

Network Routing

CO1507 Introduction to Networking

What is a Router?

- A router is an electronic device (a specialised computer) that can join 2 or more networks together
- The local router in a particular network is the 'Default Gateway'
- The router identifies:
 - Which networks are available
 - The best way to reach them
 - What to do if a network goes down

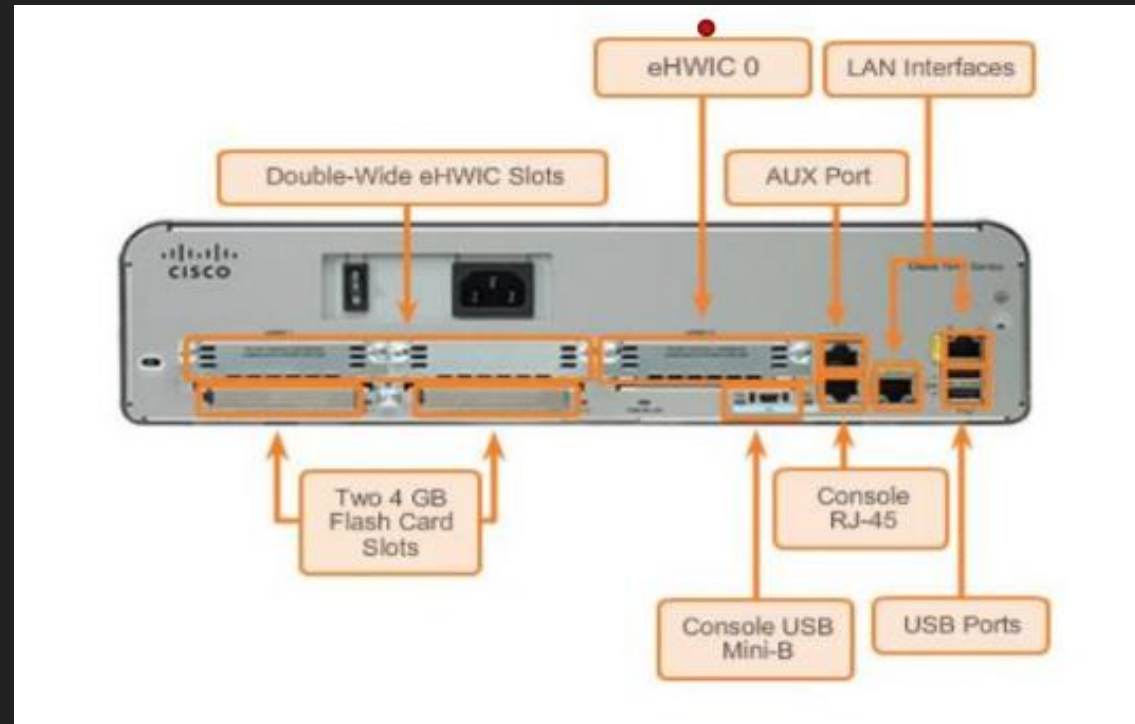
Router

- Routers can have both internal and External components operations
- The Internal Components of the Router
 - CPU
 - Memory (volatile or non-volatile)
 - ROM, Flash Memory, RAM and NVRAM
 - Power supply
 - Config registers (boot options, console speed etc.)
- The External components are:
 - Management ports
 - LAN and WAN interface
 - USB ports
 - Flashcard slots
 - EHWic slots (**E**nhanced **H**igh-speed **W**AN **I**nterface **C**ard)

Router



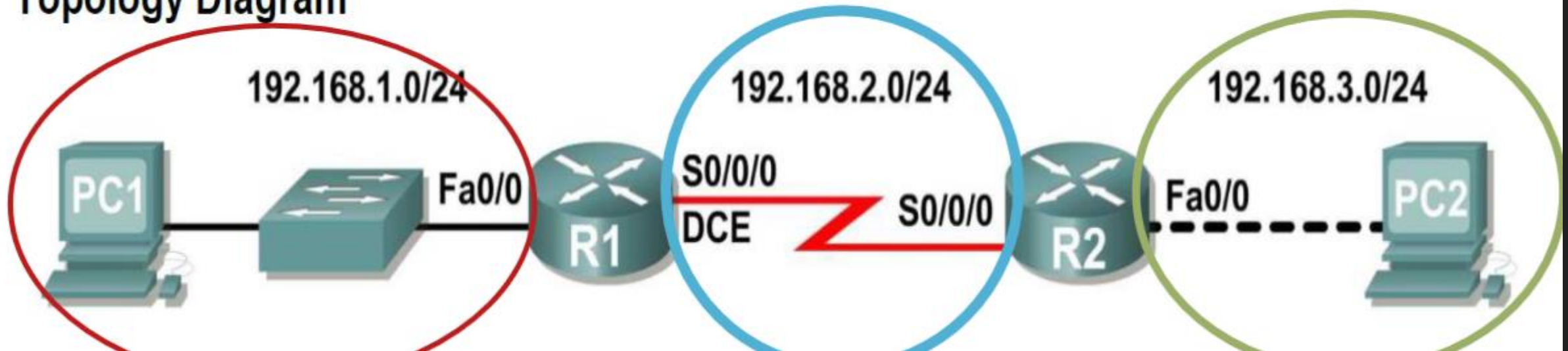
The first ARPANET router 1969



Typical router interfaces

How Many Subnets Can You See?

Topology Diagram



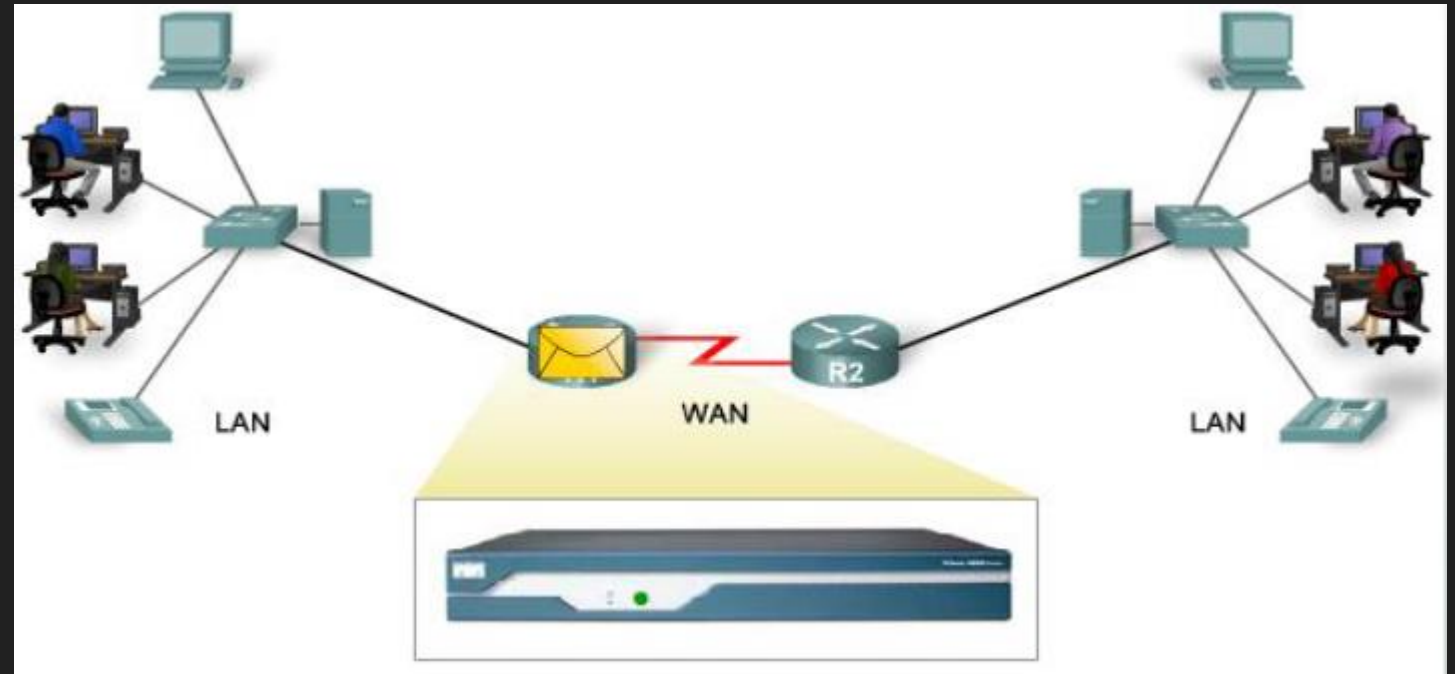
Three Different Networks

Default Gateway

- The default gateway is the network device (i.e. router) that can route traffic to other networks
- Default gateway is usually a router with these features:
 - It has a local **IP address** in the **same** address range as other hosts on the local network
 - It can accept data into the local network and forward data out of the local network
 - It routes traffic to other networks

Routers Choose Best Paths

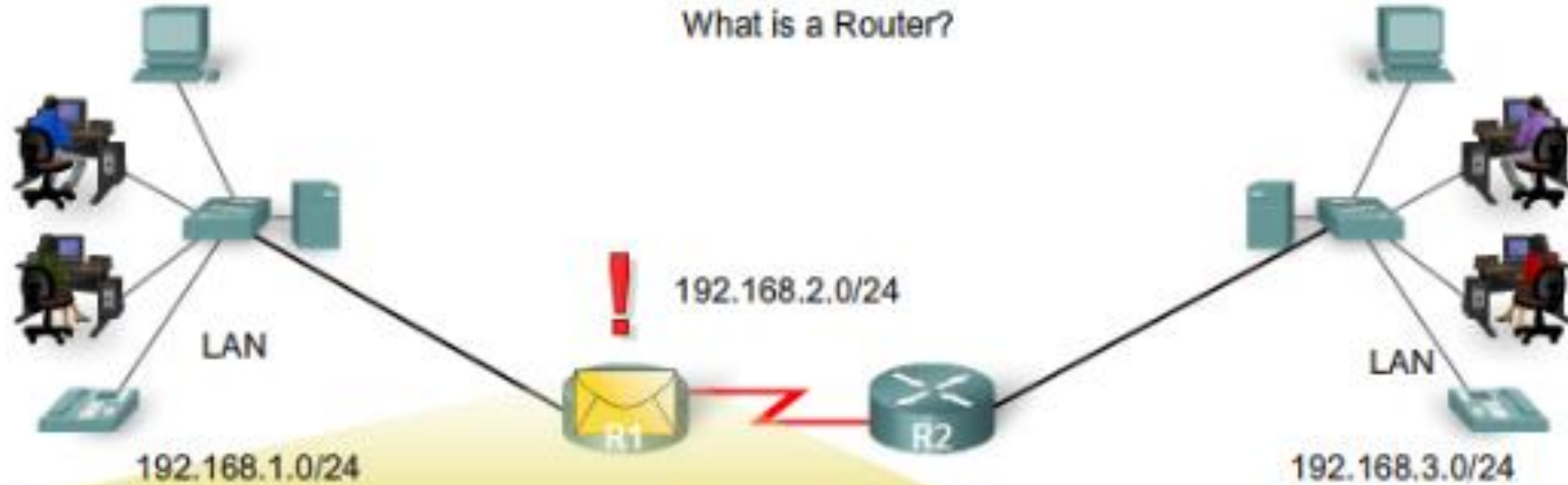
- The router's primary responsibility is to forward packets destined for local and remote networks by:
 - Determining the best path to send the packets
 - Forwarding the packets towards their destination



Routing Table

- The routing table is a file stored in NVRAM that contains information about:
 - **Local** and **directly connected** routes
 - **Remote** routes
 - **Network** or **next hop** associations
- The router uses its routing table to determine the best path to forward the packet
- When receiving a packet, it examines the destination IP and searches for the best match with a network address in the routing table
- When a match is found:
 - The router encapsulates the packet into the data link frame
 - Forwards the packet out that interface to its destination

What is a Router?



```
R1#show ip route
```

```
Codes: C - connected, S - static, I - IGRP, 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
```

```
C    192.168.1.0/24 is directly connected, FastEthernet0/0  
C    192.168.2.0/24 is directly connected, Serial0/0/0  
S    192.168.3.0/24 is directly connected, Serial0/0/0
```

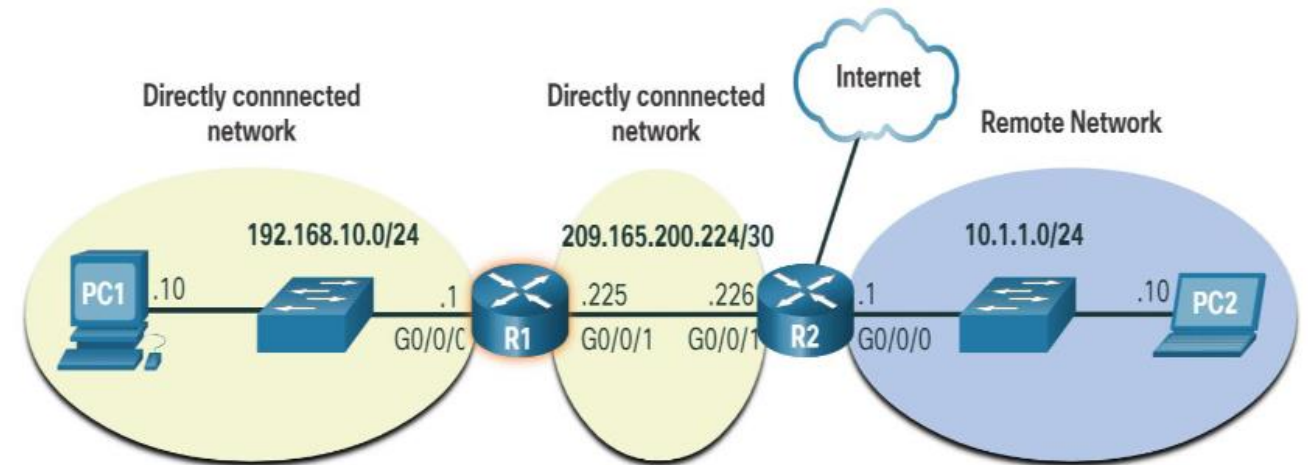
Routers use the routing table like a map to discover the best path for a given address.

IP Router Routing Table

Directly-connected networks

These network route entries are active router interfaces

Routers add a directly connected route when an interface is configured with an IP address and is activated



R1 has two directly connect networks:

- 192.168.10.0/24
- 209.165.200.224/30

R1 also has remote networks (i.e. 10.1.1.0/24 and the internet) that it can learn about.

IP Router Routing Table

Local routes

If the packet is destined for the routers own interface it does not leave the router but is instead forwarded the routers own interface

e.g. 192.168.10.1/**32**

'/32' specifies ONLY this ONE address (e.g. all 32 bits)

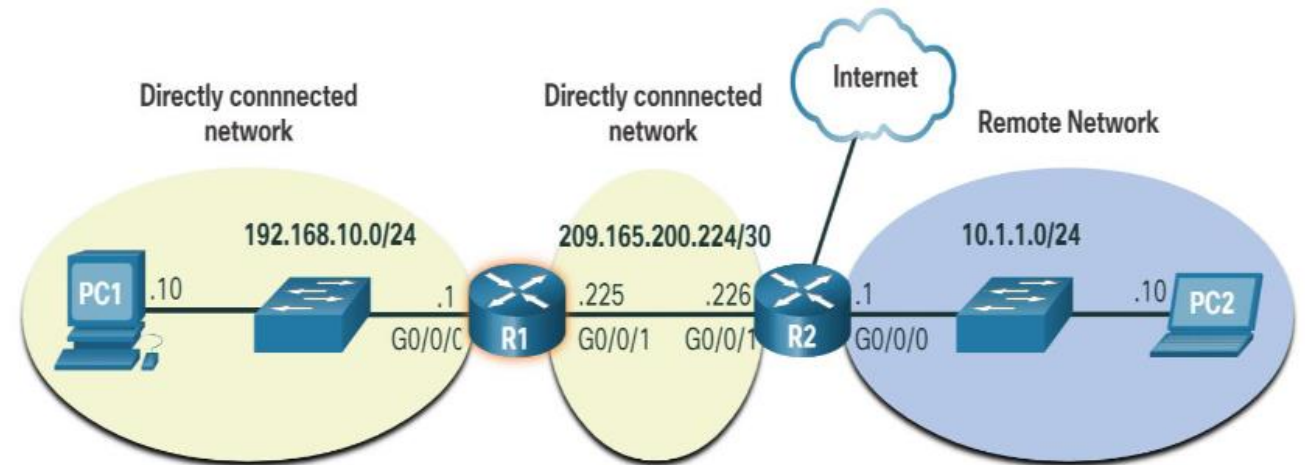
A connected route to 192.168.10.0/**24** would overlap with this (it matches any one of 256 addresses)

IMPORTANT: However, a router will default to the **most specific** matching route

IP Router Routing Table

Remote networks

These network route entries are connected to other routers



R1 has two directly connect networks:

- 192.168.10.0/24
- 209.165.200.224/30

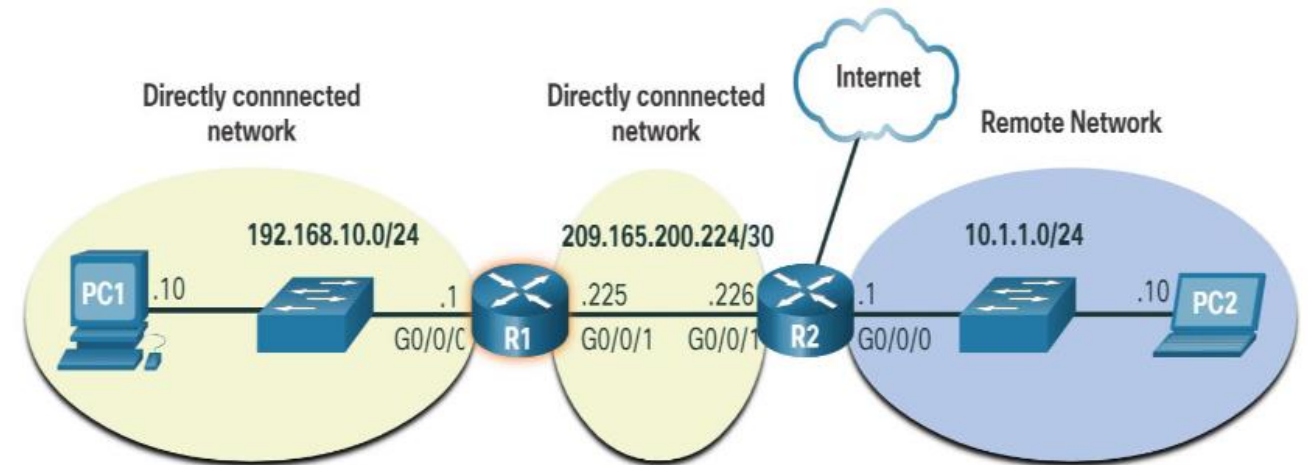
R1 also has remote networks (i.e. 10.1.1.0/24 and the internet) that it can learn about.

IP Router Routing Table

Default route

Like a host, most routers also include a default route entry, a gateway of last resort

The default route is used when there is no better (longer) match in the IP routing table



R1 has two directly connect networks:

- 192.168.10.0/24
- 209.165.200.224/30

R1 also has remote networks (i.e. 10.1.1.0/24 and the internet) that it can learn about.

Reach Remote Networks

A router can learn about remote networks in one of two ways:

- **Manually** - Remote networks are manually entered into the route table using static routes
- **Dynamically** - Remote networks are automatically learned using a dynamic routing protocol such as:
 - RIP (Routing Information protocol)
 - OSPF (Open Shortest Path First)
 - EIGRP (Enhanced Interior Gateway Routing Protocol)

Static Route

- A **static** route is created, maintained, and updated by a network administrator, manually
- A static route to every network must be configured on every router for full connectivity

```
Router(config)# ip route remote network address subnet mask {ip-address | exit-interface}
```

Parameter	Description
network-address	Destination network address of the remote network to be added to the routing table.
subnet-mask	• Subnet mask of the remote network to be added to the routing table. • The subnet mask can be modified to summarize a group of networks.
ip-address	• Commonly referred to as the next-hop router's IP address. • Typically used when connecting to a broadcast media (i.e., Ethernet). • Commonly creates a recursive lookup.
exit-intf	• Use the outgoing interface to forward packets to the destination network. • Also referred to as a directly attached static route. • Typically used when connecting in a point-to-point configuration.



Next hop

Static Route – two types

1. A **recursive** static route relies on the next hop router for packets to be sent to its destination. A recursive static route requires two routing table lookups

```
Router(config)# ip route remote network address subnet mask {next hop  
router ip-address}
```

2. A **directly attached** static route relies on its exit interface for packets to be sent to its destination

```
Router(config)# ip route remote network address subnet mask {exit-  
interface}
```

Why Use Static Routing?

Static routing provides some advantages over dynamic routing, these include:

- Improved security
- Reduced CPU and RAM overhead
- Saving on bandwidth

Why Not Use Static Routing?

- Initial configuration and maintenance is time-consuming
- Configuration is error-prone, especially in large networks
- Administrator intervention is required to maintain changing route information
- Does not scale well with growing networks; maintenance becomes cumbersome
- Requires complete knowledge of the whole network for proper implementation

When to Use Static Routes

- Small networks:

Providing ease of routing table maintenance in smaller networks that are not expected to grow significantly

- Default route:

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

Default routes are used to send traffic to any destination beyond the next upstream router

- Routing to and from stub networks:

A stub network is a network accessed by a single route, and the router has no other neighbours (only one router)

Verify a Static Route

Useful commands to verify static routes include:

- `show ip route`
- `show ip route static`
- `show ip route network`

Default Static Route

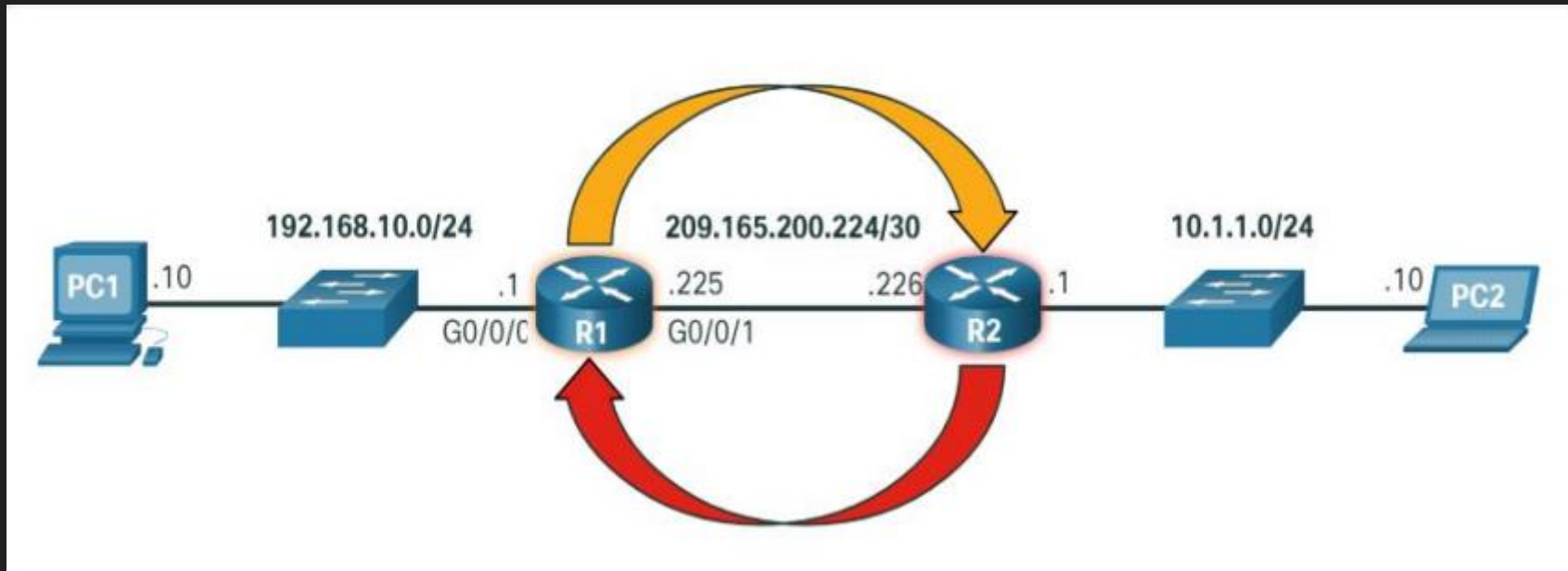
- The default static route is the network route used by a router when no other known route exists for a destination network. A static route is used to route traffic to a specific network

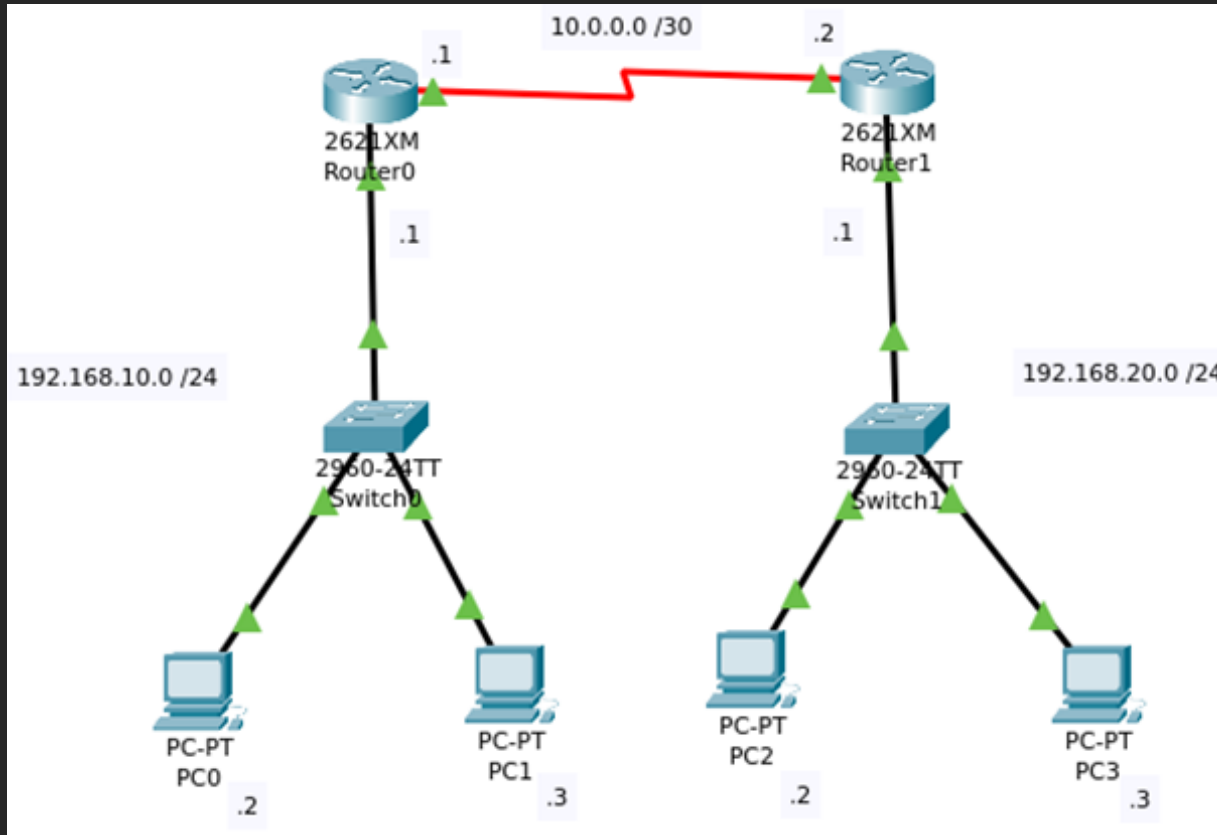
```
Router # ip route 0.0.0.0 0.0.0.0 {ip-address | exit-interface}
```

- 0.0.0.0 0.0.0.0 refers to all subnets
- The first 0.0.0.0 means the actual subnet, in this case any, and the second 0.0.0.0 means the subnet mask, also any

Dynamic Routing

- A dynamic routing protocol allows the routers to automatically learn about remote networks, including a default route, from other routers
- Routers that use dynamic routing protocols automatically share routing information with other routers and compensate for any topology changes without involving the network administrator





```

Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
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       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 0.0.0.0 to network 0.0.0.0

```

      10.0.0.0/30 is subnetted, 1 subnets
C       10.0.0.0 is directly connected, Serial0/0
C    192.168.10.0/24 is directly connected, FastEthernet0/0
S    192.168.20.0/24 [1/0] via 10.0.0.2
S*   0.0.0.0/0 is directly connected, Serial0/0
  
```

Router 0

Router#

```

Router#show ip route
Codes: C - connected, S - static, I - IGRP, 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
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```

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

```

      10.0.0.0/30 is subnetted, 1 subnets
C       10.0.0.0 is directly connected, Serial0/0
S    192.168.10.0/24 [1/0] via 10.0.0.1
C    192.168.20.0/24 is directly connected, FastEthernet0/0
S*   0.0.0.0/0 is directly connected, FastEthernet0/0
  
```

Router 1

Router#