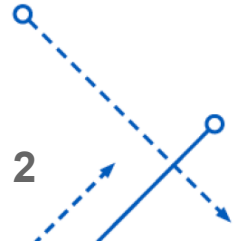
The University of Danang
University of Science and Technology

RIP & EIGRP

FACULTY OF INFORMATION TECHNOLOGY
PhD. LE TRAN DUC

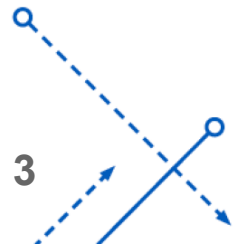
OUTLINE

1. Routing Information Protocol (RIP)
2. Enhanced Interior Gateway Routing Protocol (EIGRP)



RIP

- **Routing Information Protocol** (industry standard)
- Distance vector IGP (uses routing-by-rumor logic to learn/share routes)
- Uses hop count as its metric. One router = one hop (bandwidth is irrelevant!)
- The maximum hop count is **15** (anything more than that is considered unreachable)
- Has three versions:
  RIPv1 and **RIPv2**, used for IPv4
  RIPng (RIP Next Generation), used for IPv6
- Uses two message types:
  Request: To ask RIP-enabled neighbor routers to send their routing table
  Response: To send the local router's routing table to neighboring routers
- By default, RIP-enabled routers will share their routing table every 30 seconds



RIPv1 vs RIPv2

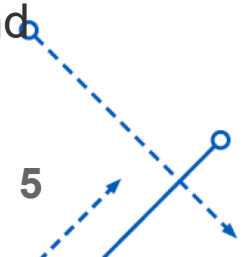
- **RIPv1:**
  -only advertises *classful* addresses (Class A, Class B, Class C)
  -doesn't support VLSM, CIDR
  -doesn't include subnet mask information in advertisements (Response messages)
  10.1.1.0/24 will be become 10.0.0.0 (Class A address, so assumed to be /8)
  172.16.192.0/18 will become 172.16.0.0 (Class B address, so assumed to be /16)
  192.168.1.4/30 will become 192.168.1.0 (Class C address, so assumed to be /24)
  -messages are broadcast to 255.255.255.255

- **RIPv2:**
  -supports VLSM, CIDR
  -includes subnet mask information in advertisements
  -messages are **multicast** to 224.0.0.9

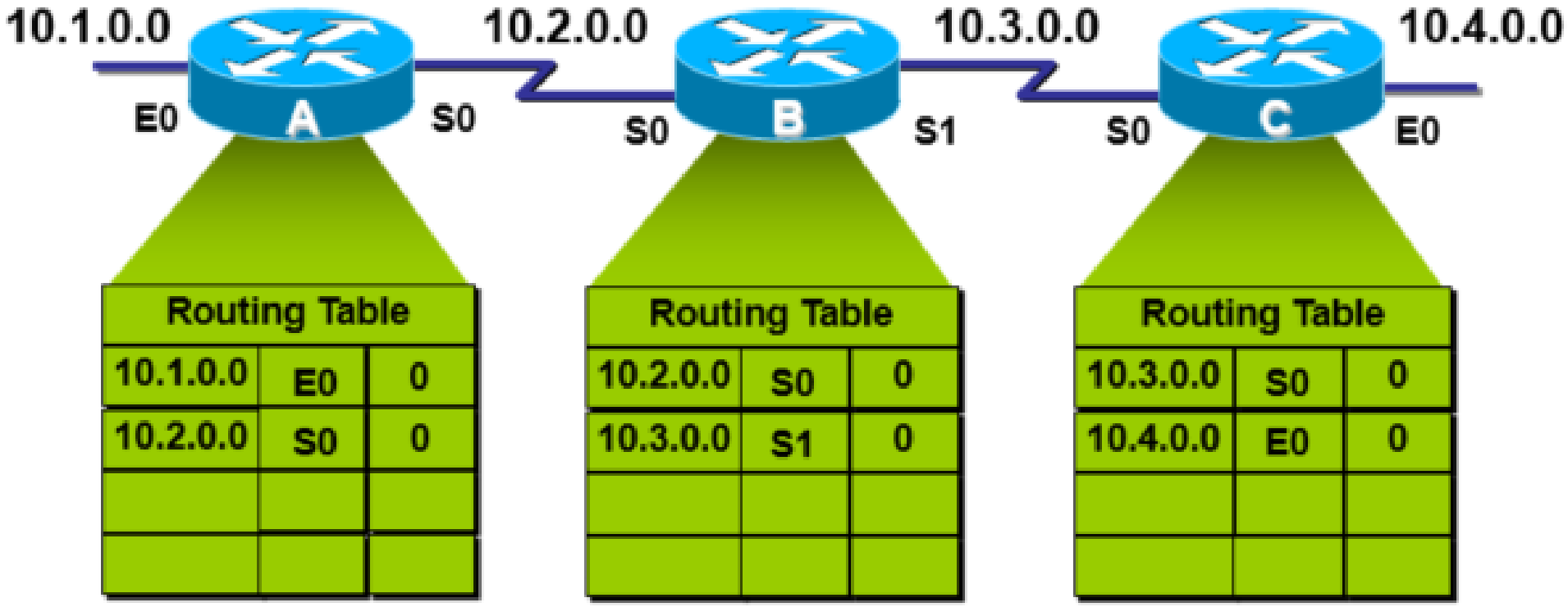
Broadcast messages are delivered to all devices on the local network.
Multicast messages are delivered only to devices that have joined that specific *multicast group.*

CHARACTERISTICS OF DISTANCE VECTOR ROUTING PROTOCOLS

- **Periodic updates**
  - Periodic Updates sent at regular intervals (**30 seconds for RIP**). Even if the topology has not changed in several days,
- **Neighbors**
  - The router is only aware of the network addresses of its own interfaces and the remote network addresses it can reach through its neighbors.
  - It has no broader knowledge of the network topology
- **Broadcast updates**
  - Broadcast Updates are sent to 255.255.255.255.
  - Some distance vector routing protocols use multicast addresses instead of broadcast addresses.
- **Entire routing table is included with routing update**
  - Entire Routing Table Updates are sent, with some exceptions to be discussed later, periodically to all neighbors.
  - Neighbors receiving these updates must process the entire update to find pertinent information and discard the rest.
  - Some distance vector routing protocols like EIGRP do not send periodic routing table updates.

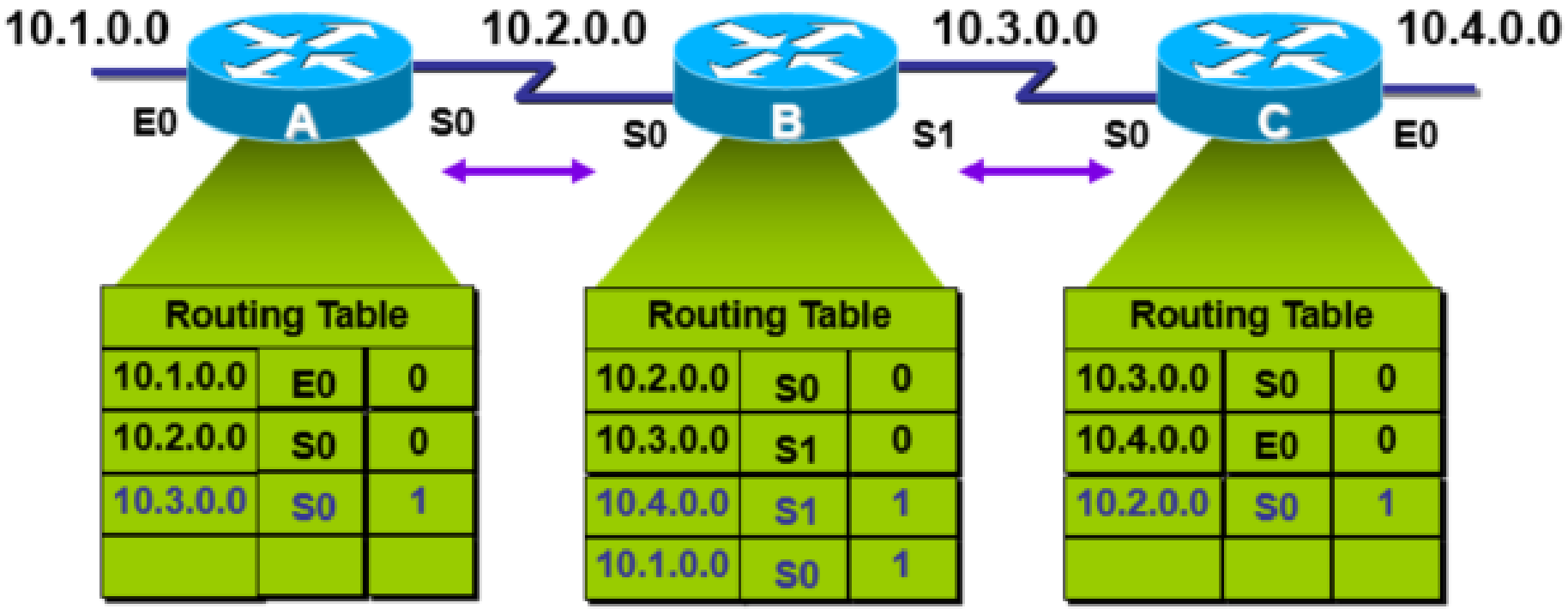


DISTANCE VECTOR – DISCOVERING ROUTES



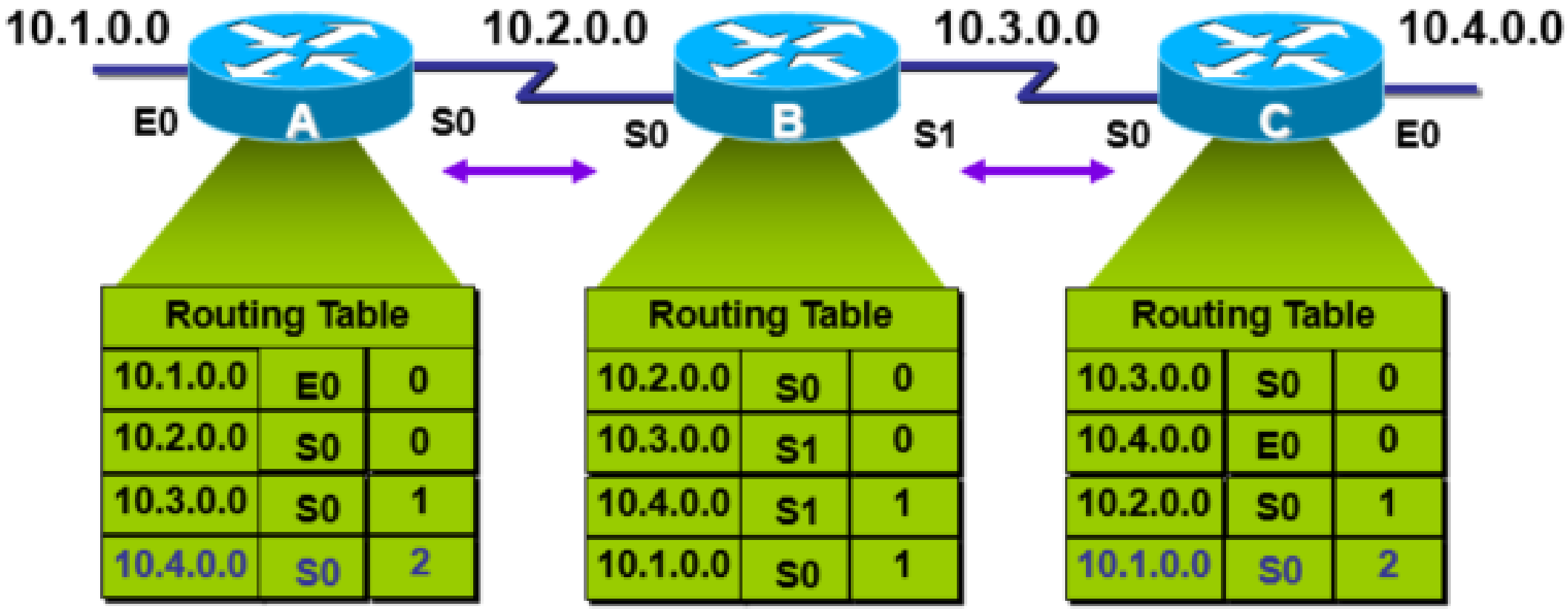
- Routers discover the best path to destinations from each neighbor → **RIP protocol**

DISTANCE VECTOR – DISCOVERING ROUTES



- Routers discover the best path to destinations from each neighbor

DISTANCE VECTOR – DISCOVERING ROUTES



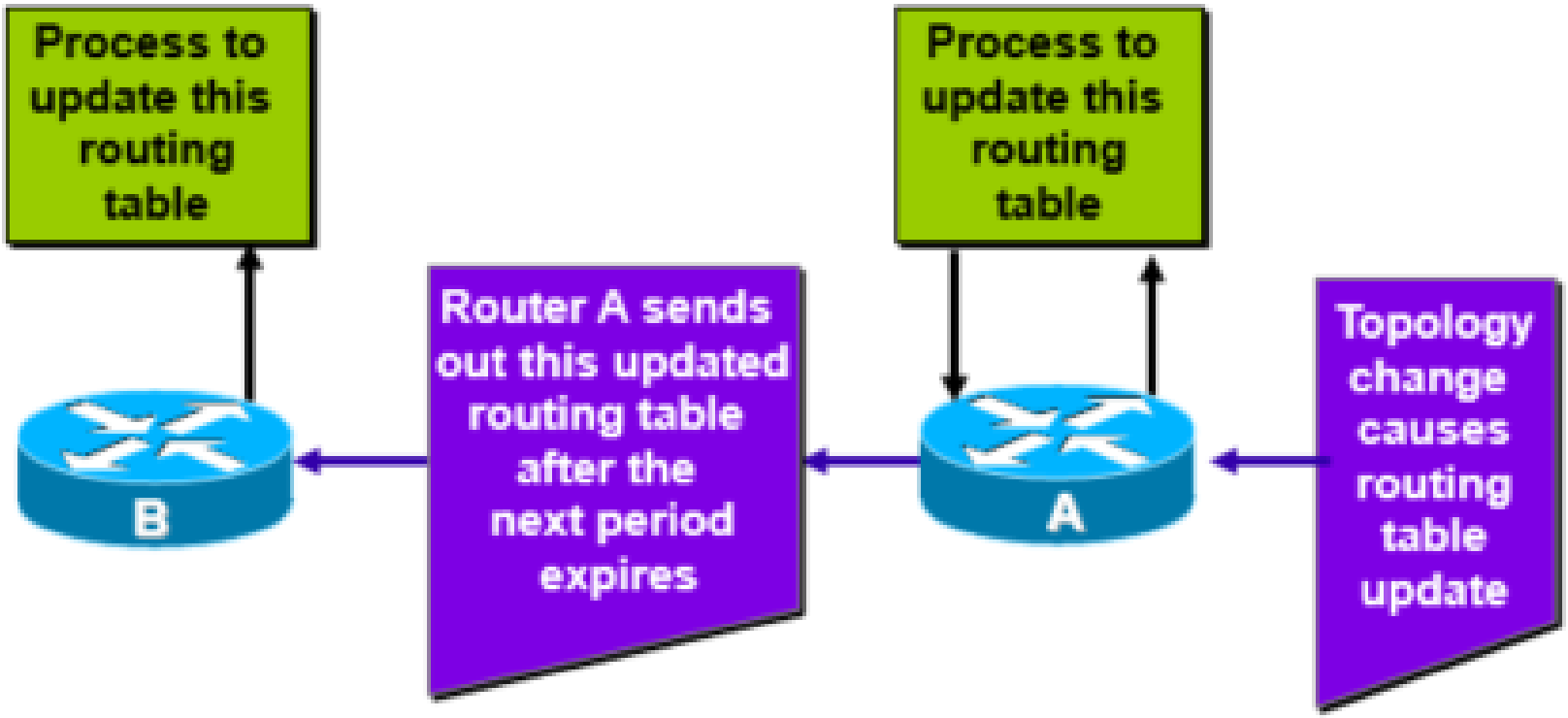
Routing Table		
10.1.0.0	E0	0
10.2.0.0	S0	0
10.3.0.0	S0	1
10.4.0.0	S0	2

Routing Table		
10.2.0.0	S0	0
10.3.0.0	S1	0
10.4.0.0	S1	1
10.1.0.0	S0	1

Routing Table		
10.3.0.0	S0	0
10.4.0.0	E0	0
10.2.0.0	S0	1
10.1.0.0	S0	2

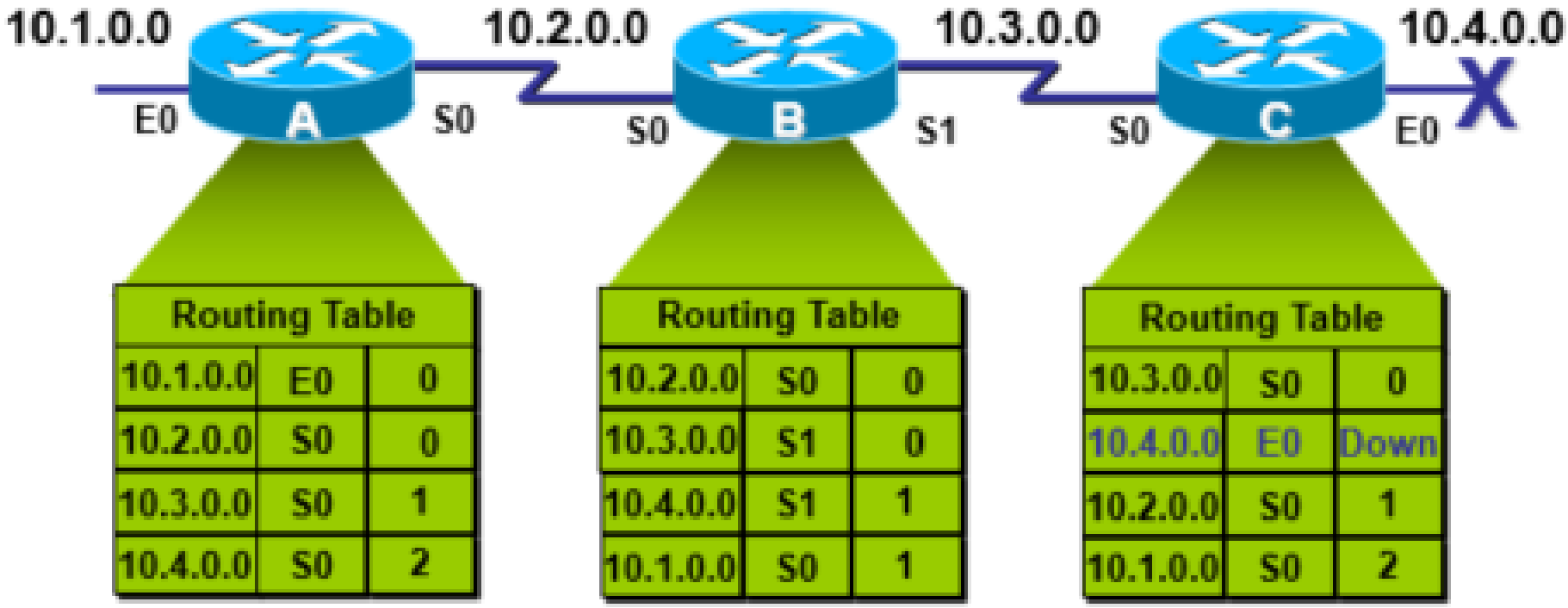
- Each node maintains the distance from itself to each possible destination network

MAINTAINING ROUTING INFORMATION



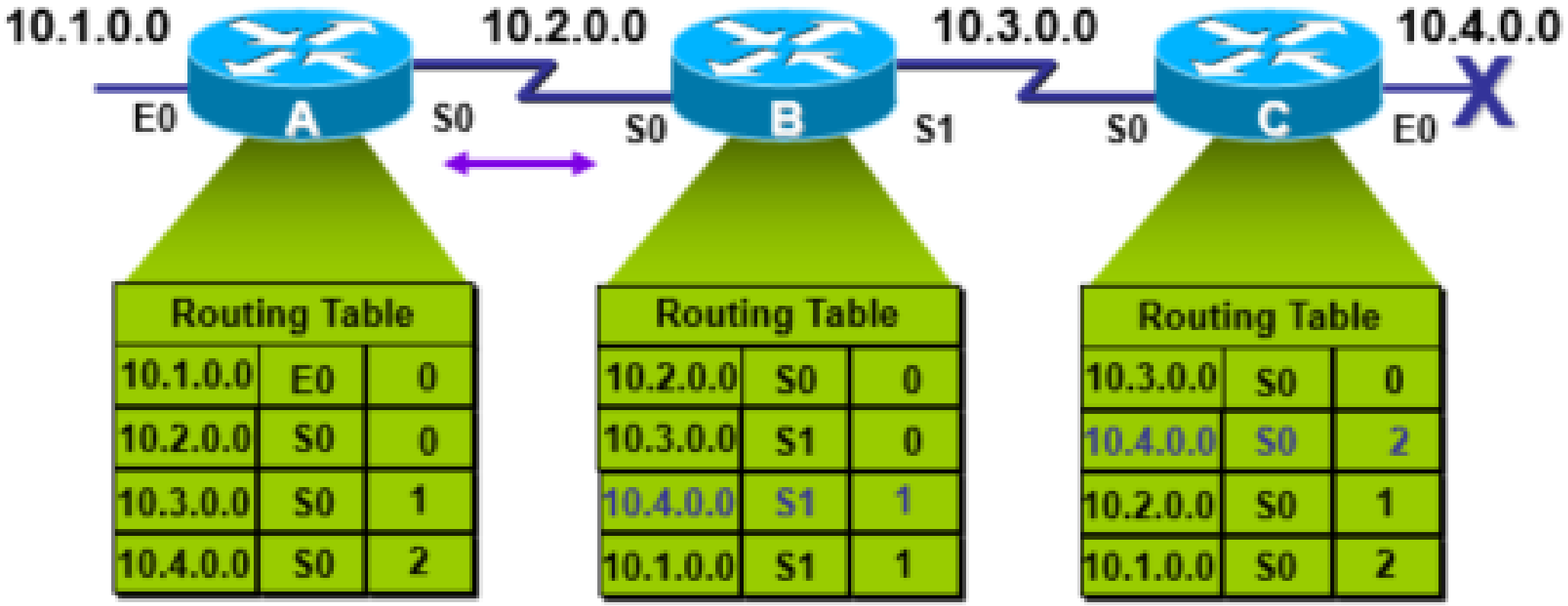
- Updates proceed step-by-step from router to router

PROBLEM – ROUTING LOOPS



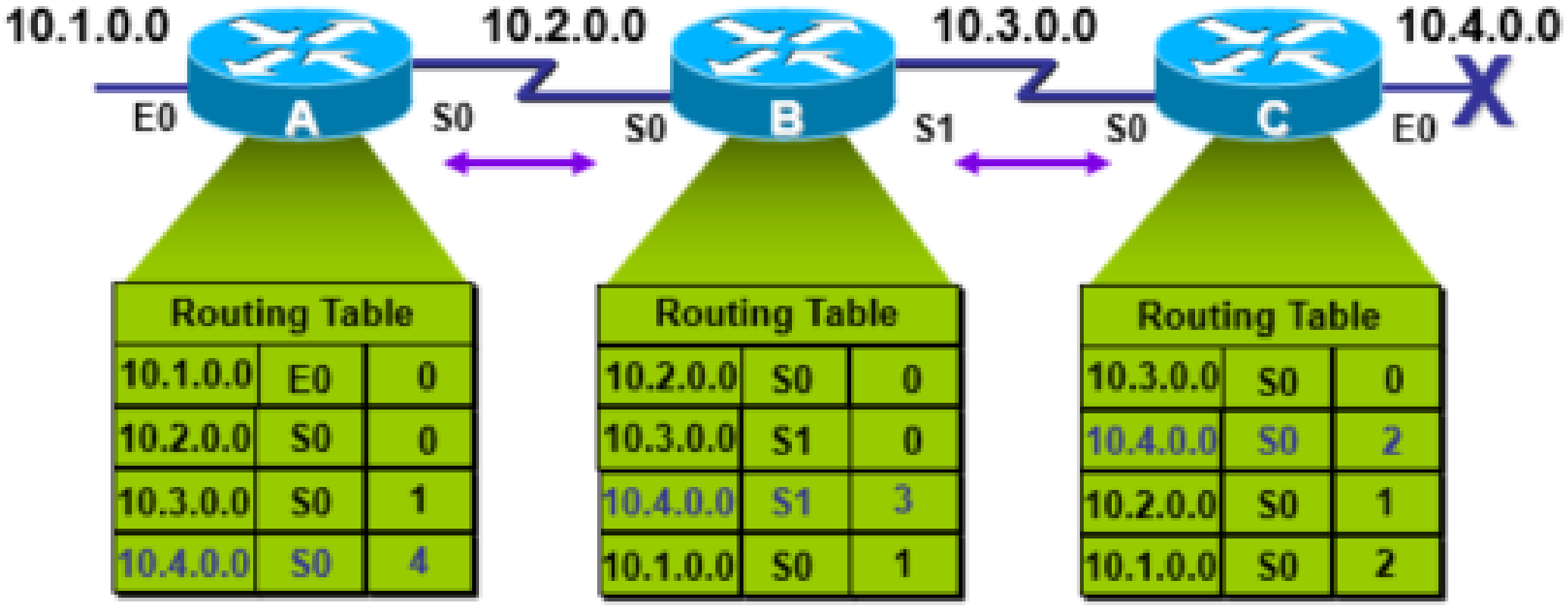
- Slow convergence produces inconsistent routing

PROBLEM – ROUTING LOOPS



Router C concludes that the best path to network 10.4.0.0 is through Router B

PROBLEM – ROUTING LOOPS



Routing Table

10.1.0.0	E0	0
10.2.0.0	S0	0
10.3.0.0	S0	1
10.4.0.0	S0	4

Routing Table

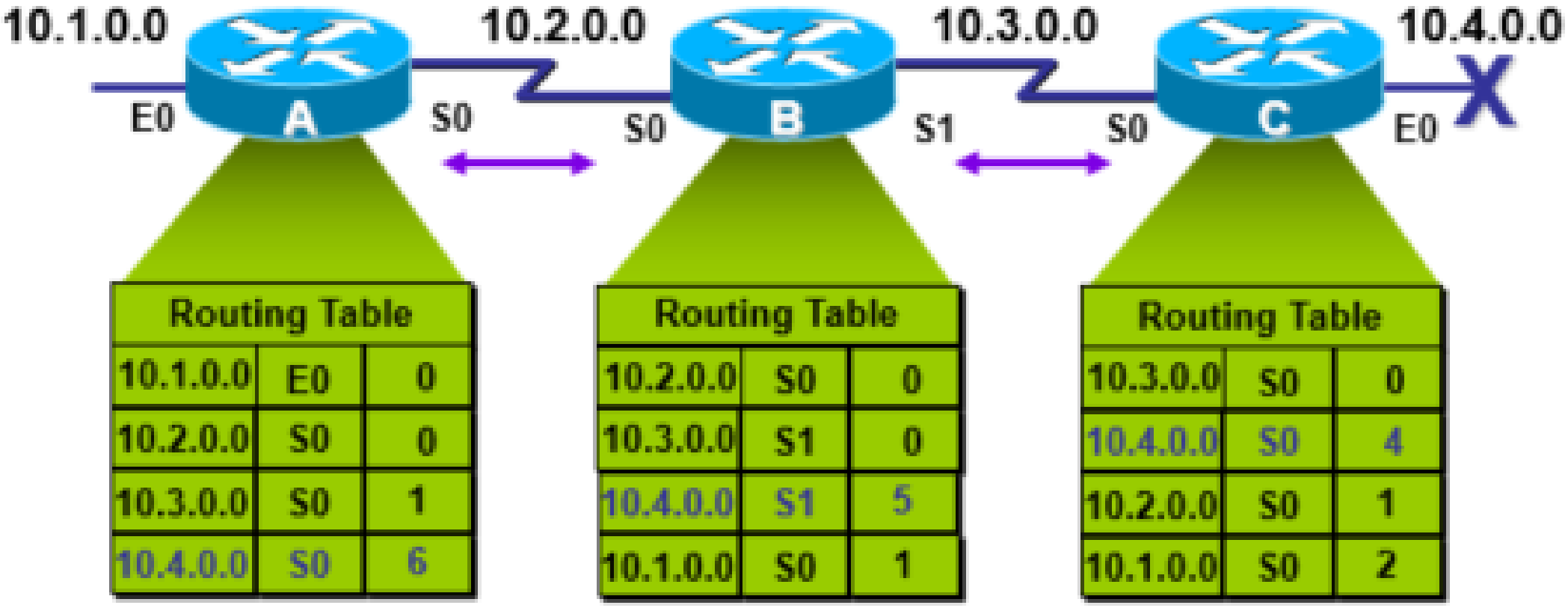
10.2.0.0	S0	0
10.3.0.0	S1	0
10.4.0.0	S1	3
10.1.0.0	S0	1

Routing Table

10.3.0.0	S0	0
10.4.0.0	S0	2
10.2.0.0	S0	1
10.1.0.0	S0	2

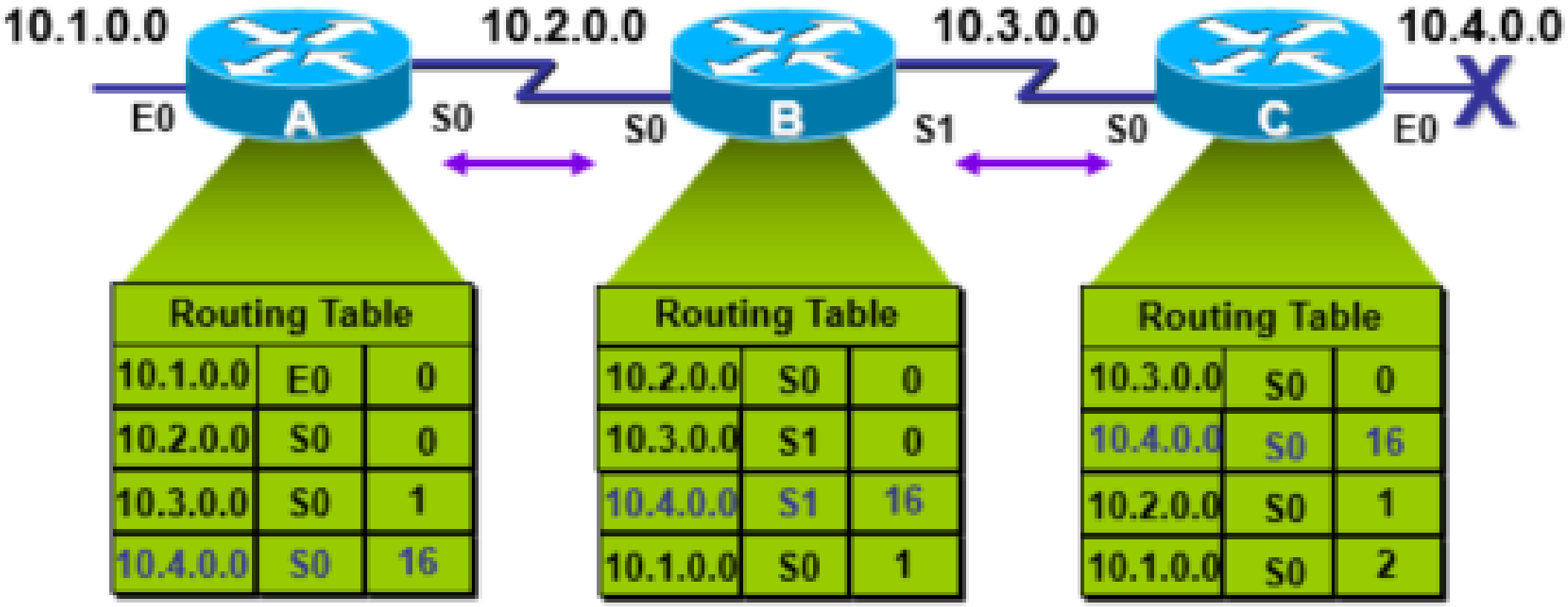
Router A updates its table to reflect the new but erroneous hop count

SYMPTOM: COUNTING TO INFINITY



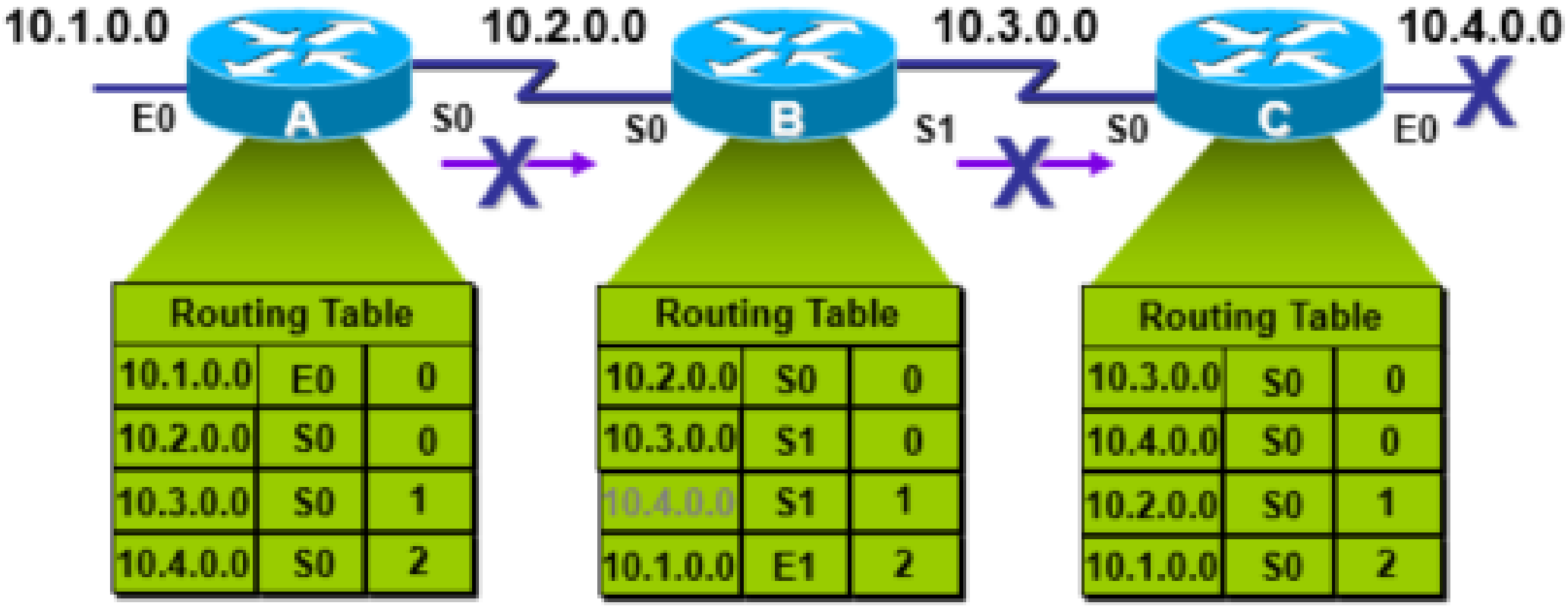
- Packets for network 10.4.0.0 bounce between routers A, B, and C
- Hop count for network 10.4.0.0 counts to infinity

SOLUTION: DEFINING A MAXIMUM



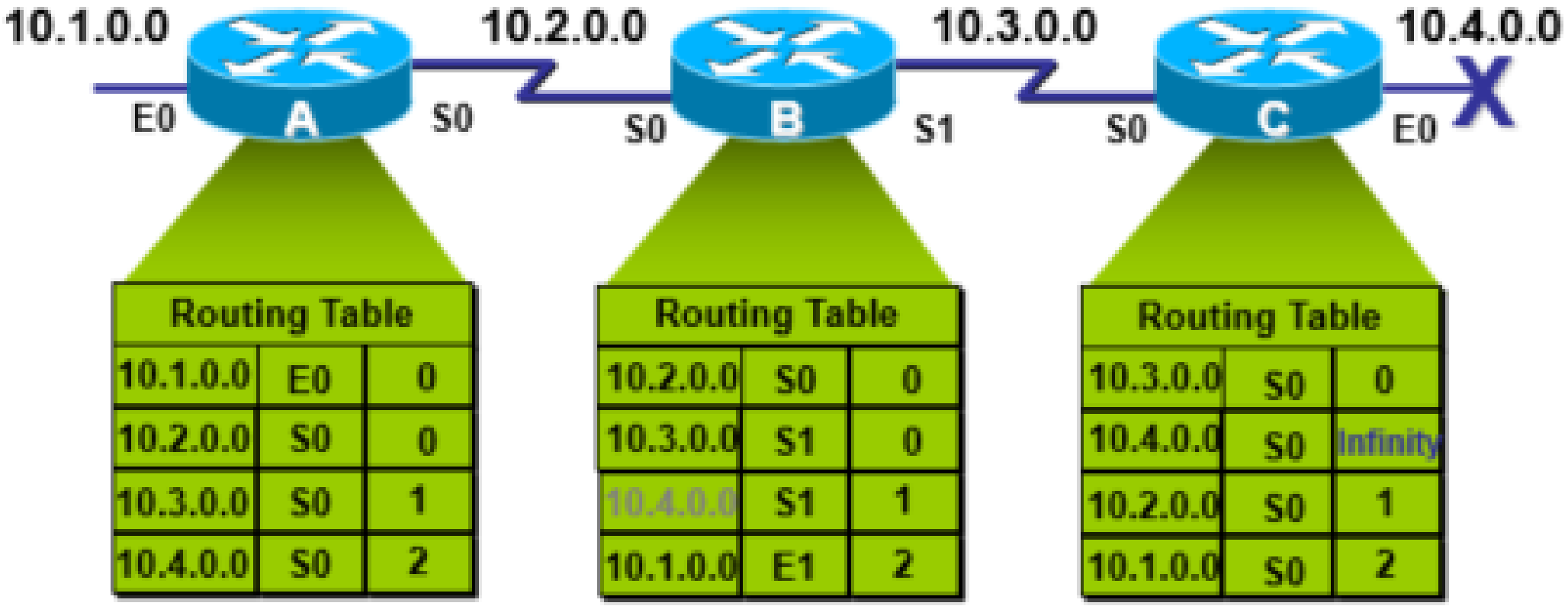
- Define a limit on the number of hops to prevent infinite loops

SOLUTION: SPLIT HORIZON



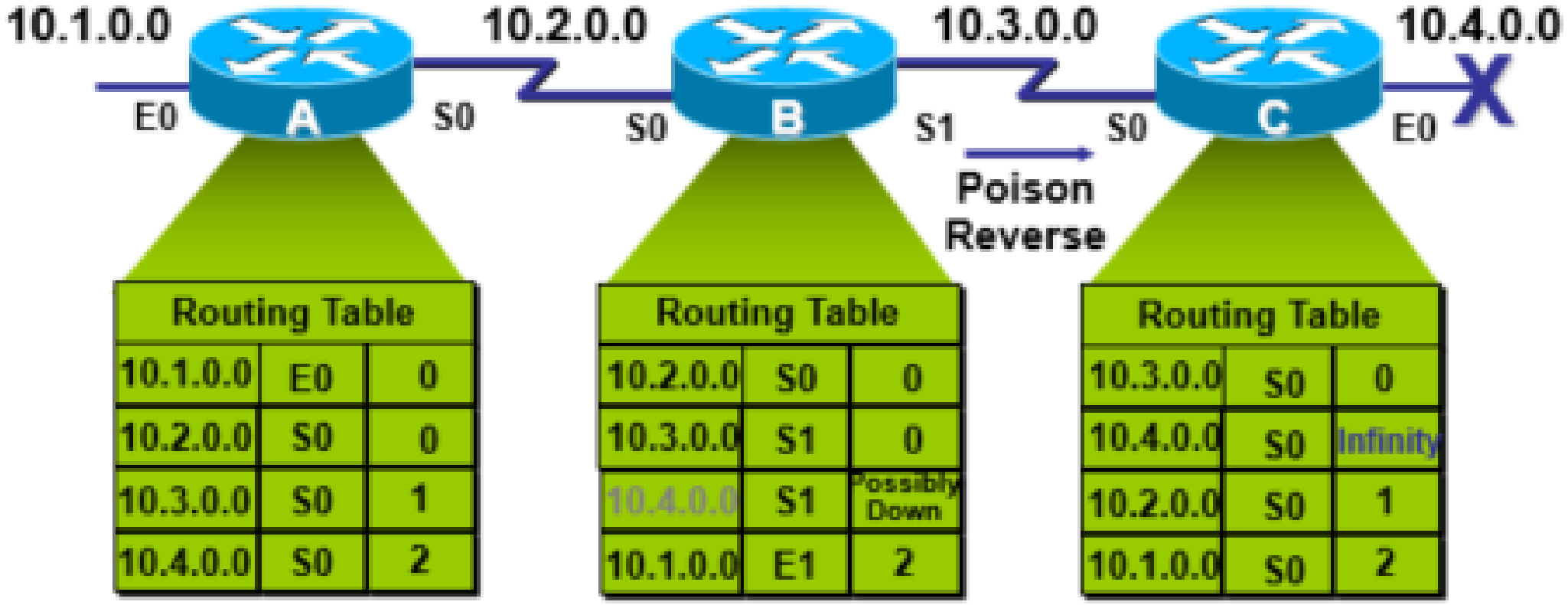
- It is never useful to send information about a route back in the direction from which the original packet came

SOLUTION: ROUTE POISONING



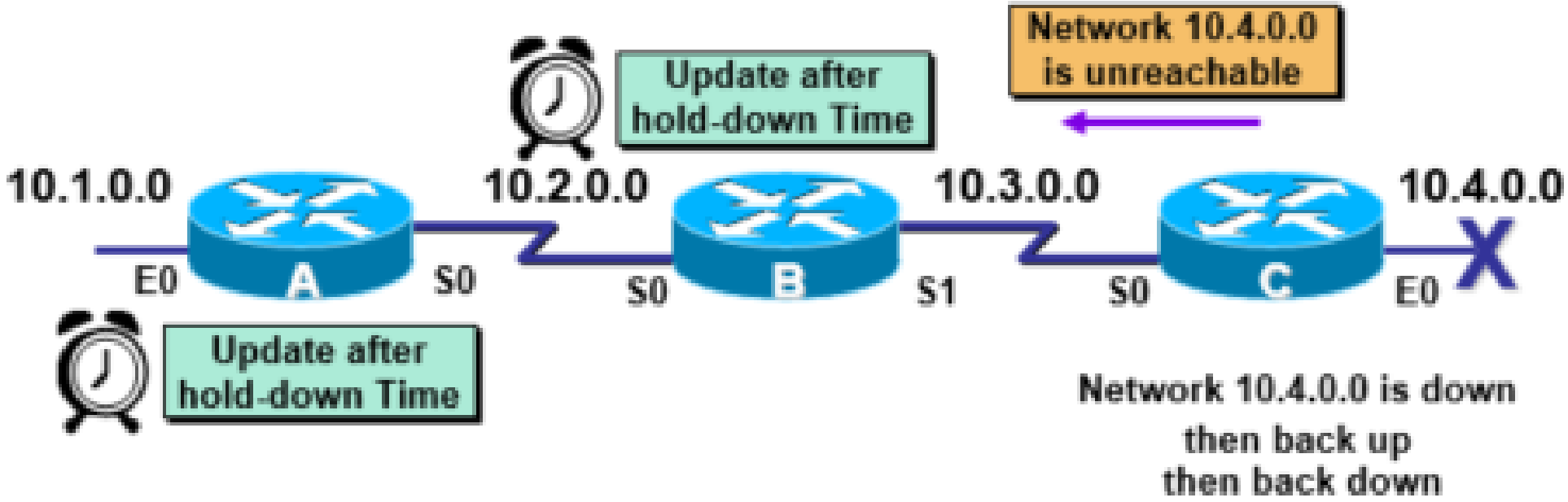
- Routers set the distance of routes that have gone down to infinity

SOLUTION: POISON REVERSE



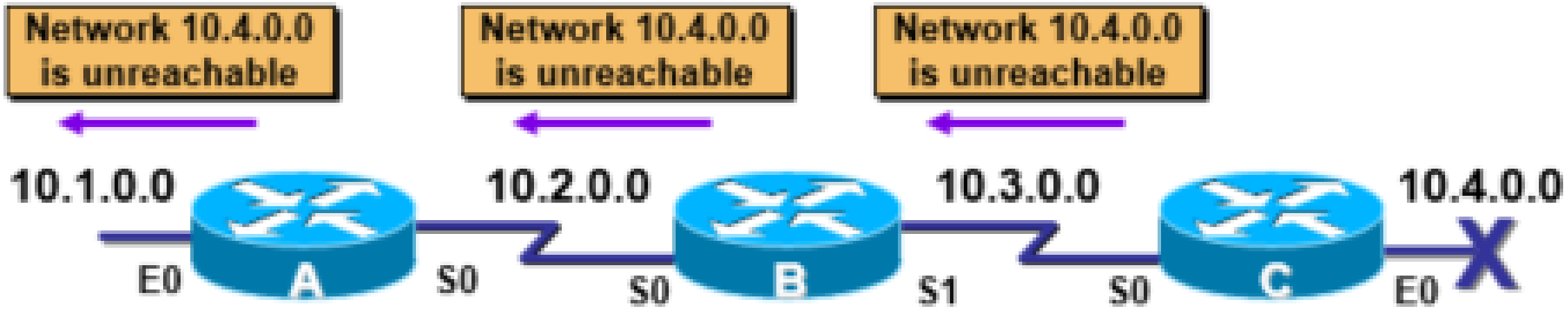
- Poison Reverse overrides split horizon

SOLUTION: HOLD-DOWN TIMERS



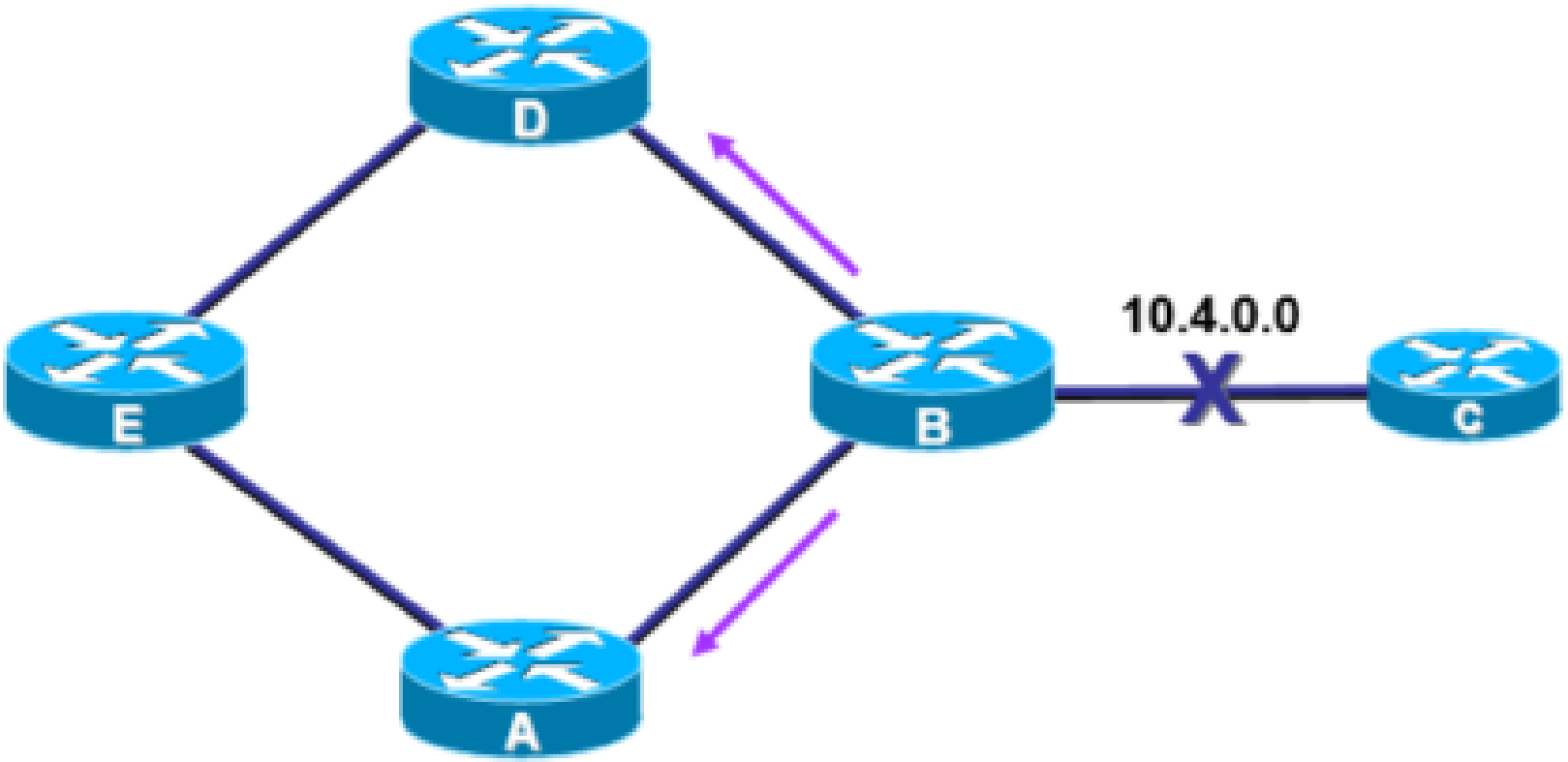
- Router keeps an entry for the network possibly down state, allowing time for other routers to recompute for this topology change

SOLUTION: TRIGGERED UPDATES

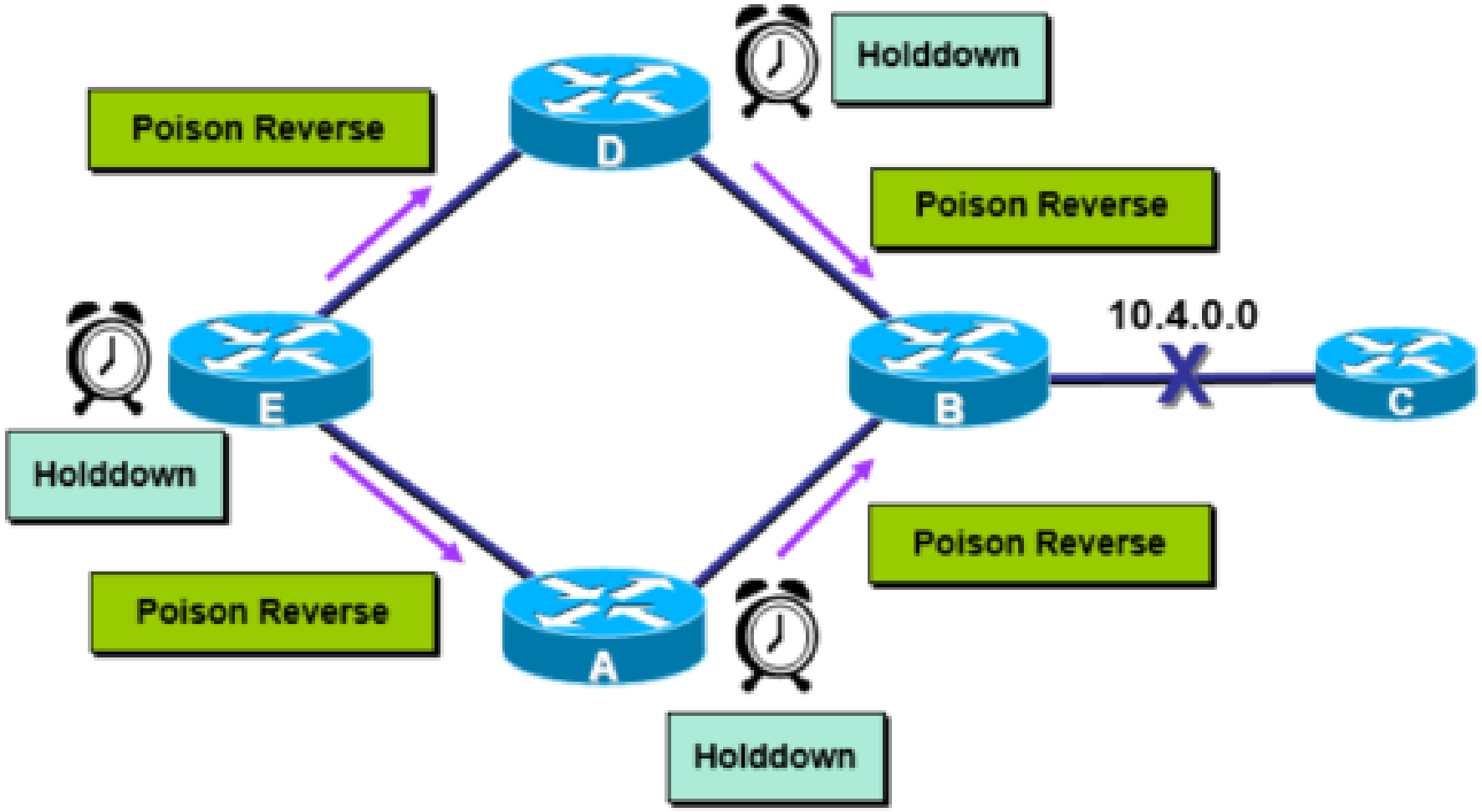


- Router sends updates when a change in its routing table occurs

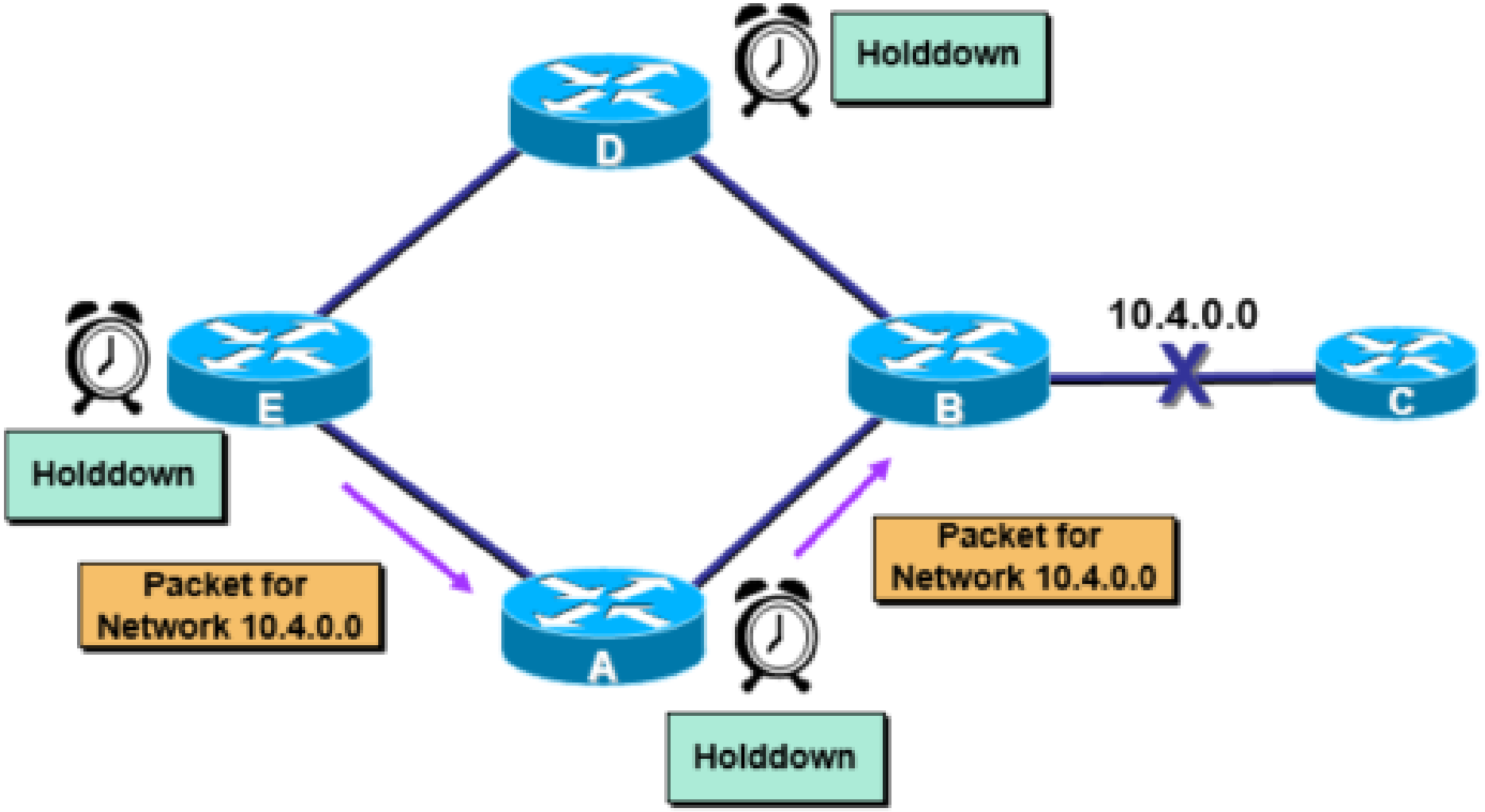
IMPLEMENTING SOLUTIONS IN MULTIPLE ROUTES



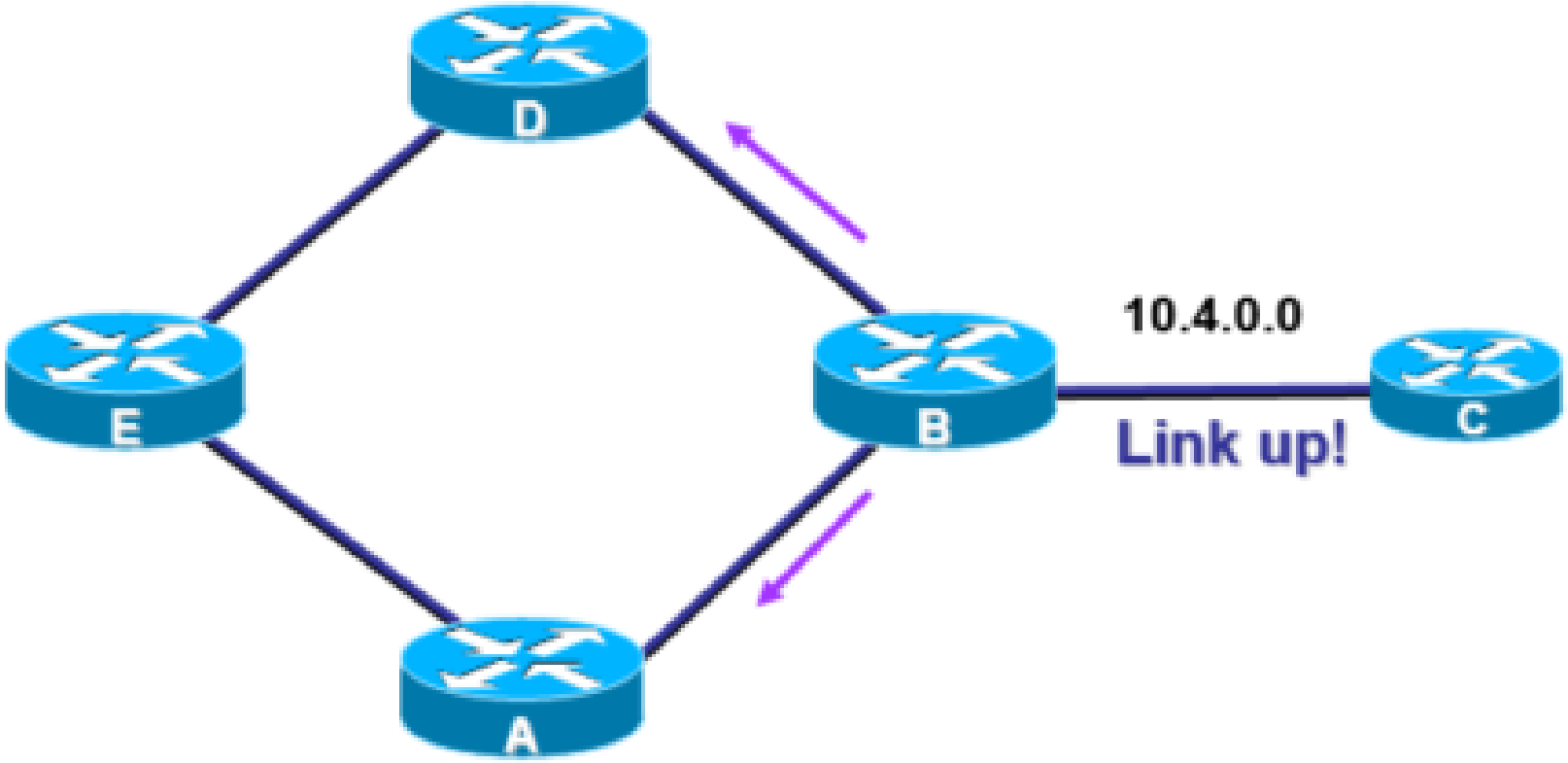
IMPLEMENTING SOLUTIONS IN MULTIPLE ROUTES



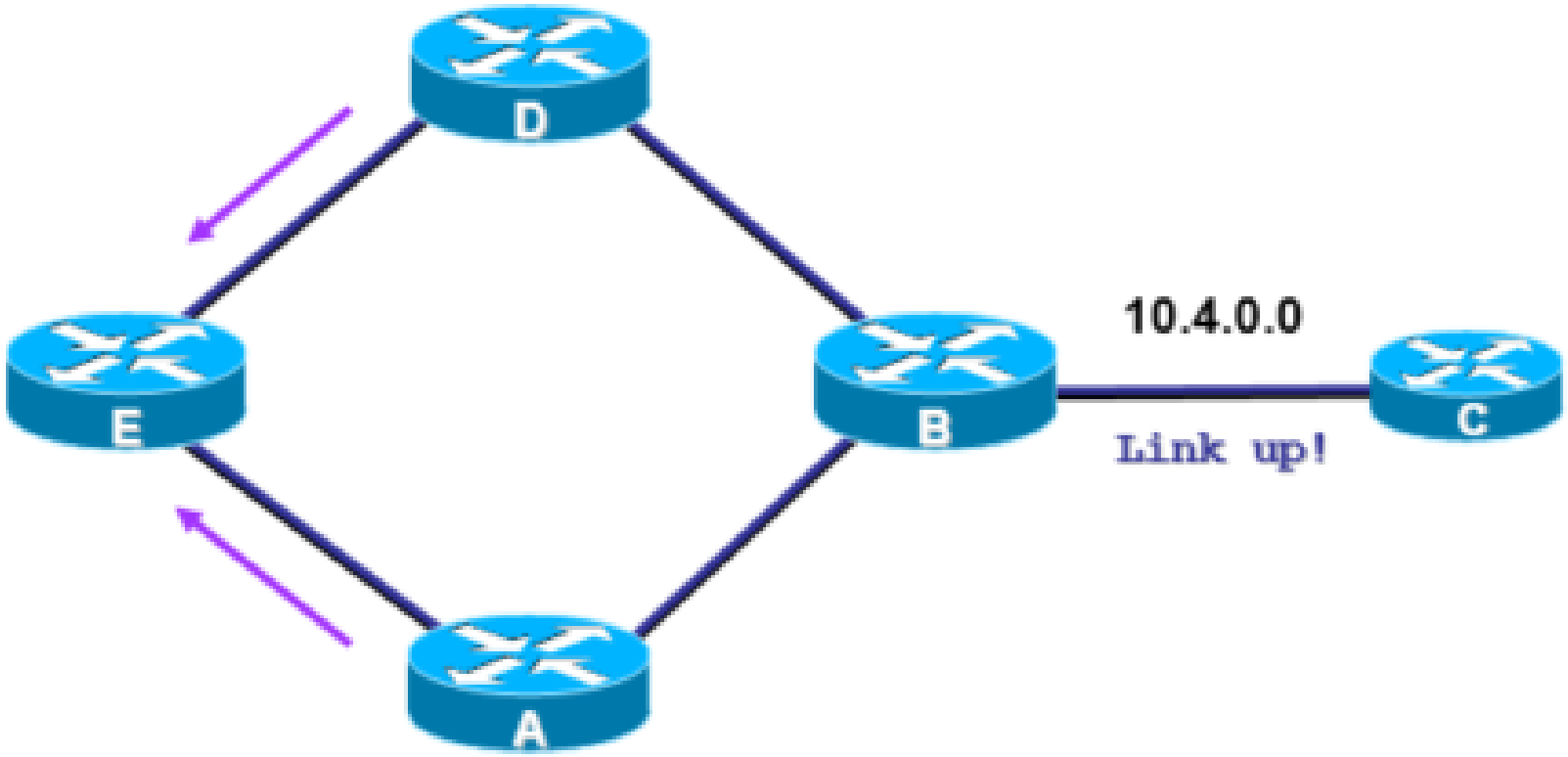
IMPLEMENTING SOLUTIONS IN MULTIPLE ROUTES



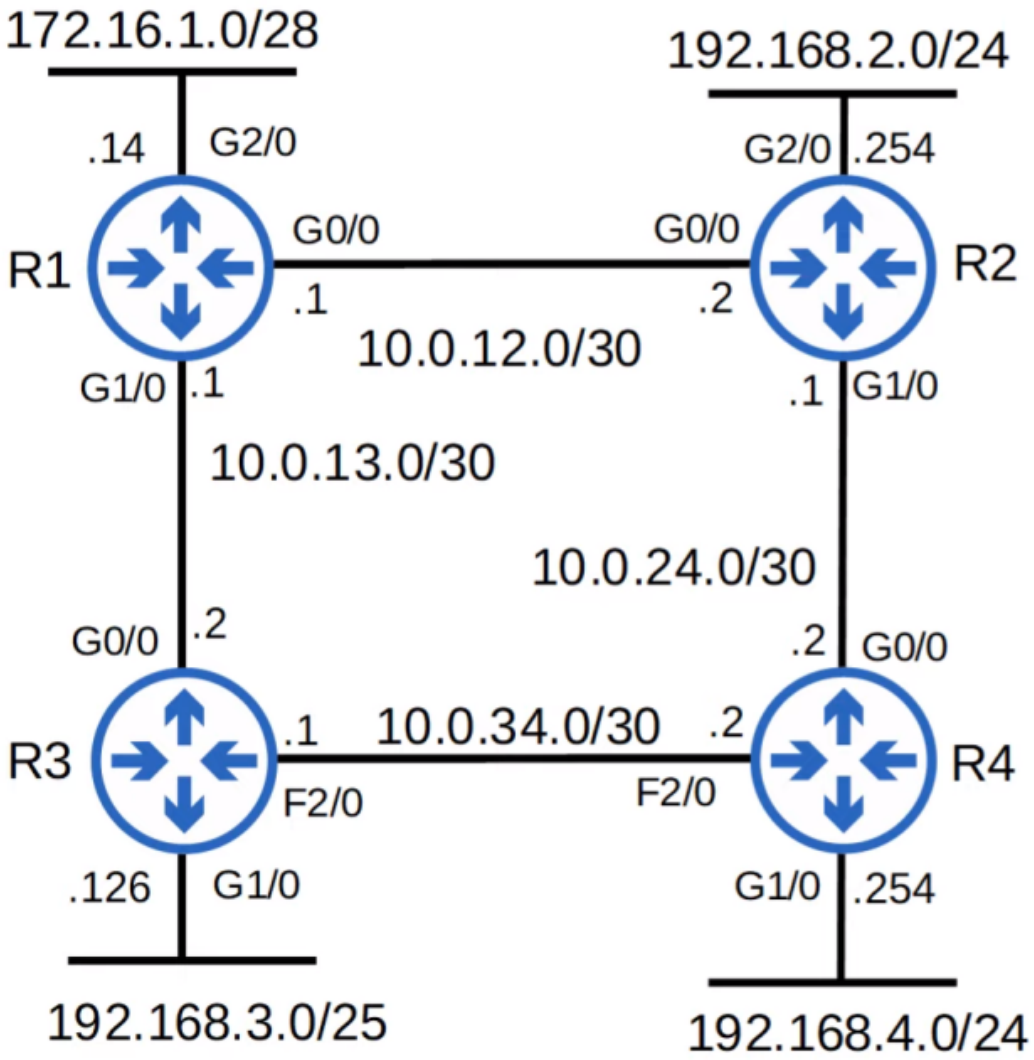
IMPLEMENTING SOLUTIONS IN MULTIPLE ROUTES



IMPLEMENTING SOLUTIONS IN MULTIPLE ROUTES



RIP CONFIGURATION




```
R1(config)#router rip
R1(config-router)#version 2
R1(config-router)#no auto-summary
R1(config-router)#network 10.0.0.0
R1(config-router)#network 172.16.0.0
```

- The RIP 'network' command is classful, it will automatically convert to classful networks.
- For example, even if you enter the command **`network 10.0.12.0`**, it will be converted to **`network 10.0.0.0`** (a class A network)
- There is no need to enter the network mask

THE *NETWORK* COMMAND

- The **network** command tells the router to:

  -look for interfaces with an IP address that is in the specified range

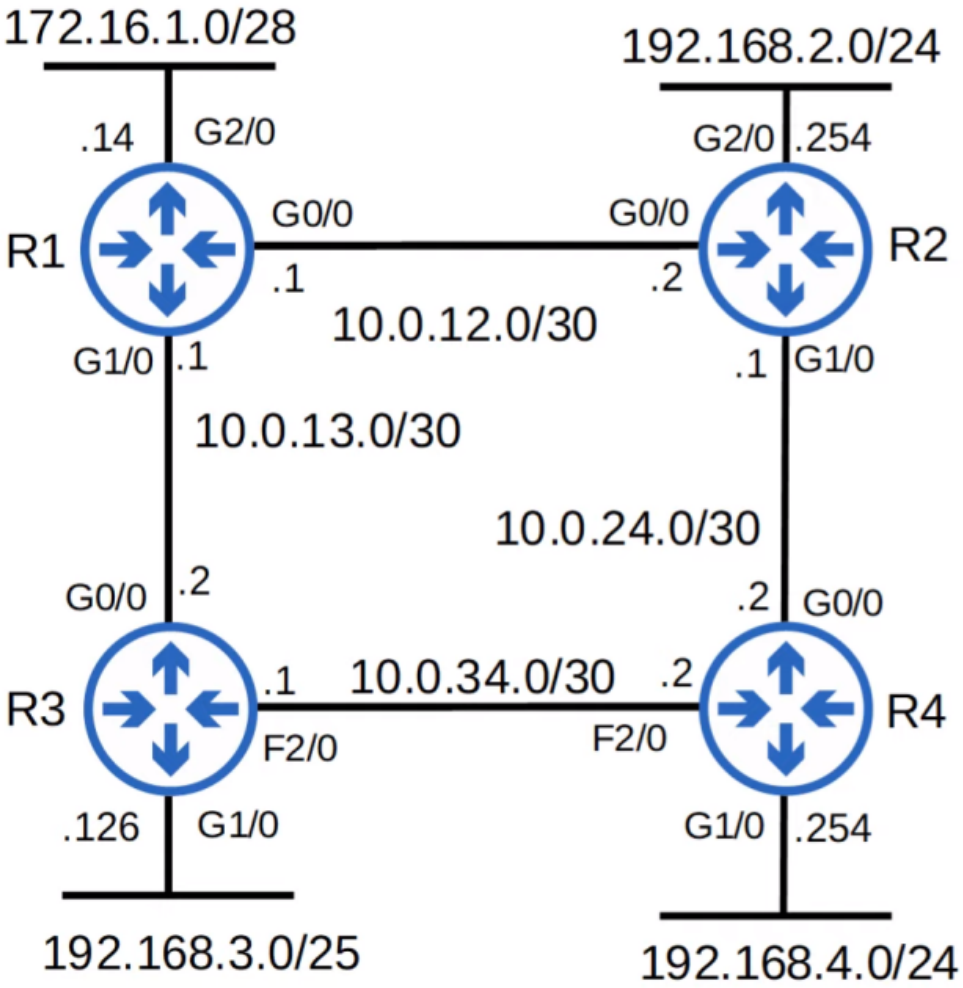
  -active RIP on the interfaces that fall in the range

  -form adjacencies with connected RIP neighbors

  -advertise **the network prefix of the interface** (NOT the prefix in the **network** command)

- The OSPF and EIGRP **network** commands operate in the same way.

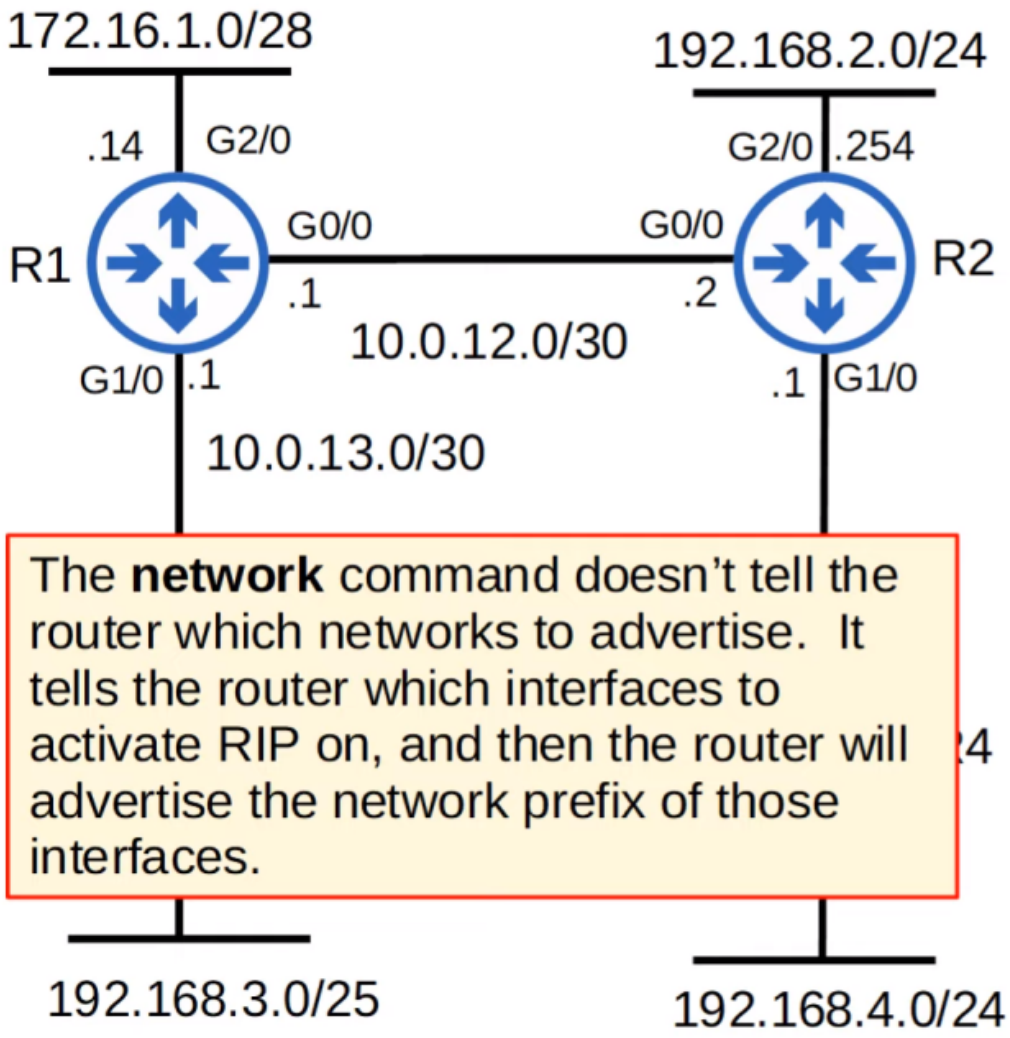
THE *NETWORK* COMMAND




```
R1(config-router)#network 10.0.0.0
```

- Because the **network** command is classful, 10.0.0.0 is assumed to be 10.0.0.0/8
- R1 will look for any interfaces with an IP address that matches 10.0.0.0/8 (because it is /8 it only needs to match the first 8 bits)
- 10.0.12.1 and 10.0.13.1 both match, so RIP is activated on G0/0 and G1/0.
- R1 forms adjacencies with its neighbors R2 and R3.
- R1 advertises 10.0.12.0/30 and 10.0.13.0/30 (NOT 10.0.0.0/8) to its RIP neighbors.

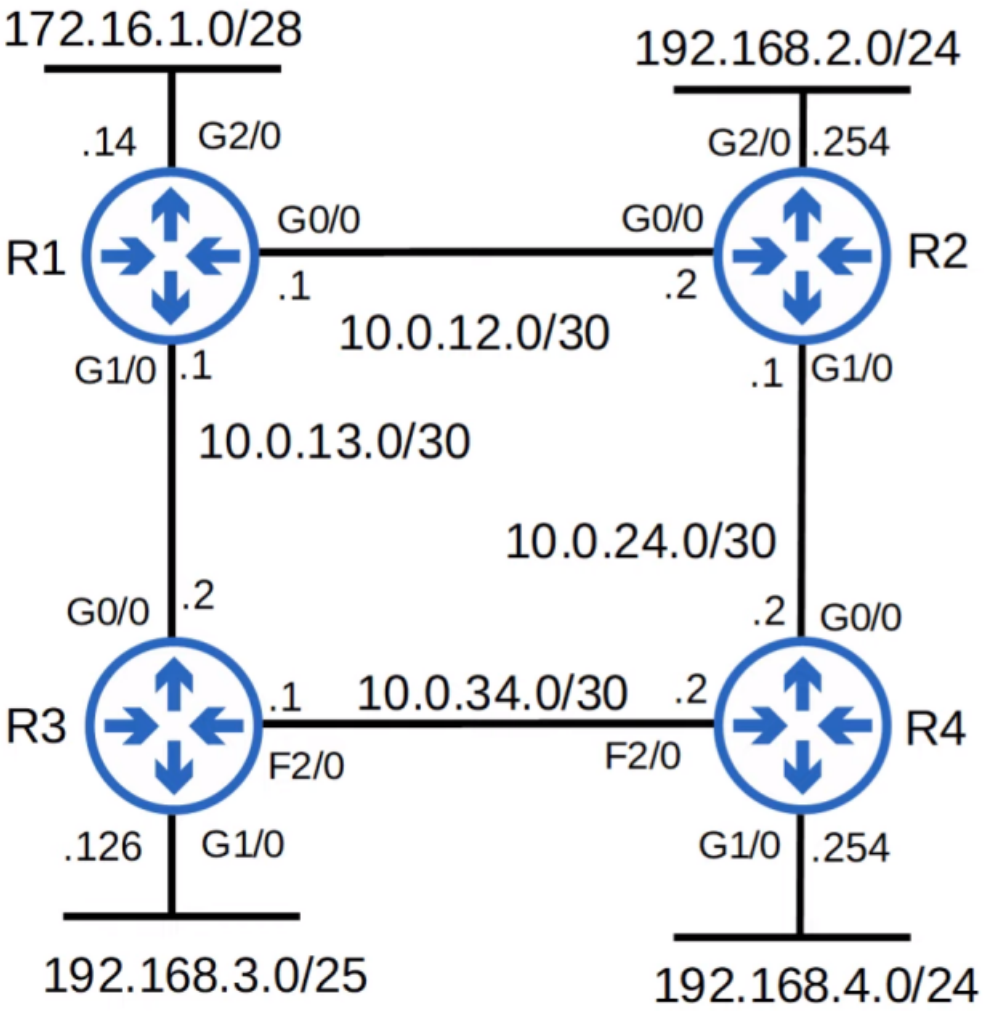
THE *NETWORK* COMMAND




```
R1(config-router)#network 10.0.0.0
```

- Because the **network** command is classful, 10.0.0.0 is assumed to be 10.0.0.0/8
- R1 will look for any interfaces with an IP address that matches 10.0.0.0/8 (because it is /8 it only needs to match the first 8 bits)
- 10.0.12.1 and 10.0.13.1 both match, so RIP is activated on G0/0 and G1/0.
- R1 forms adjacencies with its neighbors R2 and R3.
- R1 advertises 10.0.12.0/30 and 10.0.13.0/30 (NOT 10.0.0.0/8) to its RIP neighbors.

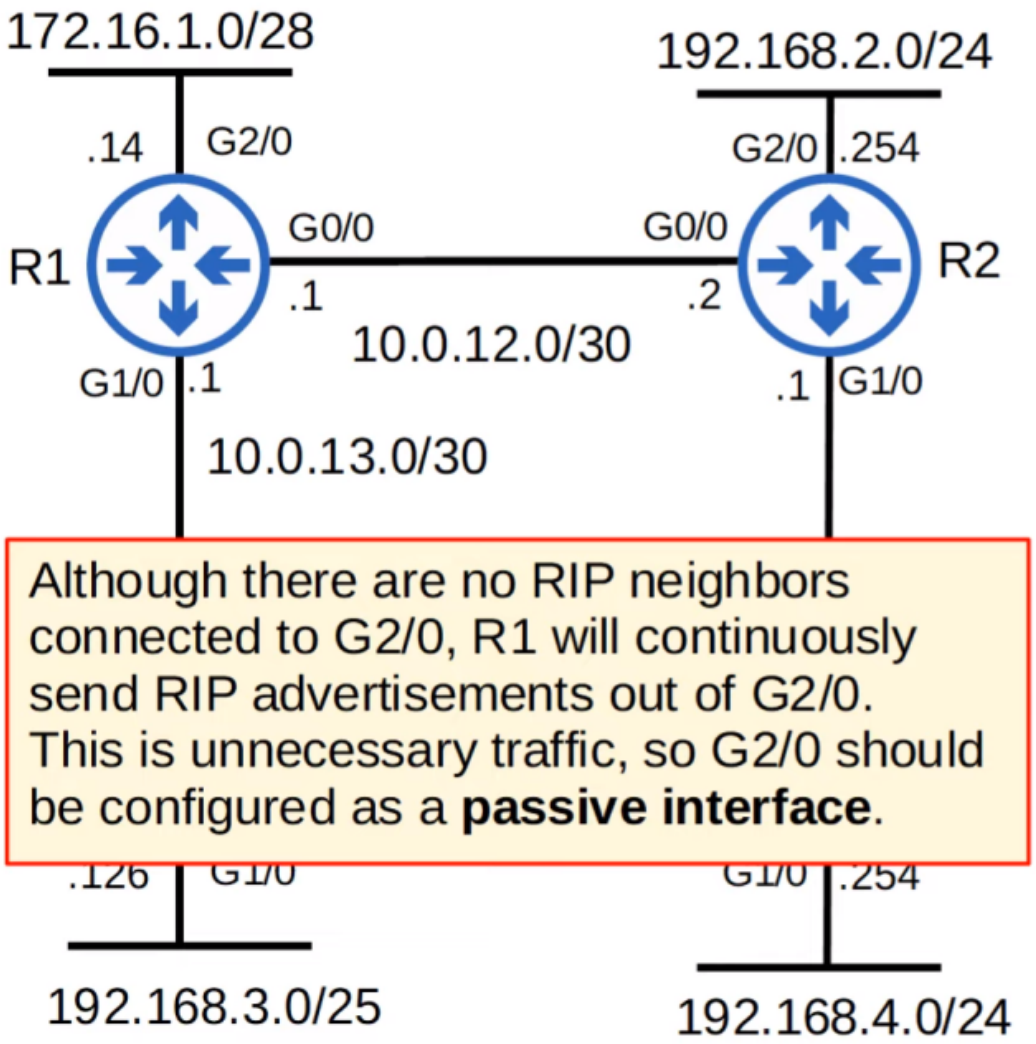
THE *NETWORK* COMMAND




```
R1(config-router)#network 172.16.0.0
```

- Because the **network** command is classful, 172.16.0.0 is assumed to be 172.16.0.0/16
- R1 will look for any interfaces with an IP address that matches 172.16.0.0/16
- 172.16.1.14 matches, so R1 will activate RIP on G2/0.
- There are no RIP neighbors connected to G2/0, so no new adjacencies are formed.
- R1 advertises 172.16.1.0/28 (NOT 172.16.0.0/16) to its RIP neighbors.

THE *NETWORK* COMMAND

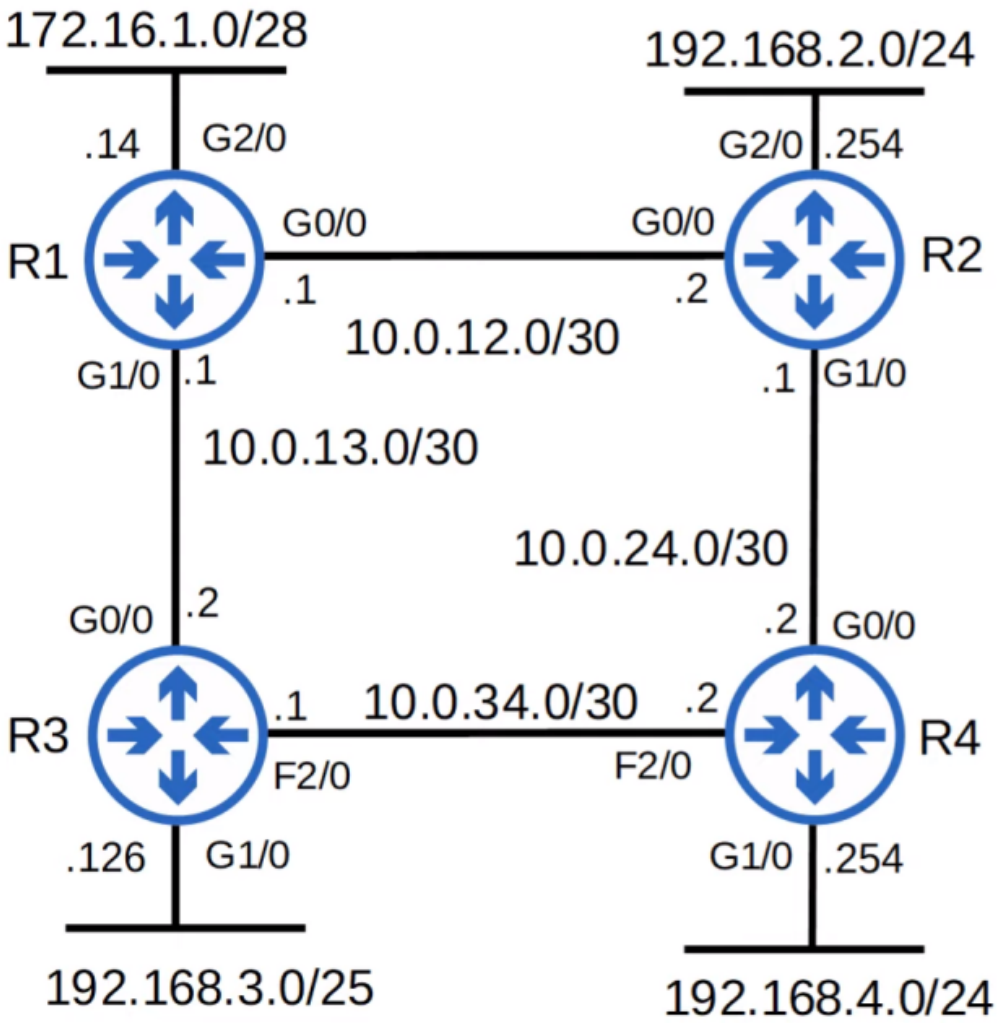


Although there are no RIP neighbors connected to G2/0, R1 will continuously send RIP advertisements out of G2/0. This is unnecessary traffic, so G2/0 should be configured as a **passive interface**.

```
R1(config-router)#network 172.16.0.0
```

- Because the **network** command is classful, 172.16.0.0 is assumed to be 172.16.0.0/16
- R1 will look for any interfaces with an IP address that matches 172.16.0.0/16
- 172.16.1.14 matches, so R1 will activate RIP on G2/0.
- There are no RIP neighbors connected to G2/0, so no new adjacencies are formed.
- R1 advertises 172.16.1.0/28 (NOT 172.16.0.0/16) to its RIP neighbors.

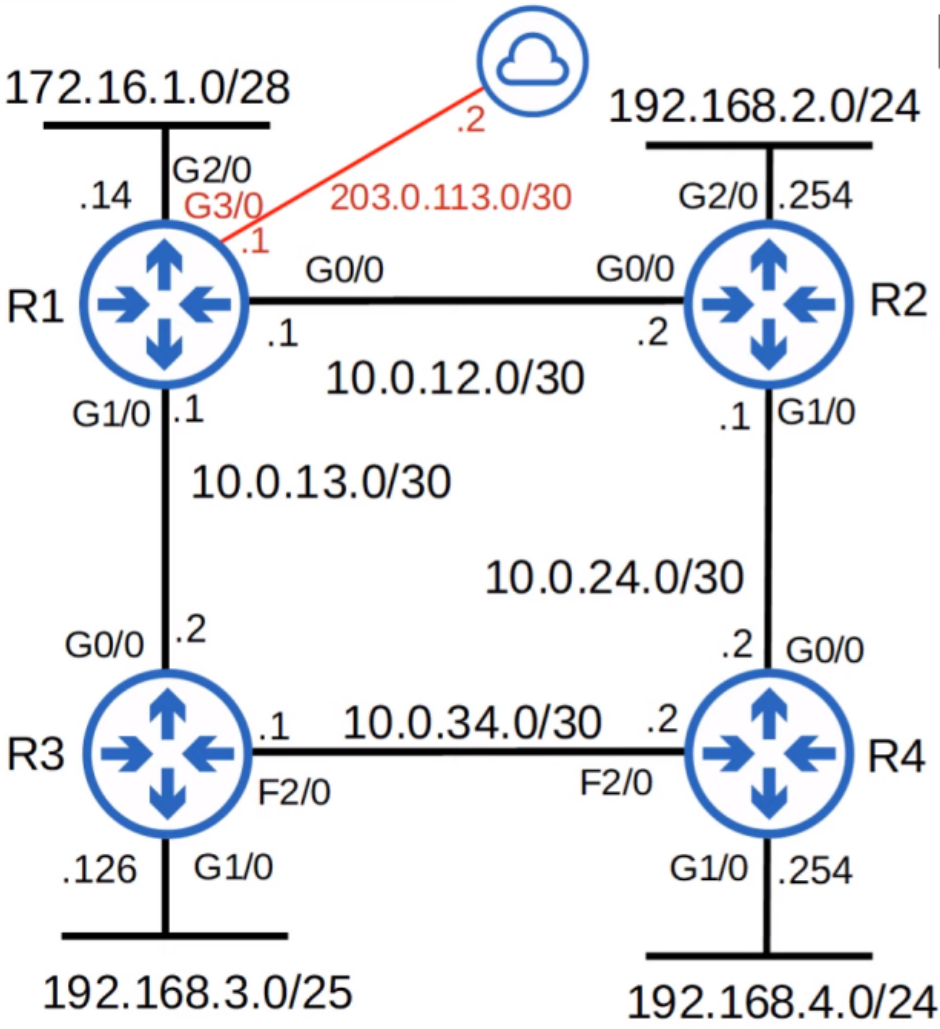
THE *NETWORK* COMMAND




```
R1(config-router)#passive-interface g2/0
```

- The **passive-interface** command tells the router to stop sending RIP advertisements out of the specified interface (G2/0)
- However, the router will continue to advertise the network prefix of the interface (172.16.1.0/28) to its RIP neighbors (R2, R3).
- You should always use this command on interfaces which don't have any RIP neighbors.
- EIGRP and OSPF both have the same passive interface functionality, using the same command.

ADVERTISE A DEFAULT ROUTE INTO RIP

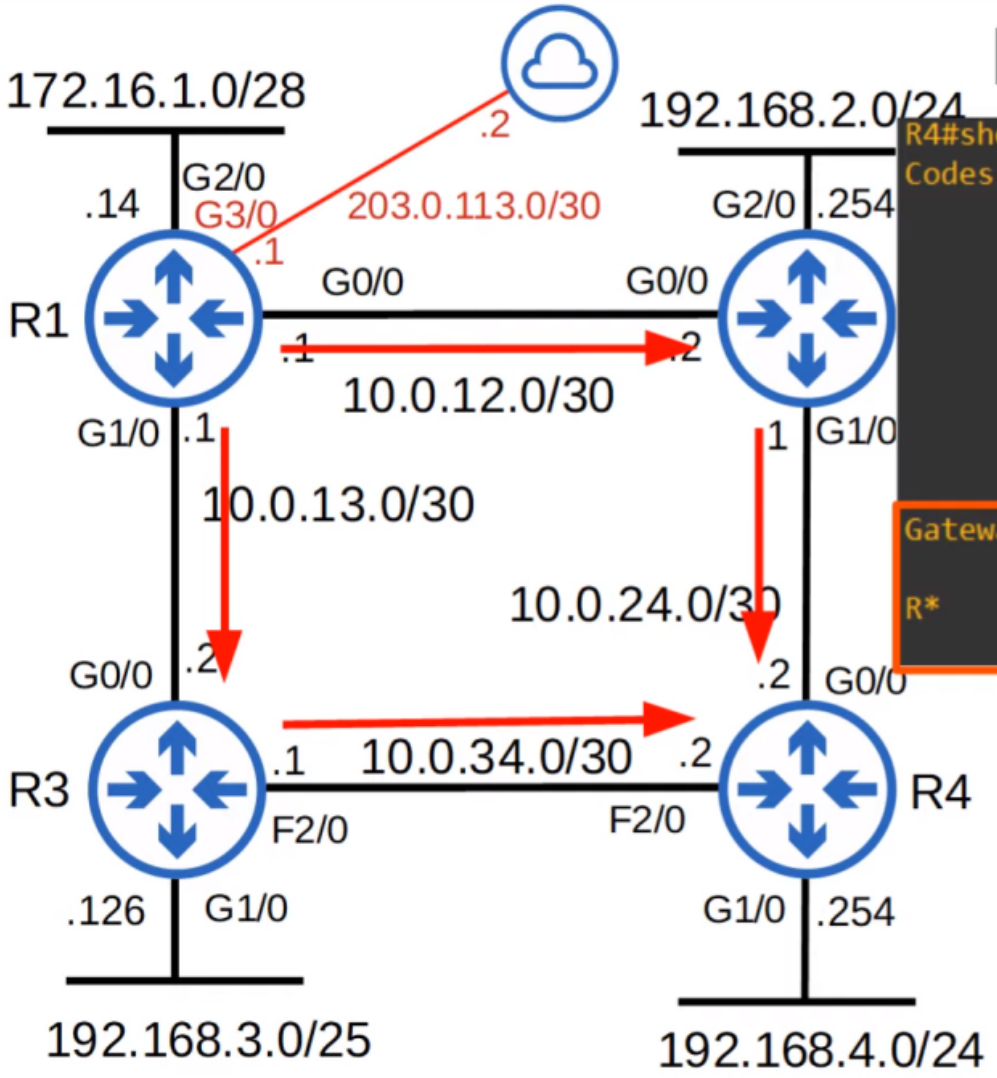



```
R1(config)#ip route 0.0.0.0 0.0.0.0 203.0.113.2
```

```
Gateway of last resort is 203.0.113.2 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 203.0.113.2
      10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C        10.0.12.0/30 is directly connected, GigabitEthernet0/0
L        10.0.12.1/32 is directly connected, GigabitEthernet0/0
C        10.0.13.0/30 is directly connected, GigabitEthernet1/0
L        10.0.13.1/32 is directly connected, GigabitEthernet1/0
R        10.0.24.0/30 [120/1] via 10.0.12.2, 00:00:24, GigabitEthernet0/0
R        10.0.34.0/30 [120/1] via 10.0.13.2, 00:00:19, GigabitEthernet1/0
      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.16.1.0/28 is directly connected, GigabitEthernet2/0
L        172.16.1.14/32 is directly connected, GigabitEthernet2/0
R     192.168.2.0/24 [120/1] via 10.0.12.2, 00:00:24, GigabitEthernet0/0
      192.168.3.0/25 is subnetted, 1 subnets
R        192.168.3.0 [120/1] via 10.0.13.2, 00:00:09, GigabitEthernet1/0
R     192.168.4.0/24 [120/2] via 10.0.13.2, 00:00:19, GigabitEthernet1/0
      203.0.113.0/24 is variably subnetted, 2 subnets, 2 masks
C        203.0.113.0/30 is directly connected, GigabitEthernet3/0
L        203.0.113.1/32 is directly connected, GigabitEthernet3/0
```

THE *DEFAULT-INFORMATION ORIGINATE* COMMAND




```
R1(config-router)#default-information originate
```

```
R4#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter are
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS
       ia - IS-IS inter area, * - candidate default, U - per-user st
       o - ODR, P - periodic downloaded static route, H - NHRP, l -
       + - replicated route, % - next hop override

Gateway of last resort is 10.0.34.1 to network 0.0.0.0

R*    0.0.0.0/0 [120/2] via 10.0.34.1, 00:00:06, FastEthernet2/0
                [120/2] via 10.0.24.1, 00:00:01, GigabitEthernet0/0
```

SHOW IP PROTOCOLS

```
R1#show ip protocols
*** IP Routing is NSF aware ***

Routing Protocol is "rip"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Sending updates every 30 seconds, next due in 28 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Redistributing: rip
  Default version control: send version 2, receive version 2
    Interface              Send  Recv  Triggered RIP  Key-chain
    GigabitEthernet0/0     2     2
    GigabitEthernet1/0     2     2
  Automatic network summarization is not in effect
  Maximum path: 4
  Routing for Networks:
    10.0.0.0
    172.16.0.0
  Passive Interface(s):
    GigabitEthernet2/0
  Routing Information Sources:
    Gateway         Distance      Last Update
    10.0.12.2            120      00:00:21
    10.0.13.2            120      00:00:06
  Distance: (default is 120)
```

```
R1(config-router)#maximum-paths ?
  <1-32>  Number of paths

R1(config-router)#maximum-paths 8
```

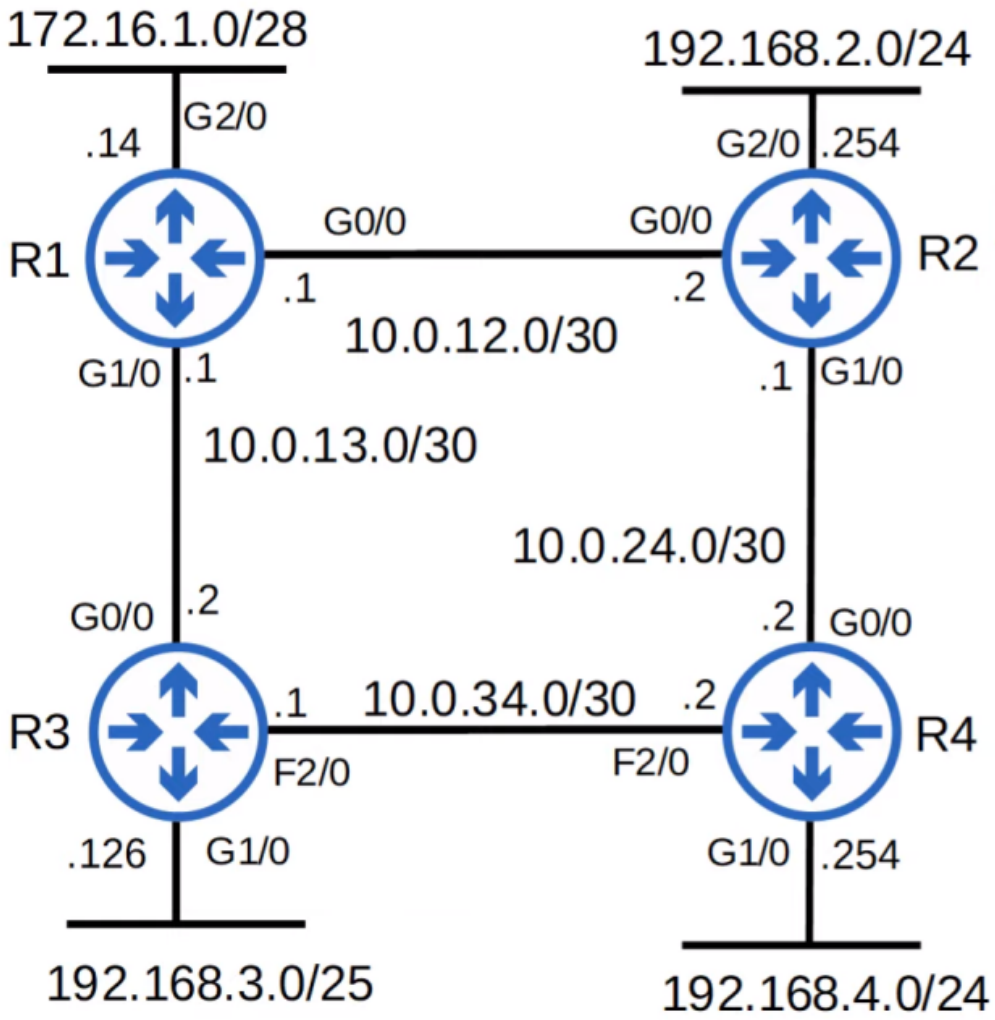
```
R1(config-router)#distance ?
  <1-255>  Administrative distance

R1(config-router)#distance 85
```

EIGRP

- **Enhanced Interior Gateway Routing Protocol**
- Was Cisco proprietary, but Cisco has now published it openly so other vendors can implement it on their equipment.
- Considered an ‘advanced’ / ‘hybrid’ distance vector routing protocol.
- Much faster than RIP in reacting to changes in the network.
- Does not have the 15 ‘hop-count’ limit of RIP.
- Sends messages using multicast address 224.0.0.10.
- Is the only IGP that can perform **unequal**-cost load-balancing (by default it performs ECMP load-balancing over 4 paths like RIP)

EIGRP CONFIGURATION




```
R1(config)#router eigrp 1
R1(config-router)#no auto-summary
R1(config-router)#passive-interface g2/0
R1(config-router)#network 10.0.0.0
R1(config-router)#network 172.16.1.0 0.0.0.15
```

- The AS (Autonomous System) number must match between routers, or they will not form an adjacency and share route information.
- Auto-summary might be enabled or disabled by default, depending on the router/IOS version. If it's enabled, disable it.
- The **network** command will assume a classful address if you don't specify the mask.
- EIGRP uses a *wildcard mask* instead of a regular subnet mask.

WILDCARD MASKS

- A wildcard mask is basically an 'inverted' subnet mask.
- All 1s in the subnet mask are 0 in the equivalent wildcard mask. All 0s in the subnet mask are 1 in the equivalent wildcard mask.

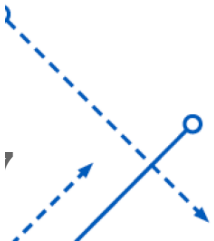
11111111 . 11111111 . 11111111 . 00000000

255 . 255 . 255 . 0

00000000 . 00000000 . 00000000 . 11111111

0 . 0 . 0 . 255

/24



WILDCARD MASKS

11111111 . 11111111 . 00000000 . 00000000

255 . 255 . 0 . 0

00000000 . 00000000 . 11111111 . 11111111

0 . 0 . 255 . 255

/16

WILDCARD MASKS

11111111 . 00000000 . 00000000 . 00000000

255 . 0 . 0 . 0

00000000 . 11111111 . 11111111 . 11111111

0 . 255 . 255 . 255

/8

WILDCARD MASKS

11111111 . 11111111 . 11111111 . 11110000

255 . 255 . 255 . 240

00000000 . 00000000 . 00000000 . 00001111

0 . 0 . 0 . 15

/28

WILDCARD MASKS

11111111 . 11111111 . 11111111 . 100000

255 . 255 . 255 . 128

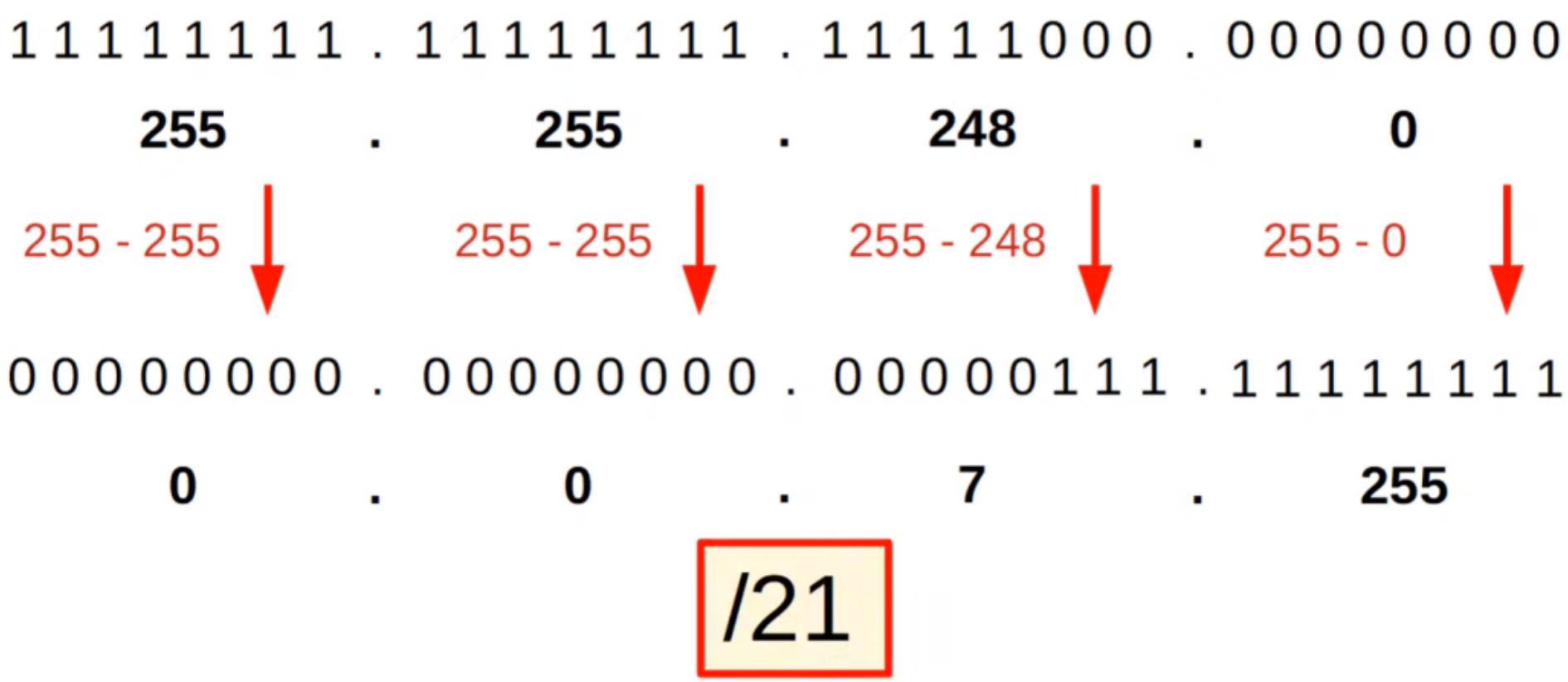
00000000 . 00000000 . 00000000 . 01111111

0 . 0 . 0 . 127

/25

WILDCARD MASKS

- A shortcut is to subtract each octet of the subnet mask from 255.



WILDCARD MASKS

- '0' in the wildcard mask = must match
- '1' in the wildcard mask = don't have to match

R1 G2/0 IP address:

10101100 . 00010000 . 00000001 . 00001110

172 . 16 . 1 . 14

EIGRP **network** command:

10101100 . 00010000 . 00000001 . 00000000

172 . 16 . 1 . 0

00000000 . 00000000 . 00000000 . 00001111

0 . 0 . 0 . 15

WILDCARD MASKS

- '0
- '1

Match! EIGRP will be activated on the interface.

10101100 . 00010000 . 00000001 . 00001110
172 . 16 . 1 . 14

EIGRP **network** command:

10101100 . 00010000 . 00000001 . 00000000
172 . 16 . 1 . 0

00000000 . 00000000 . 00000000 . 00001111
0 . 0 . 0 . 15

WILDCARD MASKS

- '0' in the wildcard mask = must match
- '1' in the wildcard mask = don't have to match

R1 G2/0 IP address:

10101100 . 00010000 . 00000001 . 00001110

172 . 16 . 1 . 14

EIGRP **network** command:

10101100 . 00010000 . 00000001 . 00000000

172 . 16 . 1 . 0

00000000 . 00000000 . 00000000 . 00000111

0 . 0 . 0 . 7

WILDCARD MASKS

- '0
- '1

No match! EIGRP will **not** be activated on the interface.

10101100 . 00010000 . 00000001 . 00001110
172 . **16** . **1** . **14**

EIGRP **network** command:

10101100 . 00010000 . 00000001 . 00000000
172 . **16** . **1** . **0**

00000000 . 00000000 . 00000000 . 00000111
0 . **0** . **0** . **7**

WILDCARD MASKS

- '0
- '1

Match! EIGRP will be activated on the interface.

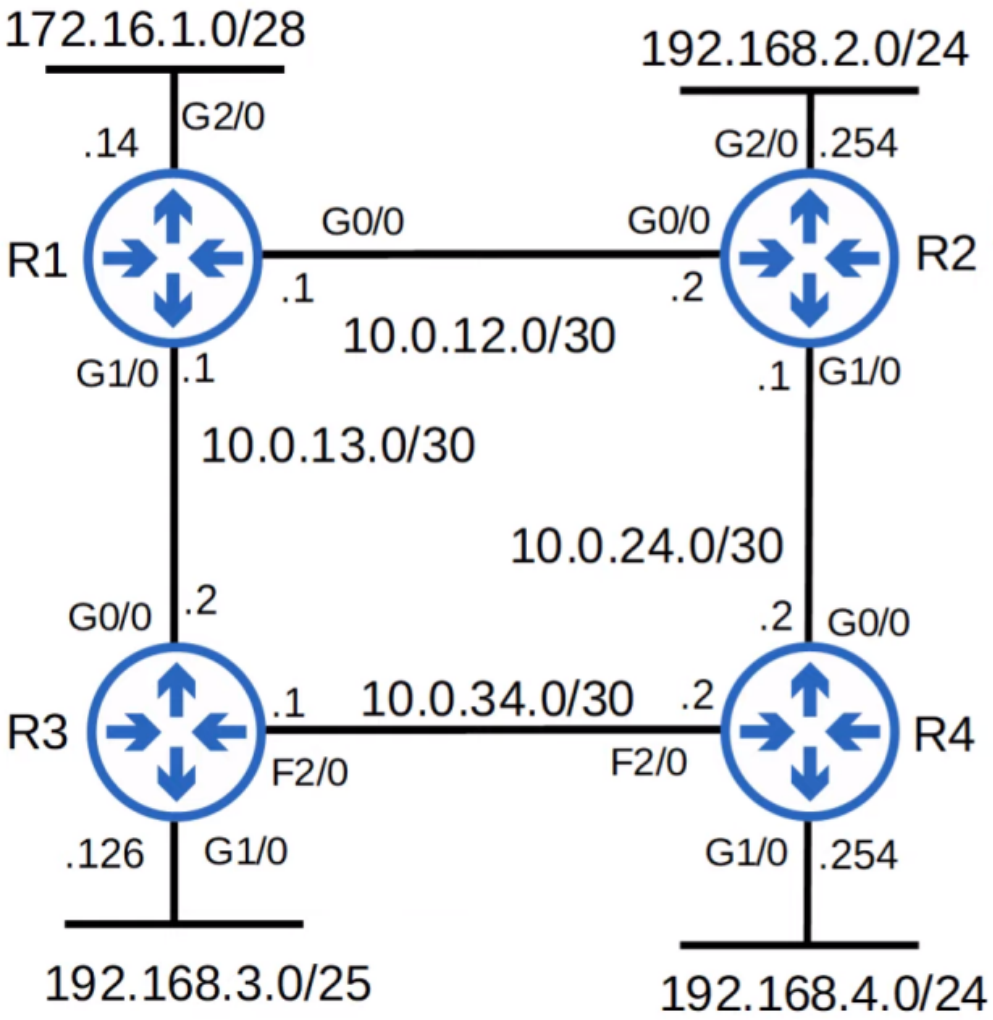
10101100 . 00010000 . 00000001 . 00001110
172 . 16 . 1 . 14

EIGRP **network** command:

10101000 . 00000000 . 00000000 . 00000000
168 . 0 . 0 . 0

00000111 . 11111111 . 11111111 . 11111111
7 . 255 . 255 . 255

EIGRP CONFIGURATION




```
R1(config)#router eigrp 1
R1(config-router)#no auto-summary
R1(config-router)#passive-interface g2/0
R1(config-router)#network 10.0.0.0
R1(config-router)#network 172.16.1.0 0.0.0.15
```

- The AS (Autonomous System) number must match between routers, or they will not form an adjacency and share route information.
- Auto-summary might be enabled or disabled by default, depending on the router/IOS version. If it's enabled, disable it.
- The **network** command will assume a classful address if you don't specify the mask.
- EIGRP uses a *wildcard mask* instead of a regular subnet mask.

SHOW IP PROTOCOLS

```
R1#show ip protocols
*** IP Routing is NSF aware ***

Routing Protocol is "eigrp 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP-IPv4 Protocol for AS(1)
    Metric weight K1=1, K2=0, K3=1, K4=0, K5=0
    NSF-aware route hold timer is 240
    Router-ID: 172.16.1.14
    Topology : 0 (base)
      Active Timer: 3 min
      Distance: internal 90 external 170
      Maximum path: 4
      Maximum hopcount 100
      Maximum metric variance 1

  Automatic Summarization: disabled
  Maximum path: 4
  Routing for Networks:
    10.0.0.0
    172.16.1.0/28
  Passive Interface(s):
    GigabitEthernet2/0
  Routing Information Sources:
    Gateway         Distance      Last Update
    10.0.12.2              90      00:00:23
    10.0.13.2              90      00:00:23
  Distance: internal 90 external 170
```

Router ID order of priority:
1) Manual configuration
2) Highest IP address on a loopback interface
3) Highest IP address on a physical interface

```
R1(config-router)#eigrp router-id ?
  A.B.C.D  EIGRP Router-ID in IP address format

R1(config-router)#eigrp router-id 1.1.1.1
```

```
  Metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  NSF-aware route hold timer is 240
  Router-ID: 1.1.1.1
  Topology : 0 (base)
```

SHOW IP PROTOCOLS

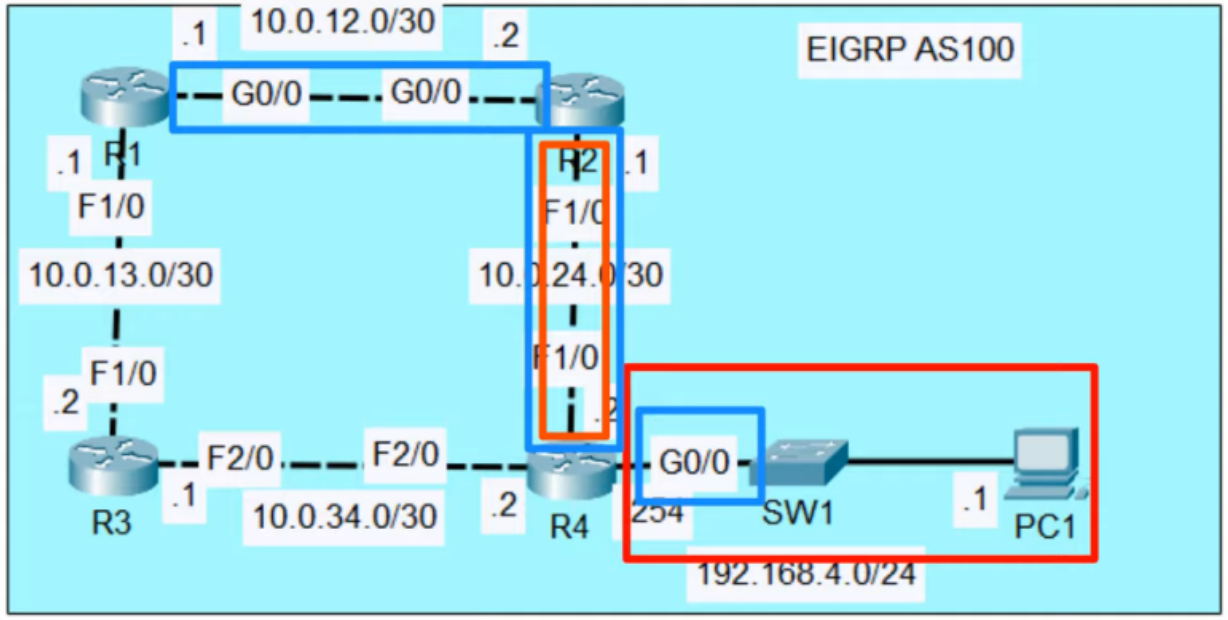
```
R1#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C        10.0.12.0/30 is directly connected, GigabitEthernet0/0
L        10.0.12.1/32 is directly connected, GigabitEthernet0/0
C        10.0.13.0/30 is directly connected, GigabitEthernet1/0
L        10.0.13.1/32 is directly connected, GigabitEthernet1/0
D        10.0.24.0/30 [90/3072] via 10.0.12.2, 00:11:09, GigabitEthernet0/0
D        10.0.34.0/30 [90/28416] via 10.0.13.2, 00:11:09, GigabitEthernet1/0
      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.16.1.0/28 is directly connected, GigabitEthernet2/0
L        172.16.1.14/32 is directly connected, GigabitEthernet2/0
D     192.168.2.0/24 [90/3072] via 10.0.12.2, 00:11:09, GigabitEthernet0/0
      192.168.3.0/25 is subnetted, 1 subnets
D        192.168.3.0 [90/3072] via 10.0.13.2, 00:11:10, GigabitEthernet1/0
D     192.168.4.0/24 [90/3328] via 10.0.12.2, 00:11:09, GigabitEthernet0/0
```

EIGRP METRIC

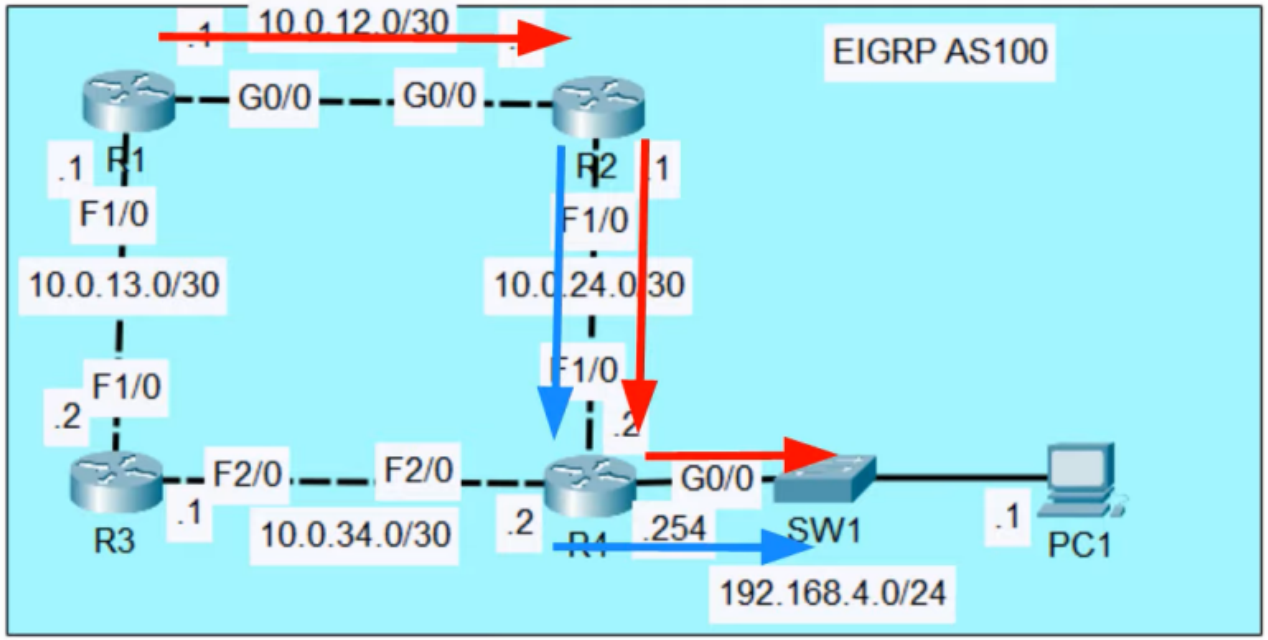
- By default, EIGRP uses **bandwidth** and **delay** to calculate metric.
- ([K1 * bandwidth + (K2 * bandwidth) / (256 - load) + K3 * delay] * [K5 / (reliability + K4)]) * 256
- The default 'K' values are K1 = 1, K2 = 0, K3 = 1, K4 = 0, K5 = 0
- You can simplify the formula like this: metric = bandwidth + delay



Bandwidth of the **slowest link**
+ the delay of **all links**

EIGRP TERMINOLOGY

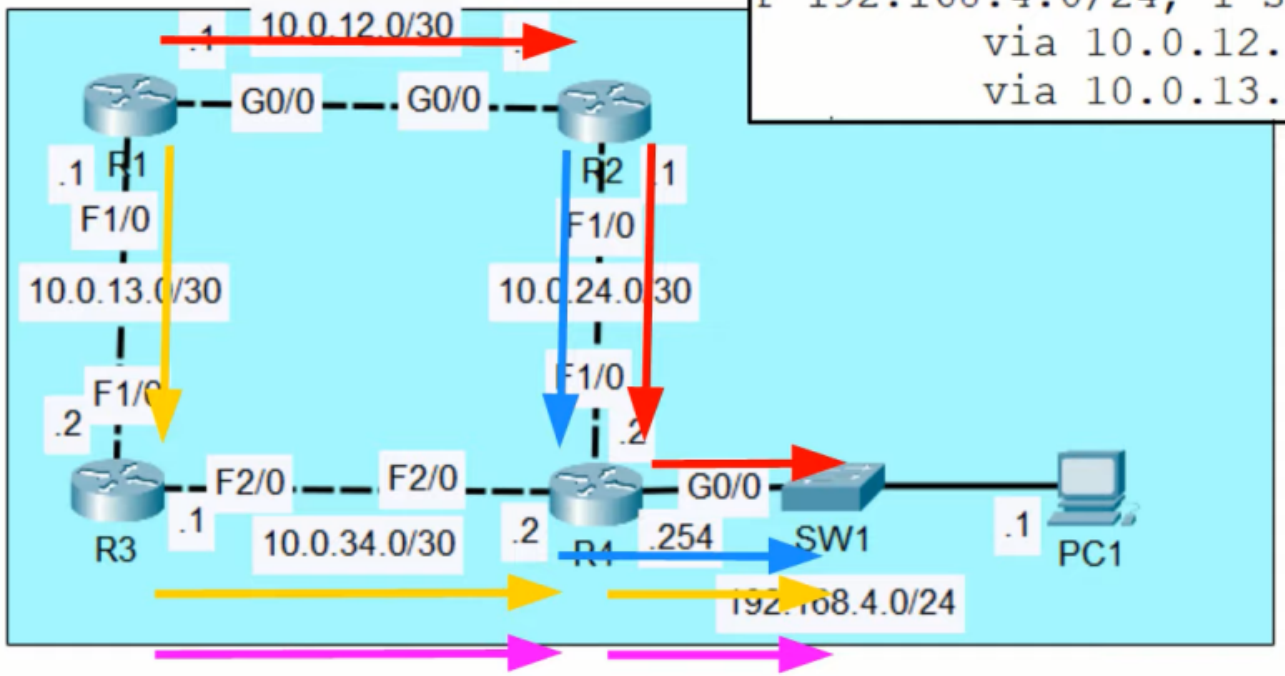
- **Feasible Distance** = This router's metric value to the route's destination.
- **Reported Distance** (aka Advertised Distance) = The neighbor's metric value to the route's destination.



EIGRP TERMINOLOGY

- **Feasible Distance** = This router's metric value to the route's destination.
- **Reported Distance** (aka Advertised Distance) = The neighbor's metric value to the route's destination.

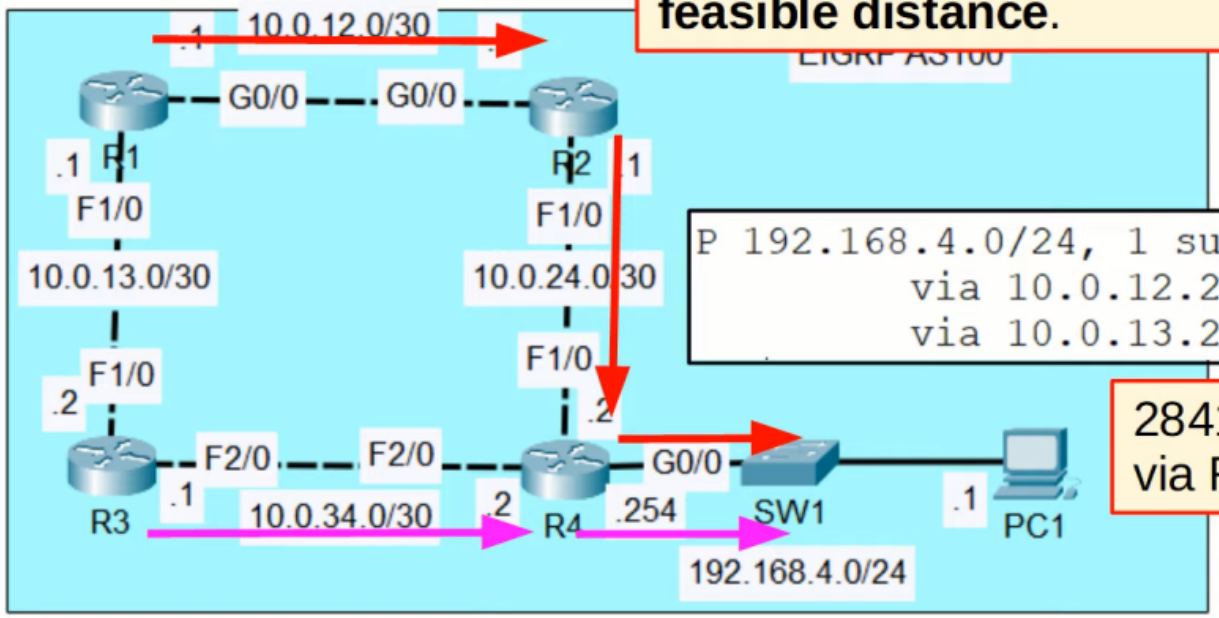
```
P 192.168.4.0/24, 1 successors, FD is 28672
        via 10.0.12.2 (28672/28416), GigabitEthernet0/0
        via 10.0.13.2 (30976/28416), FastEthernet1/0
```



EIGRP TERMINOLOGY

- **Successor** = the route with the lowest metric to the destination (the best route)
- **Feasible Successor** = an alternate route to the destination (not the best route) which meets the *feasibility condition*

Feasibility condition: A route is considered a **feasible successor** if it's **reported distance** is lower than the **successor** route's **feasible distance**.




```
P 192.168.4.0/24, 1 successors, FD is 28672
        via 10.0.12.2 (28672/28416), GigabitEthernet0/0
        via 10.0.13.2 (30976/28416), FastEthernet1/0
```

28416 is less than 28672, so the route via R3 is a **feasible successor**.

EIGRP UNEQUAL COST LOAD BALANCING

```
R1#show ip protocols

Routing Protocol is "eigrp  100 "
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
```

Variance 1 = only ECMP load-balancing will be performed

```
P 192.168.4.0/24, 1 successors, FD is 28672
        via 10.0.12.2 (28672/28416), GigabitEthernet0/0
        via 10.0.13.2 (30976/28416), FastEthernet1/0
```

EIGRP UNEQUAL COST LOAD BALANCING

```
R1(config-router)#variance ?
  <1-128>  Metric variance Multiplier
R1(config-router)#variance 2
```

Variance 2 = **feasible successor** routes with an FD up to 2x the **successor** route's FD can be used to load-balance.

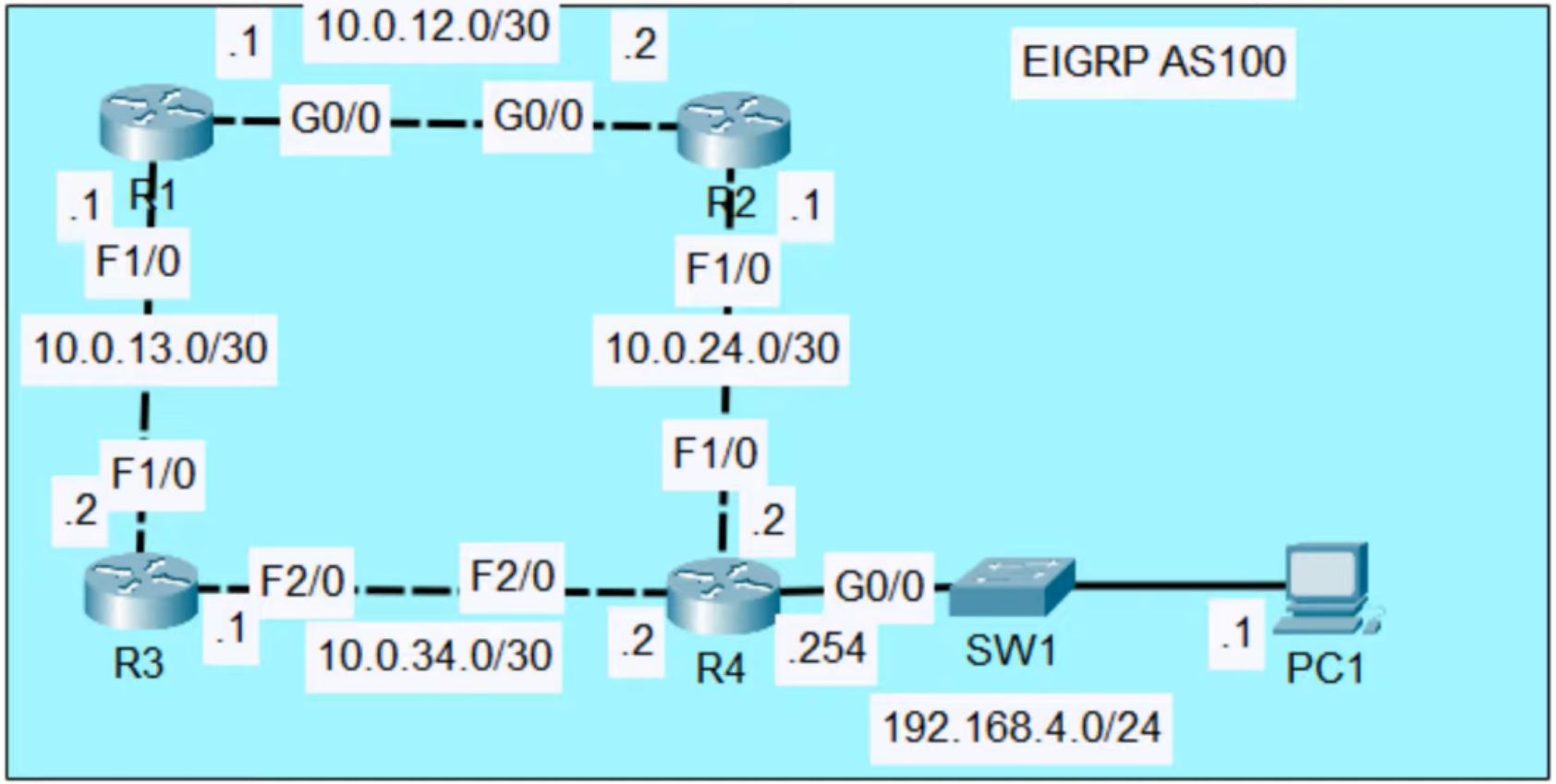
EIGRP will only perform unequal-cost load-balancing over **feasible successor** routes. If a route doesn't meet the feasibility requirement, it will NEVER be selected for load-balancing, regardless of the **variance**.

```
P 192.168.4.0/24, 1 successors, FD is 28672
        via 10.0.12.2 (28672/28416), GigabitEthernet0/0
        via 10.0.13.2 (30976/28416), FastEthernet1/0
```

28672 * 2 = 57344
30976 is less than 57344, so the route via R3 can now be used for load-balancing.

EIGRP UNEQUAL COST LOAD BALANCING

```
D    192.168.4.0/24 [90/28672 via 10.0.12.2, 00:11:21, GigabitEthernet0/0
                    [90/30976 via 10.0.13.2, 00:11:21, FastEthernet1/0
```



SUPPLEMENT: DIFFERENT DISTANCE-VECTOR ROUTING PROTOCOLS

- Routing Information Protocol (RIP)
  - RFC 1058.
  - Hop count is used as the metric for path selection.
  - If the hop count for a network is greater than 15, RIP cannot supply a route to that network.
  - Routing updates are broadcast or multicast every 30 seconds, by default.
- Interior Gateway Routing Protocol (IGRP)
  - Proprietary protocol developed by Cisco.
  - Bandwidth, delay, load and reliability are used to create a composite metric.
  - Routing updates are broadcast every 90 seconds, by default.
  - IGRP is the predecessor of EIGRP and is now obsolete.
- Enhanced Interior Gateway Routing Protocol (EIGRP)
  - Cisco proprietary distance vector routing protocol.
  - It can perform unequal cost load balancing.
  - It uses Diffusing Update Algorithm (DUAL) to calculate the shortest path.
  - There are no periodic updates as with RIP and IGRP. Routing updates are sent only when there is a change in the topology.