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Discover Your Future

IT2050 - Computer Networks

Lecture 3

Routing Protocols

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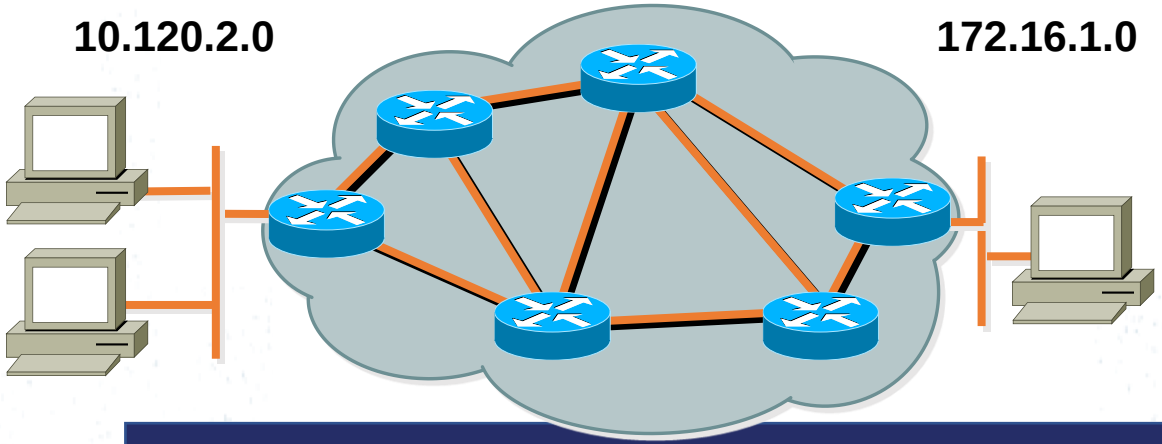
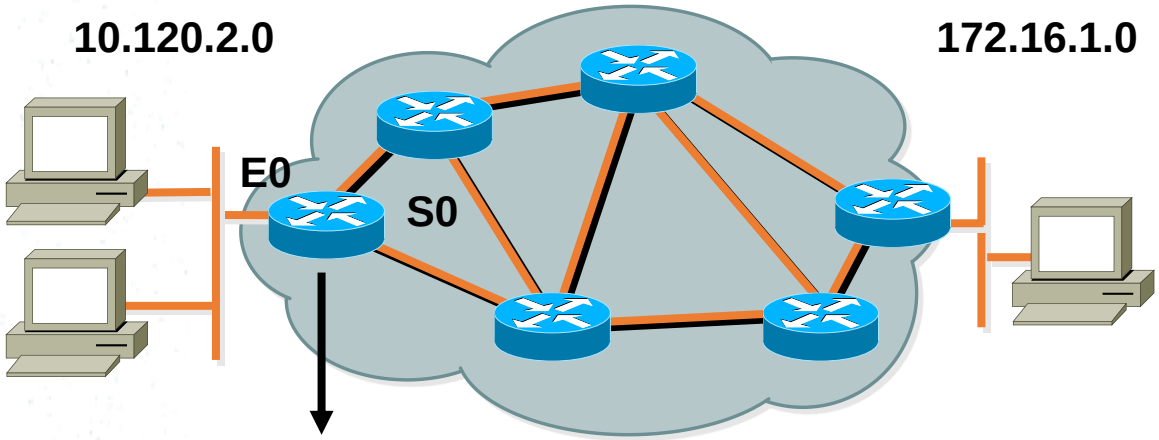
What Is Routing?

- 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

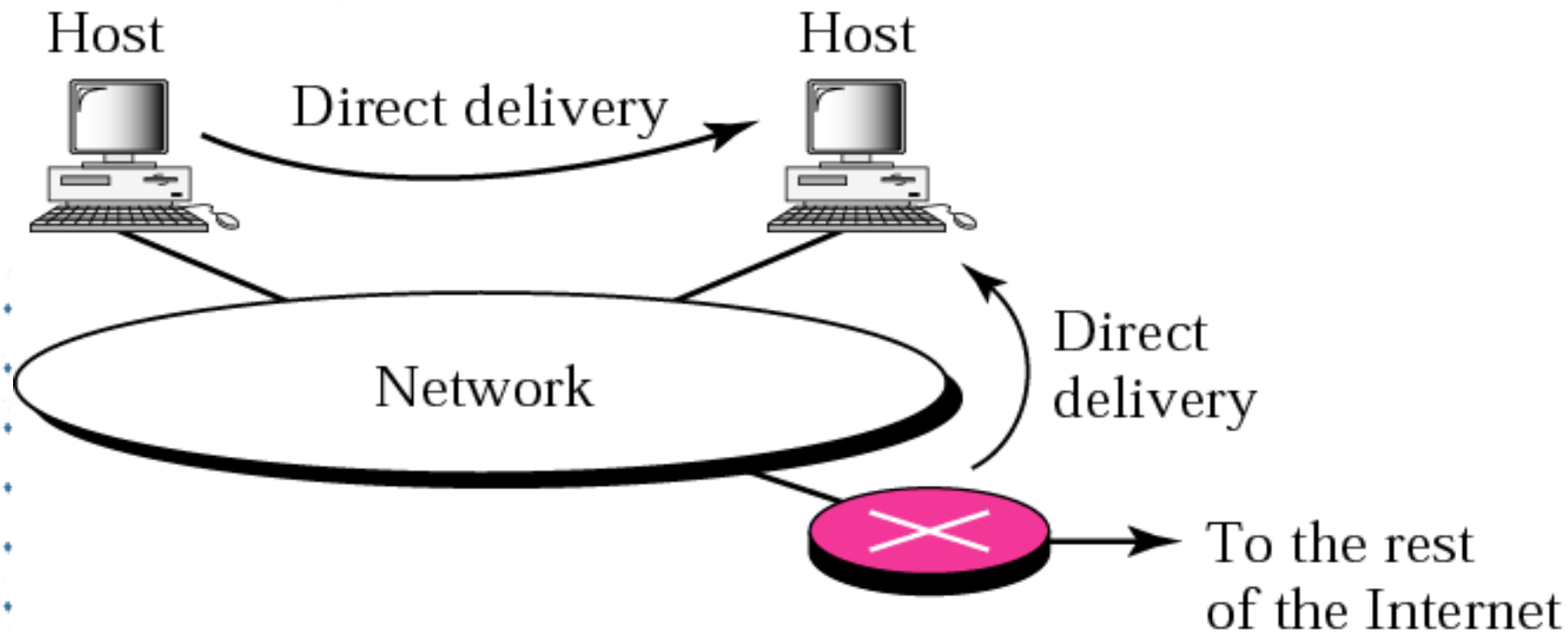
Routed Protocol: IP

- Routers must learn destinations that are not directly connected.

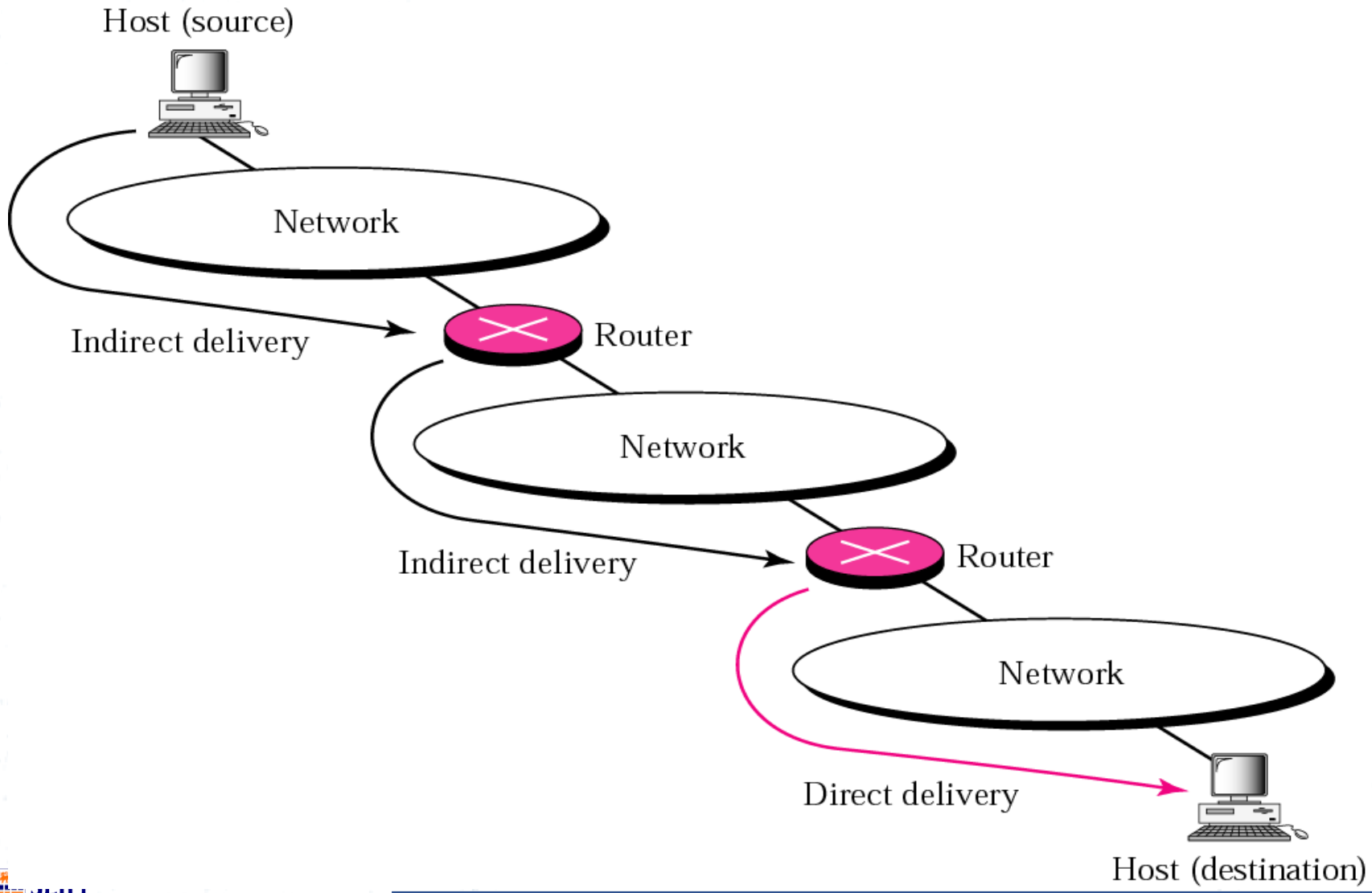
Identifying Static & Dynamic Routes

- 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 form the routing table
- The packet is sent though 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
192.168.50.1 192.168.50.6	E0 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

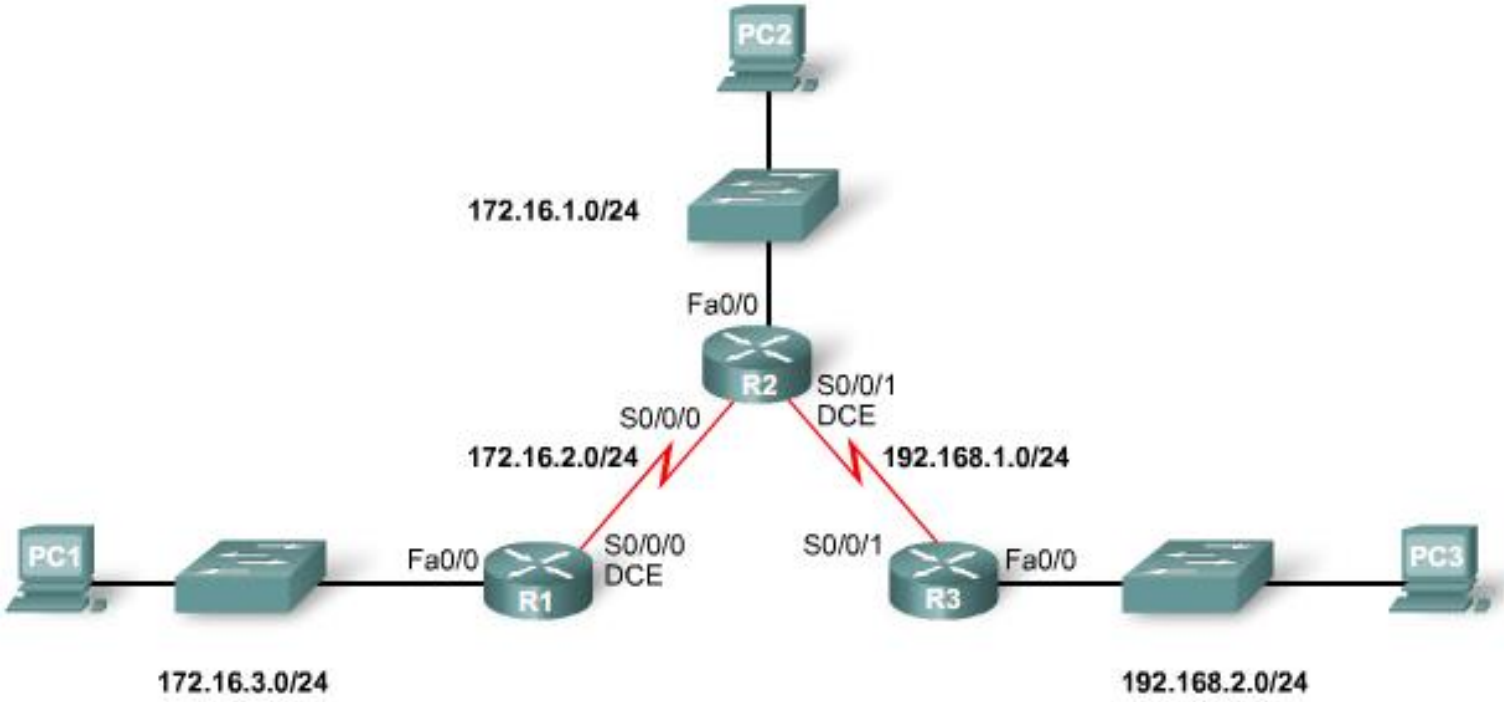
- Number of records are limited (Table updates are not for each host but for a network)
- Update is easy

Routing Table update Methods

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

Connected

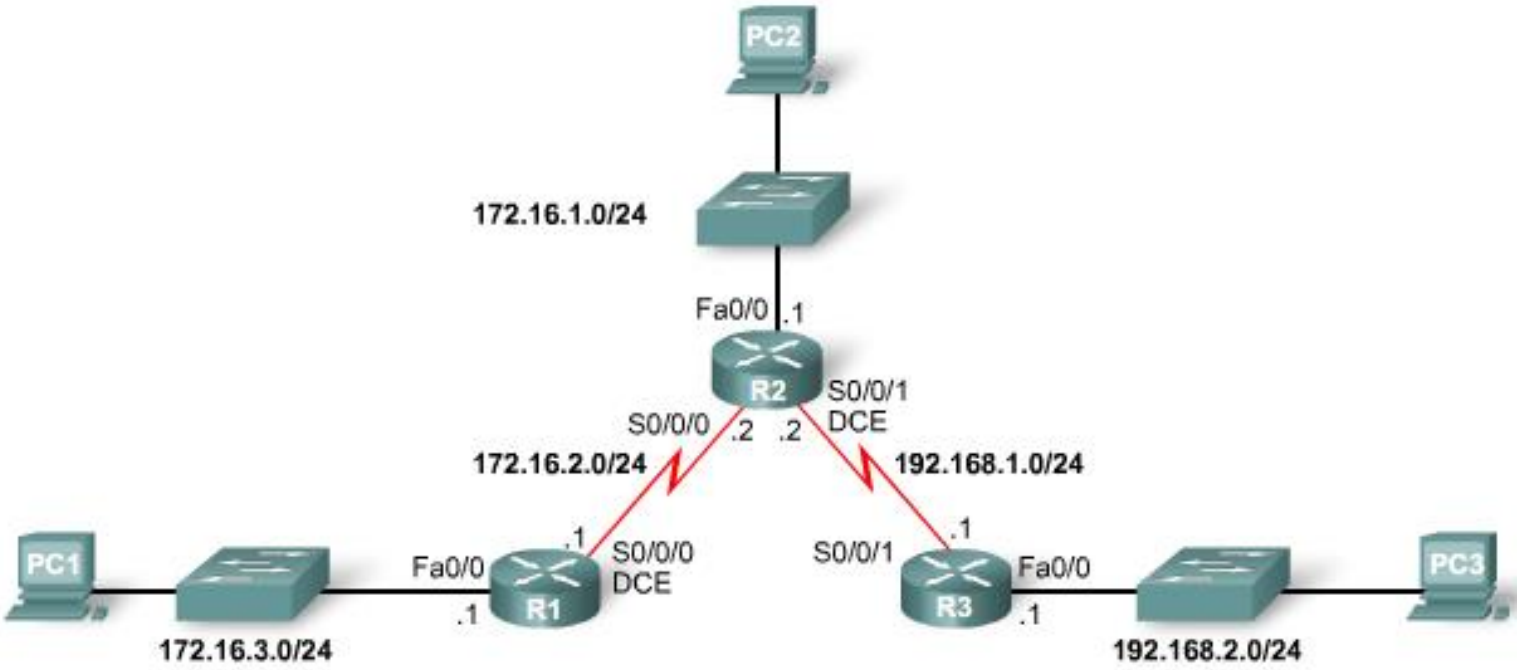
- Once the router is connected to the network its interfaces are given IP addresses
- With that router automatically identifies the network addresses to which it connected



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:

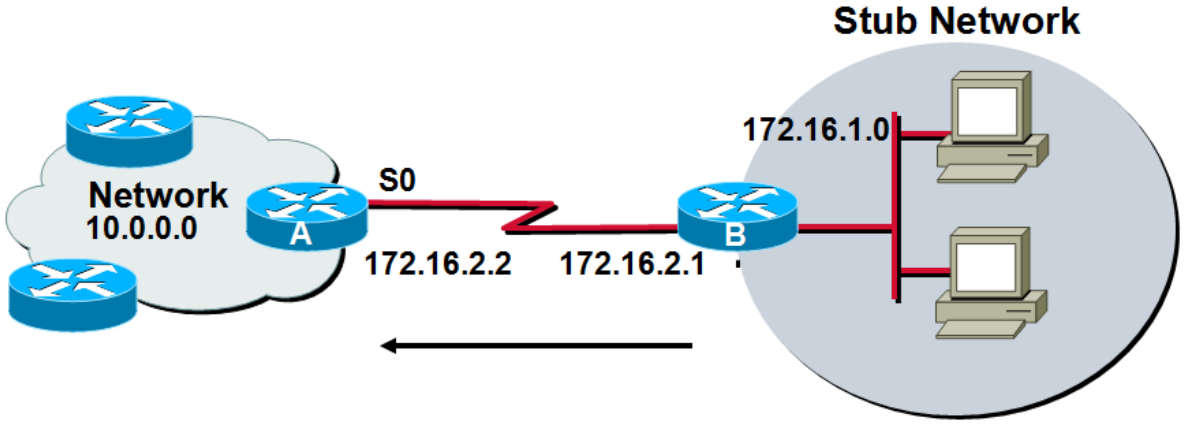
- Minimal CPU processing
- Easier for administrator to understand and configure

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



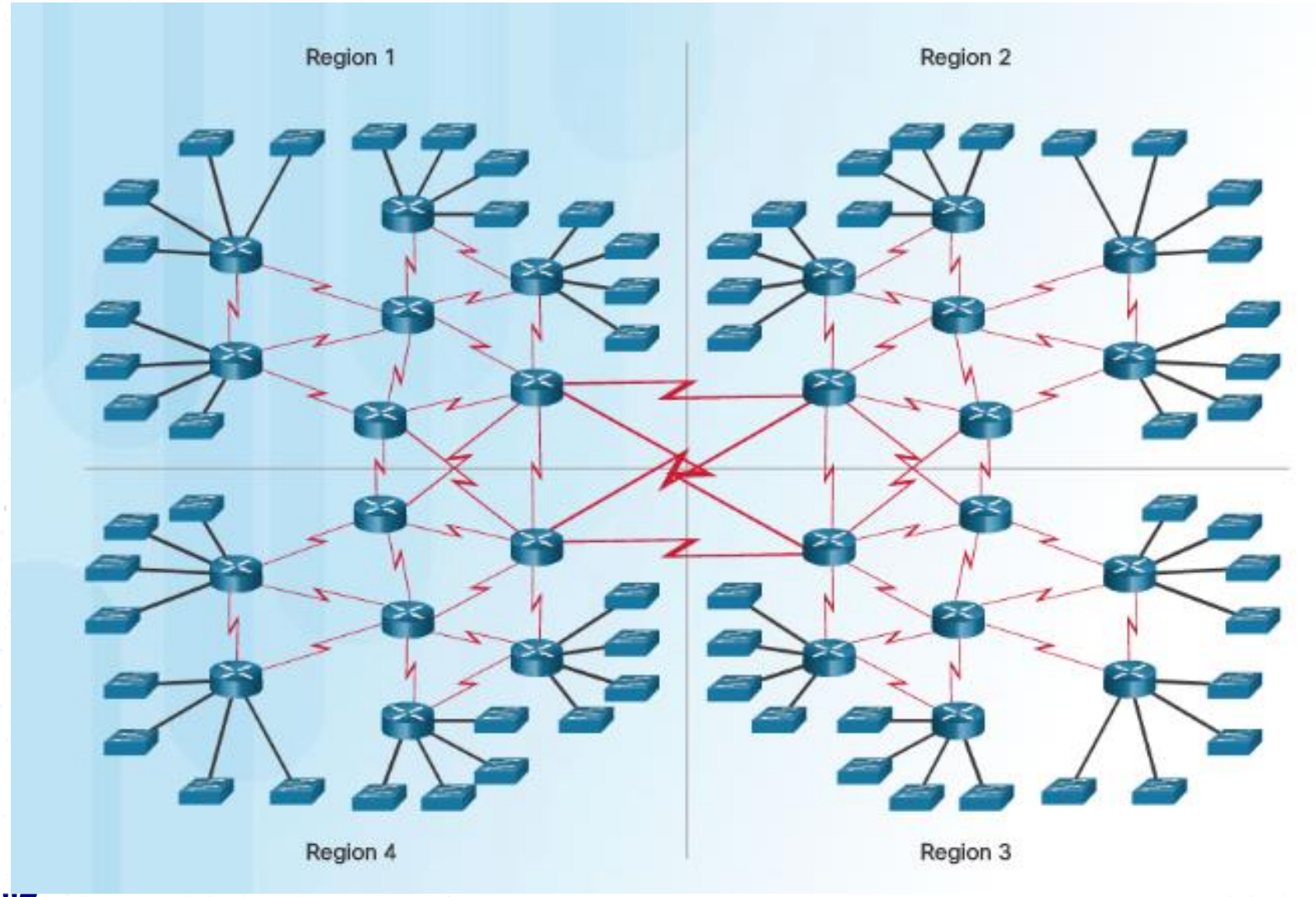

```
R(config)#ip route 0.0.0.0 0.0.0.0
<next hop ip addr | exit interface name | both>
```

Default Routing cont.

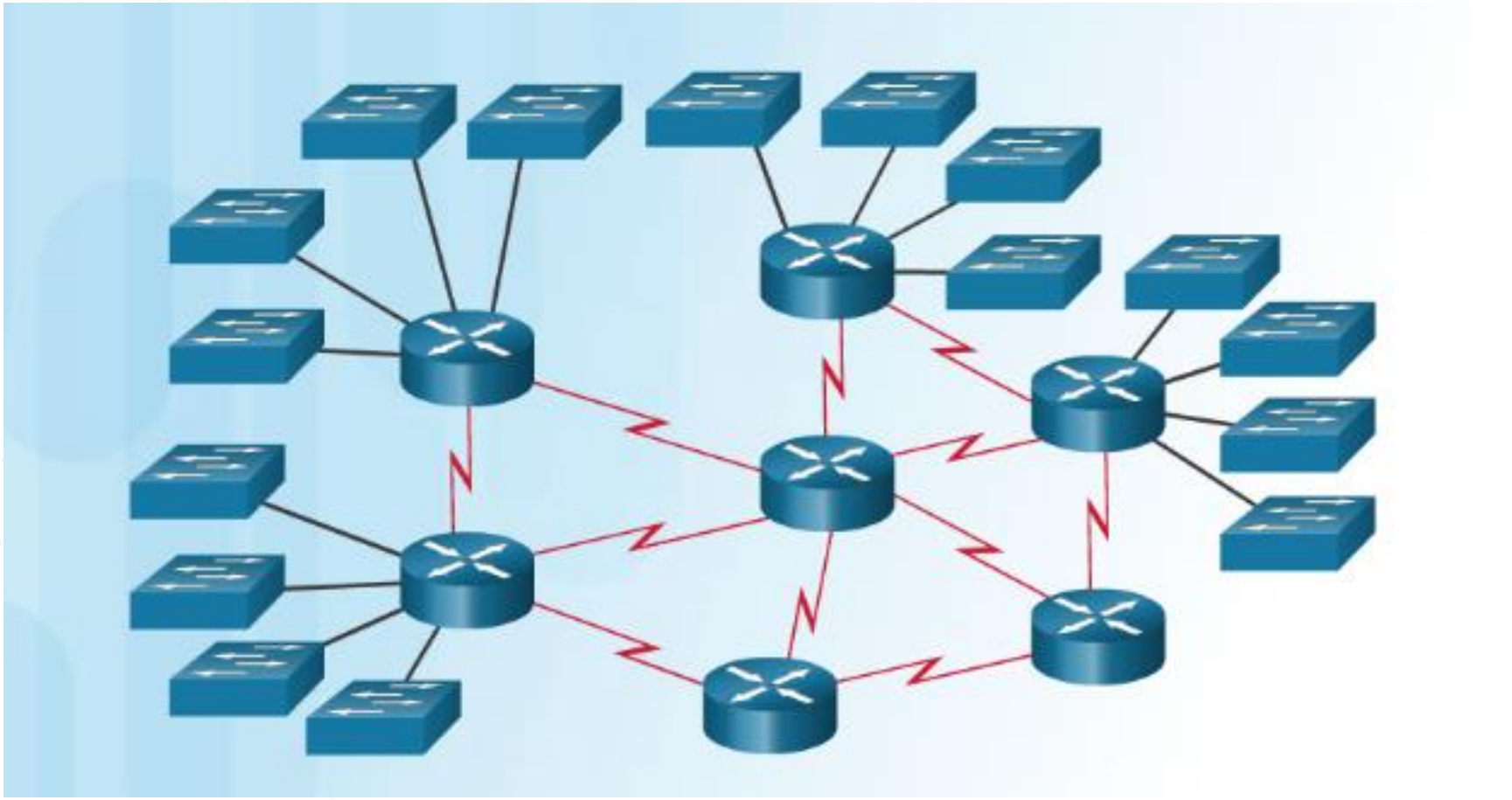
```
B(config)#
B(config)#ip route 0.0.0.0 0.0.0.0 172.16.2.2
B(config)#
```

```
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

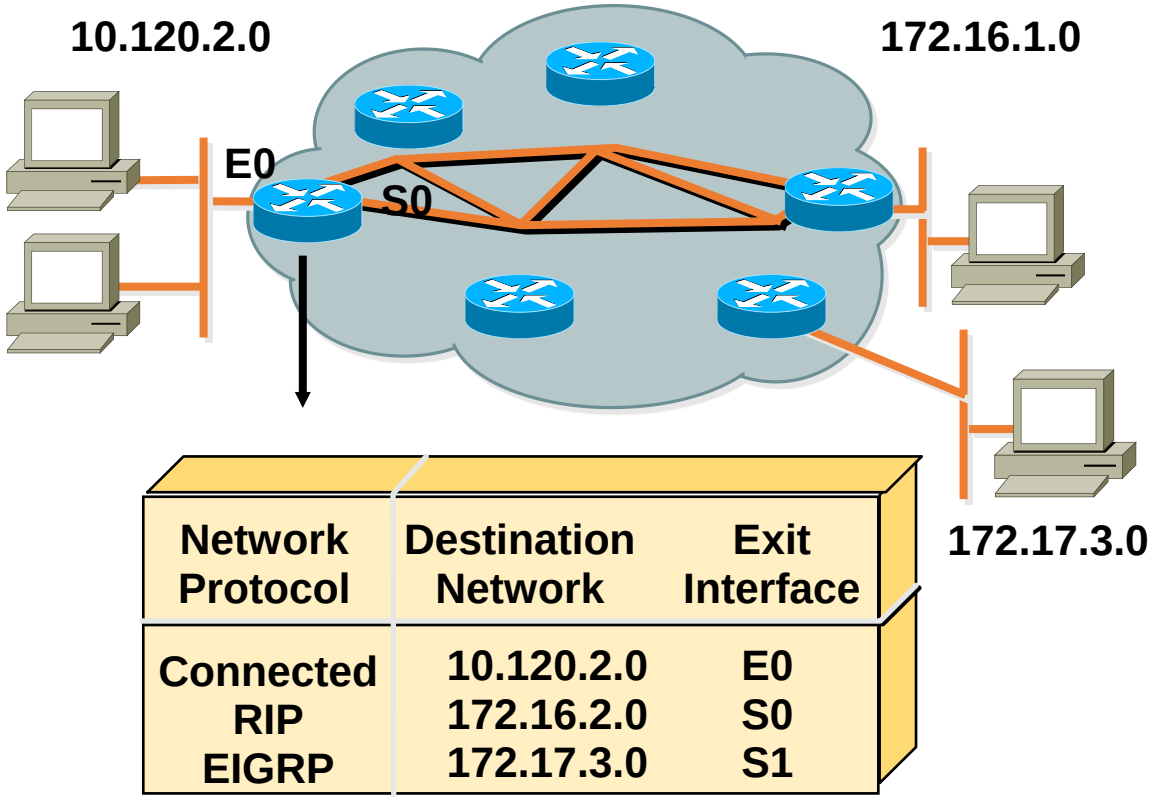
Routing Protocols

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

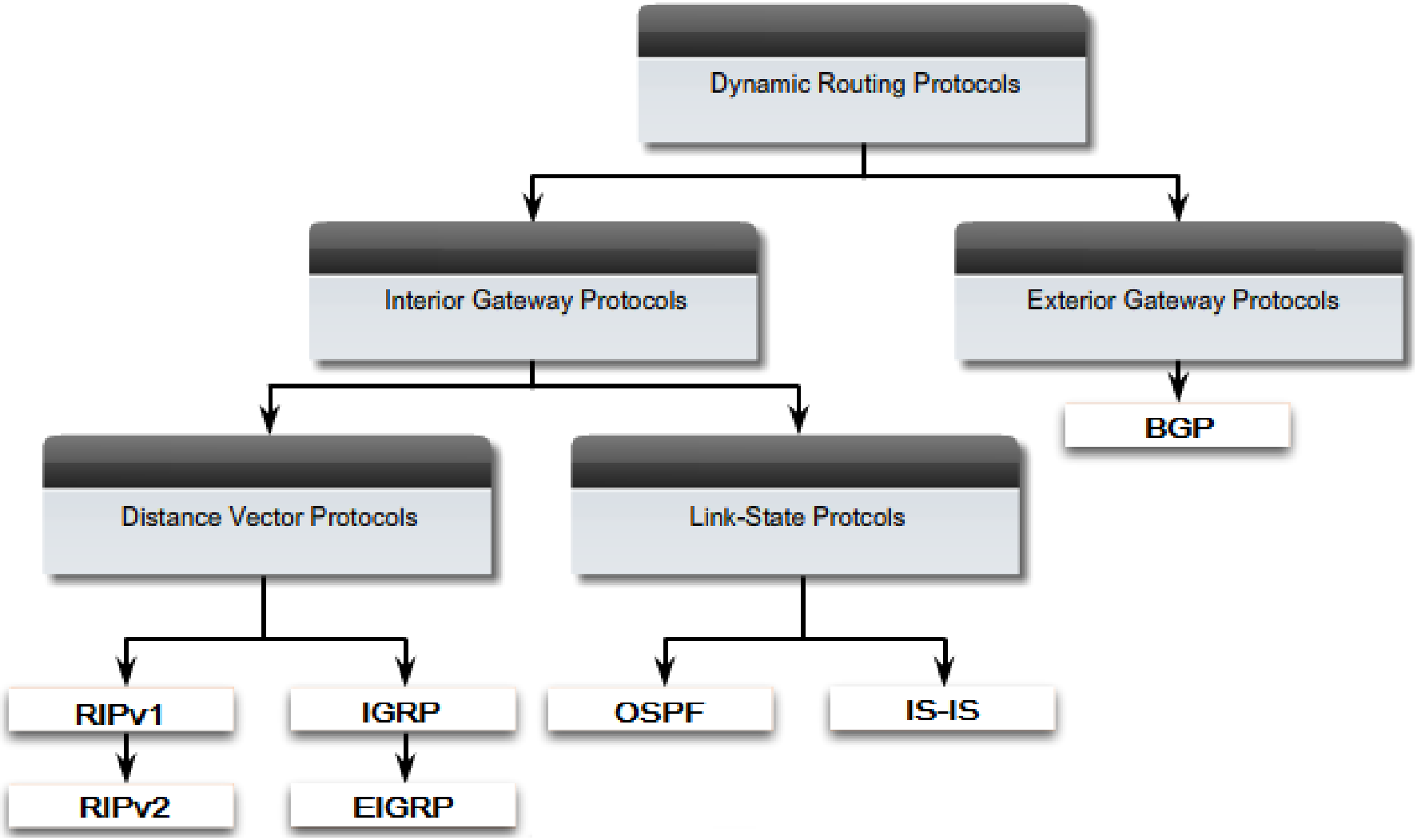
What Is a Routing Protocol?

- 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

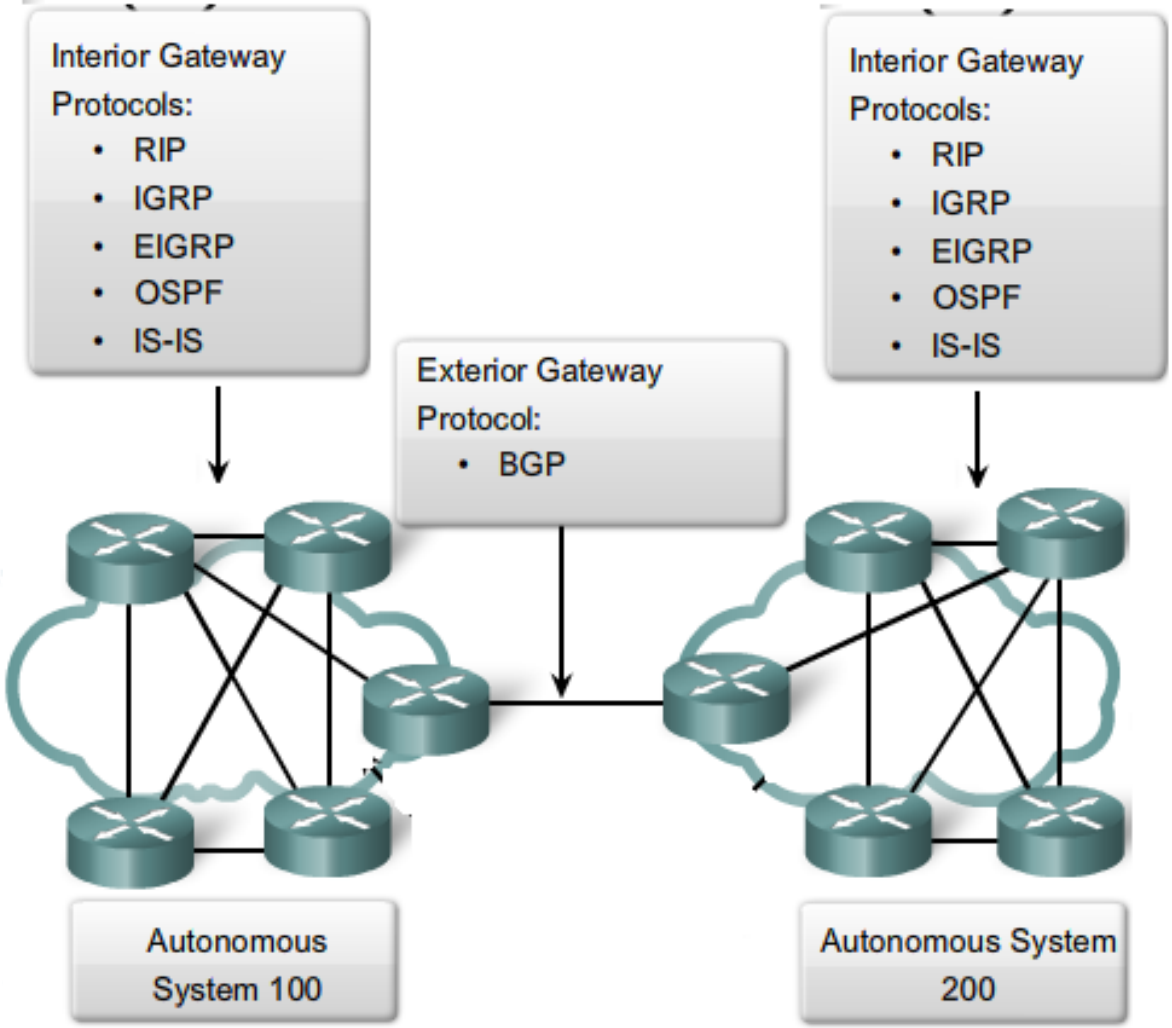
  intra-autonomous system routing

  (routing inside an autonomous system)
- Exterior Gateway Protocols (EGP) are used for

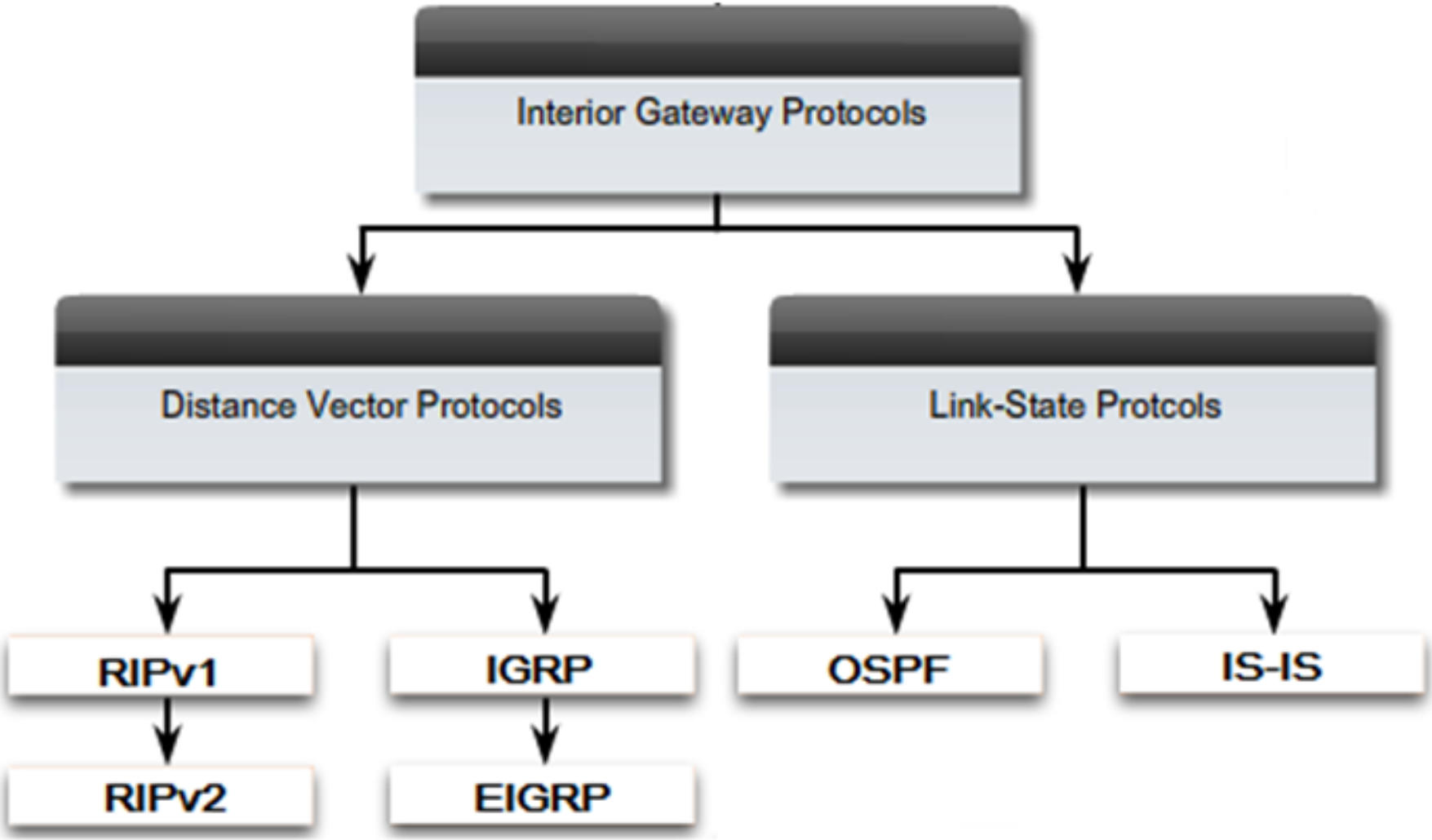
  inter-autonomous system routing

  (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 1 Class networks
RIP 2 Classless Networks

RIP Configuration

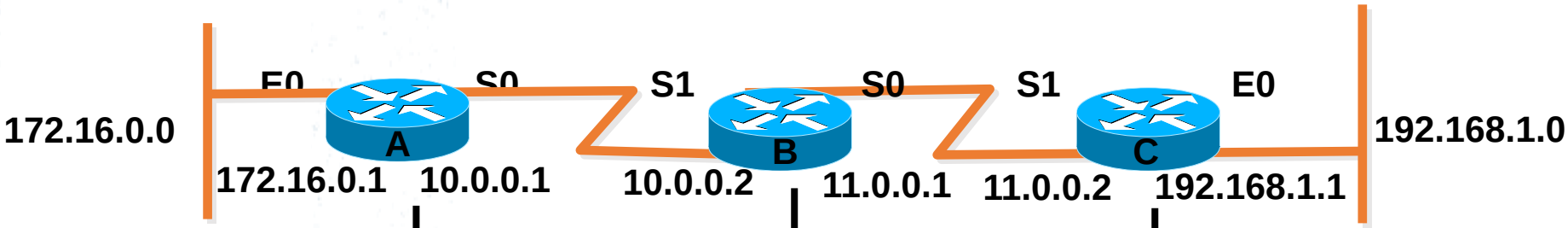
```
Router(config)#router rip
```

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

< ***network-address***>

Directly connected network addresses

RIP Configuration Example Version 1




```
router rip
network 172.16.0.0
network 10.0.0.0
```

```
router rip
network 192.168.1.0
network 11.0.0.0
```

```
router rip
network 10.0.0.0
Network 11.0.0.0
```

Configure RIP V2

Classless
Sub-networks

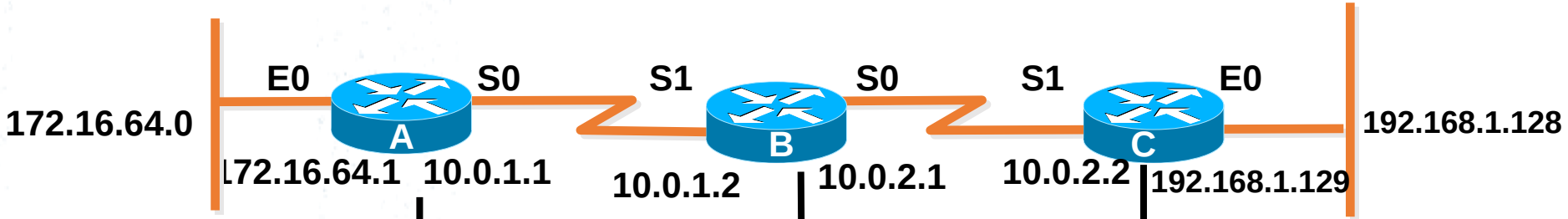
```
Router(config)#router rip
```

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

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

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

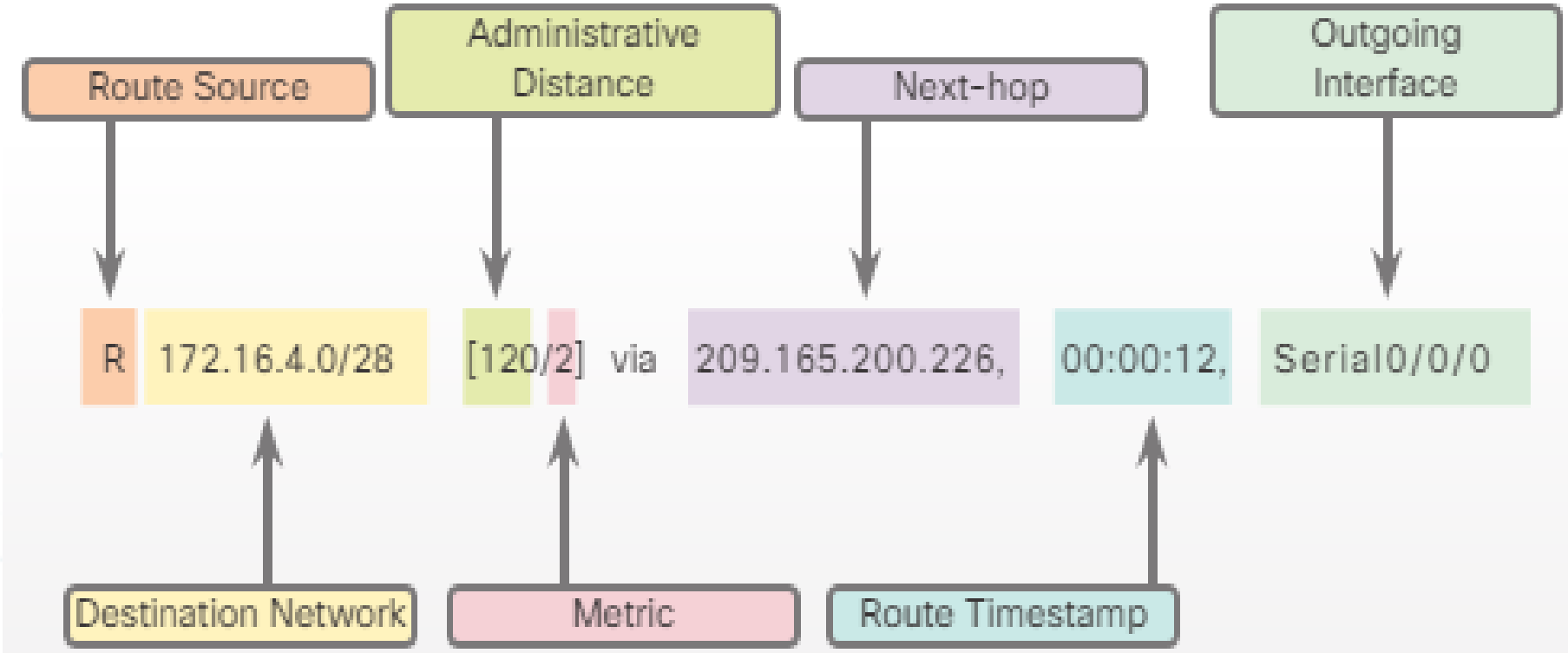
RIP Configuration Example Version 2



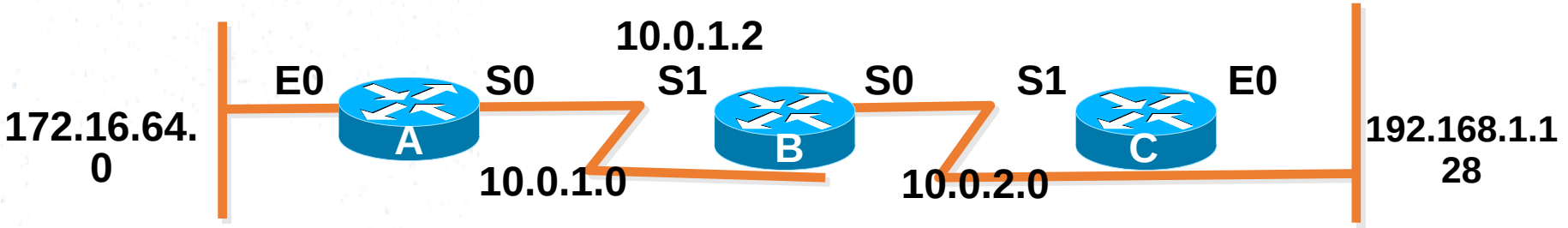

```
router rip
Version 2
No auto-summary
network 172.16.64.0
network 10.0.1.0
```

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

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

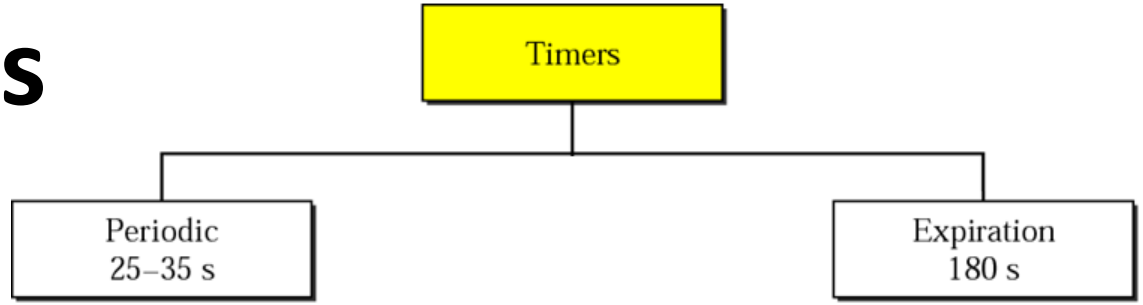

Route Source
Administrative Distance
Next-hop
Outgoing Interface
R
172.16.4.0/28
[120/2]
via
209.165.200.226,
00:00:12,
Serial0/0/0
Destination Network
Metric
Route Timestamp

Displaying the IP Routing Table




```
RouterA#sh ip route
Codes: C - connected, S - static, I - IGRP, R - RIP

     172.16.0.0/24 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.

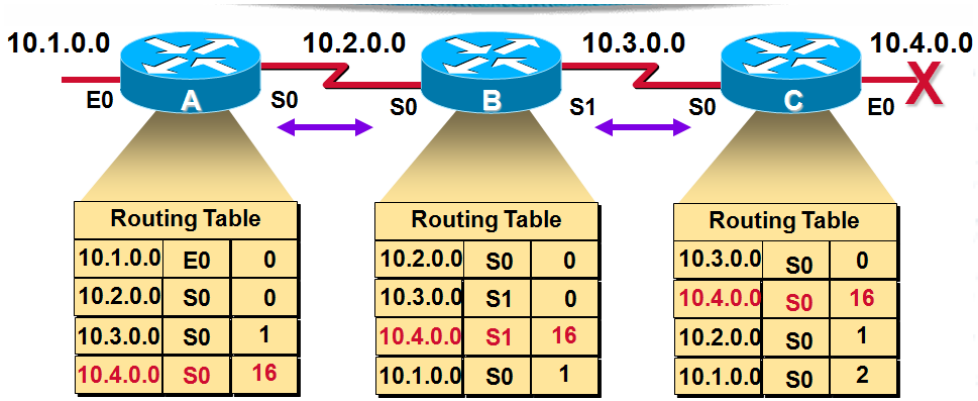
Solution

- 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

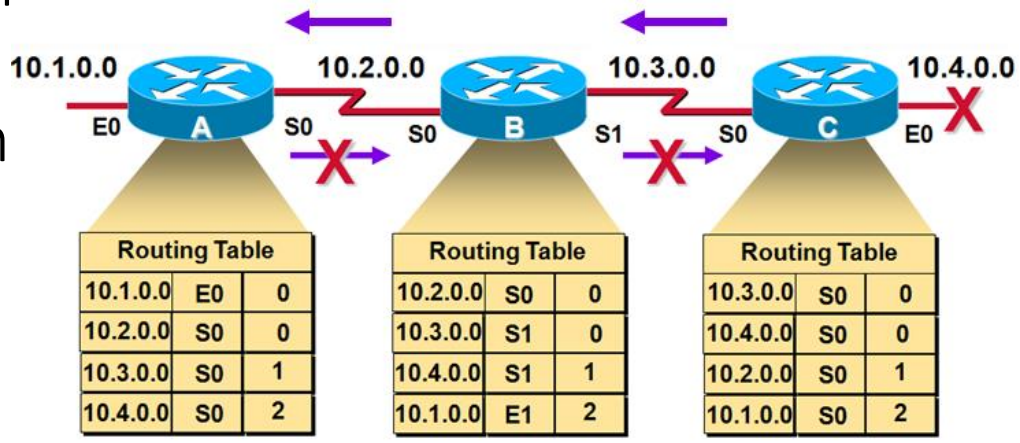
Solution

- Spilt 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:
metric = **[K1*bandwidth + K3*delay] * 256**

Complete Composite Formula:
metric = **[K1*bandwidth + (K2*bandwidth)/(256 – load) + K3*delay] * [K5/(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: Metric = [K1*bandwidth + (K2*bandwidth)/(256-load) + K3*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

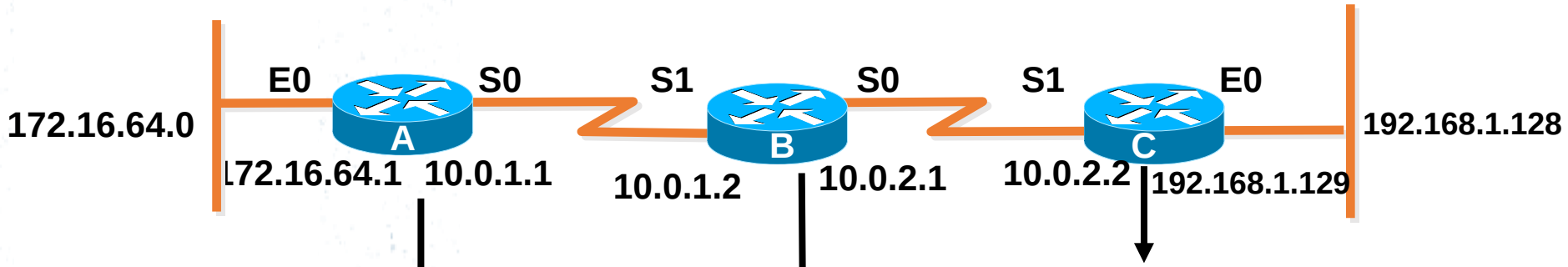
EIGRP Configuration

```
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
```

```
router eigrp 100

network 192.168.1.0
network 10.0.2.0
```

```
router eigrp 100

network 10.0.1.0
Network 10.0.2.0
```