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IT2050 - Computer Networks

Lecture 3

Routing Protocols

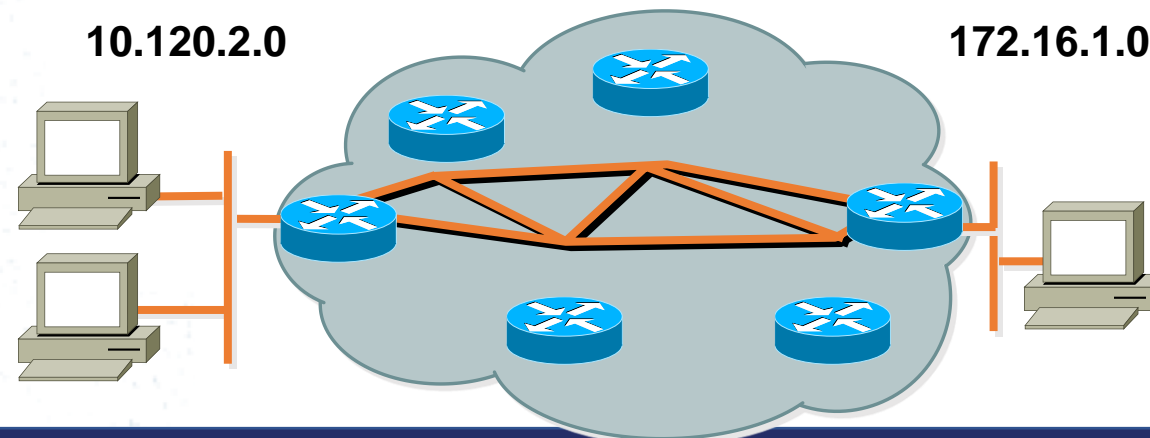
Ms. Hansika Mahaadikara



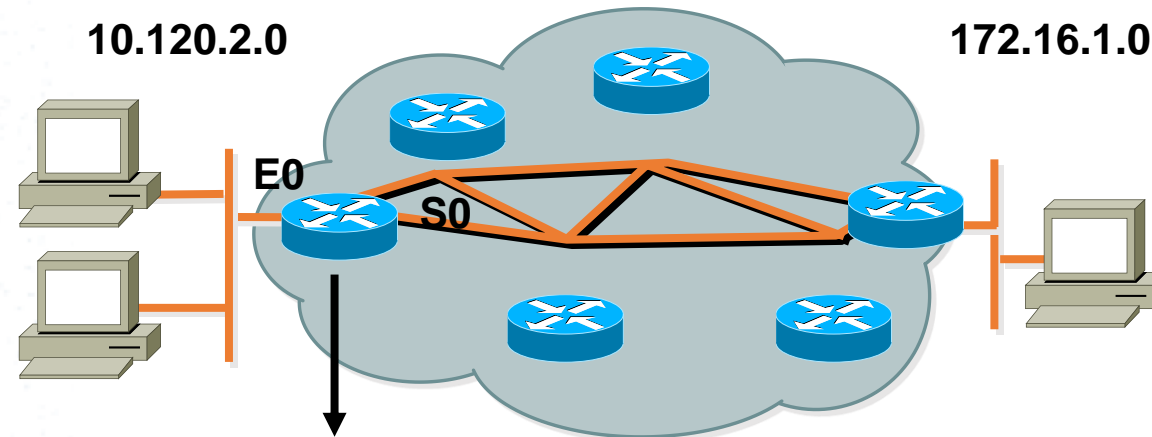
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What Is Routing?

- To route, a router needs to do the following:
 - Know the destination address.
 - Identify the sources it can learn from.
 - Discover possible routes.
 - Select the best route.
 - Maintain and verify routing information.



What Is Routing? (cont.)



Network Protocol	Destination Network	Exit Interface
Connected	10.120.2.0	E0
Learned	172.16.1.0	S0

Routed Protocol: IP

- Routers must learn destinations that are not directly connected.

Identifying Static & Dynamic Routes

- Static Route

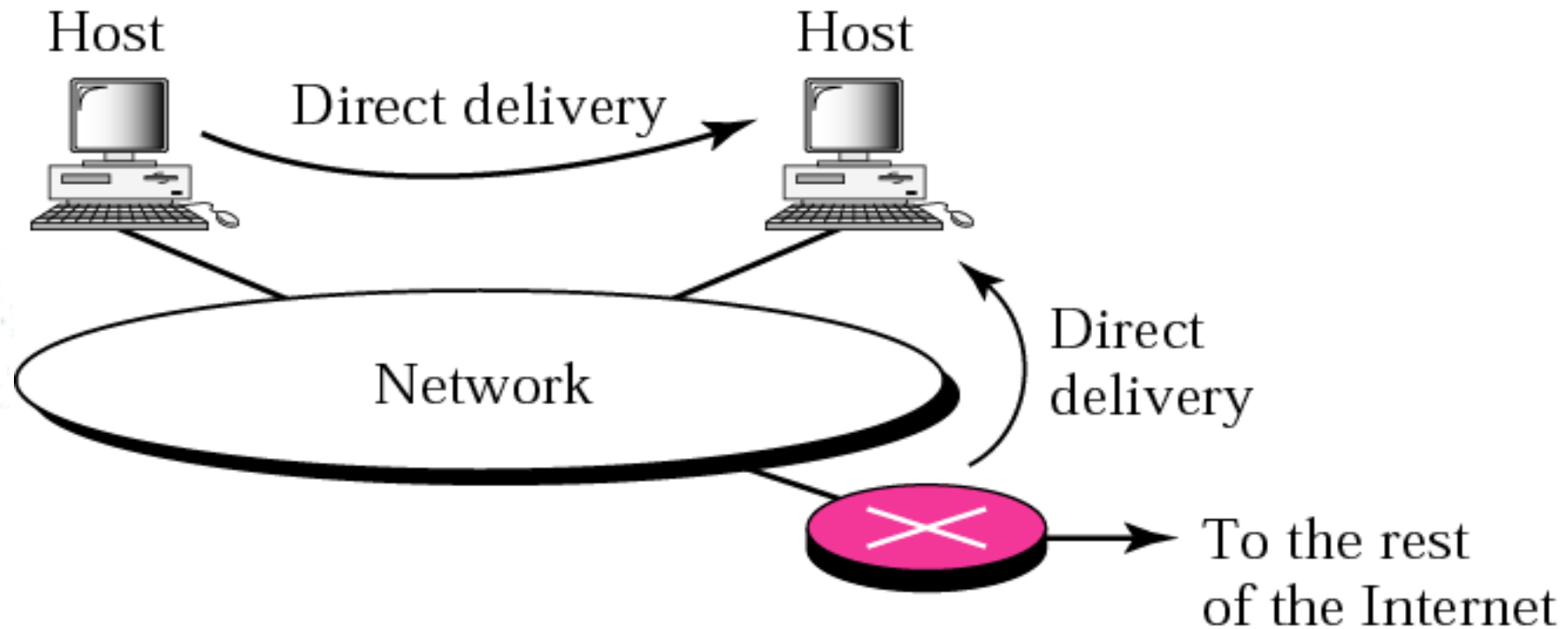
- Uses a route that a network administrator enters into the router manually

- Dynamic Route

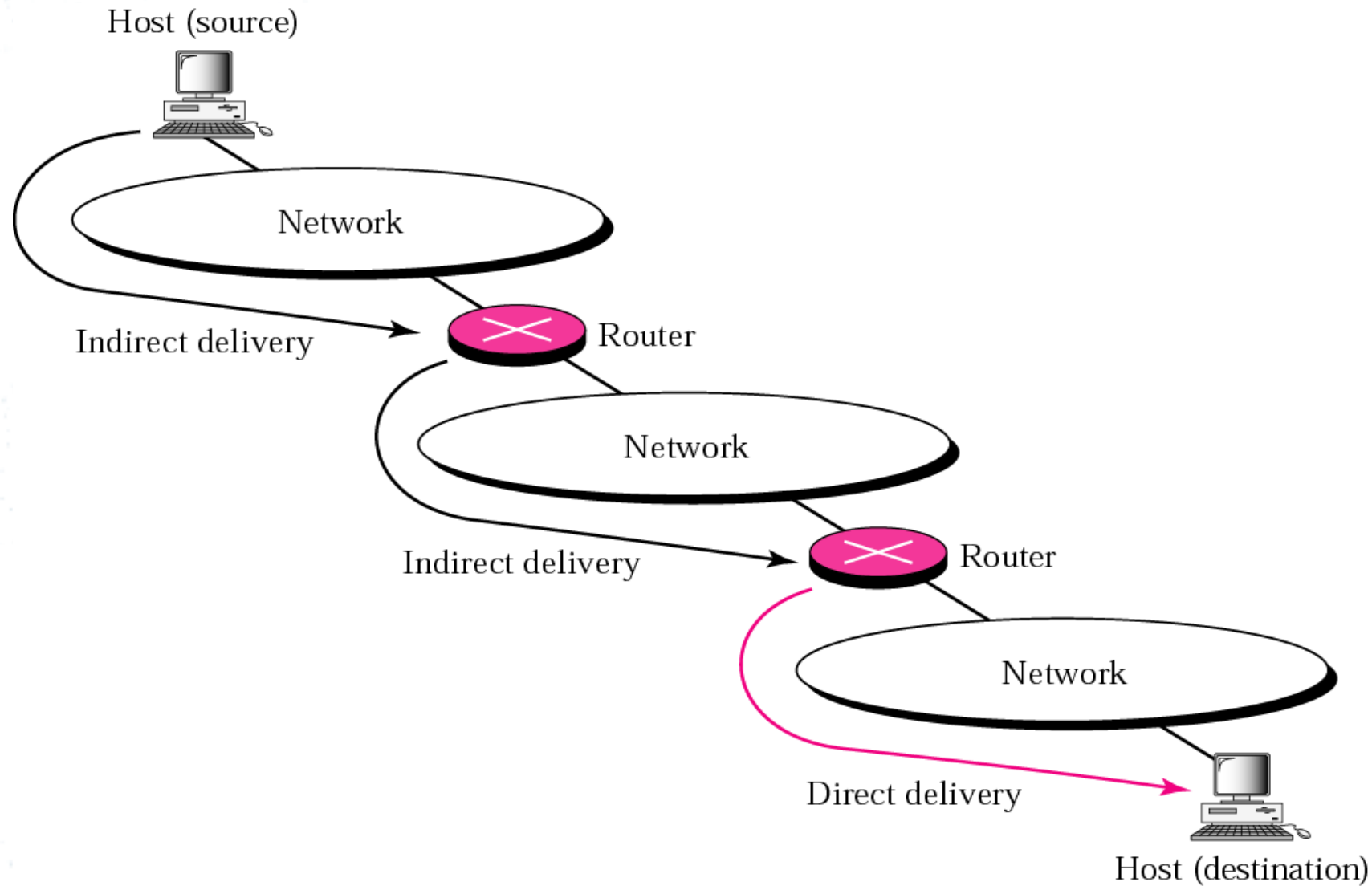
- Uses a route that a network routing protocol adjusts automatically for topology or traffic changes



Direct Delivery



Indirect Delivery



Indirect Delivery cont.

- To send a packet from source to destination, need to go to the network
(packet should go from router to router)
- All routers should maintain a routing table
- IP packet is analyzed at the router and correct path is selected from the routing table
- The packet is sent through that path
- Indirect delivery is done using the routing strategies



Routing Table

```
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
```

```
172.16.0.0/24 is subnetted, 3 subnets
```

```
S 172.16.1.0 [1/0] via 172.16.2.2
```

```
C 172.16.2.0 is directly connected, Serial0/0/0
```

```
C 172.16.3.0 is directly connected, FastEthernet0/0
```

```
S 192.168.1.0/24 [1/0] via 172.16.2.2
```

```
S 192.168.2.0/24 [1/0] via 172.16.2.2
```

Adaptive Routing



Adaptive Routing

- Each router maintains a routing table
- Routing table modifies itself according to the network changes
- Advantages
 - Network traffic is minimized
 - Low latency
 - The best route will be selected most
- Disadvantages
 - Router memory need to keep a routing table

Routing Methods used in Adaptive Routing

- Next hop routing
 - Host specific
 - Network specific
- Default routing



Host Specific Routing

- Each router keeps one record/entry for each
- Table entry has Host IP and the Interface

Host Address	Interface
192.168.50.1	E0
192.168.50.6	E0
172.18.2.9	S1
172.18.5.96	S1

Disadvantages

- Large number of records
- Table updating is difficult and complex as it should be done for each and every host (if the host IP changes)

Network Specific Routing

- Each router keeps a table entry for each network (one record for one network)
- Table entry has Network address and Interface

Network Address	Interface
192.168.50.0	E0
172.18.0.0	S1

Advantages

- Number of records are limited (Table updates are not for each host but for a network)
- Update is easy



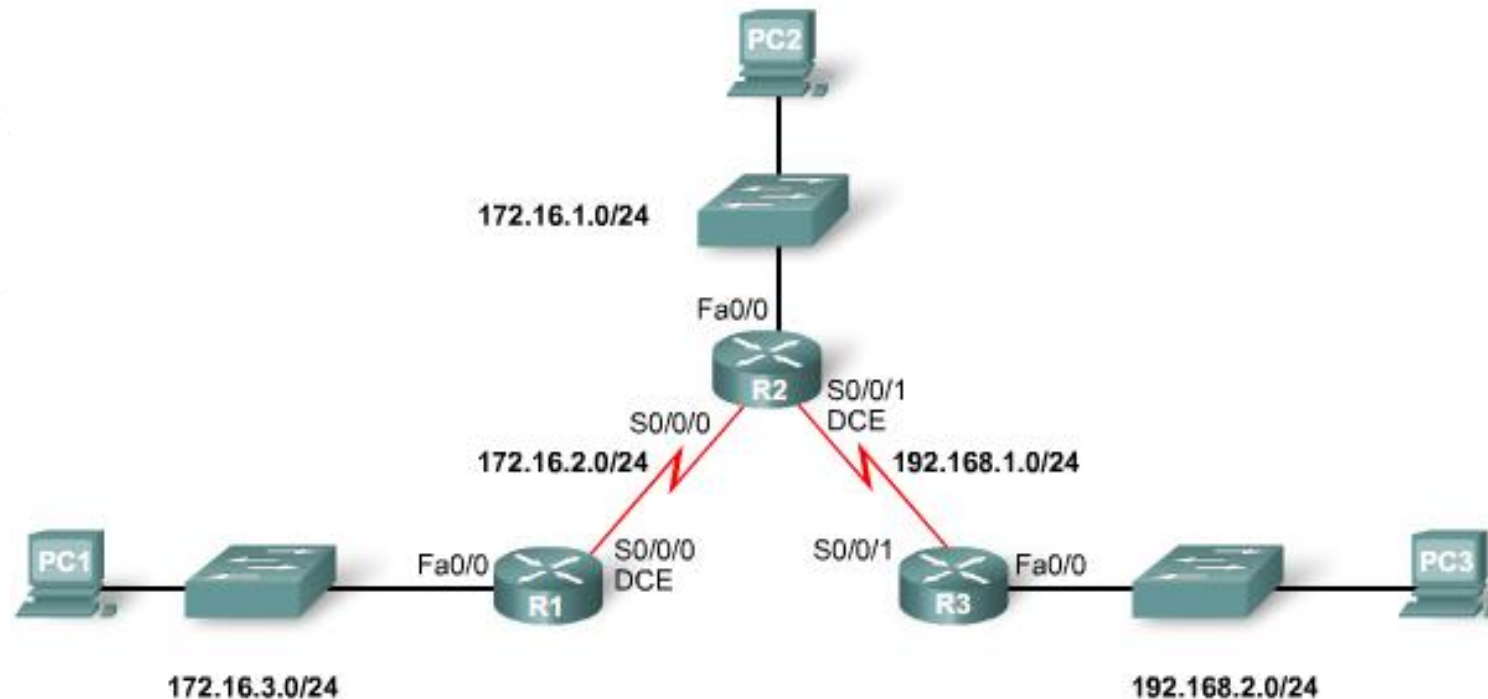
Routing Table update Methods

- Basic methods to update routing tables
 - Connected
 - Static
 - Dynamic



Connected

- Once the router is connected to the network its interfaces are given IP addresses
- With that router automatically identifies the network addresses to which it connected



Connected cont.

```
R1#show ip route
```

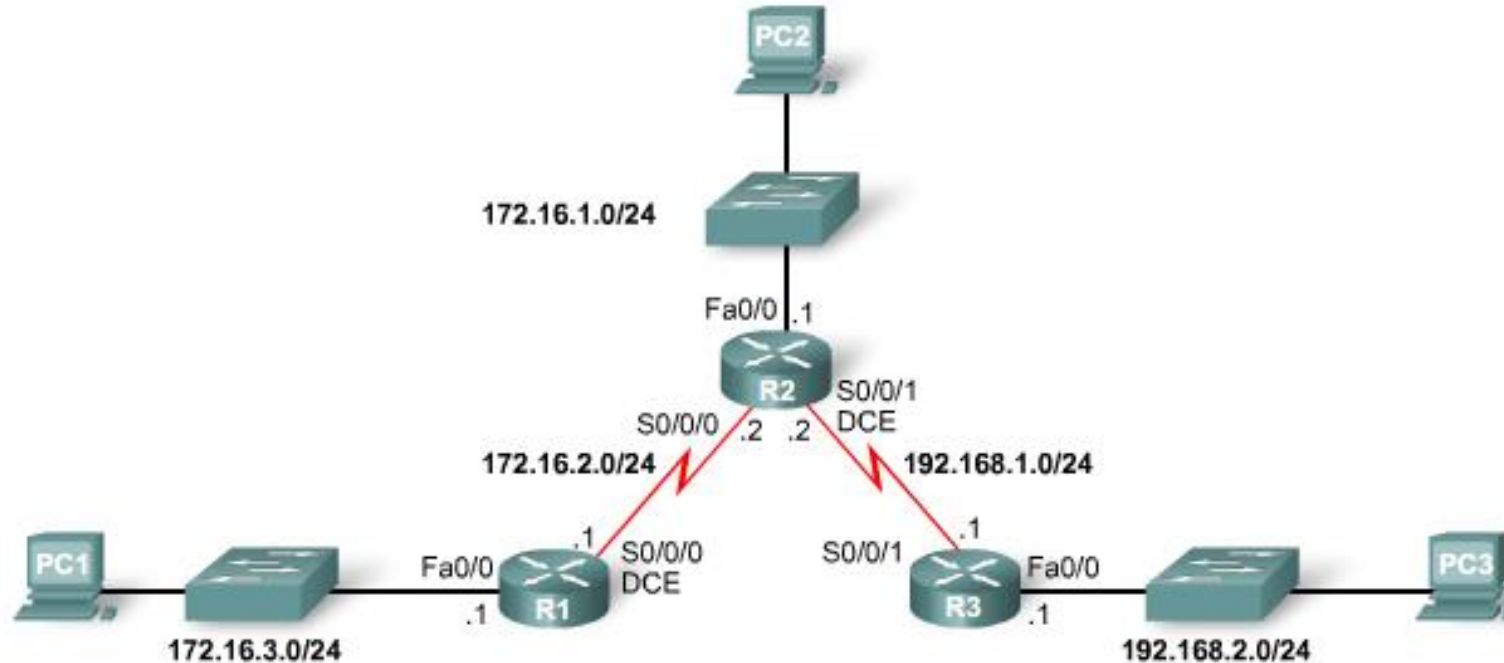
```
Codes: C - connected, S - static,  
Gateway of last resort is not set
```

```
172.16.0.0/24 is subnetted, 2 subnets
```

```
C      172.16.2.0 is directly connected, Serial0/0/0
```

```
C      172.16.3.0 is directly connected, FastEthernet0/0
```

- Administrator can manually give routing table records



```
Router(config)#ip route <destination network>  
                  <destination network subnet mask>  
                  <next hop address | exit interface | Both>
```

Static cont.

```
R1 (config) #  
R1 (config) #ip route 172.16.1.0 255.255.255.0 172.16.2.2  
R1 (config) #ip route 192.168.1.0 255.255.255.0 172.16.2.2  
R1 (config) #ip route 192.168.2.0 255.255.255.0 172.16.2.2  
R1 (config) #
```

```
R1#show ip route
```

Codes: C - connected, S - static

Gateway of last resort is not set

172.16.0.0/24 is subnetted, 3 subnets

S 172.16.1.0 [1/0] via 172.16.2.2

C 172.16.2.0 is directly connected, Serial0/0/0

C 172.16.3.0 is directly connected, FastEthernet0/0

S 192.168.1.0/24 [1/0] via 172.16.2.2

S 192.168.2.0/24 [1/0] via 172.16.2.2

Static cont.

Advantages:

- Minimal CPU processing
- Easier for administrator to understand and configure

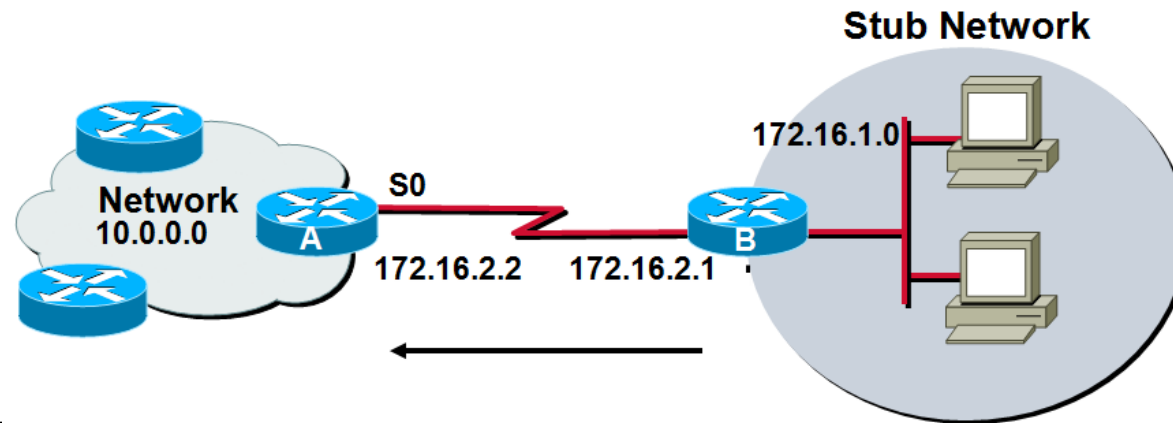
Disadvantages:

- Configuration and maintenance is time-consuming
- Configuration is error-prone
- Administrator should maintain changing route information
- Does not scale well with growing networks; maintenance becomes complex
- Requires complete knowledge of the whole network for proper implementation



Default Routing

- Last record in the routing table
- Indicates the route/path to be taken, if any of the records does not match with the IP packet destination IP address
- **Stub networks** only use default routing , **Stub networks** have only one exit port out of the network



```
R(config)#ip route 0.0.0.0 0.0.0.0  
<next hop ip addr | exit interface name | both>
```

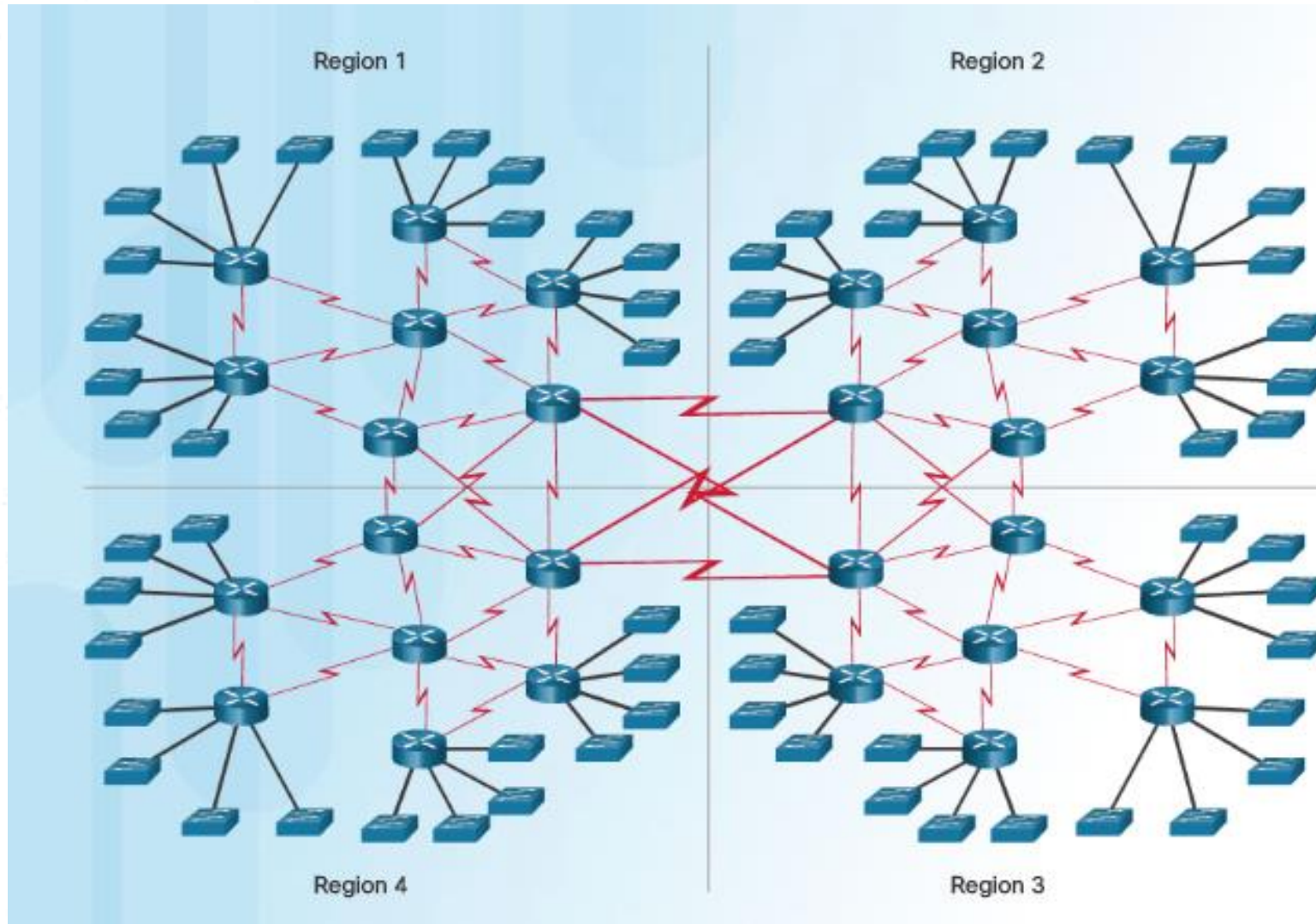
Default Routing cont.

```
B(config)#  
B(config)#ip route 0.0.0.0 0.0.0.0 172.16.2.2  
B(config)#
```

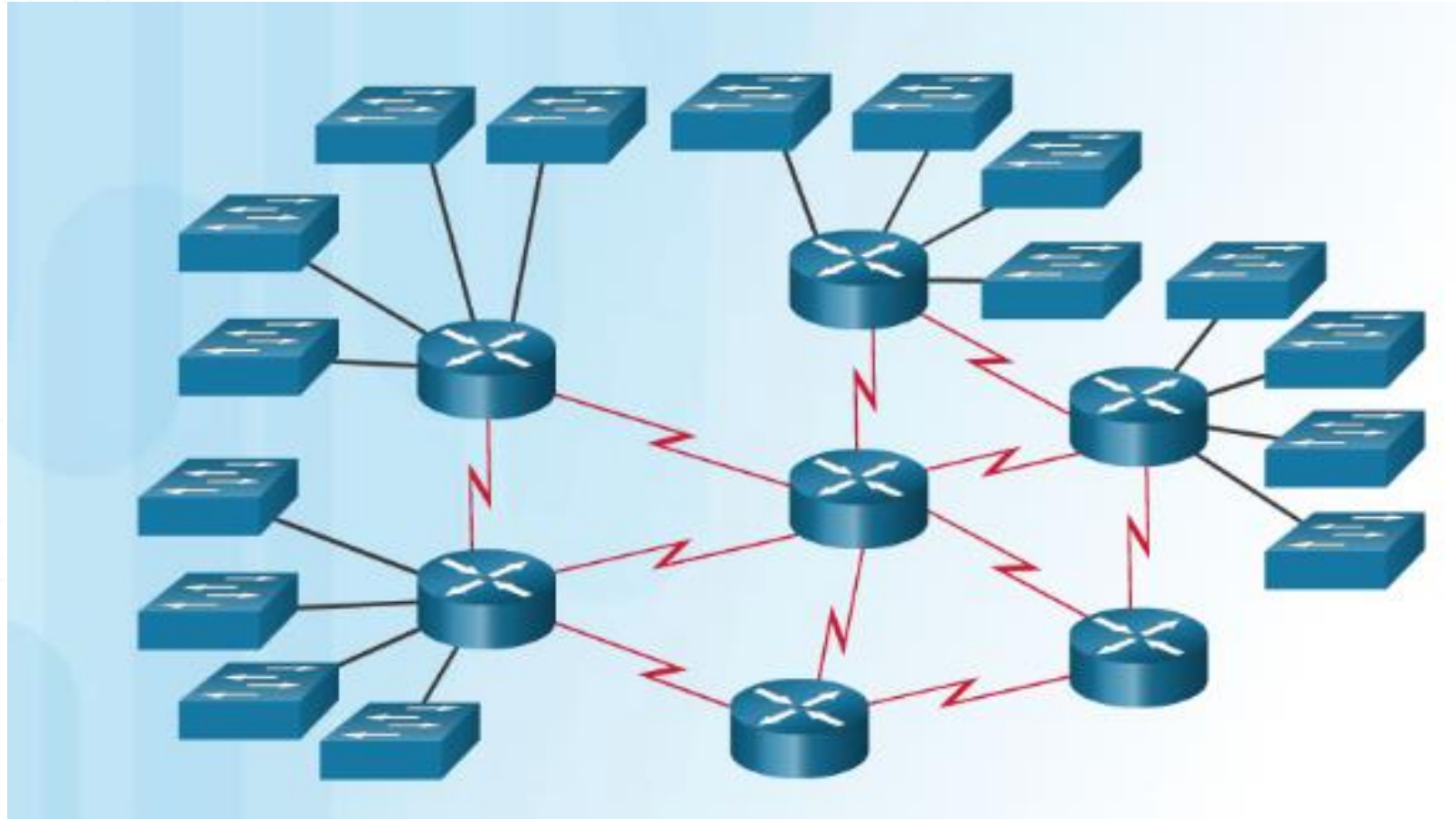
```
B#show ip route  
Codes: C - connected, S - static  
  
Gateway of last resort is 172.16.2.2 to network 0.0.0.0  
  
    172.16.0.0/24 is subnetted, 2 subnets  
C        172.16.1.0 is directly connected, FastEthernet0/0  
C        172.16.2.0 is directly connected, Serial2/0  
S*    0.0.0.0/0 [1/0] via 172.16.2.2  
B#
```



Dynamic Routing Scenario



Dynamic Routing Scenario



Dynamic

- Routing tables are updated automatically by using routing protocols
- Routing tables have
 - Initially only connected records
 - Then add static' records
 - Then automatic dynamic updates



Dynamic cont.

Advantages:

- Administrator has less work maintaining the configuration when adding or deleting networks
- Protocols automatically update, according to the topology changes.
- Configuration is less error-prone
- Suitable for More scalable, growing networks

Disadvantages:

- Router resources are used (CPU cycles, memory and bandwidth)
- More administrator knowledge is required for configuration, verification, and troubleshooting



Routing Protocols



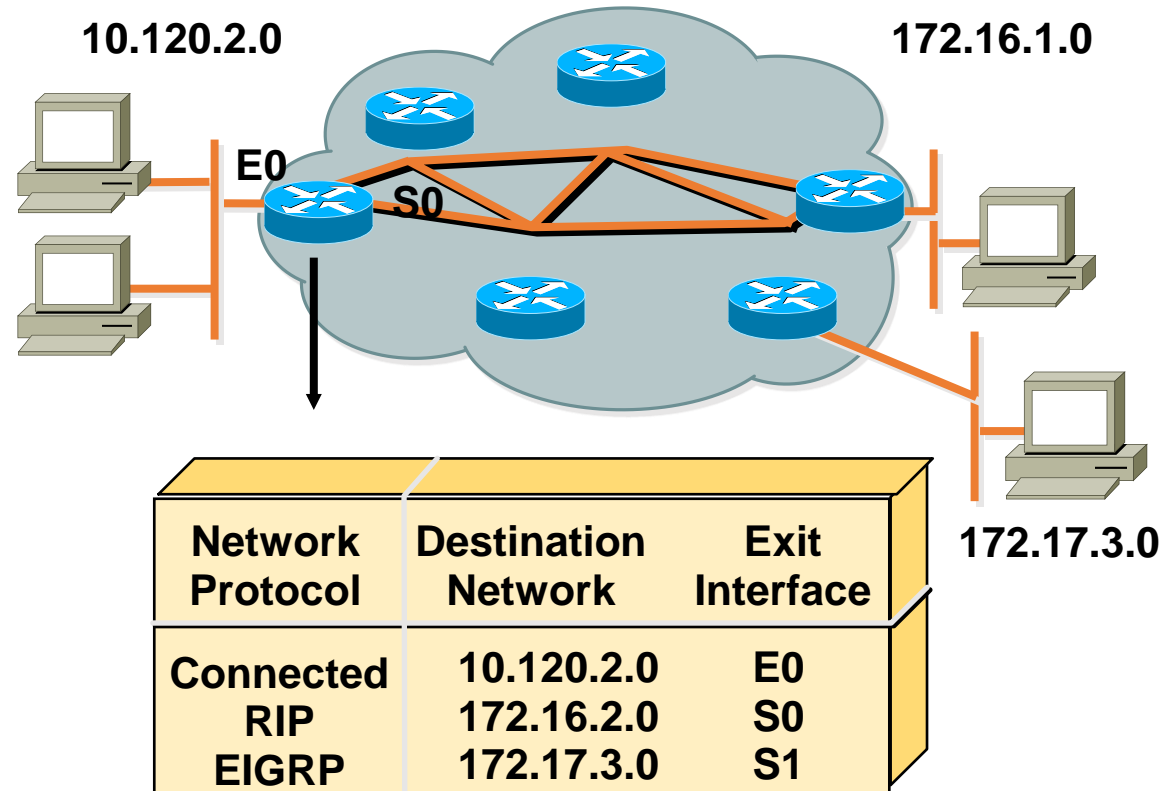
Features of Routing Protocols

- Network changes (addition or removal or fault) are automatically updated in routing tables of all routers
- When there are many routes to a destination, the best route should be selected
- Share the traffic through different routes



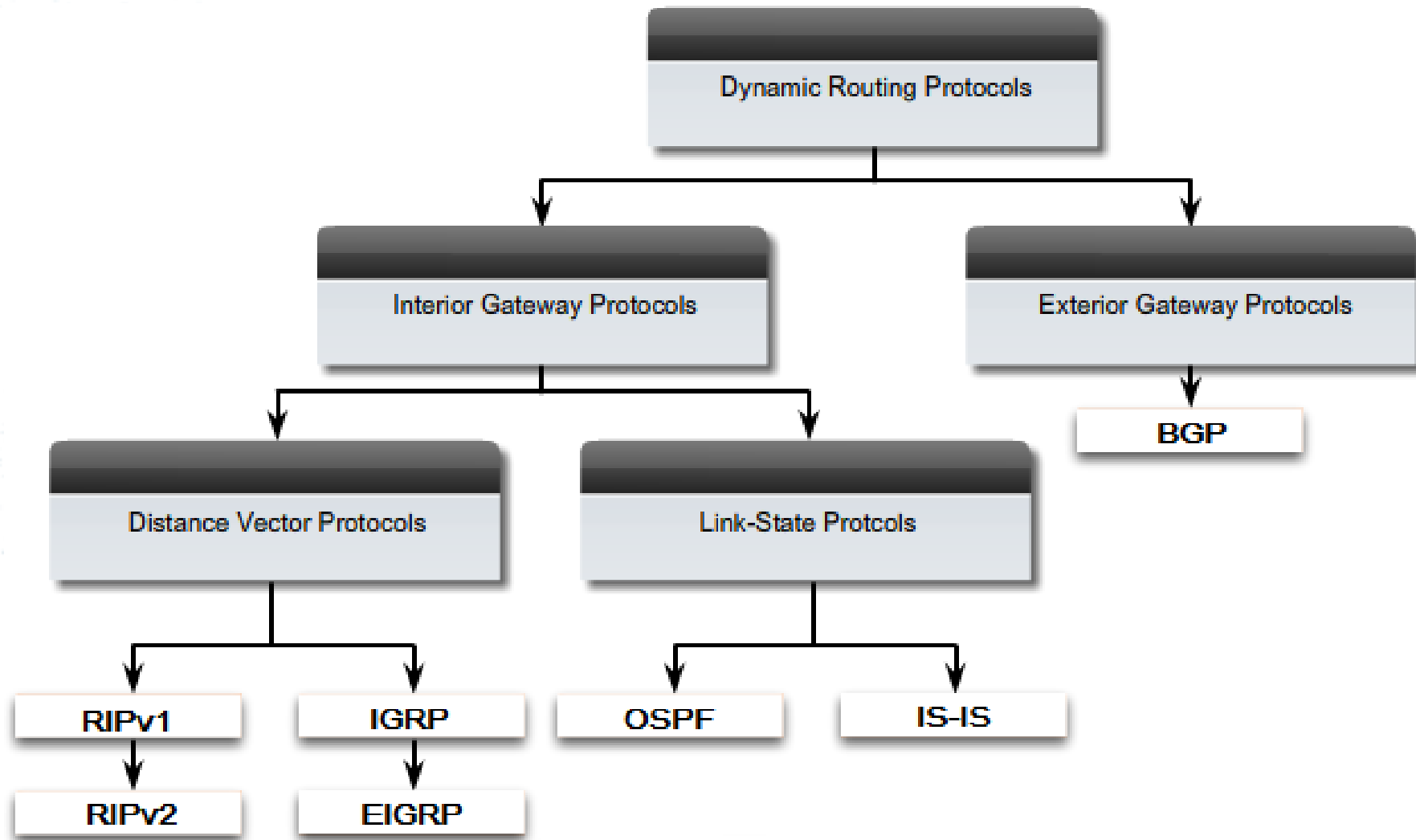
What Is a Routing Protocol?

- Routing Protocols allow routers to dynamically advertise and learn routes, determine which routes are available and which are the most efficient routes to a destination



Routing Protocol: RIP, EIGRP, OSPF

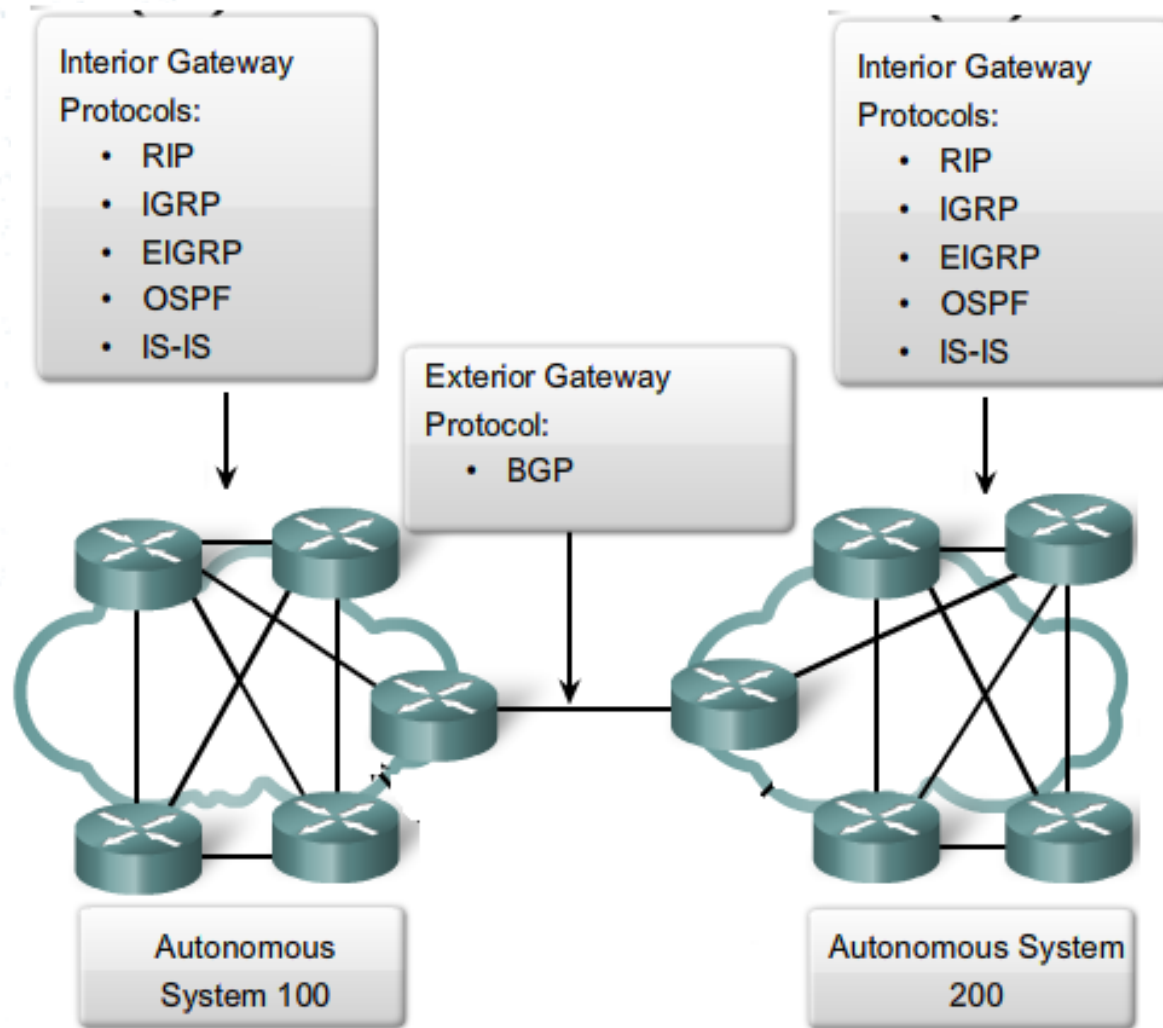
Routing Protocols



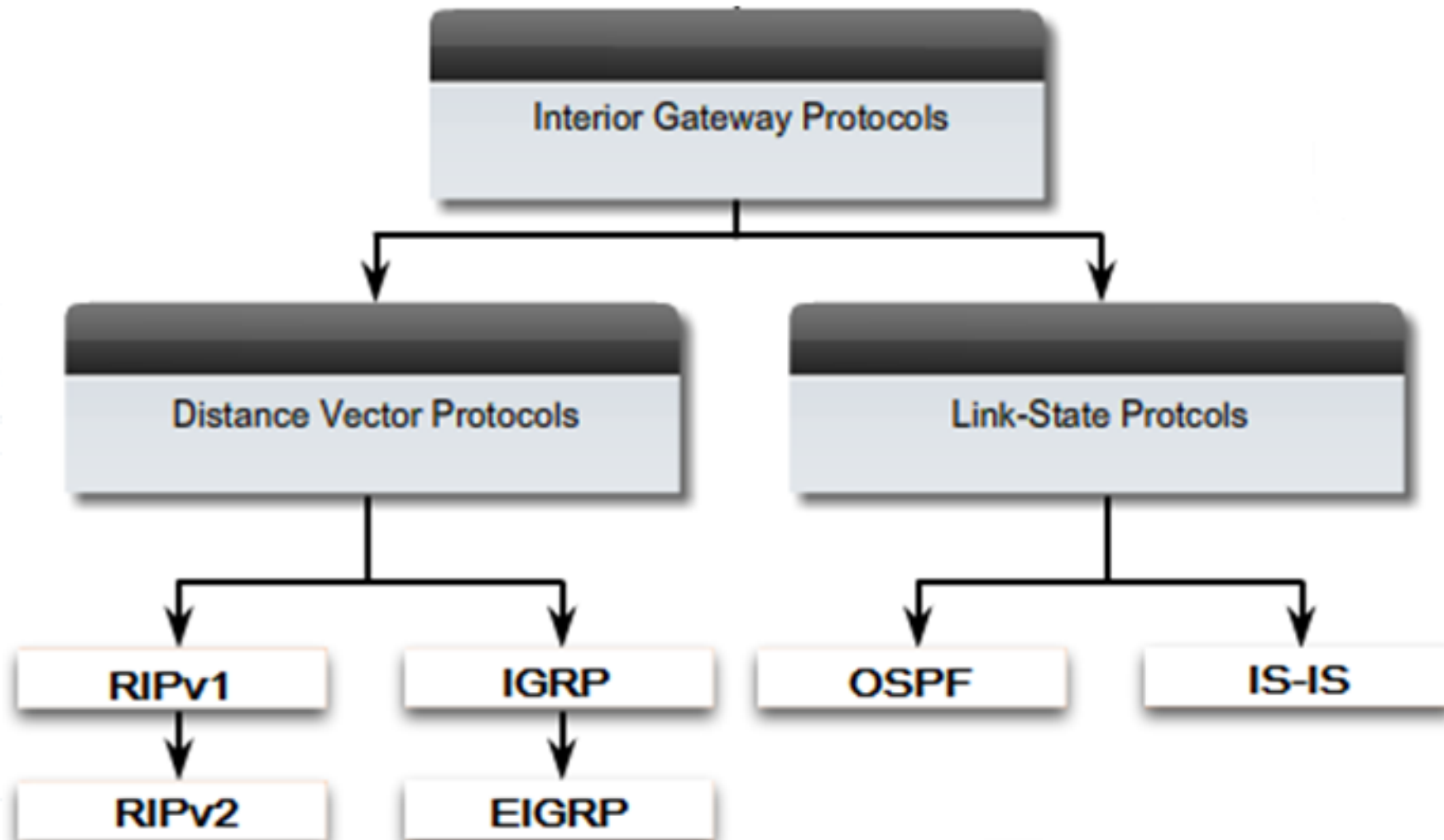
Routing Protocols cont.

- An autonomous system (AS) is a collection of routers under a common administration
ex : a company's internal network
- Interior Gateway Protocols (IGP) are used for intra-autonomous system routing
(routing inside an autonomous system)
- Exterior Gateway Protocols (EGP) are used for inter-autonomous system routing
(routing between autonomous systems)

Routing Protocols cont.



Interior Gateway Protocols (IGP)



RIP

(Routing Information Protocol)



RIP (Routing Information Protocol)

- A Distance-vector routing protocol
- It sends the complete routing table out to all active interfaces in every 30 seconds
- Only uses hop count to select best way to a remote network
- RIP works well in small networks, but it is inefficient on large networks
- There are two versions
RIP v1, RIP v2

RIP Configuration

```
Router (config) #router rip
```

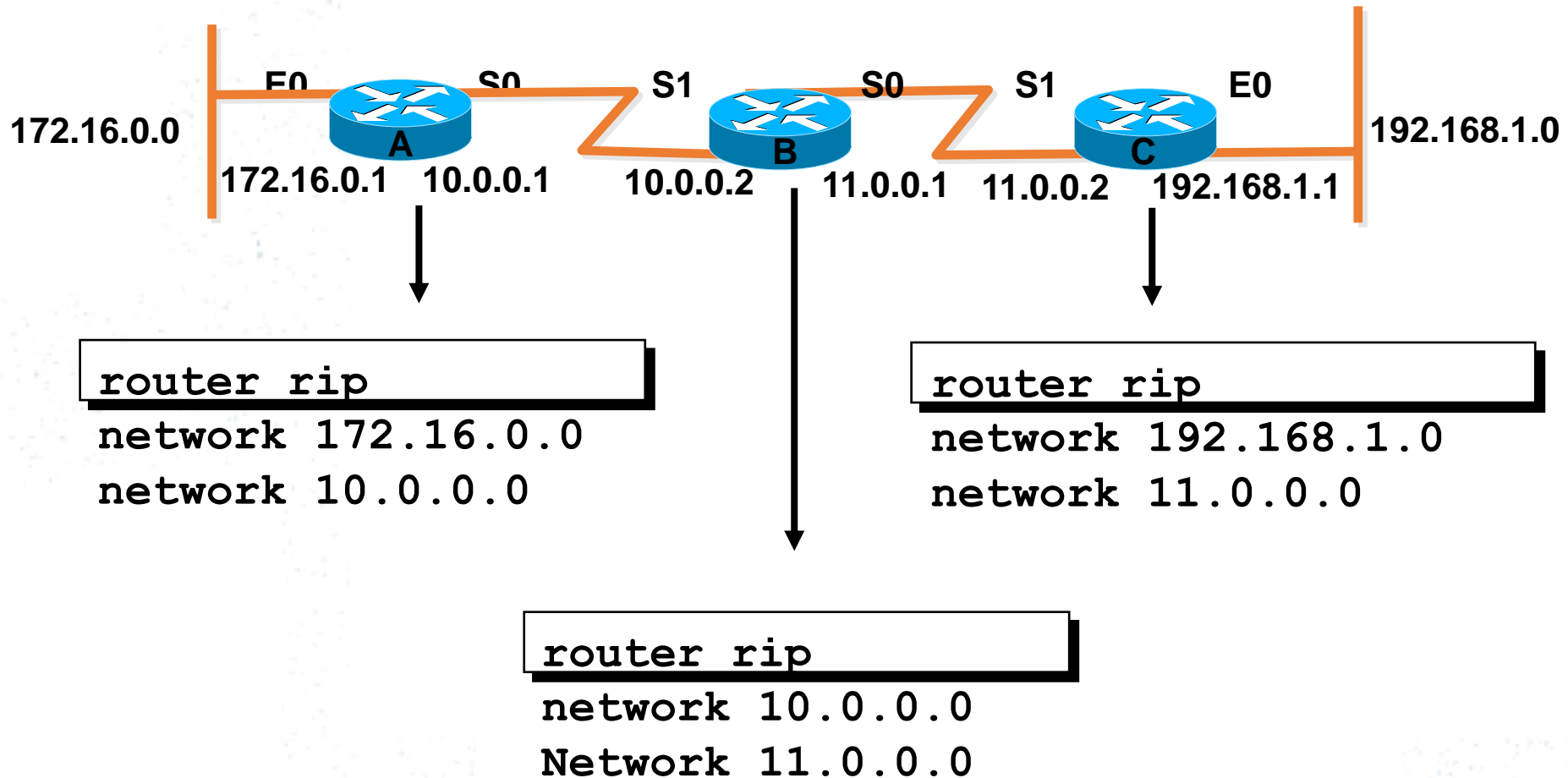
```
Router (config-router) #network <network-address>
```

< ***network-address*** >

Directly connected network addresses



RIP Configuration Example Version 1



Configure RIP V2

Classless Sub-networks

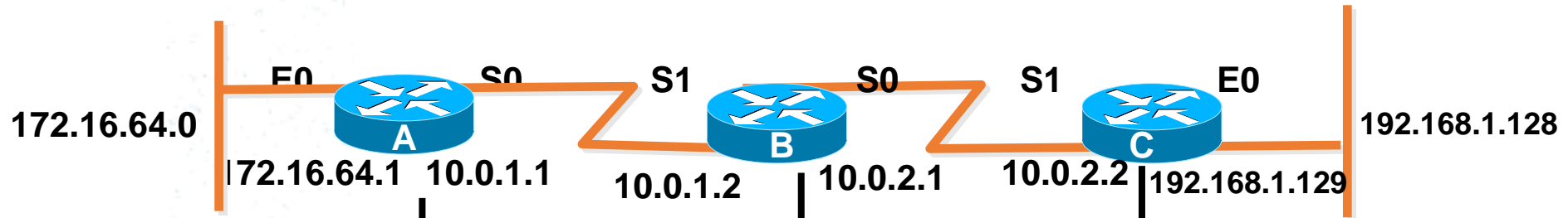
```
Router (config) #router rip
```

```
Router (config) #version 2
```

```
Router (config-router) #network <network-address>
```

- < network-address> : Directly connected sub-network addresses

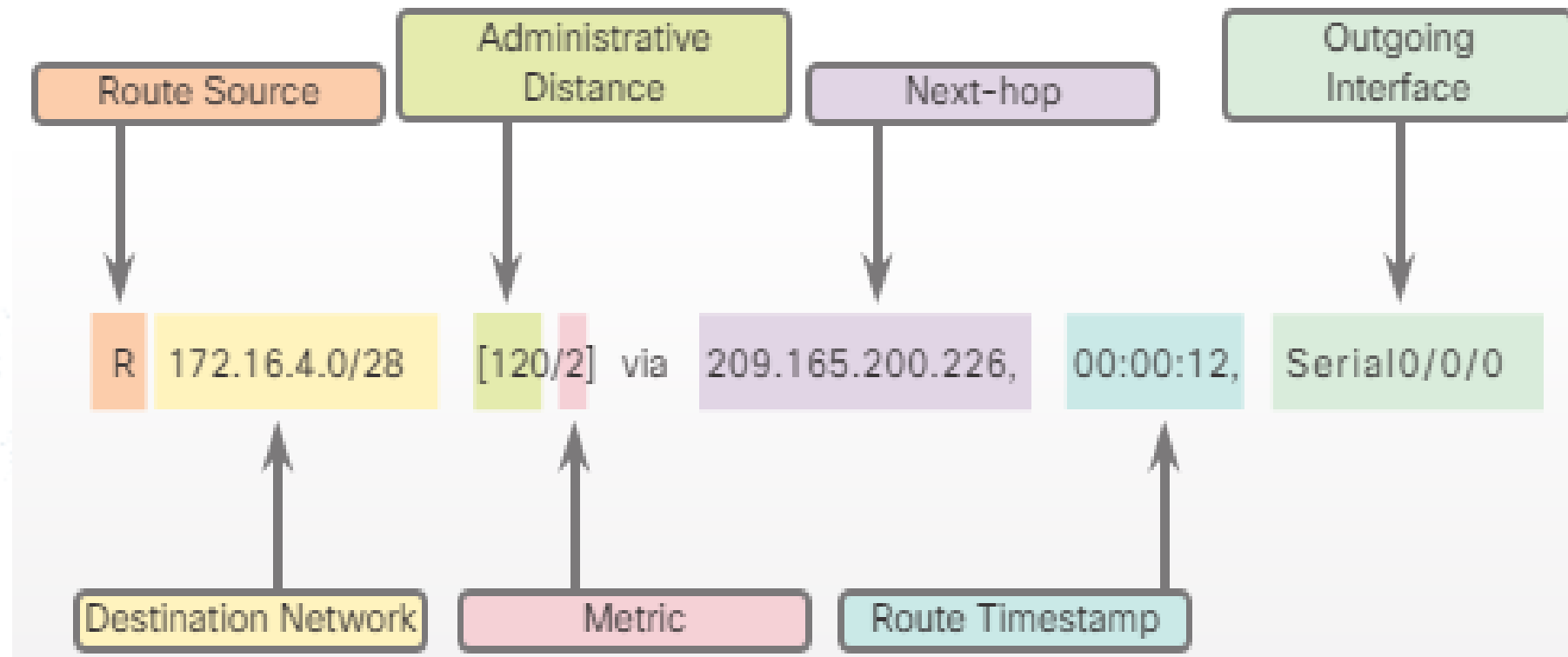
RIP Configuration Example Version 2



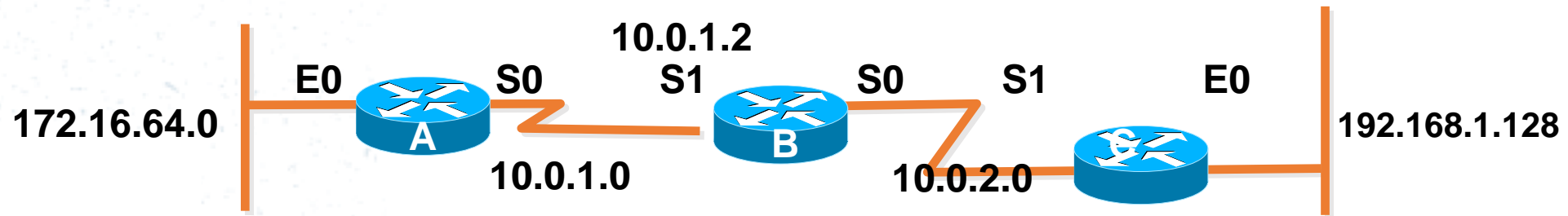
```
router rip
Version 2
No auto-summary
network 172.16.64.0
network 10.0.1.0
```

```
router rip
Version 2
No auto-summary
network 10.0.1.0
Network 10.0.2.0
```

```
router rip
Version 2
No auto-summary
network 192.168.1.0
network 10.0.2.0
```



Displaying the IP Routing Table



```
RouterA#sh ip route
```

Codes: C - connected, S - static, I - IGRP, R - RIP

```
172.16.0.0/16 is subnetted, 1 subnets
```

```
C    172.16.64.0 is directly connected, Ethernet0
```

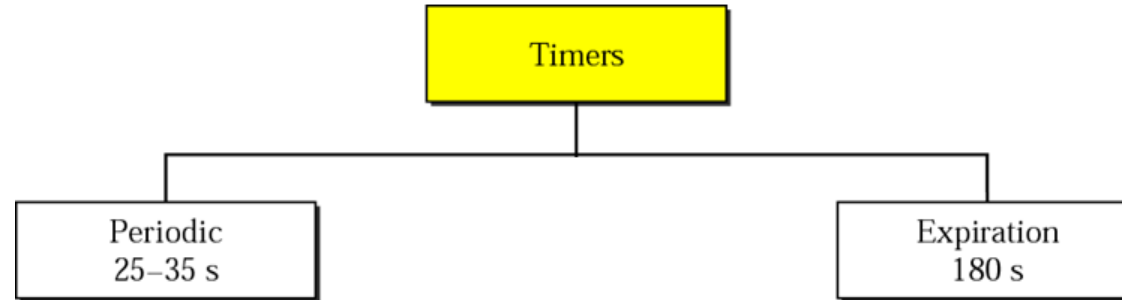
```
10.0.0.0/8 is subnetted, 2 subnets
```

```
R    10.0.2.0/24 [120/1] via 10.0.1.2, 00:00:07, Serial0
```

```
C    10.0.1.0/24 is directly connected, Serial0
```

```
R    192.168.1.128/26 [120/2] via 10.0.1.2, 00:00:07, Serial2
```

RIP Timers



- **Periodic Timer**

- A timer kept at each router for sending its routing table information to its neighbors in every 30 seconds.

- **Expiration Timer**

- If a router does not get the updates from a neighboring router for a long time ,(means it is a problem with the **neighboring** router) the main router removes the updates got from that **neighboring** router
- Is called expiration time (180 seconds)

Problems with RIP

Slow Convergence

- Routing tables are sent to neighbors every 30 seconds
- When there are large number of routers in the network ,it **will take some time** to get all the details to each and every router .There is a delay in getting an updated routing table.

Solution

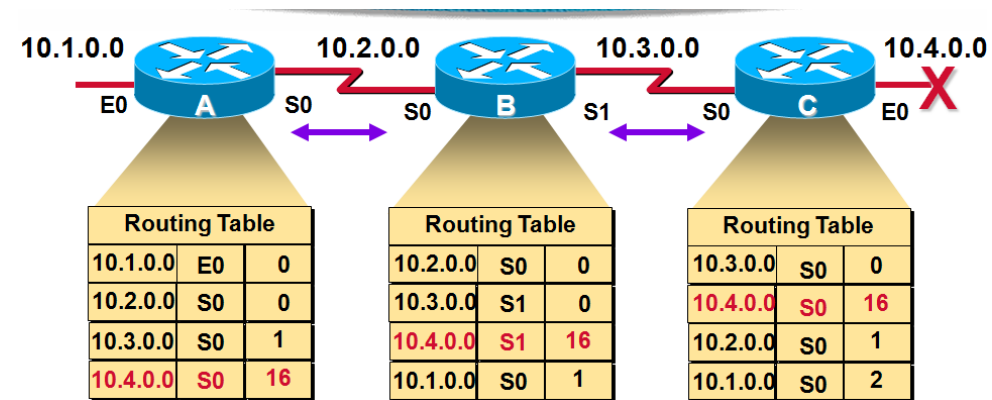
- Triggered updates
 - Information that needed to be updated immediately is informed to the other routers without waiting for the periodic time.



Counting to infinity

Solution - Route Poisoning

- When a network goes down the router that is connected to that network will get that information first
- So that router updates its table saying this network is down (unreachable)
- In the routing table it says number of hops for that particular network as infinity (or in RIP as 16)



Instability

- Once a router (P) get some updates from other router (Q) router P will updates it routing table and new routing table sent again to previous router.
- With time this will lead to having wrong updated tables in the routers and ultimately to an unstable situation

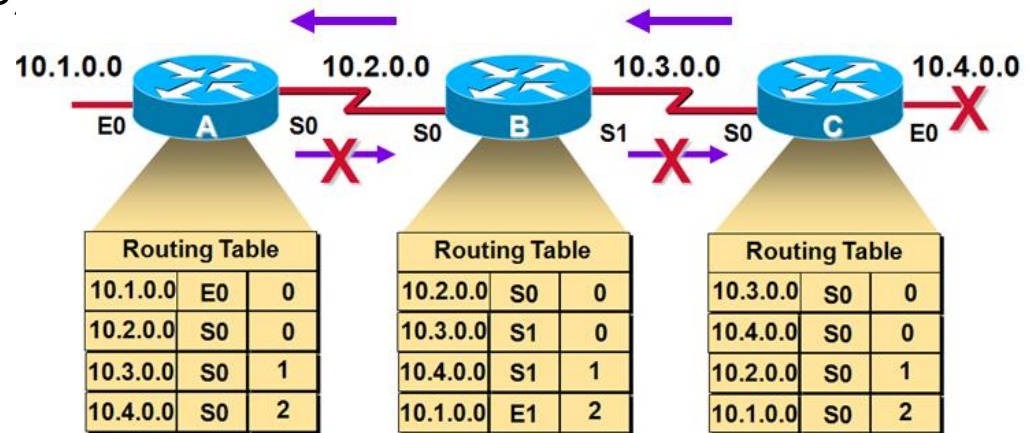
Solution

- Split Horizon
 - Do not send same information via the link which that information came from

Solutions

Split Horizon

- When the router sends routing table information to the neighbors, it will not send the information that it got from that particular router
- So the routing table information will be selected and send



Hold down Timer

- Once a network goes down, that information will be immediately sent to the other routers
- Because of the network connections there is a possibility to get some wrong information about that particular network from other routers
- Therefore once a network down information is received, the router will start the hold down timer, during which time any updates regarding that particular network is ignored.



Poison Reverse

- In general split horizon will apply for information passing
- But the split horizon will not be applied in the case of the information like network is down



IGRP AD - 100

(Interior Gateway Routing Protocol)

- A cisco proprietary distance-vector routing protocol
- Maximum hop count is 255
- Used in large networks
- EIGRP is the enhanced version of IGRP

EIGRP

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

EIGRP

(Extended Interior Gateway Routing Protocol)



Features

- EIGRP was initially released in 1992 as a proprietary protocol available only on Cisco devices.
- In 2013, Cisco released a basic functionality of EIGRP as an open standard to the IETF as an informational RFC.
- Other networking vendors can now implement EIGRP on their equipment to interoperate with both Cisco and non-Cisco routers running EIGRP.



EIGRP Metric AD - 90

- A '*Composite metric*' is used
- EIGRP uses **bandwidth and delay of the line** by default as a metric for determining the best route to an internetwork
- Metric is a combination of bandwidth, delay of the line , Reliability, load and Maximum Transmission Unit (MTU)
- Reliability, load, and Maximum Transmission Unit (MTU) are not used by default

EIGRP metric values

- **Bandwidth** - The slowest bandwidth among all of the outgoing interfaces, along the path from source to destination.
- **Delay** - The cumulative (sum) of all interface delay along the path (in microseconds).



EIGRP Composite Metric

Default Composite Formula:

$$\text{metric} = [K1 * \text{bandwidth} + K3 * \text{delay}] * 256$$

Complete Composite Formula:

$$\text{metric} = [K1 * \text{bandwidth} + (K2 * \text{bandwidth}) / (256 - \text{load}) + K3 * \text{delay}] * [K5 / (\text{reliability} + K4)]$$

(Not used if "K" values are 0)

Note: This is a conditional formula. If $K5 = 0$, the last term is replaced by 1 and the formula becomes: $\text{Metric} = [K1 * \text{bandwidth} + (K2 * \text{bandwidth}) / (256 - \text{load}) + K3 * \text{delay}]$

Default values:

K1 (bandwidth) = 1

K2 (load) = 0

K3 (delay) = 1

K4 (reliability) = 0

K5 (reliability) = 0

"K" values can be changed with the `metric weights` command

EIGRP Configuration

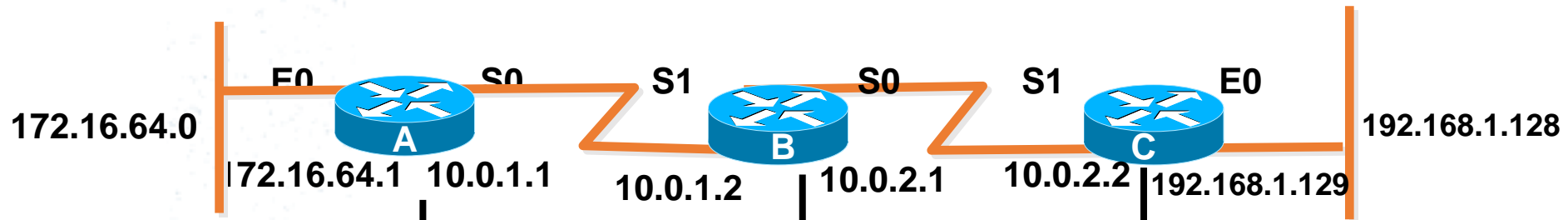
```
Router (config) #router Eigrp <AS number>
```

```
Router (config-router) #network <network-address>
```

- < network address > : Directly connected network addresses
- < AS number > : Autonomous Systems Number



EIGRP Configuration Example



```
router eigrp 100
network 172.16.64.0
network 10.0.1.0
No auto-summary
```

```
router eigrp 100
No auto-summary
network 192.168.1.0
network 10.0.2.0
```

```
router eigrp 100
No auto-summary
network 10.0.1.0
Network 10.0.2.0
```