol messages - Routing protocols use various types of messages to discover neighboring routers, exchange routing information, and other tasks to learn and maintain accurate information about the network.

Algorithm - Routing protocols use algorithms for facilitating routing information for best path determination.

DYNAMIC VERSES STATIC ROUTING

DYNAMIC ROUTING ADVANTAGES & DISADVANTAGES

Advantages	Disadvantages
Suitable in all topologies where multiple routers are required.	Can be more complex to implement.
Generally independent of the network size.	Less secure. Additional configuration settings are required to secure.
Automatically adapts topology to reroute traffic if possible.	Route depends on the current topology.
	Requires additional CPU, RAM, and link bandwidth.

ASPECTOS BÁSICOS DE VECTOR DISTANCIA

Funcionamiento del protocolo de routing dinámico

- El router envía y recibe mensajes de routing en sus interfaces.
- El router comparte mensajes de routing e información de routing con otros routers que están usando el mismo protocolo de routing.
- Los routers intercambian información de routing para obtener información sobre redes remotas.
- Cuando un router detecta un cambio en la topología, el protocolo de routing puede anunciarles dicho cambio a los otros routers.



ROUTING DINÁMICO DE ESTADO DE ENLACE

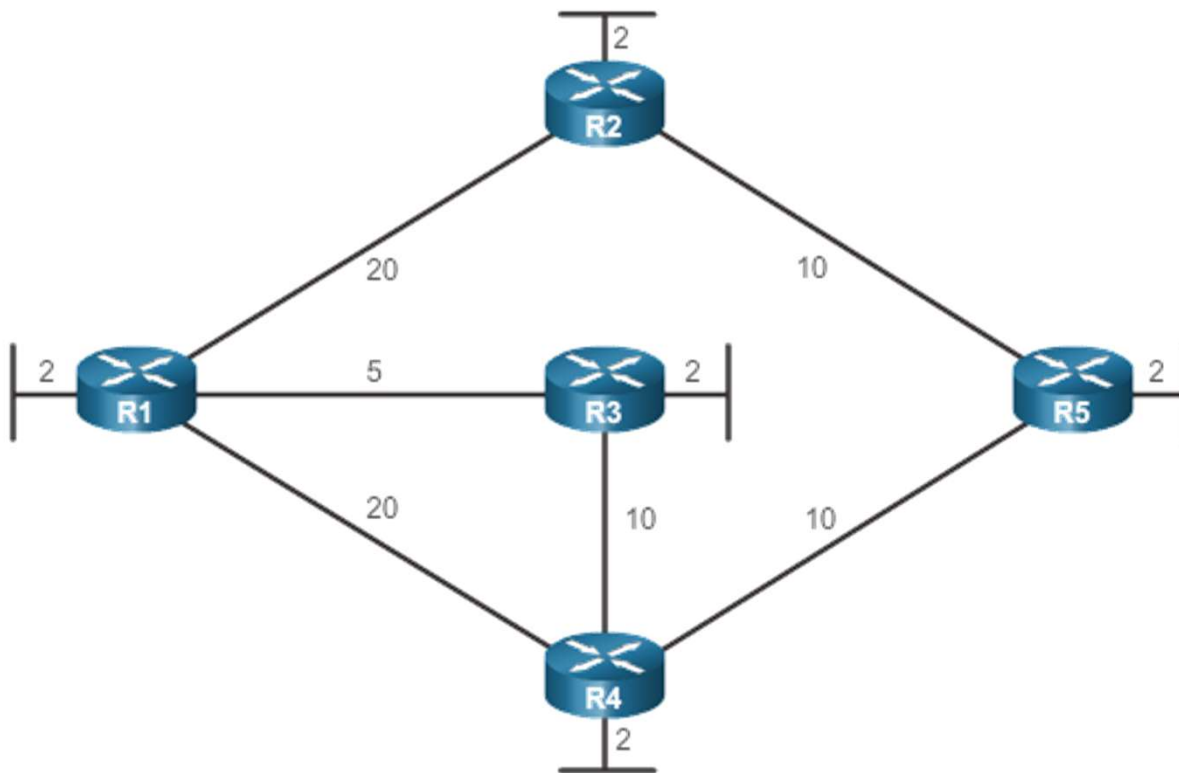
FUNCIONAMIENTO DEL PROTOCOLO DE ROUTING DE ESTADO DE ENLACE

Protocolos Shortest Path First

- OSPF e IS-IS

Algoritmo de Dijkstra

- Utilice el diagrama para determinar la ruta más corta para las siguientes situaciones:
 - Del R1 a R4
 - Del R1 a R5
 - Del R2 al R3
 - Del R3 a R5
 - Del R4 al R2
 - Del R5 al R2



BENEFICIOS DEL PROTOCOLO DE ROUTING DE ESTADO DE ENLACE

Ventajas

- Arma su propio mapa de topología de la red para determinar la ruta más corta.
- Propaga el LSP de inmediato para lograr una convergencia más rápida.
- Solo envía LSP con información nueva cuando se produce un cambio en la topología.
- Utiliza el concepto de áreas y permite el resumen.

Desventajas

- Requiere memoria adicional para mantener la base de datos y el árbol SPF.
- Requiere más procesamiento de CPU para calcular el algoritmo SPF y crear un mapa completo de la topología.
- Requiere más ancho de banda durante los arranques iniciales de los routers y podría ser un problema en redes inestables.