

ROUTING - AN OVERVIEW

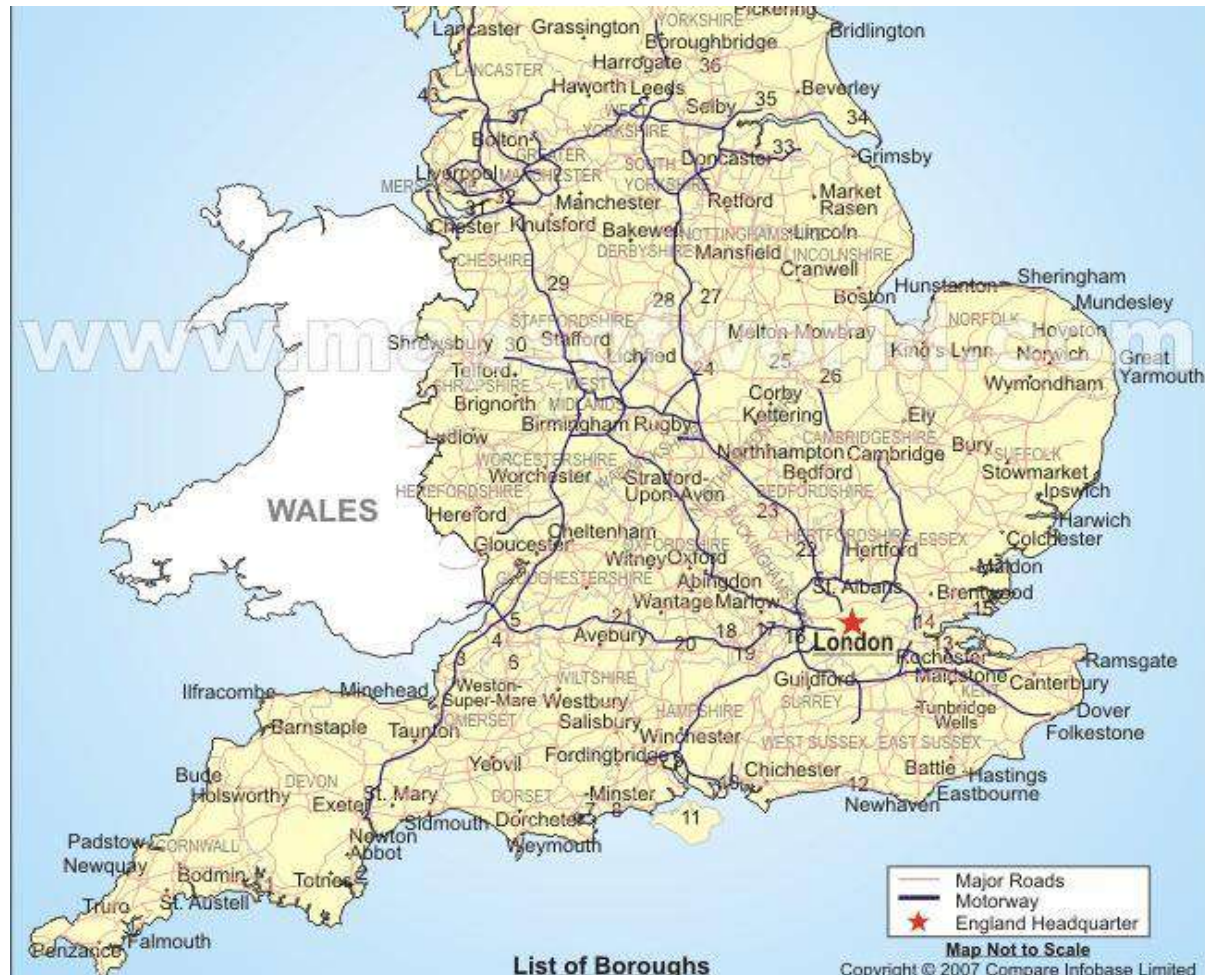
Mohammad S. Hasan

2



Routes – All roads

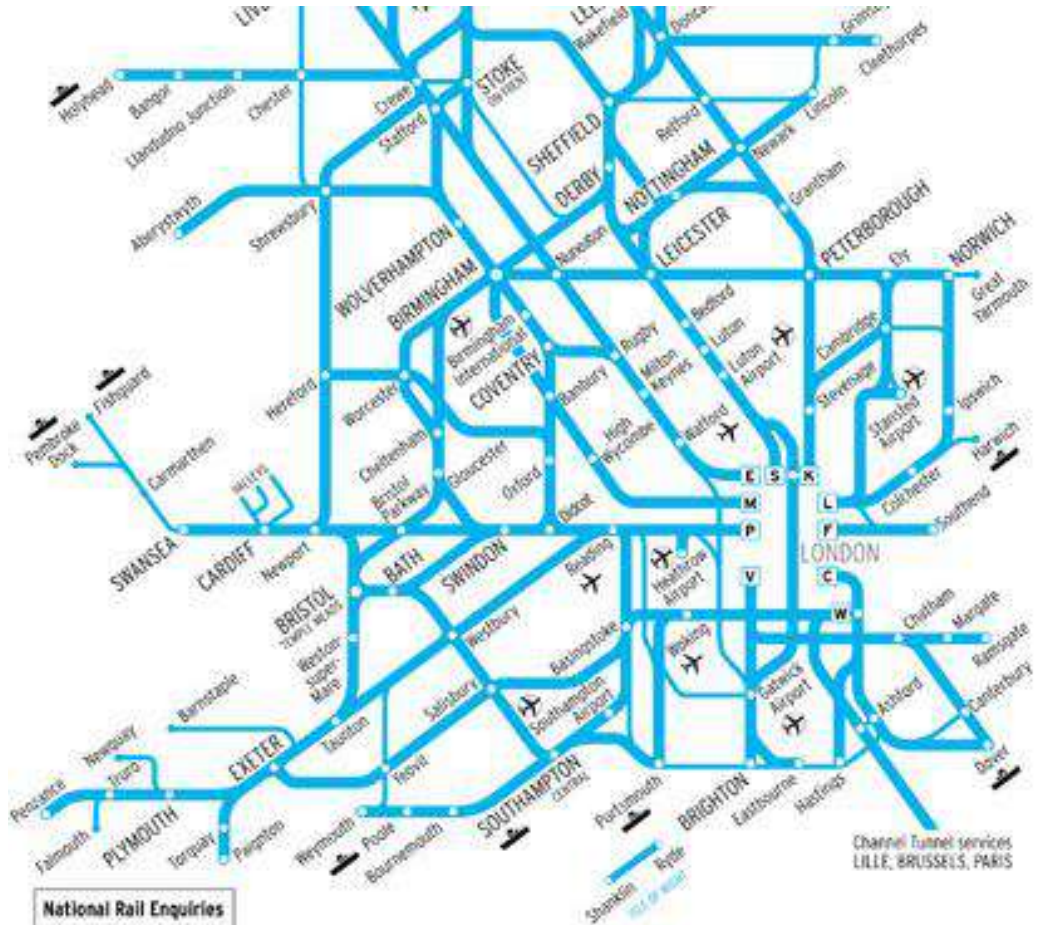
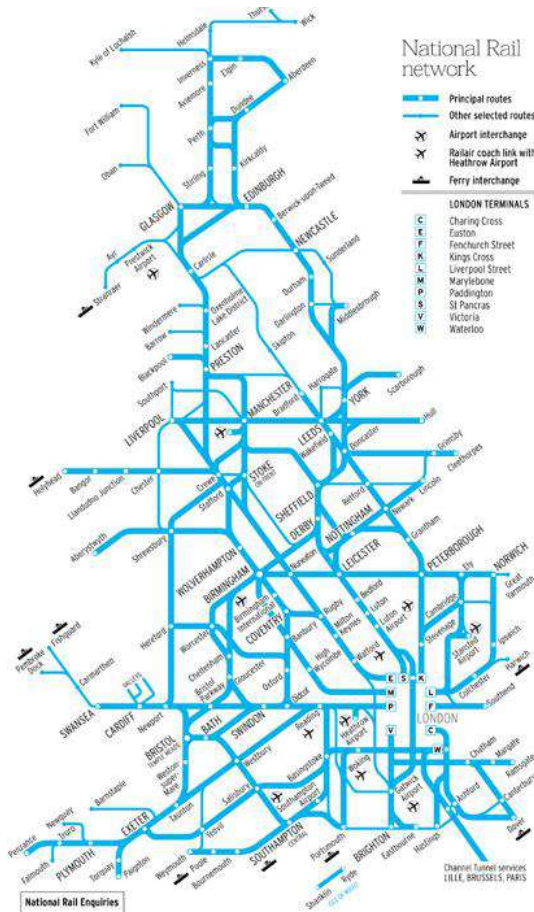
3



Routing - An overview

Trains / planes

4



Routing - An overview

Preferred route

5



Routing - An overview

Routers

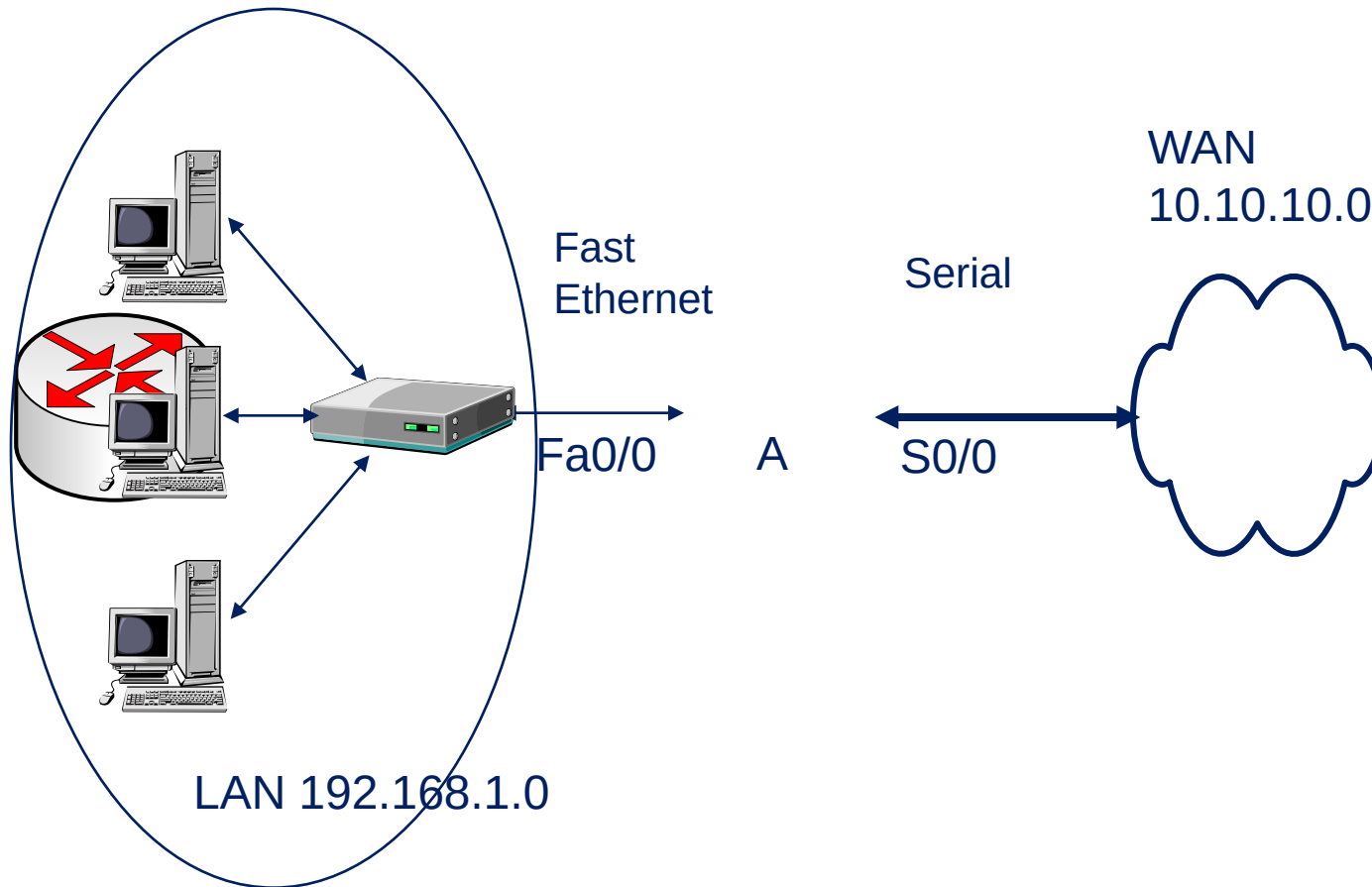
6

- Routers are:
 - ▣ Computers that specialize in sending packets over the data network.
 - ▣ Responsible for interconnecting networks by selecting the best path for a packet to travel and forwarding packets to their destination.



Functions of a Router

7



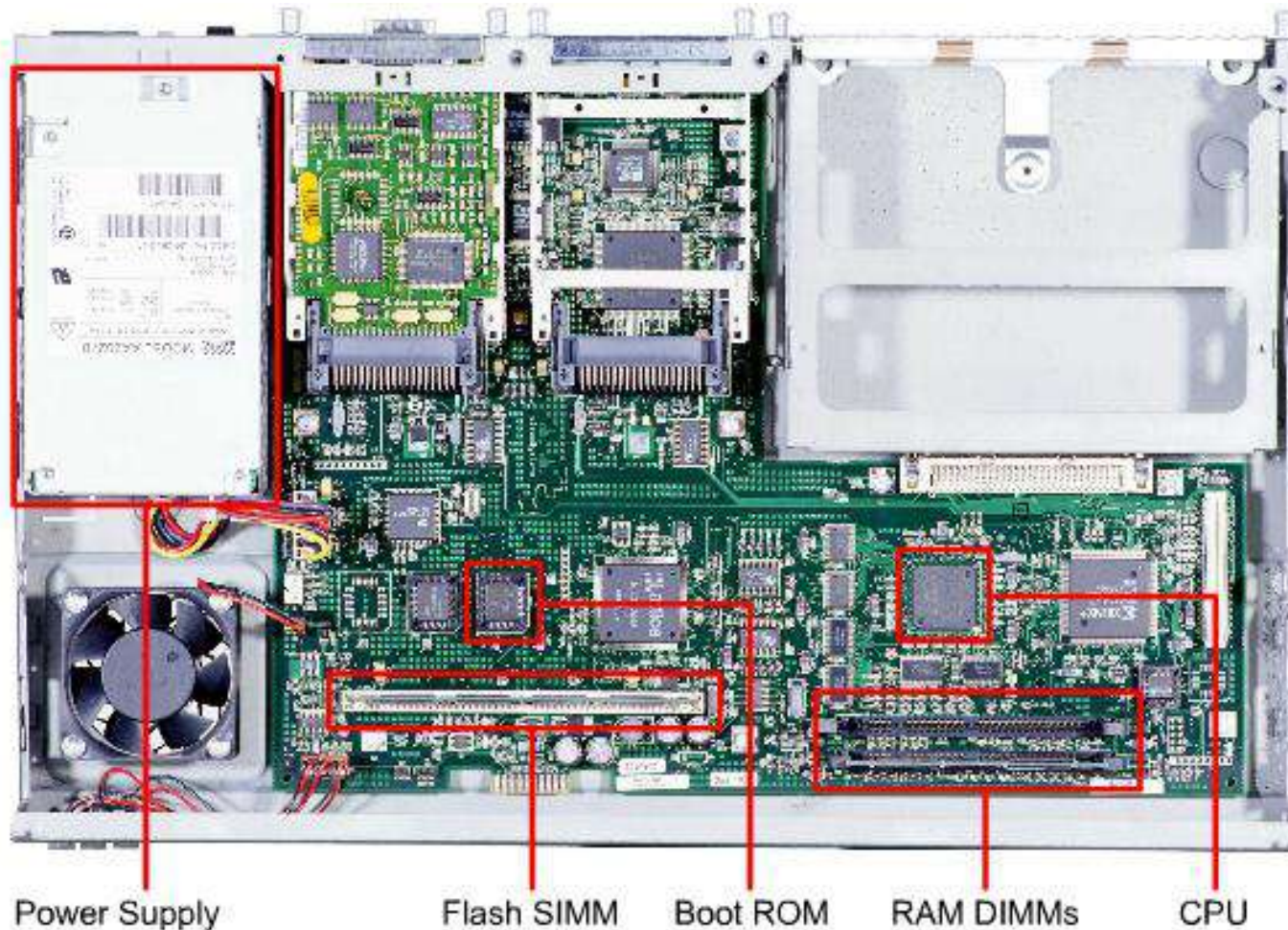
Functions of a Router

8

- A router connects multiple networks.
 - ▣ This means that it has multiple interfaces that each belong to a different IP network
- Each network that a router connects to typically requires a separate interface.
- These interfaces are used to connect a combination of both Local Area Networks (LANs) and Wide Area Networks (WANs)

Inside a Router – a Computer

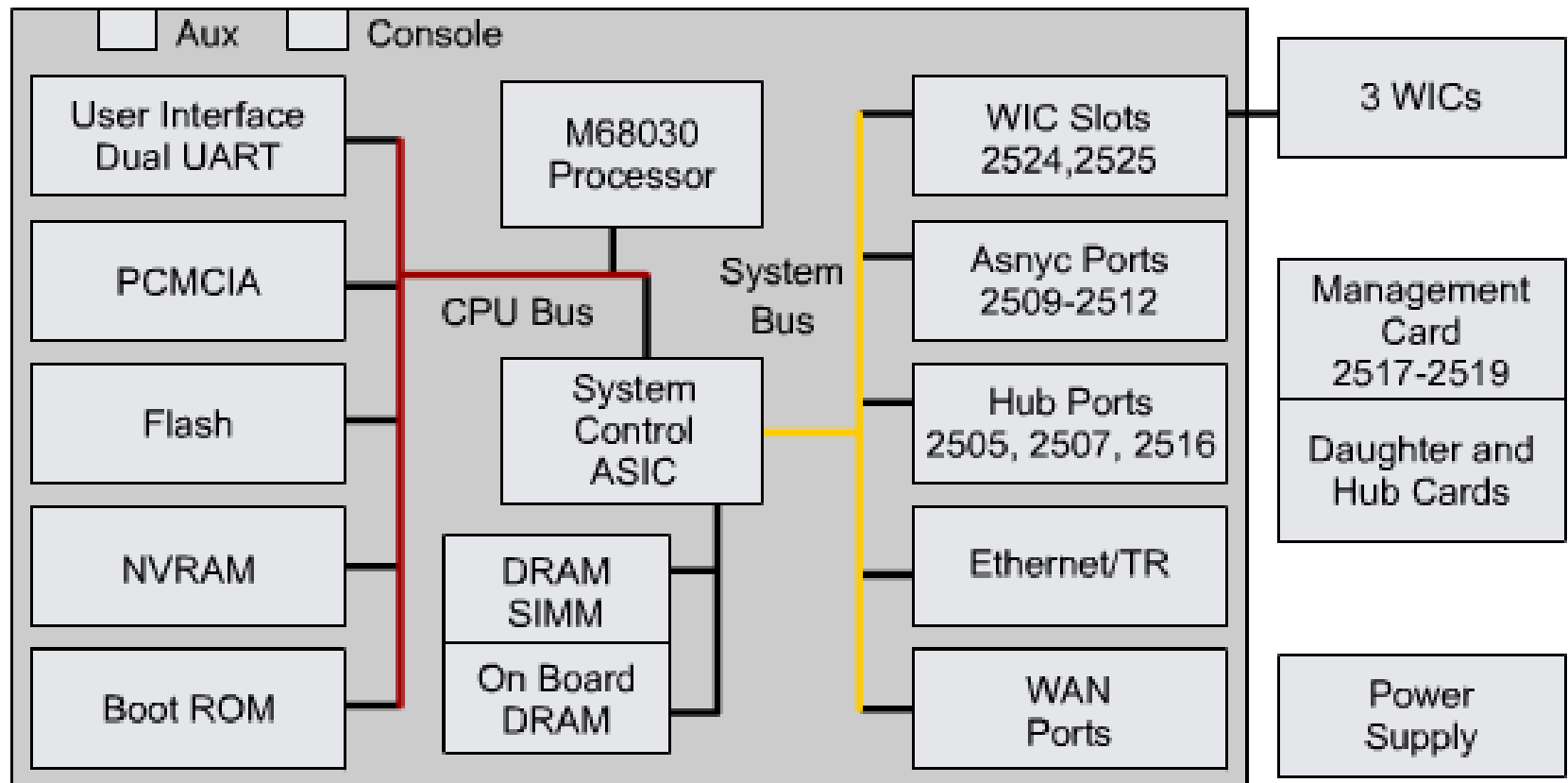
9



Routing - An overview

Router Internal Components

10



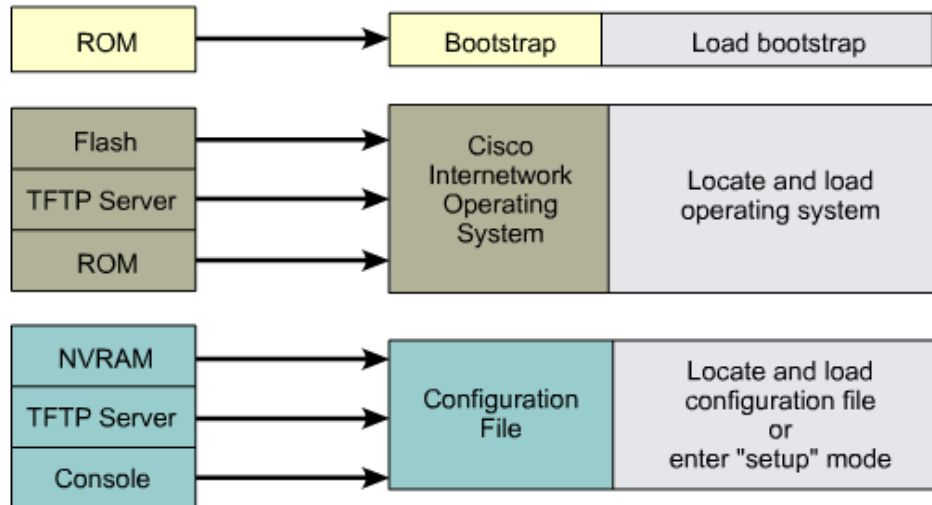
Router components and their functions

11

- ❑ CPU - Executes operating system instructions
- ❑ Random access memory (RAM) - Contains the running copy of configuration file. Stores routing table. RAM contents lost when power is off
- ❑ Read-only memory (ROM) - Holds diagnostic software used when router is powered up. Stores the router's bootstrap program.
- ❑ Non-volatile RAM (NVRAM) - Stores startup configuration. This may include IP addresses (Routing protocol, Hostname of router)
- ❑ Flash memory - Contains the operating system (Cisco IOS)
- ❑ Interfaces - There exist multiple physical interfaces that are used to connect network.

Steps in Router Initialisation.

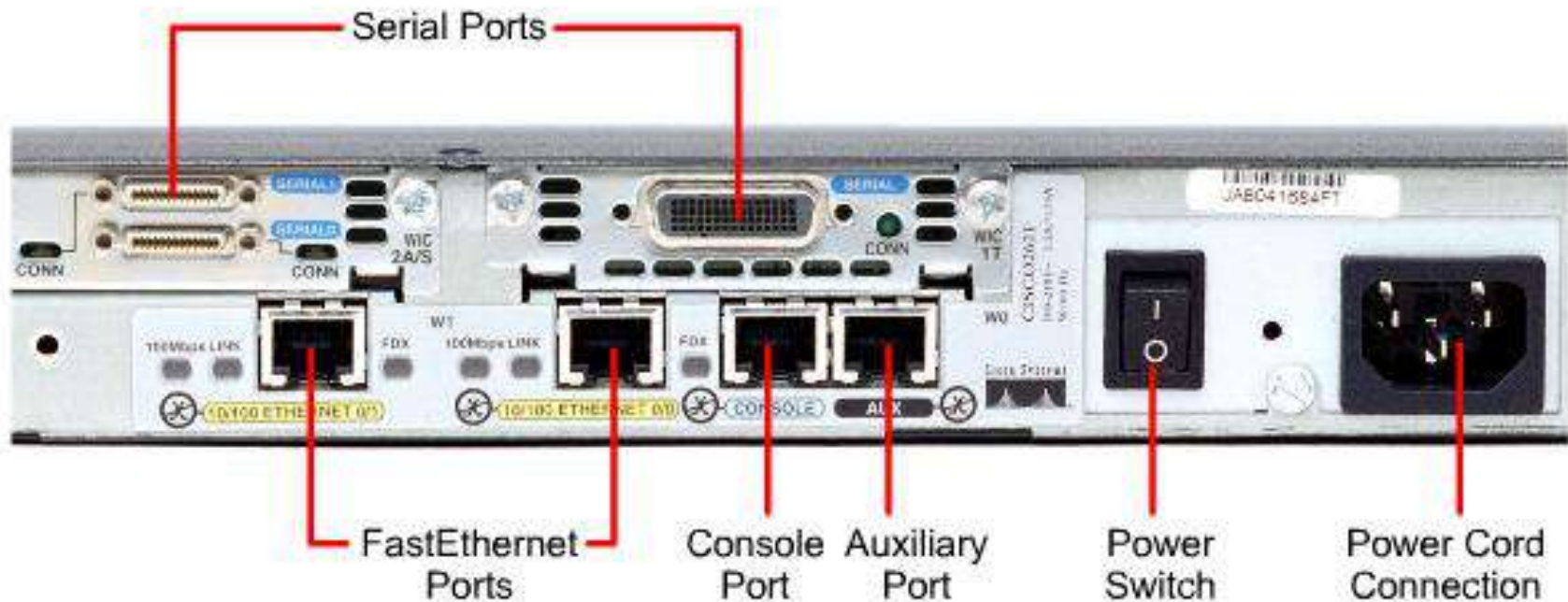
12



- ❑ Perform POST
- ❑ Execute bootstrap loader
- ❑ Located the IOS
- ❑ Load the IOS
- ❑ Locate the config file
- ❑ Execute the config file
- ❑ Enter SETUP mode

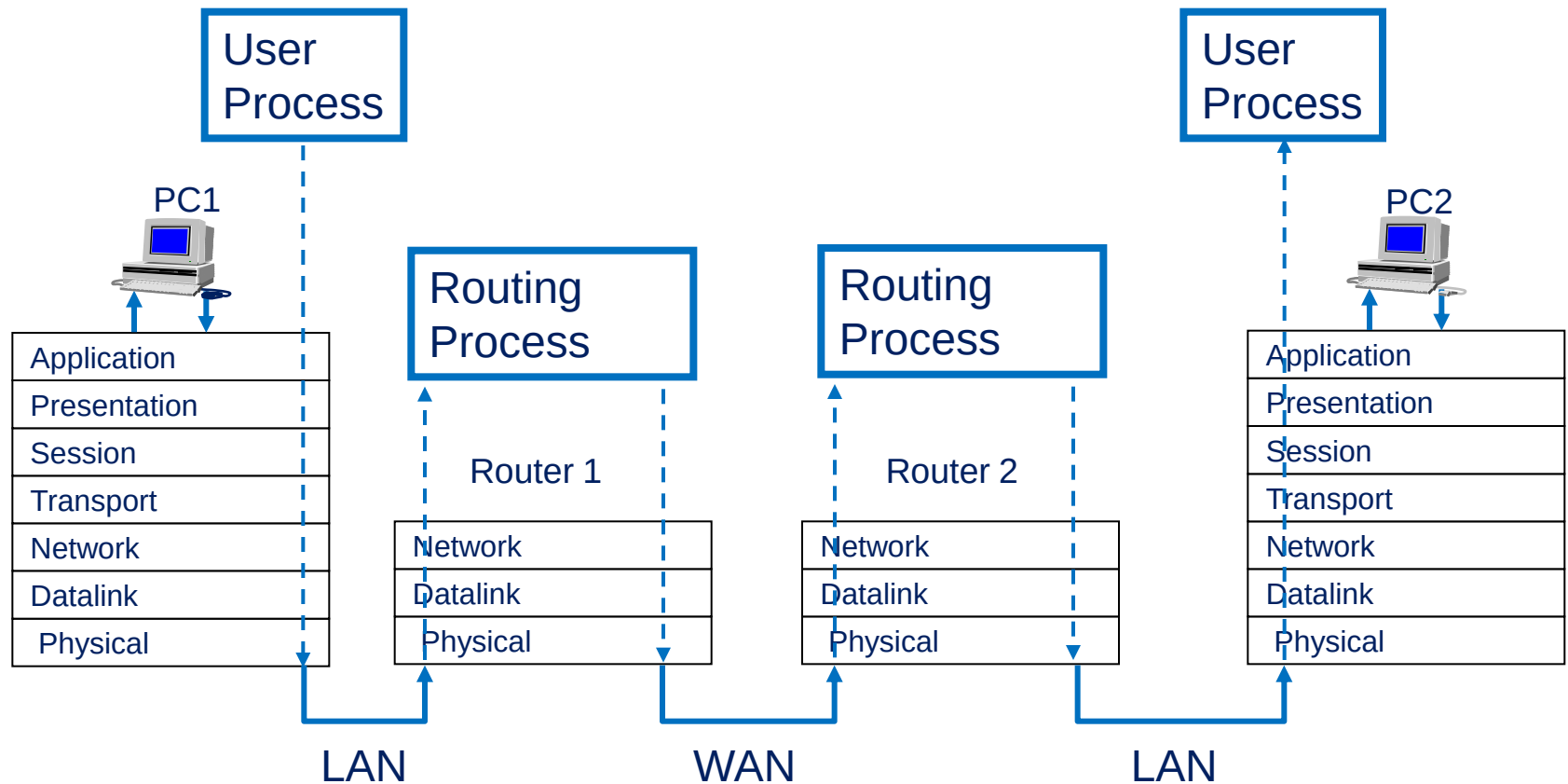
External Connections on a 2621 Router

13



Routers & Packet Forwarding

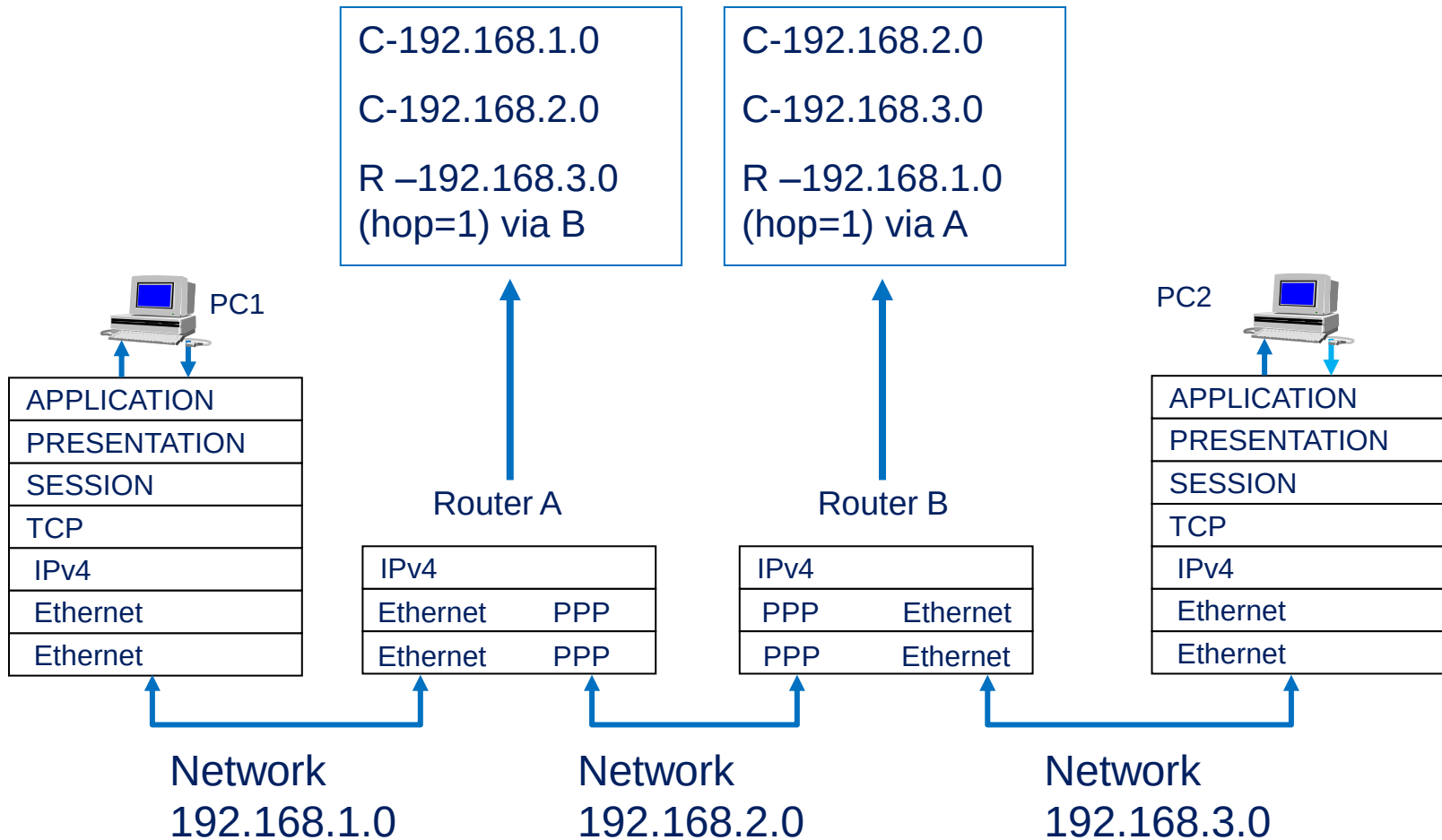
14



Routing - An overview

Packet Forwarding

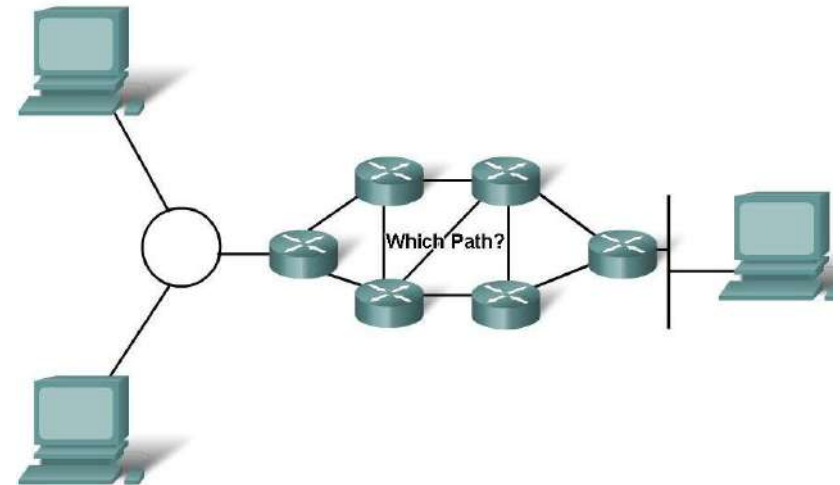
15



Router Paths and Packet Switching

16

- Path determination is a process used by a router to pick the best path to a destination.
- One of 3 path determinations results from searching for the best path:
 - ▣ 1. Directly connected network.
 - ▣ 2. Remote network.
 - ▣ 3. No route determined.



IP Datagram Format

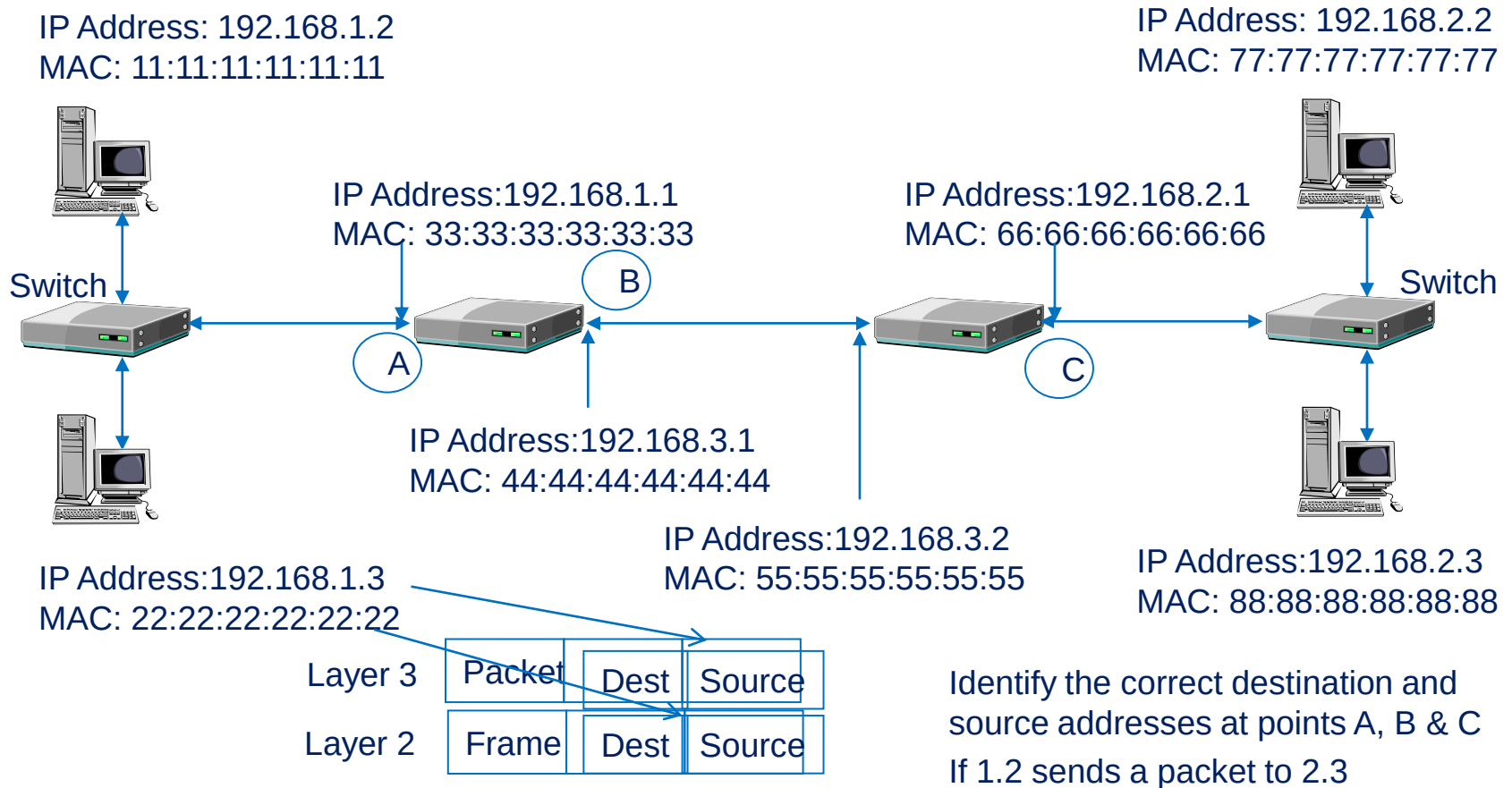
17

- IP Data Payload – Contains the data (segment) passed from the Transport layer

0	4	8	16	24	31
Version	IHL	Type of Service	Total Length		
Identification			Flags	Fragment Offset	
Time to Live		Protocol	Header Checksum		
Source IP Address					
Destination IP Address					
IP Options (optional)				Padding	
Data (Variable Length)					

Router Paths and Packet Switching

18



Packet forwarding operation of a Router

19

- Switching Function of Router is the process used by a router to switch a packet from an incoming interface to an outgoing interface as follows:
 - ▣ Strips off layer 2 headers.
 - ▣ Examines destination IP address located in Layer 3 header to find best route to destination.
 - ▣ Re-encapsulates layer 3 packet into layer 2 frame.
 - ▣ Forwards frame out exit interface.

Router Paths and Packet Switching

20

- As a packet travels from one networking device to another:
 - ▣ The Source and Destination IP addresses NEVER change.
 - ▣ The Source & Destination MAC addresses CHANGE as packet is forwarded from one router to the next.
 - ▣ TTL field decrement by one until a value of zero is reached at which point router discards packet (prevents packets from endlessly traversing the network).

Routing Table Structure

21

- Routing Table is stored in RAM and contains information about
 - ▣ Directly connected networks - this occurs when a device is connected to another router interface.
 - ▣ Remotely connected networks - this is a network that is NOT directly connected to a particular router.
 - ▣ Detailed information about the networks include source of information, network address & subnet mask, and IP address of next-hop router
- Show ip route command is used to view a routing table

Routing Table Principles

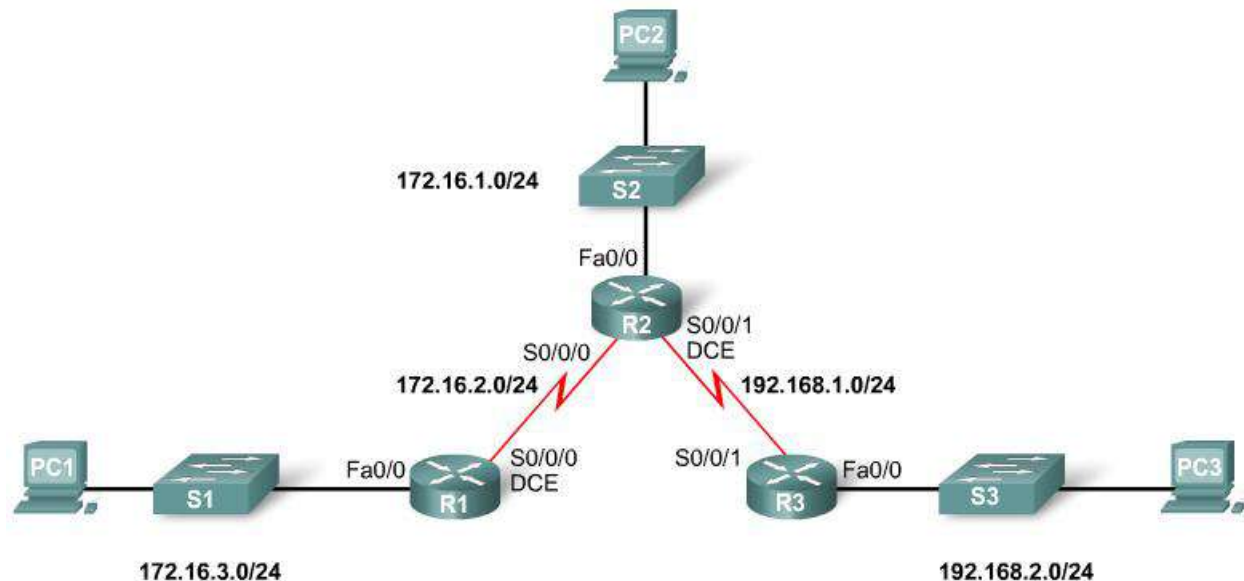
22

- Principle 1:
 - ▣ Every router makes its decision alone, based on the information it has in its own routing table.
- Principle 2:
 - ▣ The fact that one router has certain information in its routing table does NOT mean that other routers have the same information.
- Principle 3:
 - ▣ Routing information about a path from one network to another does not provide routing information about the reverse, or return path.

Routing Table Principles

23

- Static routes – if a network is not directly connected, a static route must be entered.
- For R1 – 172.16.3.0 & 172.16.2.0 are directly connected.
- For R1 – 172.16.1.0, 192.168.1.0 & 192.168.2.0 must be assigned static routes.



Directly Connected Networks

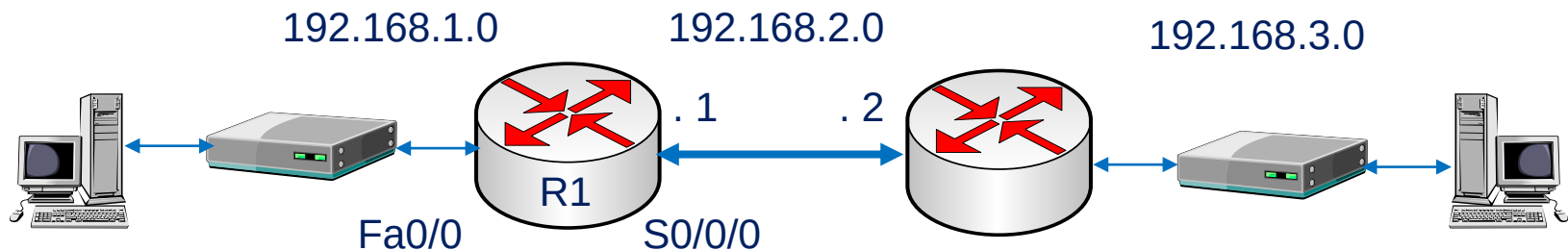
24

```
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
```



Routing - An overview

Static Routes

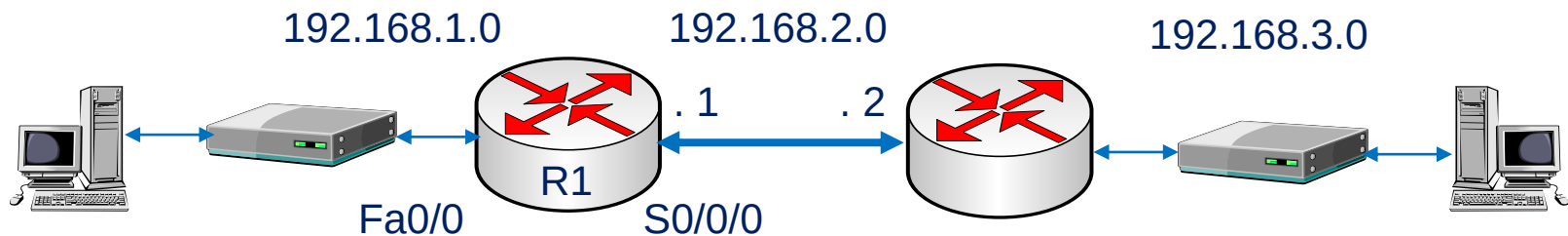
25

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```

```
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 [1/0] via 192.168.2.2
```



Static Routes

26

- When to use static routes:
 - ▣ When network only consists of a few routers
 - ▣ Network is connected to internet only through one ISP
 - ▣ Hub & spoke topology is used on a large network

Dynamic Routes

27

```
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  
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E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP  
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area  
* - candidate default, U - per-user static route, o - ODR  
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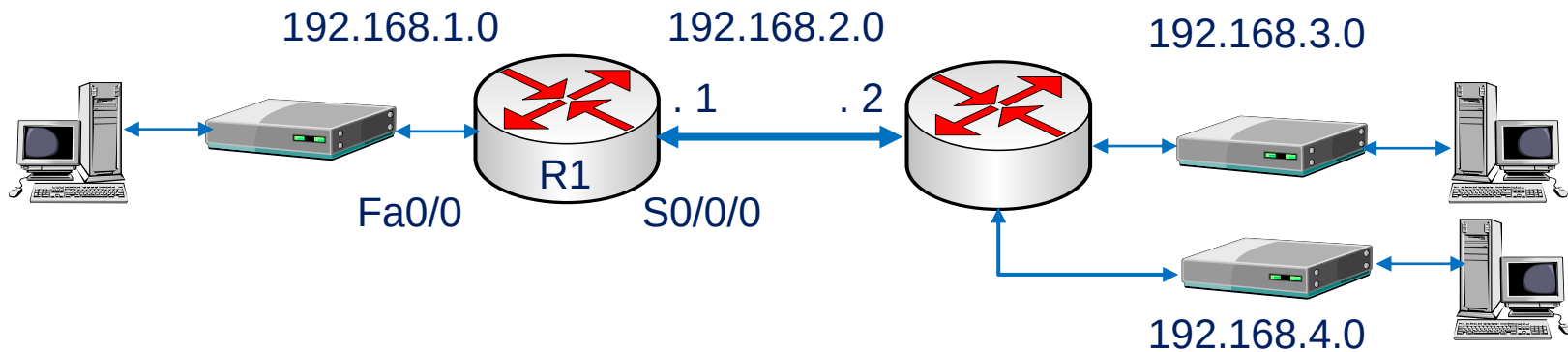
```
Gateway of last resort is not set
```

```
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 [1/0] via 192.168.2.2
```

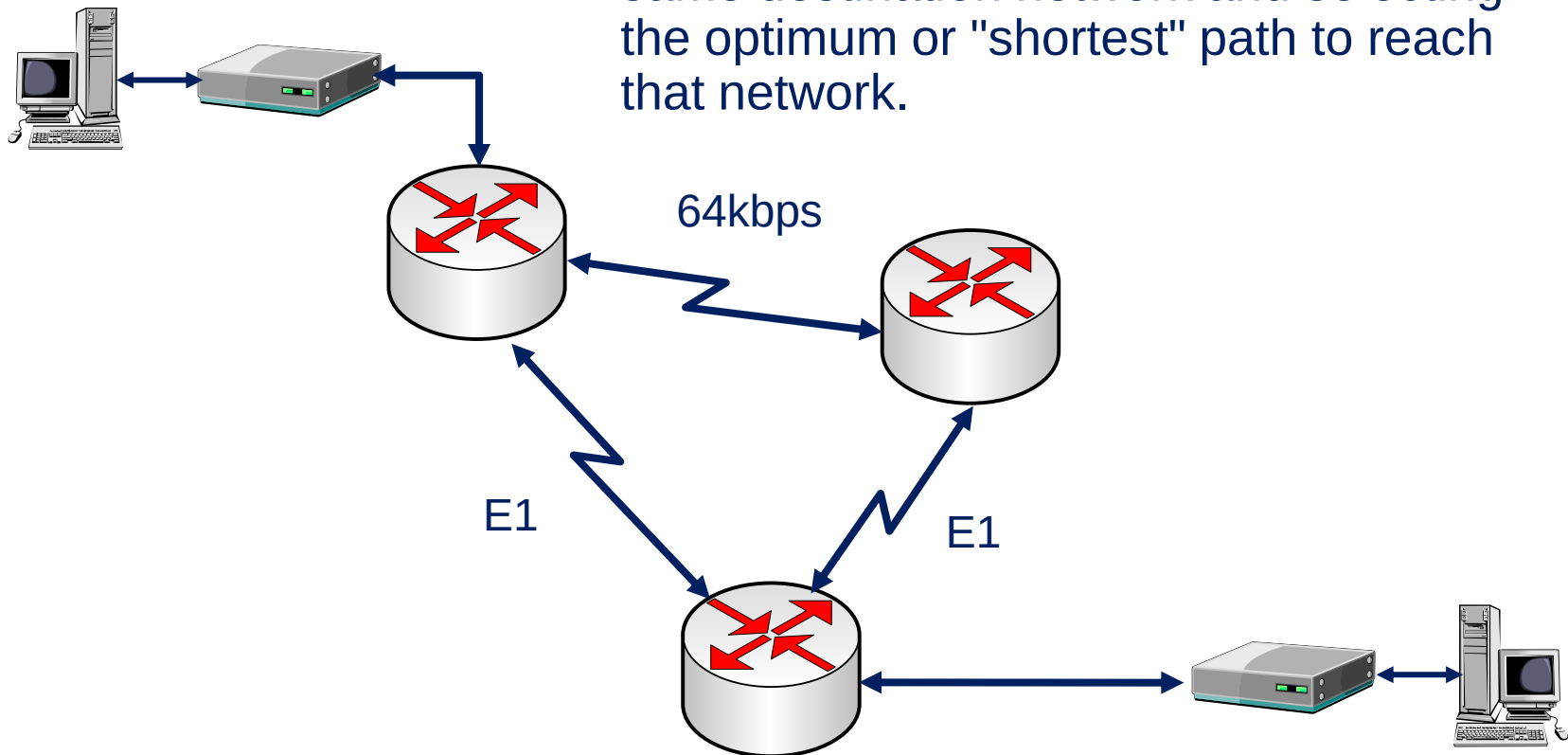
```
R 192.168.4.0/24 [120/1] via 192.168.2.2, 00:00:20, Serial0/0/0
```



Best Path & Metric

28

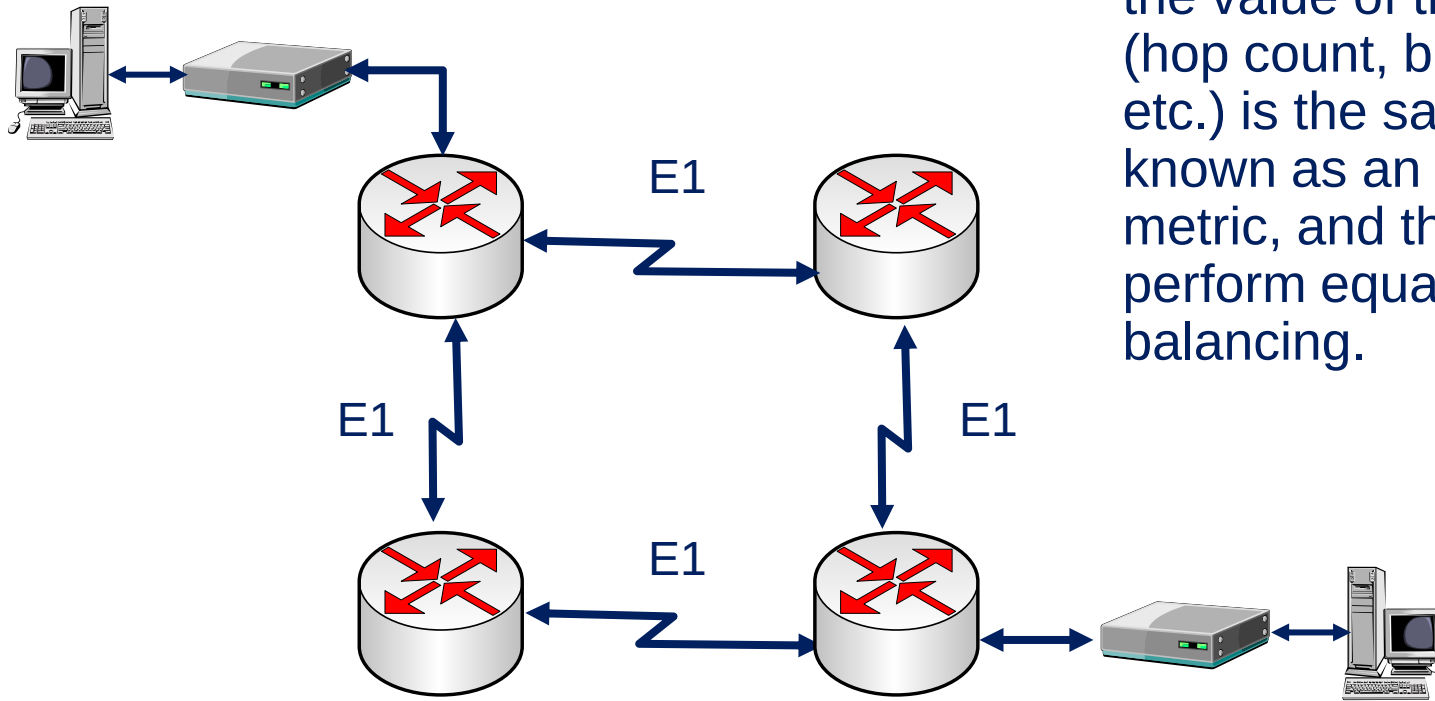
Determining a router's best path involves the evaluation of multiple paths to the same destination network and selecting the optimum or "shortest" path to reach that network.



Routing - An overview

Equal Cost Load Balancing

29



When a router has multiple paths to a destination network and the value of that metric (hop count, bandwidth, etc.) is the same, this is known as an equal cost metric, and the router will perform equal cost load balancing.