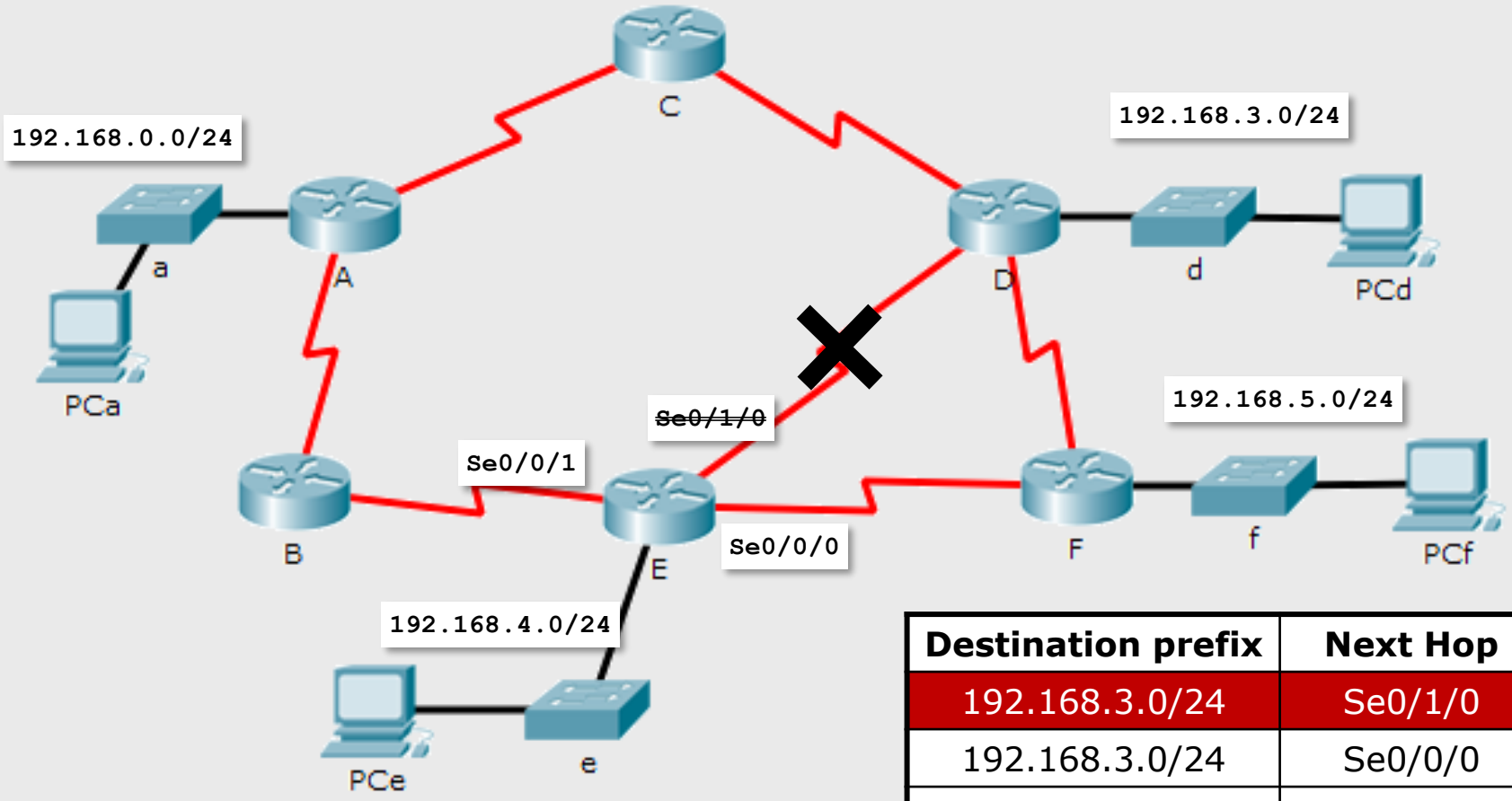
Lab5

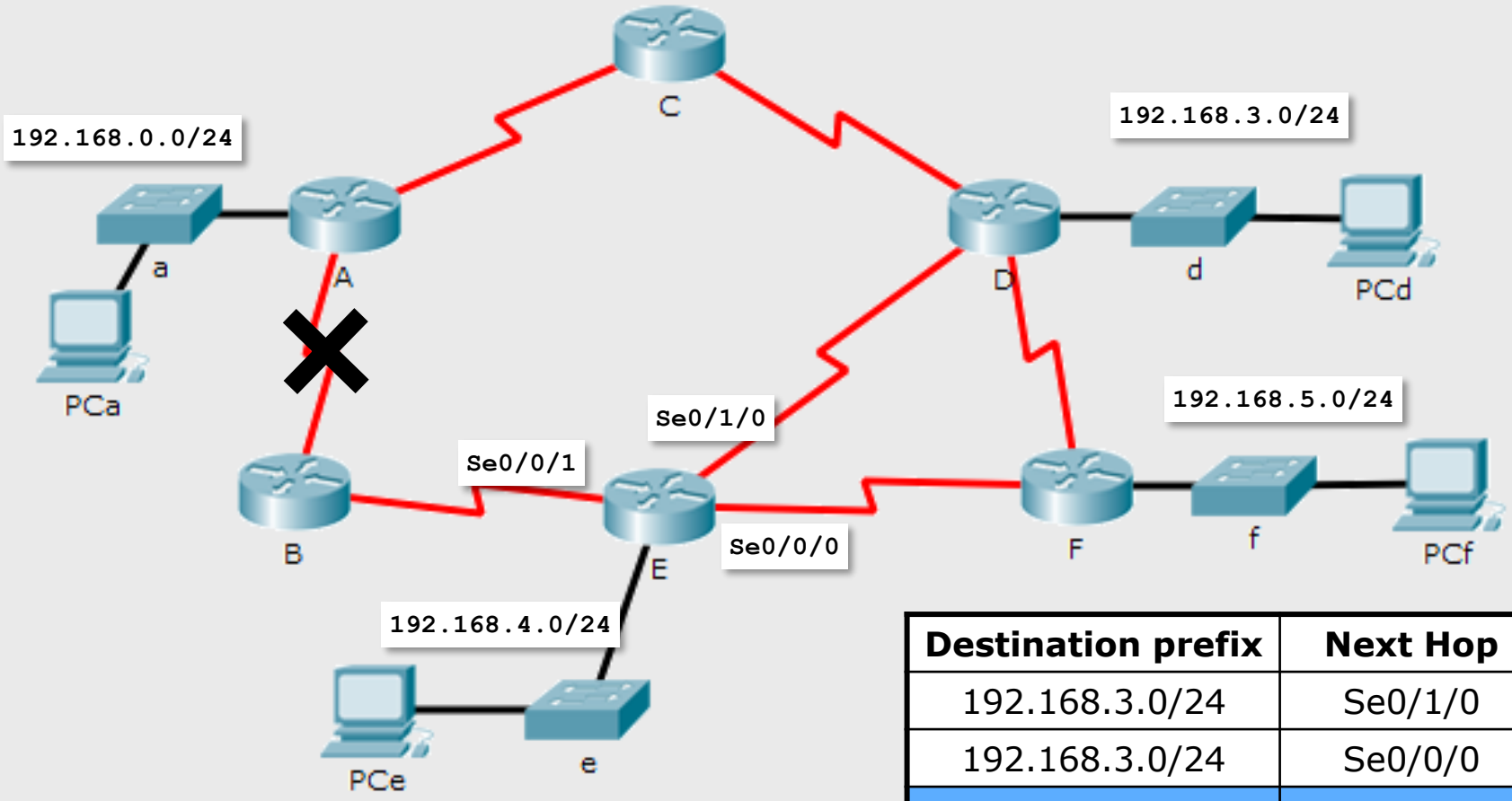
RIP routing protocol

Static routing limits



Destination prefix	Next Hop	Cost
192.168.3.0/24	Se0/1/0	30
192.168.3.0/24	Se0/0/0	40
192.168.0.0/24	Se0/0/1	30
192.168.0.0/24	Se0/1/0	40
192.168.5.0/24	Se0/0/0	30

Static routing limits



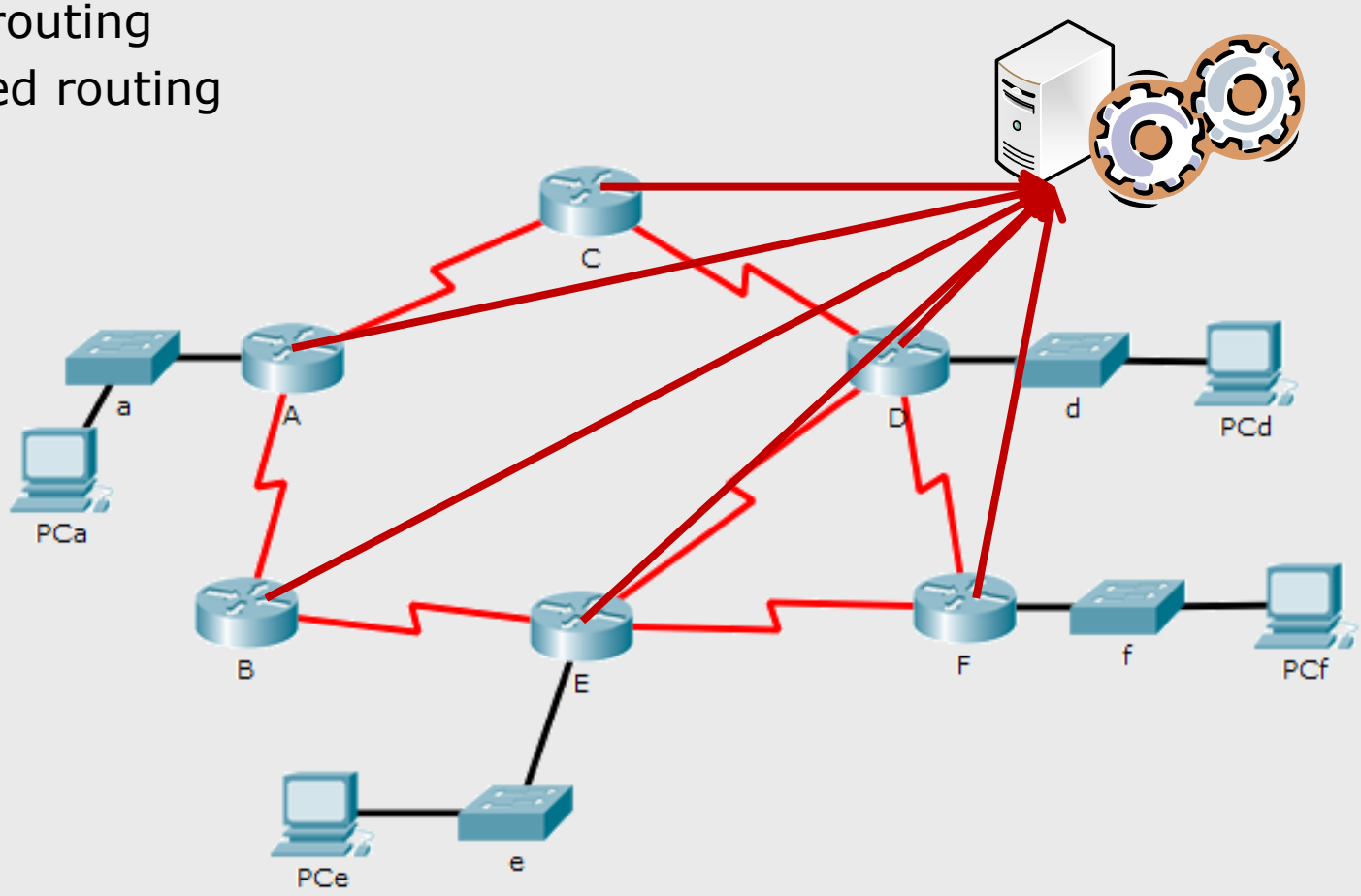
Destination prefix	Next Hop	Cost
192.168.3.0/24	Se0/1/0	30
192.168.3.0/24	Se0/0/0	40
192.168.0.0/24	Se0/0/1	30
192.168.0.0/24	Se0/1/0	40
192.168.5.0/24	Se0/0/0	30

Dynamic routing

- Routing tables are dynamically determined based on the computation done in the network according to a specific algorithm
  - Centralized routing
  - Isolated routing
  - Distributed routing

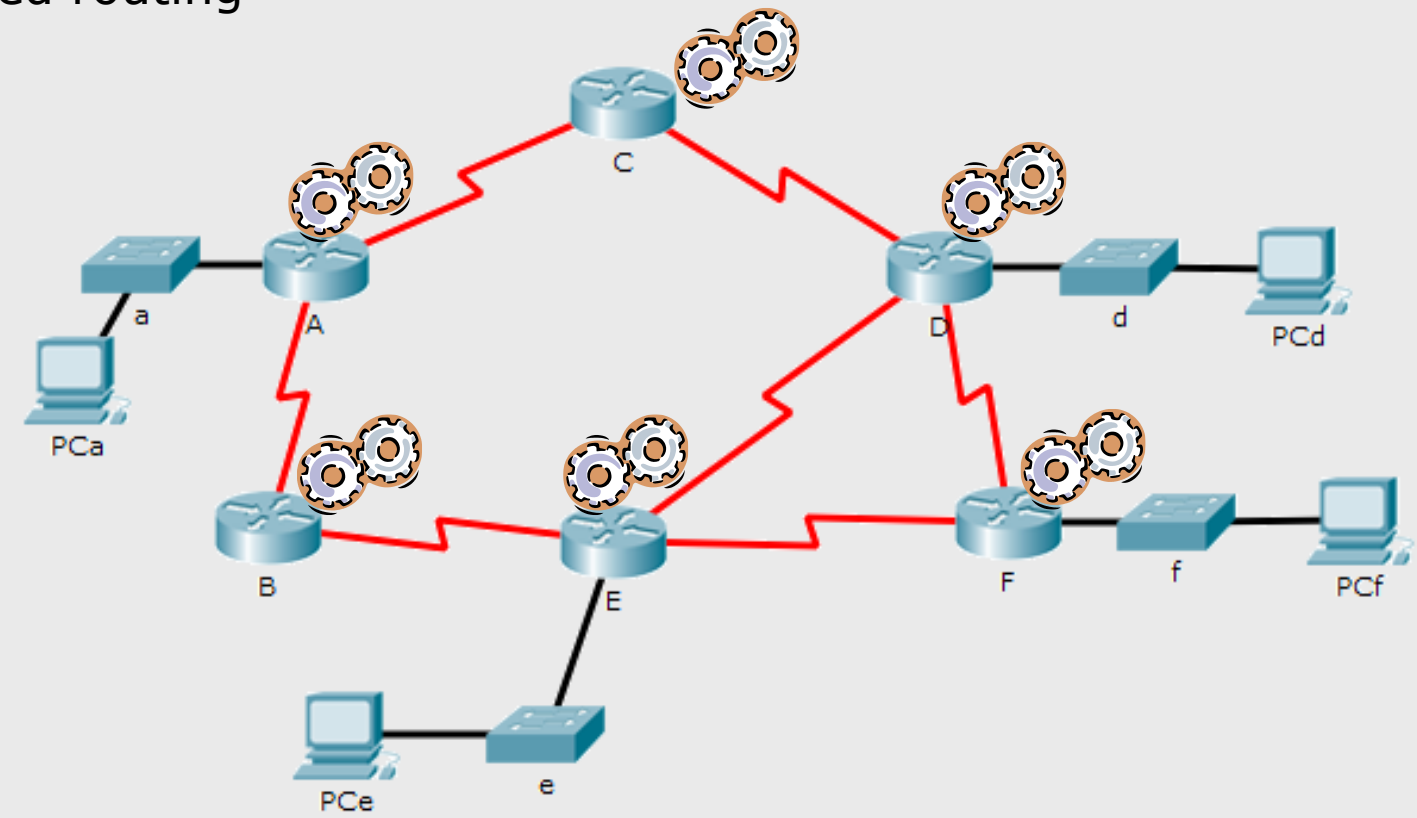
Centralized dynamic routing

- Routing tables are dynamically determined based on the computation done in the network according to a specific algorithm
  - **Centralized routing**: computation is done by a central unit and tables are then installed on all routers
  - Isolated routing
  - Distributed routing



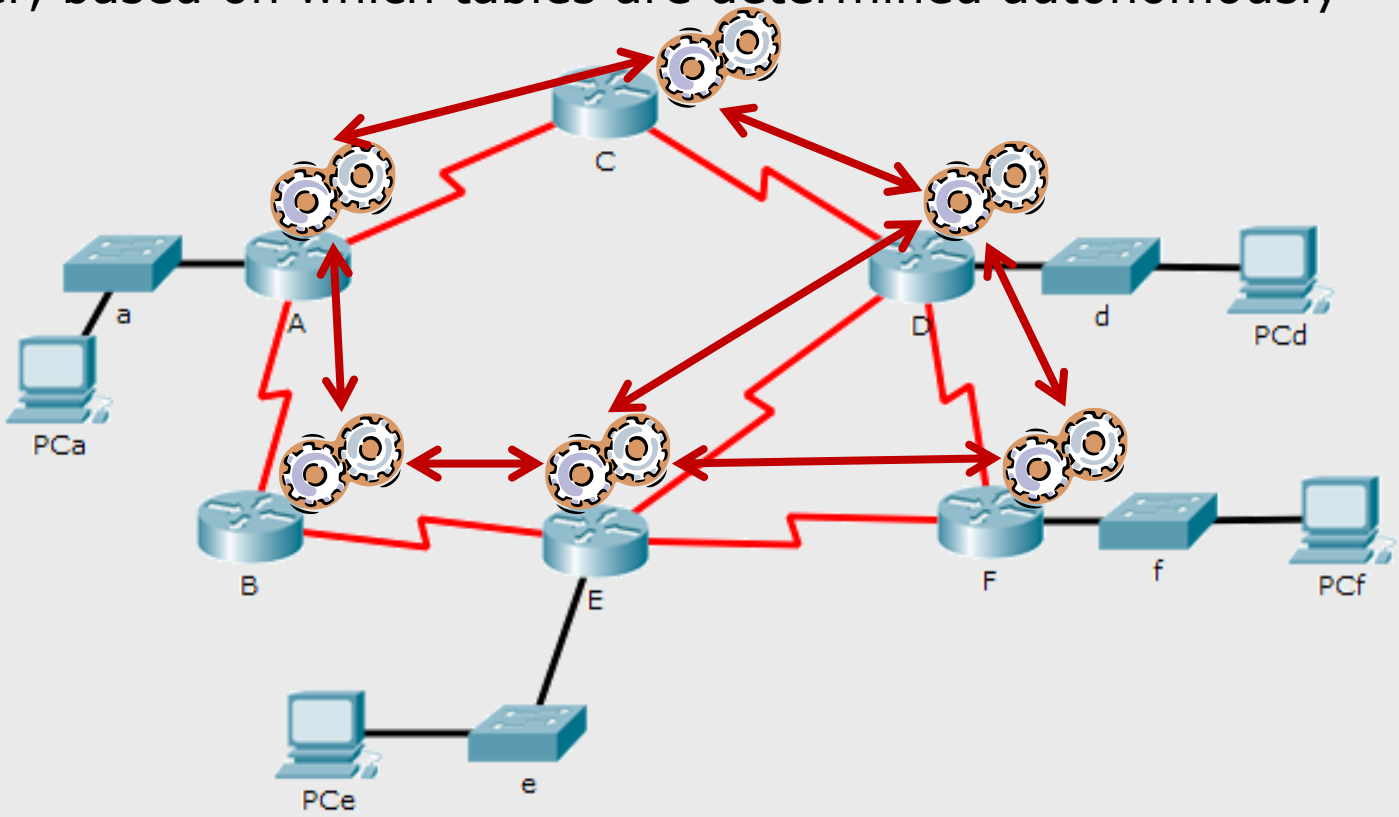
Isolated dynamic routing

- Routing tables are dynamically determined based on the computation done in the network according to a specific algorithm
  - Centralized routing
  - **Isolated routing**: each router builds its own table autonomously without interacting with other routers
  - Distributed routing

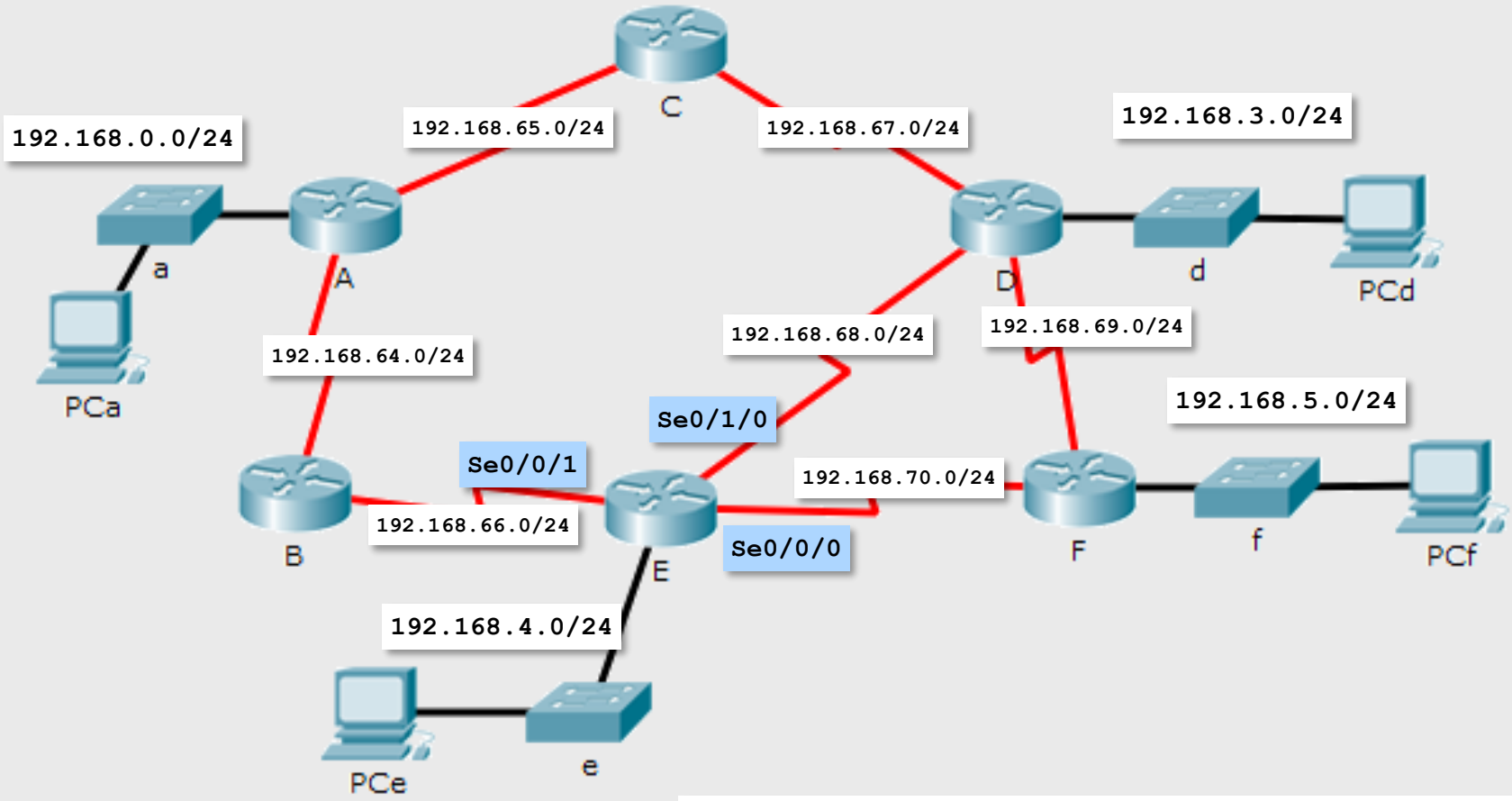


Distributed dynamic routing

- Routing tables are dynamically determined based on the computation done in the network according to a specific algorithm
  - Centralized routing
  - Isolated routing
  - **Distributed routing**: routers exchange topology information with each other, based on which tables are determined autonomously



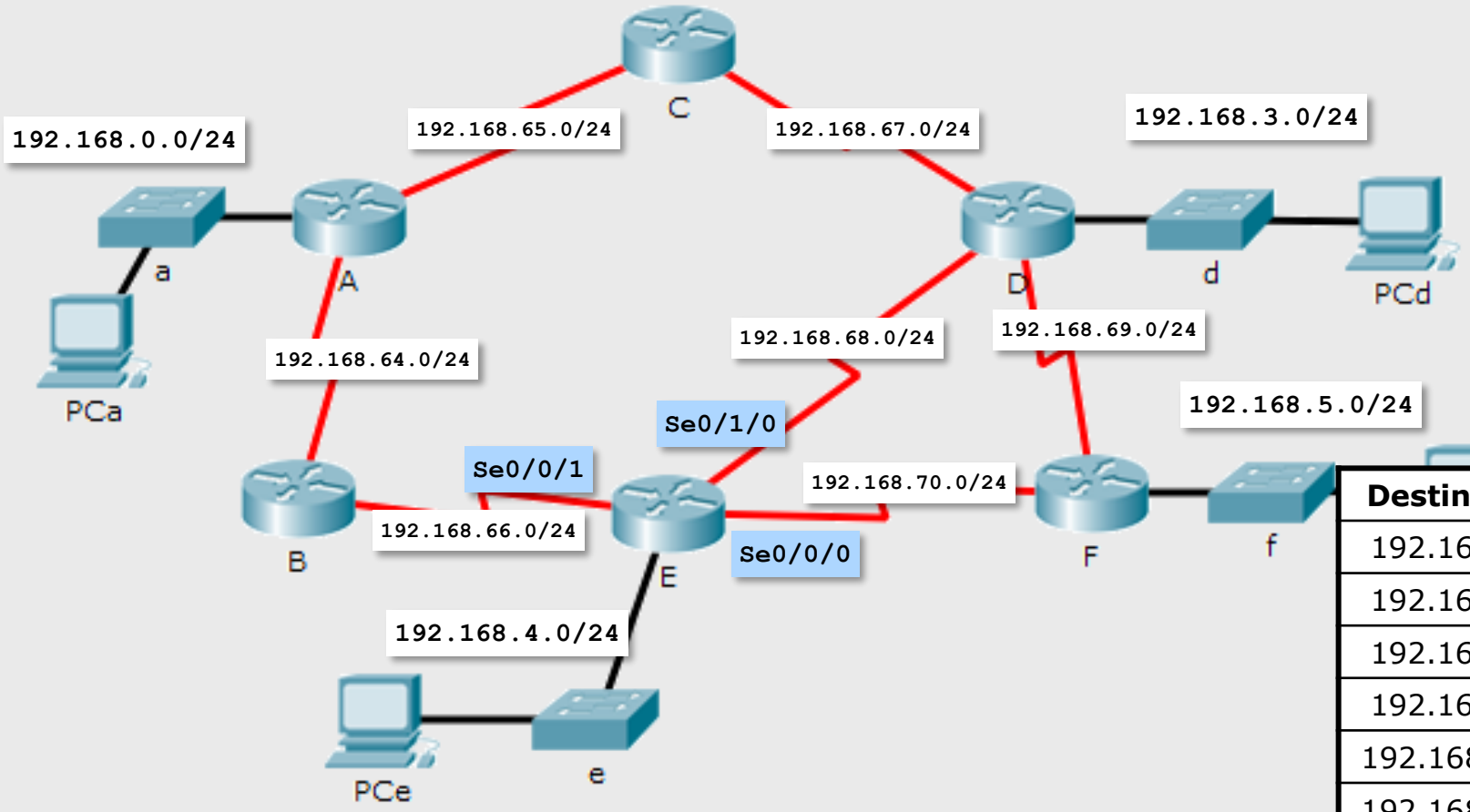
Distance Vector



Distance metric: ***hop count***

- The hop count is the number of routers that can be traversed in a route
- A directly connected network has a metric of zero
- *An unreachable network has a metric of 16*

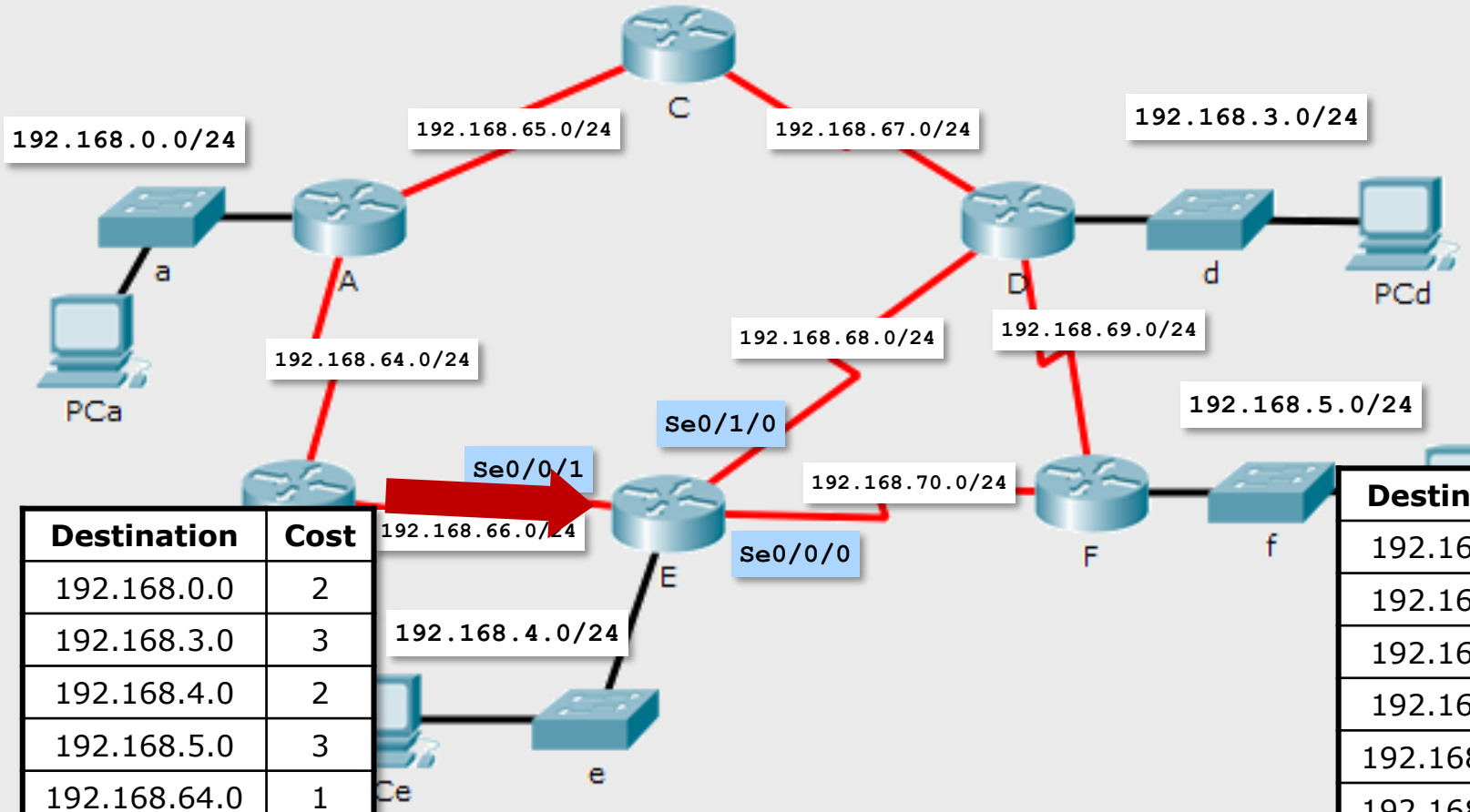
Distance Vector



Destination	Cost
192.168.0.0	1
192.168.3.0	2
192.168.4.0	1
192.168.5.0	2
192.168.64.0	0
192.168.65.0	1
192.168.66.0	0
192.168.67.0	2
192.168.68.0	1
192.168.69.0	2
192.168.70.0	1

Routing table (B)

Distance Vector



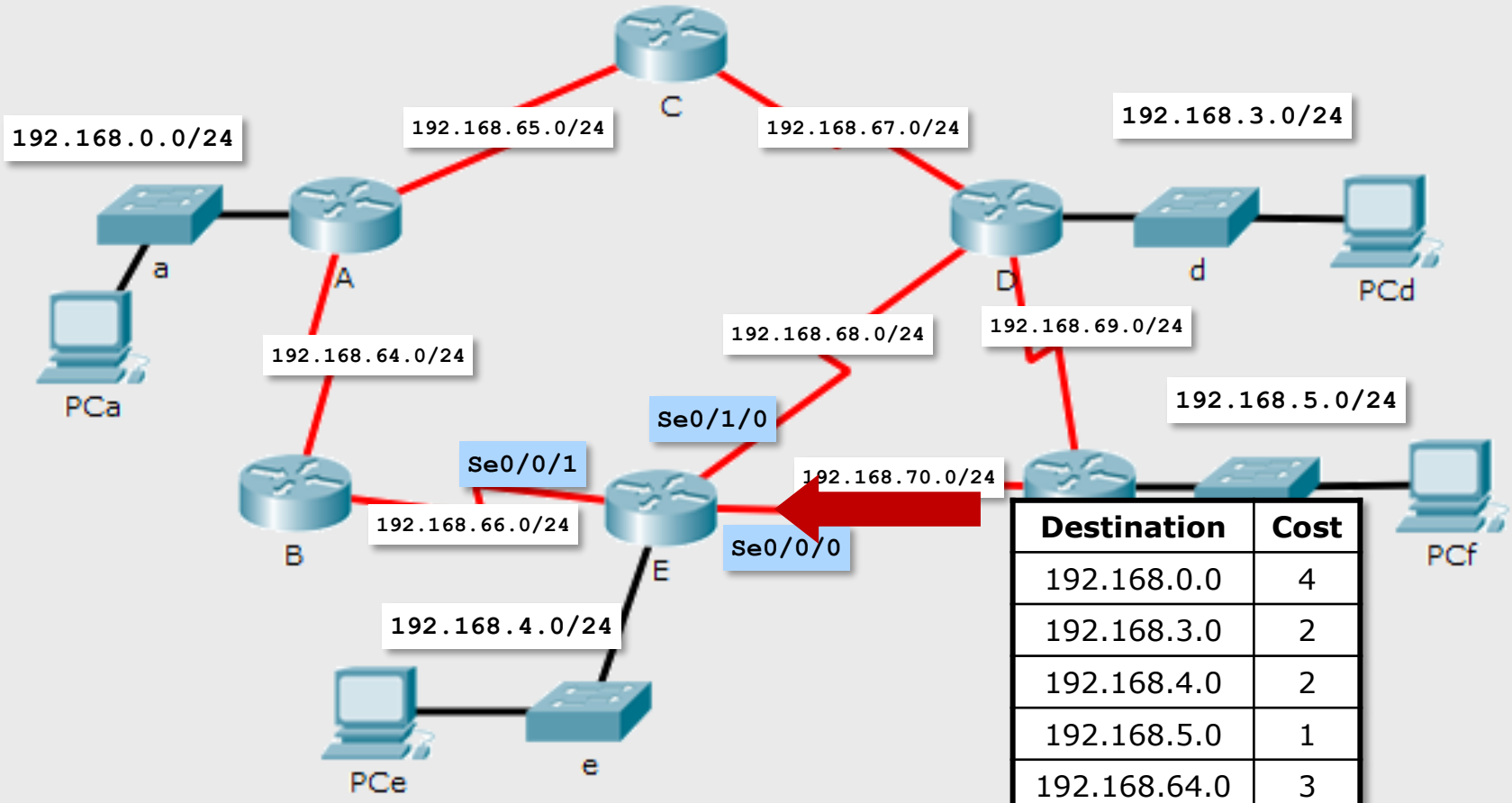
DV from **192.168.66.1** on **Se0/0/1** (E)

Destination	Cost
192.168.0.0	2
192.168.3.0	3
192.168.4.0	2
192.168.5.0	3
192.168.64.0	1
192.168.65.0	2
192.168.67.0	3
192.168.68.0	2
192.168.69.0	3
192.168.70.0	2

Routing table (B)

Destination	Cost
192.168.0.0	1
192.168.3.0	2
192.168.4.0	1
192.168.5.0	2
192.168.64.0	0
192.168.65.0	1
192.168.66.0	0
192.168.67.0	2
192.168.68.0	1
192.168.69.0	2
192.168.70.0	1

Distance Vector



DV from **192.168.70.2** on **Se0/0/0** (E)

Destination	Cost
192.168.0.0	4
192.168.3.0	2
192.168.4.0	2
192.168.5.0	1
192.168.64.0	3
192.168.65.0	3
192.168.66.0	2
192.168.67.0	2
192.168.68.0	2
192.168.69.0	1

Distance Vector merging

DV from **192.168.66.1** on **Se0/0/1**

Destination	Cost
192.168.0.0	2
192.168.3.0	3
192.168.4.0	2
192.168.5.0	3
192.168.64.0	1
192.168.65.0	2
192.168.67.0	3
192.168.68.0	2
192.168.69.0	3
192.168.70.0	2

DV from **192.168.70.2** on **Se0/0/0**

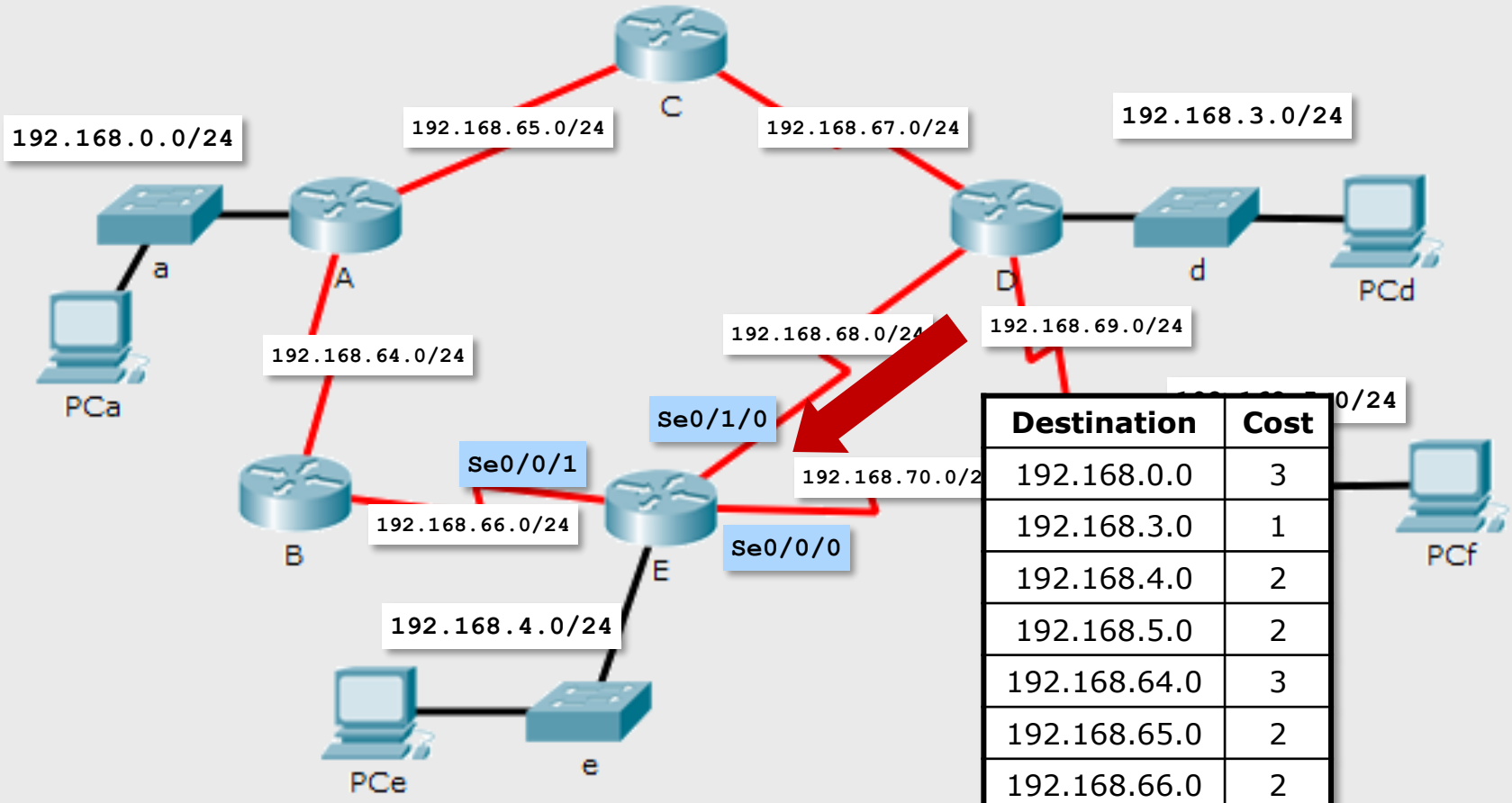
Destination	Cost
192.168.0.0	4
192.168.3.0	2
192.168.4.0	2
192.168.5.0	1
192.168.64.0	3
192.168.65.0	3
192.168.66.0	2
192.168.67.0	2
192.168.68.0	2
192.168.69.0	1

Destination	Next Hop	Cost
192.168.0.0	Se0/0/1	2
192.168.3.0	Se0/0/0	2
192.168.4.0	Fa0/0	0
192.168.5.0	Se0/0/0	1
192.168.64.0	Se0/0/1	1
192.168.65.0	Se0/0/1	2
192.168.66.0	Se0/0/1	0
192.168.67.0	Se0/0/0	2
192.168.68.0	Se0/1/0	0
192.168.69.0	Se0/0/0	1
192.168.70.0	Se0/0/0	0

DV (auto)

Destination	Cost
192.168.4.0	0
192.168.66.0	0
192.168.68.0	0
192.168.70.0	0

Distance Vector

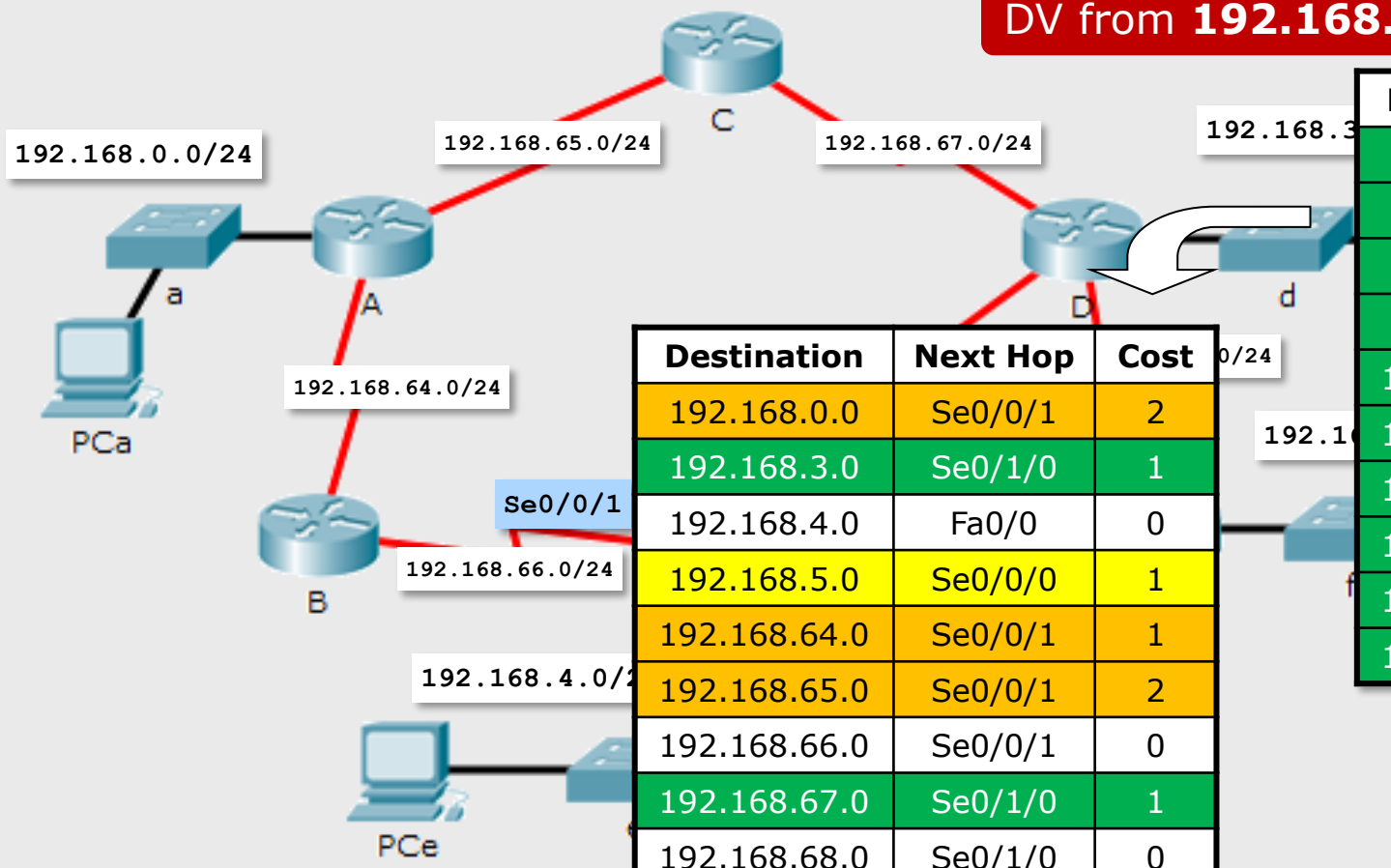


Destination	Cost
192.168.0.0	3
192.168.3.0	1
192.168.4.0	2
192.168.5.0	2
192.168.64.0	3
192.168.65.0	2
192.168.66.0	2
192.168.67.0	1
192.168.69.0	1
192.168.70.0	2

DV from **192.168.68.1** on **Se0/1/0**

Distance Vector merging

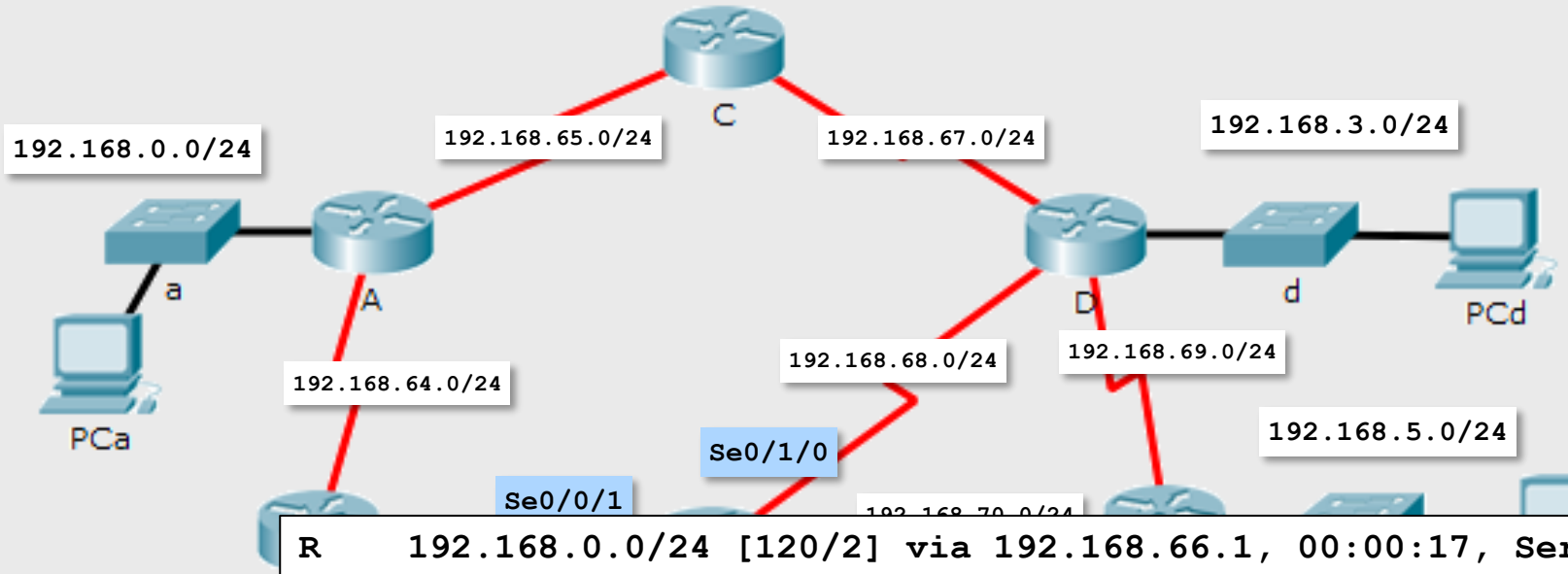
DV from **192.168.68.1** on **Se0/1/0**



Destination	Next Hop	Cost
192.168.0.0	Se0/0/1	2
192.168.3.0	Se0/1/0	1
192.168.4.0	Fa0/0	0
192.168.5.0	Se0/0/0	1
192.168.64.0	Se0/0/1	1
192.168.65.0	Se0/0/1	2
192.168.66.0	Se0/0/1	0
192.168.67.0	Se0/1/0	1
192.168.68.0	Se0/1/0	0
192.168.69.0	Se0/0/0	1
192.168.70.0	Se0/0/0	0

Destination	Cost
192.168.0.0	3
192.168.3.0	1
192.168.4.0	2
192.168.5.0	2
192.168.64.0	3
192.168.65.0	2
192.168.66.0	2
192.168.67.0	1
192.168.69.0	1
192.168.70.0	2

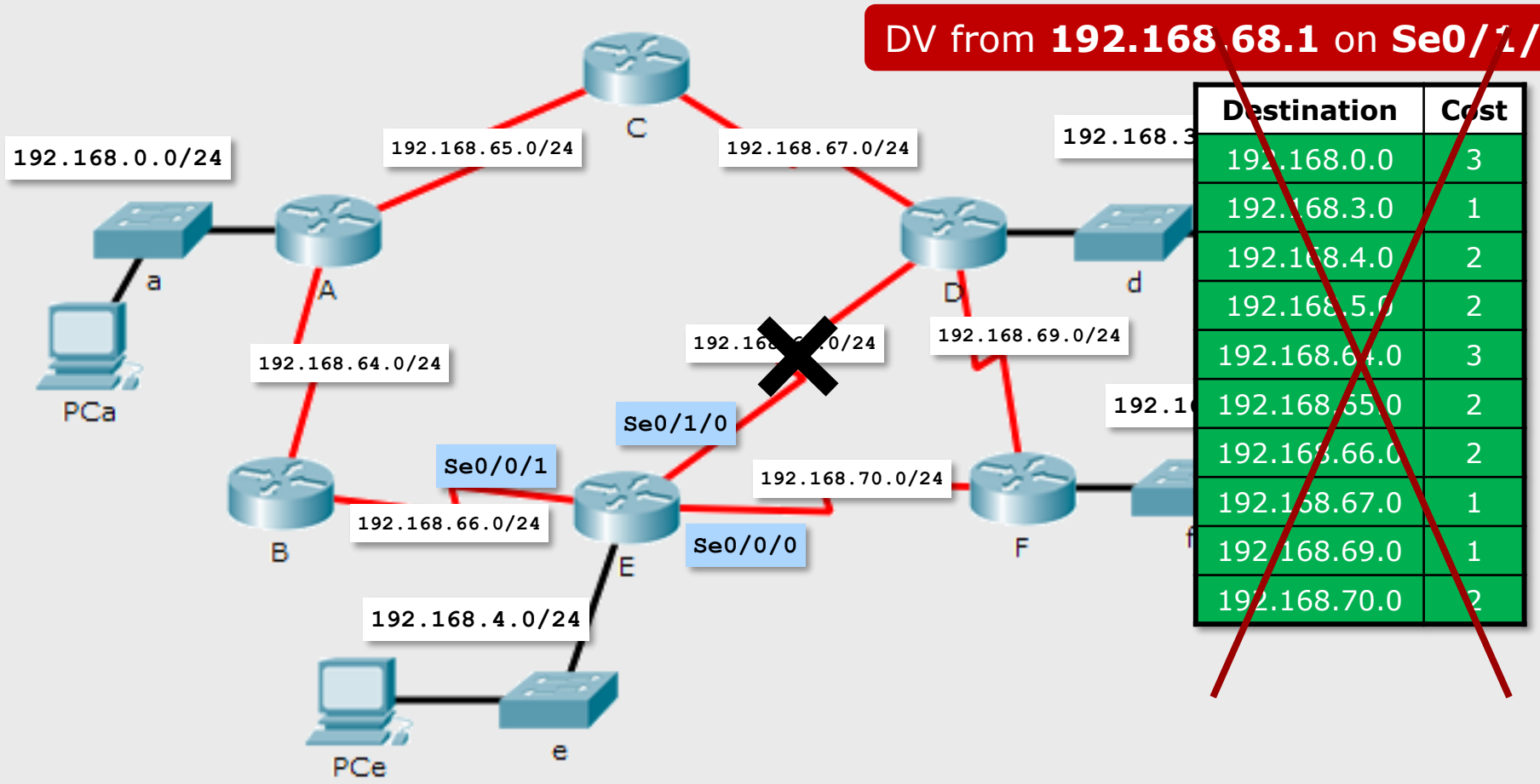
Distance Vector merging



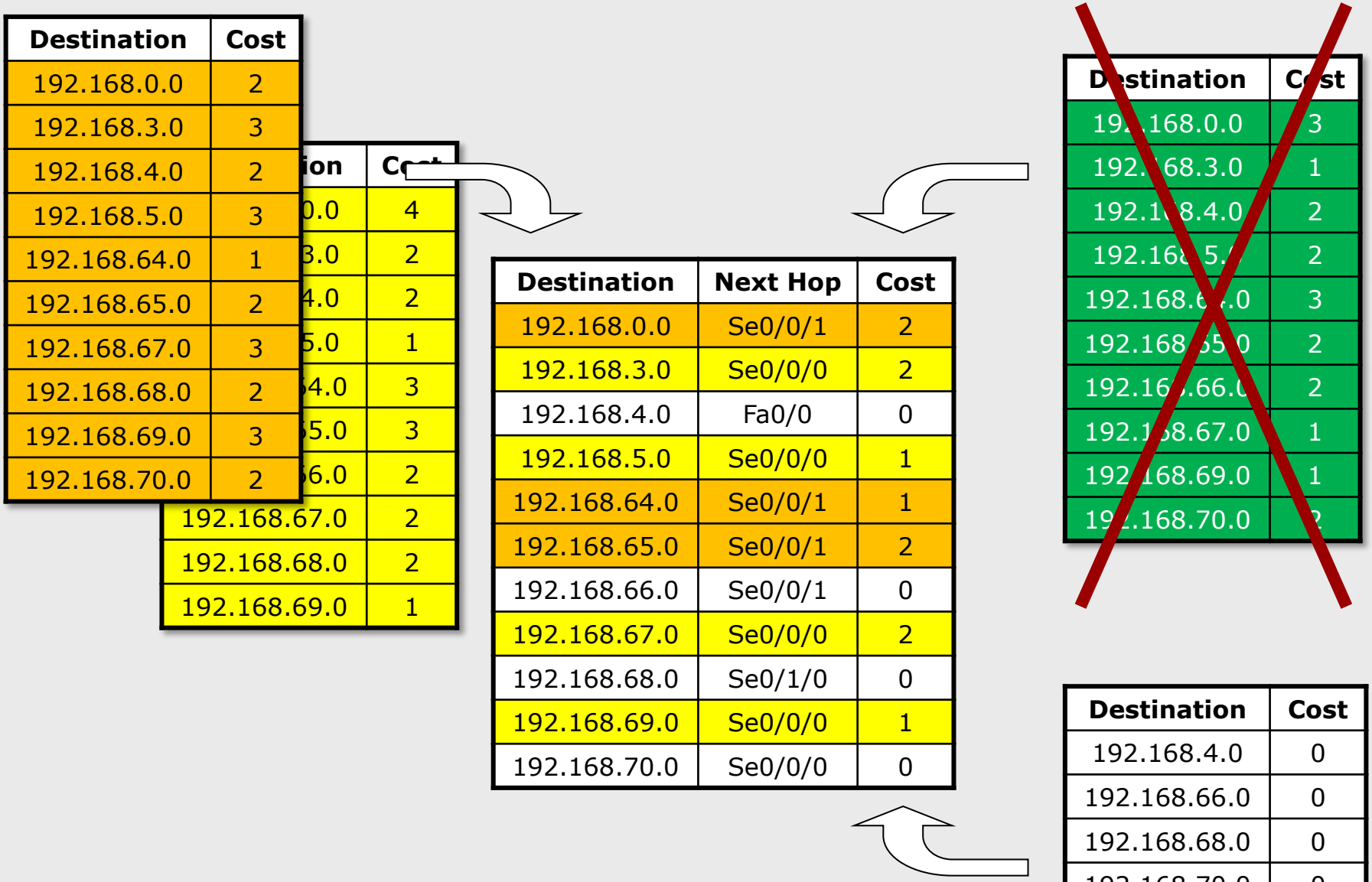

```
R    192.168.0.0/24 [120/2] via 192.168.66.1, 00:00:17, Serial0/0/1
R    192.168.3.0/24 [120/1] via 192.168.68.1, 00:00:15, Serial0/1/0
C    192.168.4.0/24 is directly connected, FastEthernet0/0
R    192.168.5.0/24 [120/1] via 192.168.70.2, 00:00:17, Serial0/0/0
R    192.168.64.0/24 [120/1] via 192.168.66.1, 00:00:17, Serial0/0/1
R    192.168.65.0/24 [120/2] via 192.168.66.1, 00:00:17, Serial0/0/1
                     [120/2] via 192.168.68.1, 00:00:15, Serial0/1/0
C    192.168.66.0/24 is directly connected, Serial0/0/1
R    192.168.67.0/24 [120/1] via 192.168.68.1, 00:00:15, Serial0/1/0
C    192.168.68.0/24 is directly connected, Serial0/1/0
R    192.168.69.0/24 [120/1] via 192.168.70.2, 00:00:17, Serial0/0/0
                     [120/1] via 192.168.68.1, 00:00:15, Serial0/1/0
C    192.168.70.0/24 is directly connected, Serial0/0/0
```

Routing table (E)

Topology change



Topology change

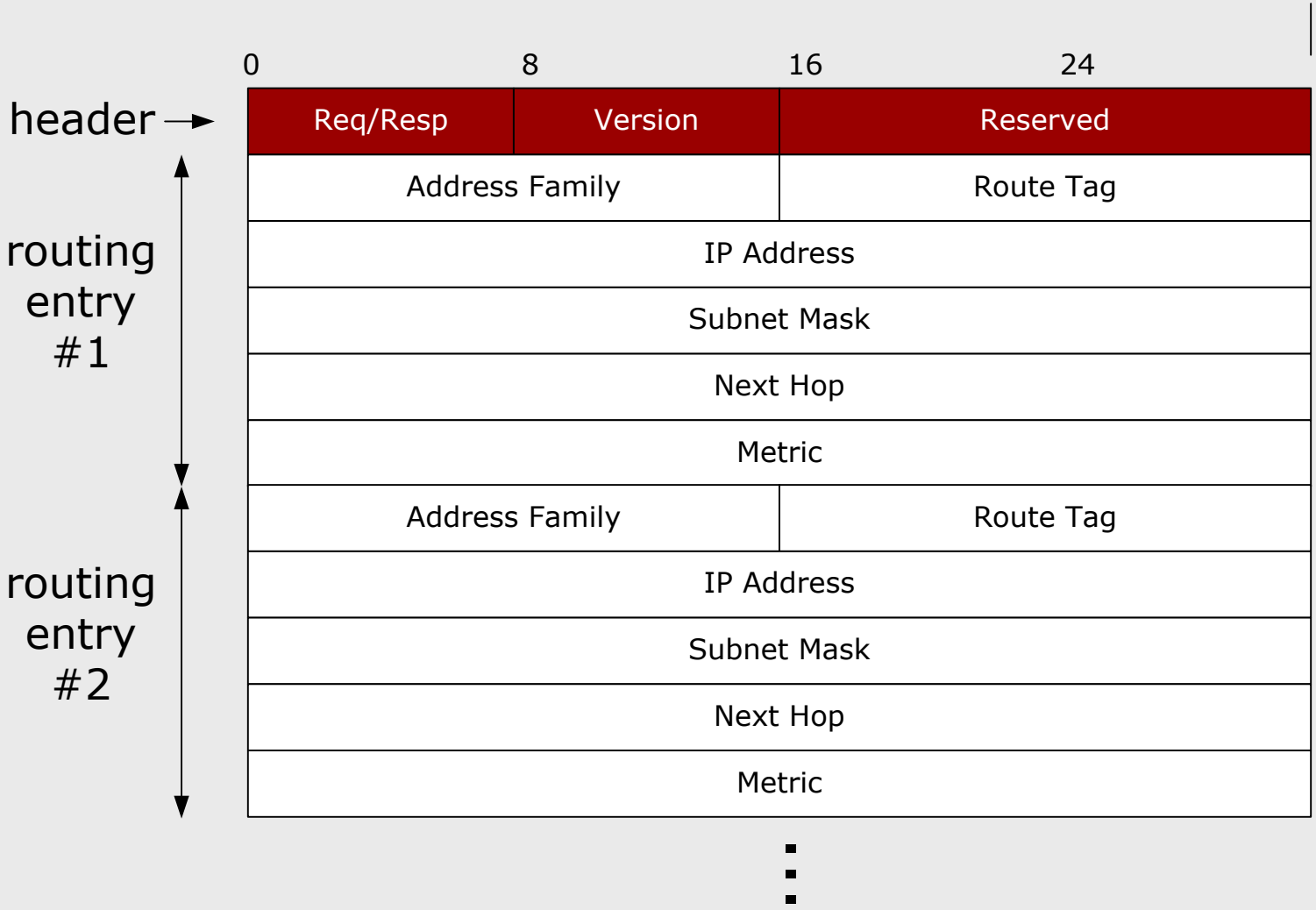


RIP (Routing Information Protocol)

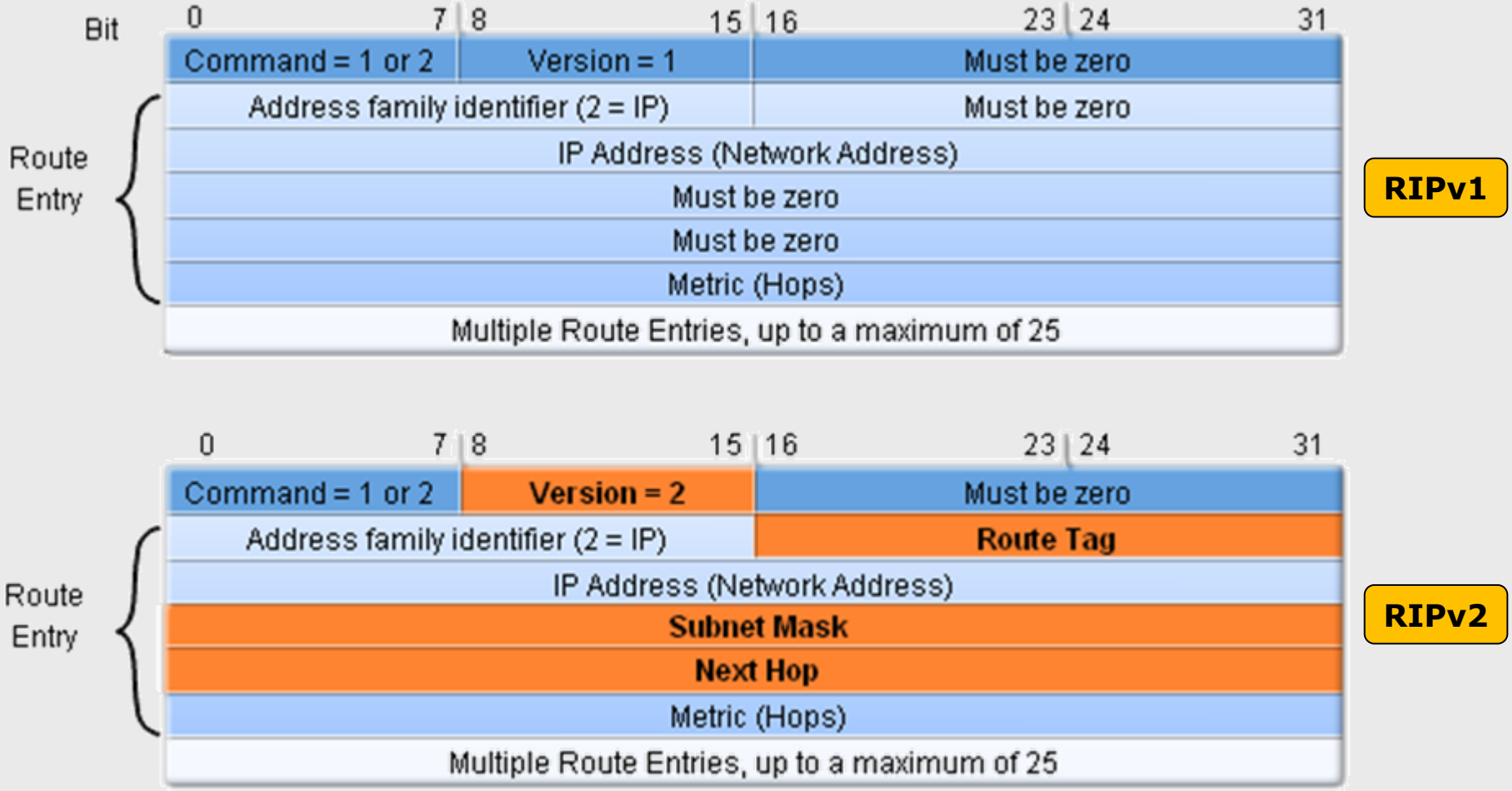
- RIP is the oldest *distance vector* IP routing protocol
- Versions
  - RIP v1 [RFC 1058] – classful IP addressing
  - **RIP v2** [RFC 2453] – extends RIPv1 to support VLSM
- RIP routers exchange information in order to build the routing table (named ***routing database*** in IETF documents)
- Exchanged messages are named ***routing updates***, sent periodically (30 s) or after a topology change, in UDP datagrams addressed to port 520
- RIP routing metric is the **"the sum of the costs of the networks to traverse"** in order to get to the destination
  - Maximum cost is **15**
  - A cost equal to **16** means 'destination unreachable' (infinite distance)
- Both IOS and JUNOS measure the cost of a path as **the number of routers to traverse** in order to get to the destination

RIPv2 – packet format

- RIPv2 messages are sent to the reserved IP multicast address 224.0.0.9



RIPv2 vs. RIPv1



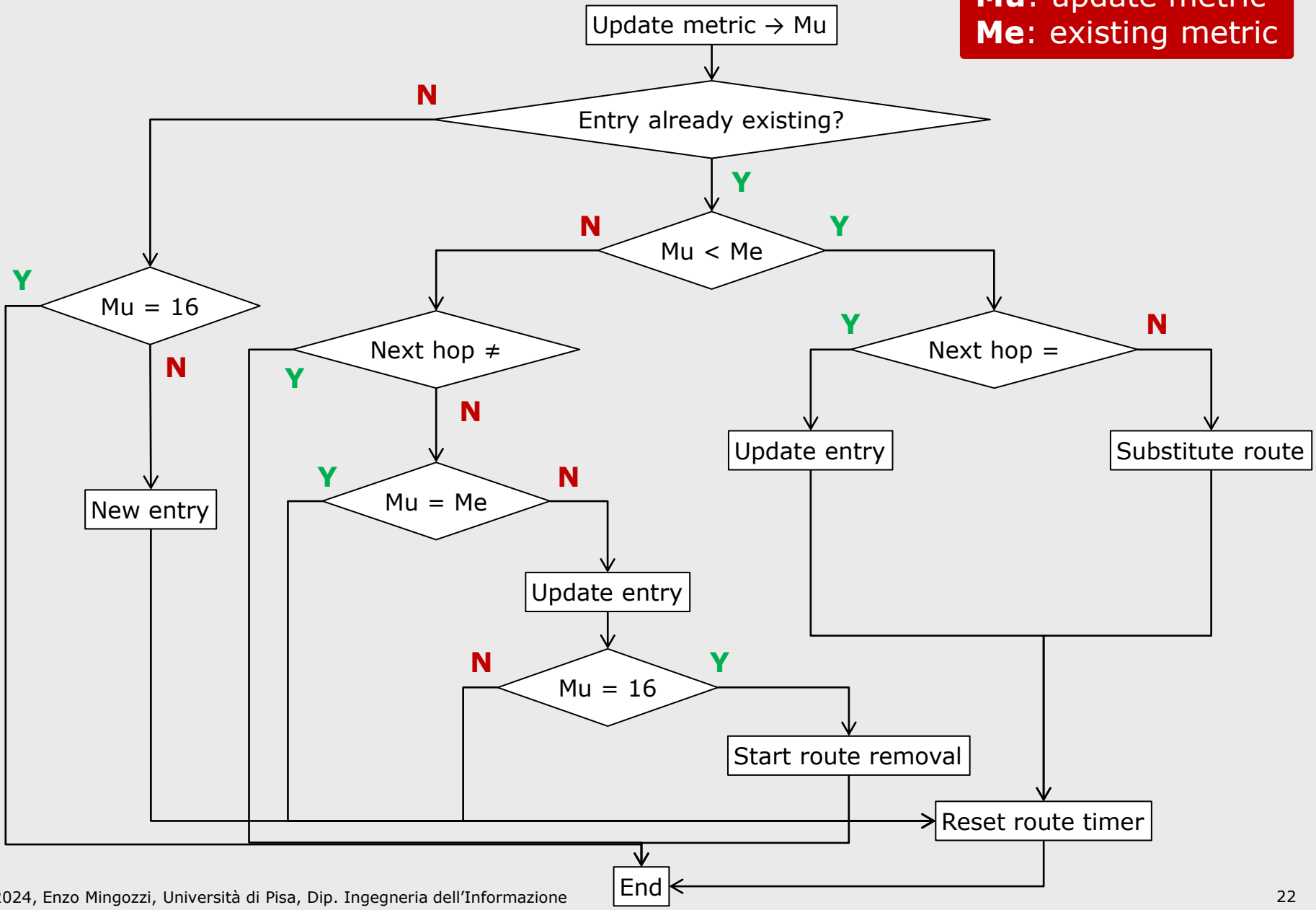
Routing table

- Network address and mask
- Next hop address and exit interface
- Metric
- *Route timer* – time since last received update

```
RouterA#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 172.17.0.0/16 is directly connected, Serial0
C 172.18.0.0/16 is directly connected, Ethernet0
R 172.16.0.0/16 [120/3] via 172.17.1.1, 00:00:27, Serial0
…
```

Routing update calculation

Mu: update metric
Me: existing metric

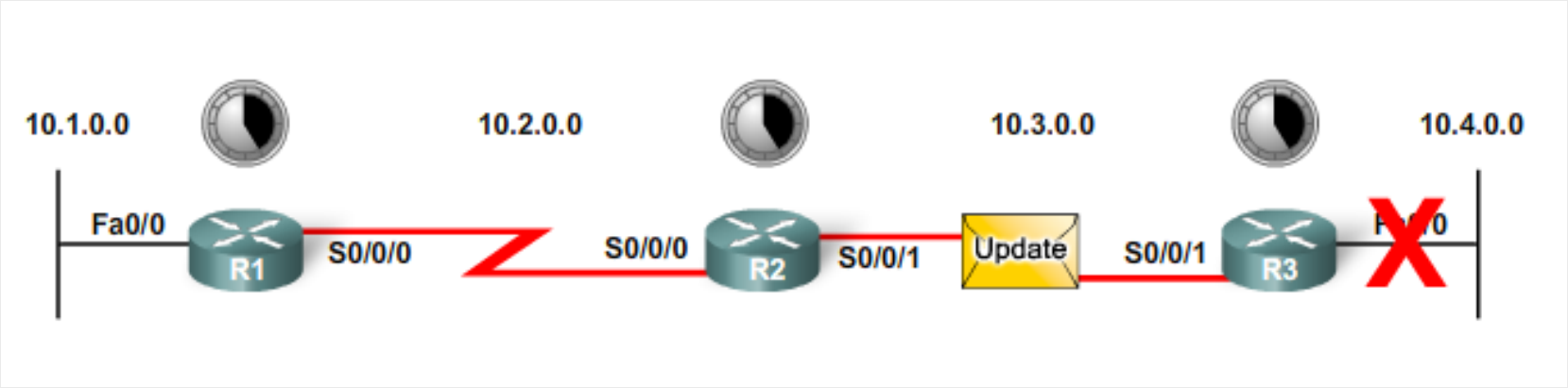


RIP timers

- ***update timer*** (30s): sending period of routing updates
- ***route timer*** (180s) [*IOS: invalid timer (180s)*]: max time of validity of a route.
  - If an update has not been received to refresh an existing route before the timer expires, the route is marked as invalid by setting the metric to 16
- ***holddown timer*** (120s) [*IOS: (180s)*]
  - Started when a route is marked as unreachable
    - the route timer expires, or
    - a routing update with metric 16 is received
  - During this time, the route is advertised with metric 16
    - long enough for all routers in the topology to learn about the unreachable network
  - Until either the timer expires (route is removed) or a routing update with a better metric is received
- *[IOS: flush timer (240s)]: controls route removal independently of the holddown timer*

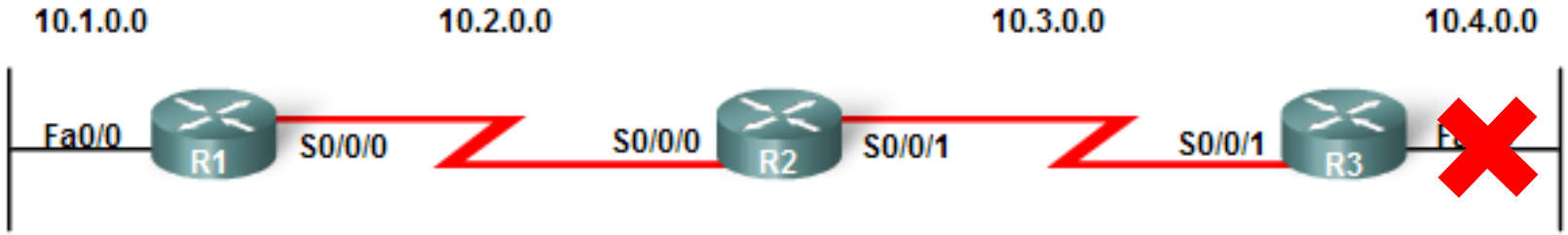
RIP timers

- ***Triggered update***: after a topology change, a routing update is sent before waiting the routing timer expiration
  - An interface changes state (up or down)
  - A route has entered (or exited) the "unreachable" state
  - A route is installed in the routing table



Counting to infinity

- A *Routing Update* from R1 arrives to R2 before R2 propagates the information about non reachability of 10.4.0.0



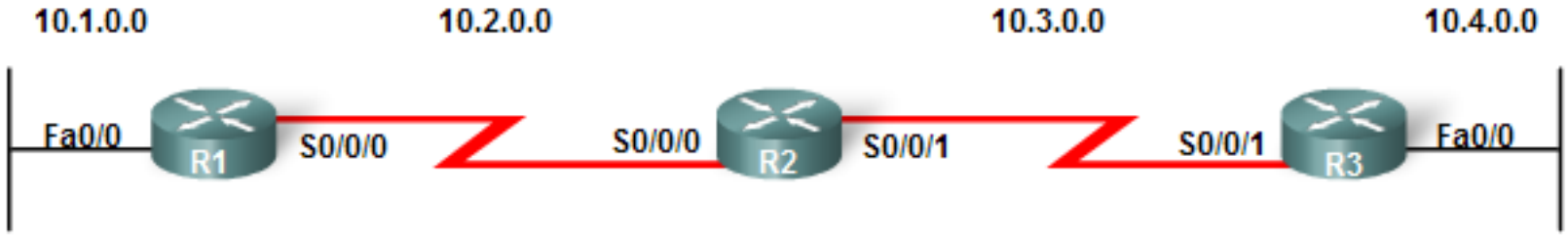
Network	Interface	Hop
10.1.0.0	Fa0/0	0
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/0	1
10.4.0.0	S0/0/0	2

Network	Interface	Hop
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/1	0
10.1.0.0	S0/0/0	1
10.4.0.0	S0/0/1	16

Network	Interface	Hop
10.3.0.0	S0/0/1	0
~~10.4.0.0~~	~~Fa0/0~~	~~0~~
10.2.0.0	S0/0/1	1
10.1.0.0	S0/0/1	2

Countermeasures in RIP

- ***Split horizon***: a route should not be advertised through the interface from which the update originated



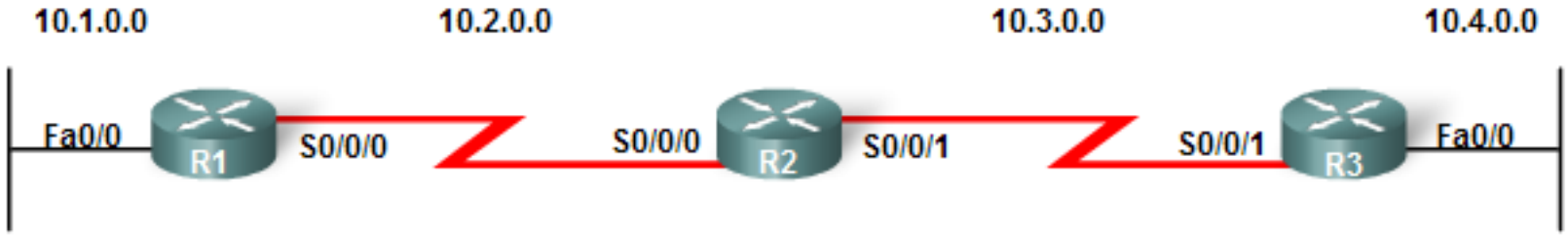
Network	Interface	Hop
10.1.0.0	Fa0/0	0
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/0	1
10.4.0.0	S0/0/0	2

Network	Interface	Hop
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/1	0
10.1.0.0	S0/0/0	1
10.4.0.0	S0/0/1	1

Network	Interface	Hop
10.3.0.0	S0/0/1	0
10.4.0.0	Fa0/0	0
10.2.0.0	S0/0/1	1
10.1.0.0	S0/0/1	2

Countermeasures in RIP

- ***Split horizon with poisoned reverse***: a route is advertised with metric 16 through the interface from which the update originated



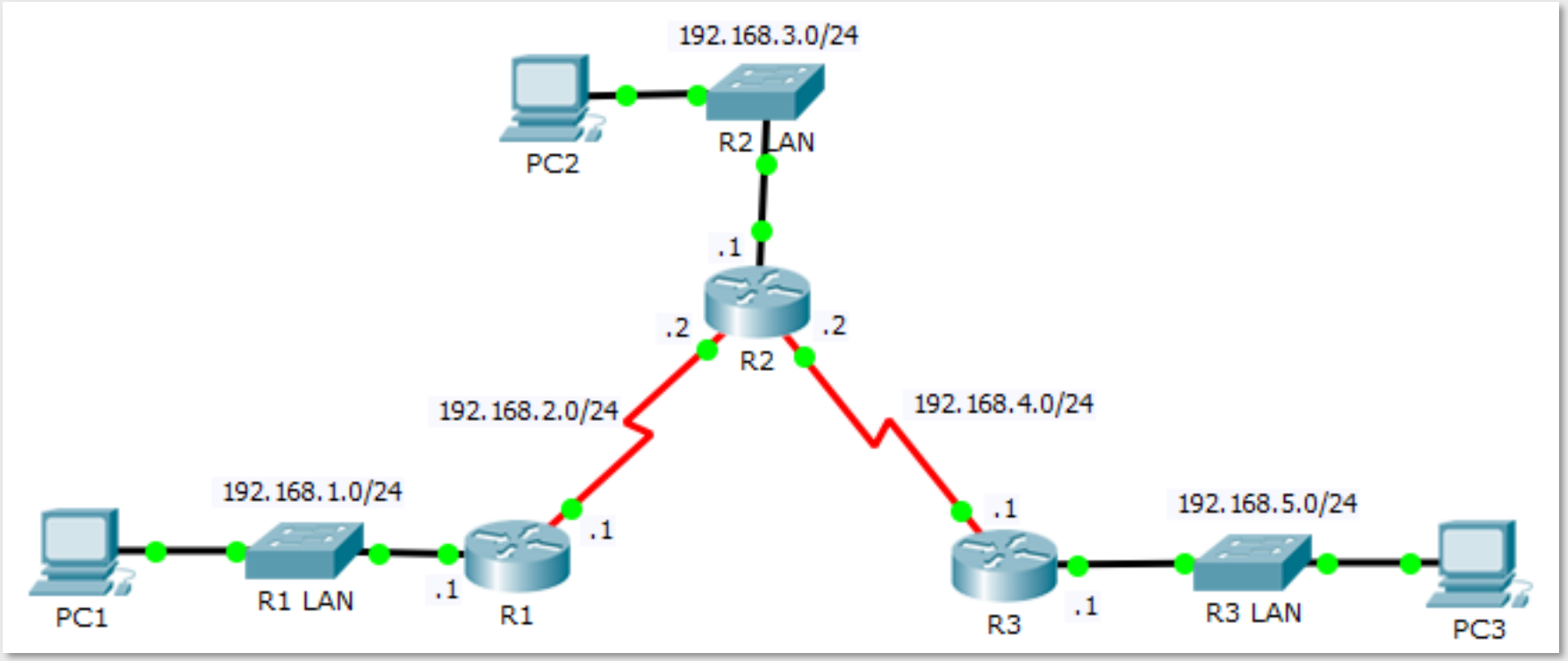
Network	Interface	Hop
10.1.0.0	Fa0/0	0
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/0	1
10.4.0.0	S0/0/0	2

Network	Interface	Hop
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/1	0
10.1.0.0	S0/0/0	1
10.4.0.0	S0/0/1	1

Network	Interface	Hop
10.3.0.0	S0/0/1	0
10.4.0.0	Fa0/0	0
10.2.0.0	S0/0/1	1
10.1.0.0	S0/0/1	2

IOS RIP configuration

- Reference topology



IOS RIP configuration

- The command only provides access to routing configuration, does not start the RIP process
  - **`no router rip`** stops the process and erases all existing configurations

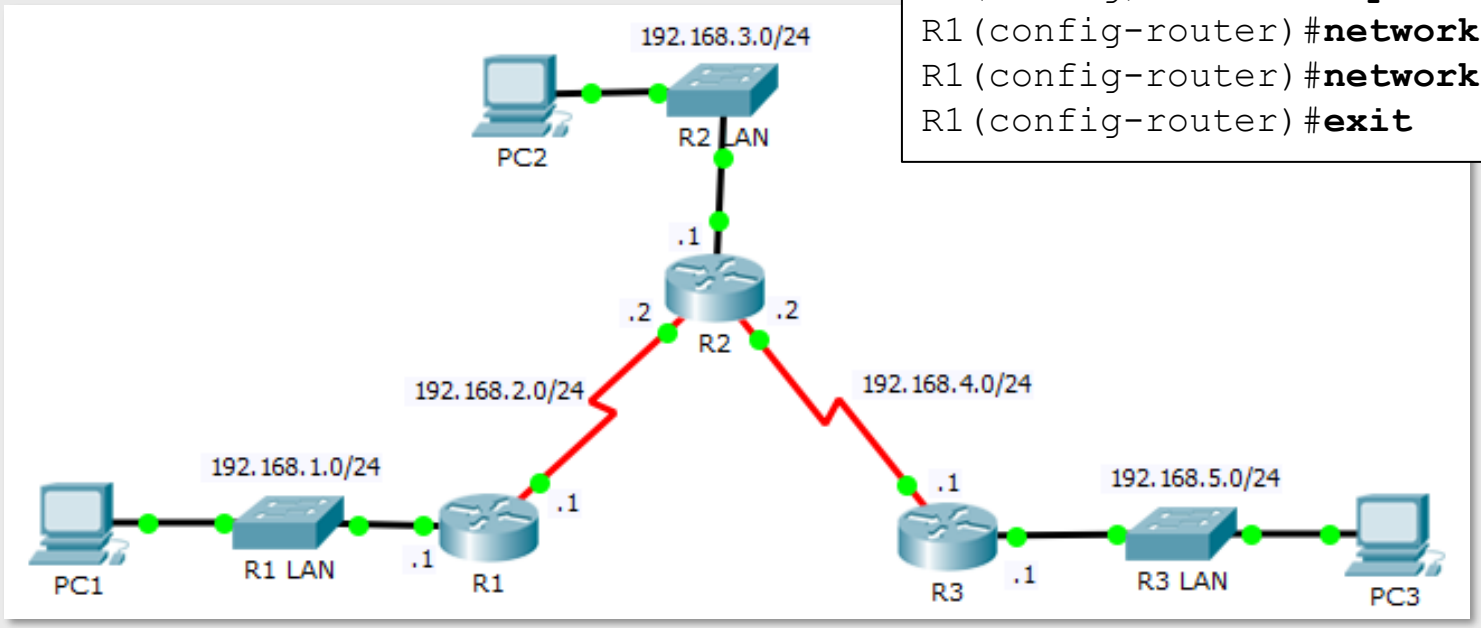
```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#router ?
  bgp         Border Gateway Protocol (BGP)
  egp         Exterior Gateway Protocol (EGP)
  eigrp       Enhanced Interior Gateway Routing Protocol (EIGRP)
  igrp        Interior Gateway Routing Protocol (IGRP)
  isis        ISO IS-IS
  iso-igrp    IGRP for OSI networks
  mobile      Mobile routes
  odr         On Demand stub Routes
  ospf        Open Shortest Path First (OSPF)
  rip         Routing Information Protocol (RIP)

R1(config)#router rip
R1(config-router)#
```

IOS RIP configuration

```
Router(config-router)#network directly-connected-classful-network-address
```

- Enables RIP on all interfaces <u>that belong to a specific network</u>
  - Associated interfaces will now both send and receive RIP updates
- Advertises the specified network in RIP routing updates

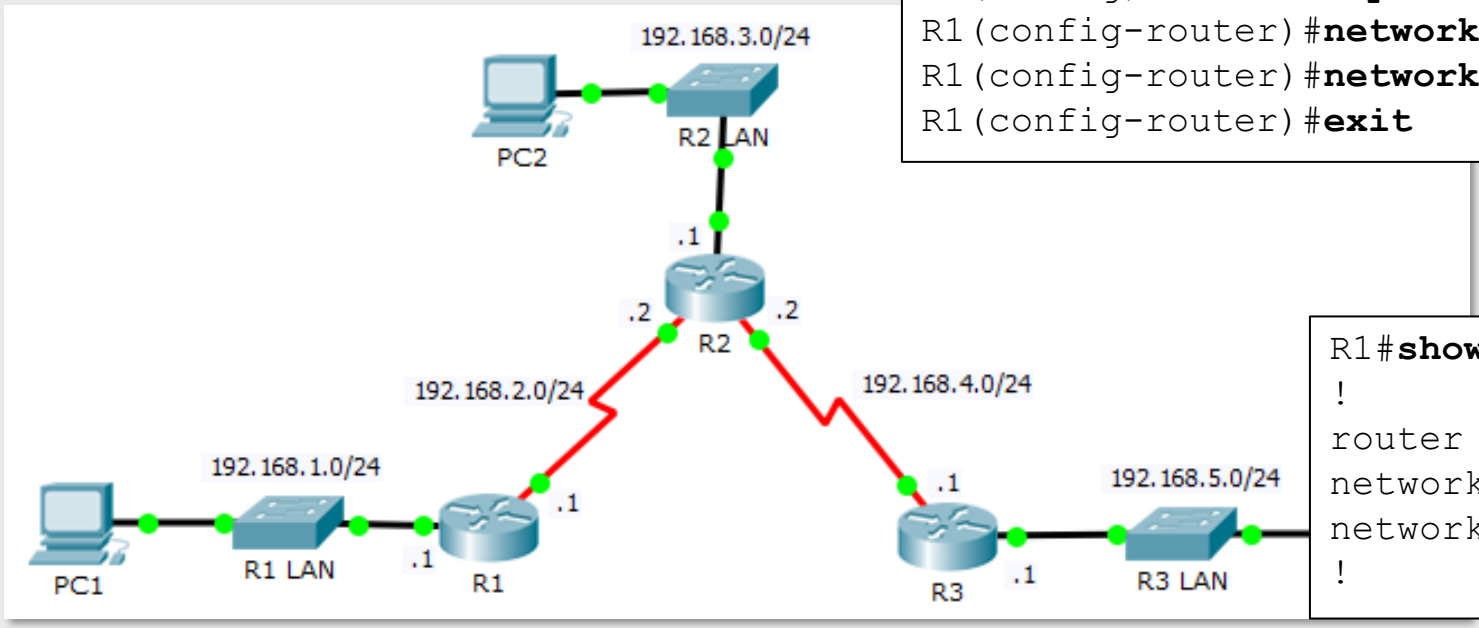
```
R1(config)#router rip
R1(config-router)#network 192.168.1.0
R1(config-router)#network 192.168.2.0
R1(config-router)#exit
```



IOS RIP configuration

```
Router(config-router)#network directly-connected-classful-network-address
```

- Enables RIP on all interfaces <u>that belong to a specific network</u>
  - Associated interfaces will now both send and receive RIP updates
- Advertises the specified network in RIP routing updates

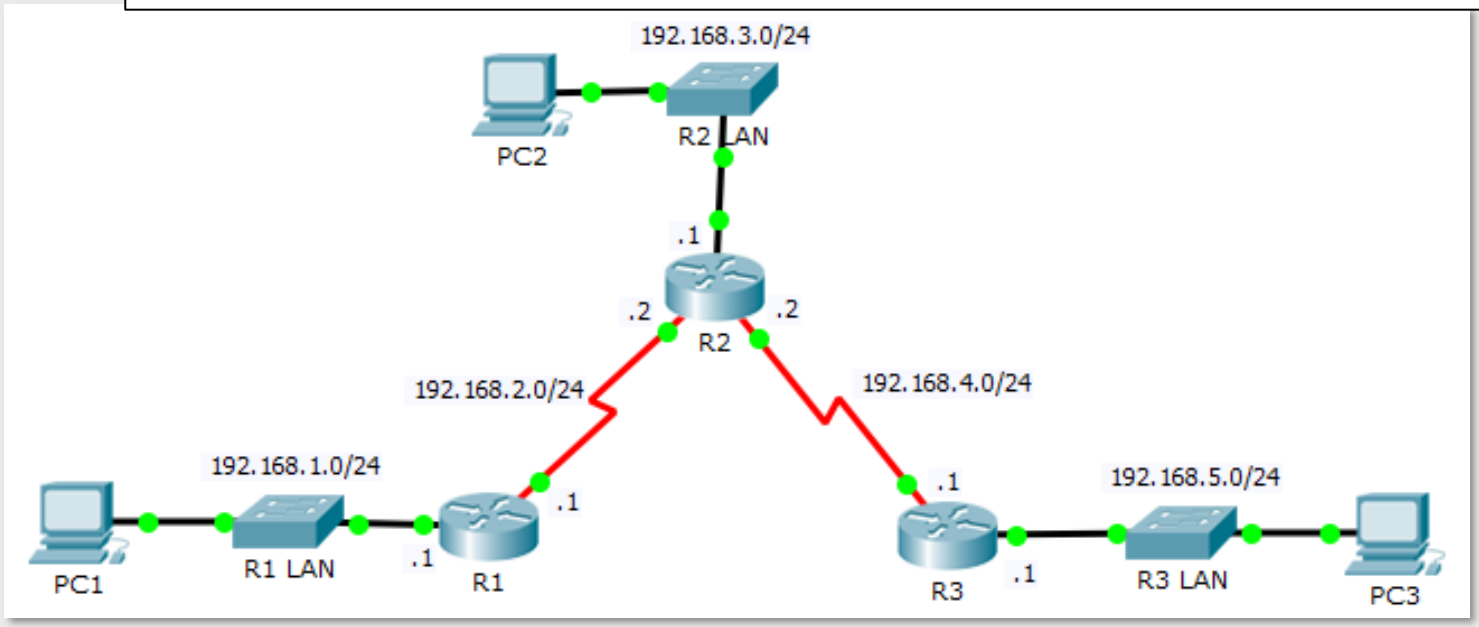



```
R1(config)#router rip
R1(config-router)#network 192.168.1.32
R1(config-router)#network 192.168.2.0
R1(config-router)#exit
```

```
R1#show running-config
!
router rip
network 192.168.1.0
network 192.168.2.0
!
```

Verifying RIP configuration

```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
(**output omitted**)

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
R    192.168.3.0/24 [120/1] via 192.168.2.2, 00:00:10, Serial0/0/0
R    192.168.4.0/24 [120/1] via 192.168.2.2, 00:00:10, Serial0/0/0
R    192.168.5.0/24 [120/2] via 192.168.2.2, 00:00:10, Serial0/0/0
R1#
```



Verifying RIP configuration

```
R1#show ip protocols

Routing Protocol is "rip"

Sending updates every 30 seconds, next due in 20 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Redistributing: rip

Default version control: send version 1, receive any version
  Interface              Send  Recv  Triggered RIP  Key-chain
  FastEthernet0/0        1     2 1
  Serial0/0/0            1     2 1

Automatic network summarization is in effect
Maximum path: 4

Routing for Networks:
          192.168.1.0
          192.168.2.0
Passive Interface(s):

Routing Information Sources:
          Gateway         Distance      Last Update
          192.168.2.2           120      00:00:24
Distance: (default is 120)
R1#
```

RIP is configured and running

Configured timers values

The configured version of RIP is v1

The router is currently summarizing at the classful network boundary

Networks included in RIP updates

RIP neighbors

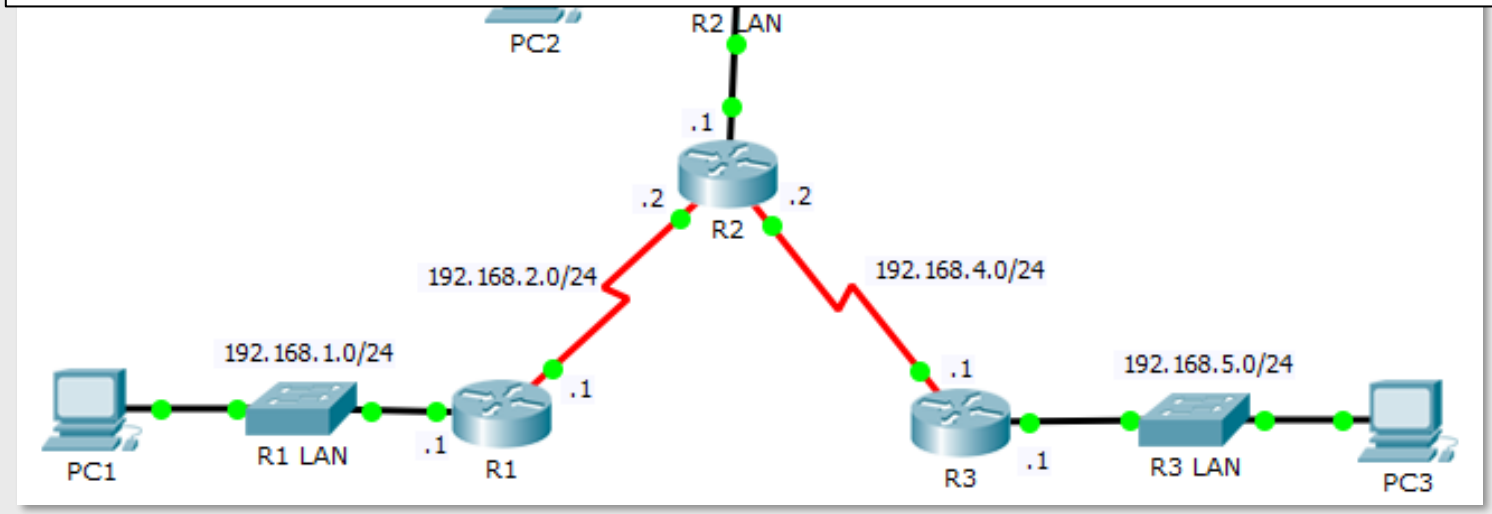
Verifying RIP configuration

```
R1#debug ip rip
RIP protocol debugging is on
R1#
RIP: sending  v1 update to 255.255.255.255 via FastEthernet0/0 (192.168.1.1)
RIP: build update entries
      network 192.168.2.0 metric 1
      network 192.168.3.0 metric 2
      network 192.168.4.0 metric 2
      network 192.168.5.0 metric 3
RIP: sending  v1 update to 255.255.255.255 via Serial0/0/0 (192.168.2.1)
RIP: build update entries
      network 192.168.1.0 metric 1
RIP: received v1 update from 192.168.2.2 on Serial0/0/0
      192.168.3.0 in 1 hops
      192.168.4.0 in 1 hops
      192.168.5.0 in 2 hops
```

R1 sends an update out Fa0/0 including all networks in the routing table except 192.168.1.0

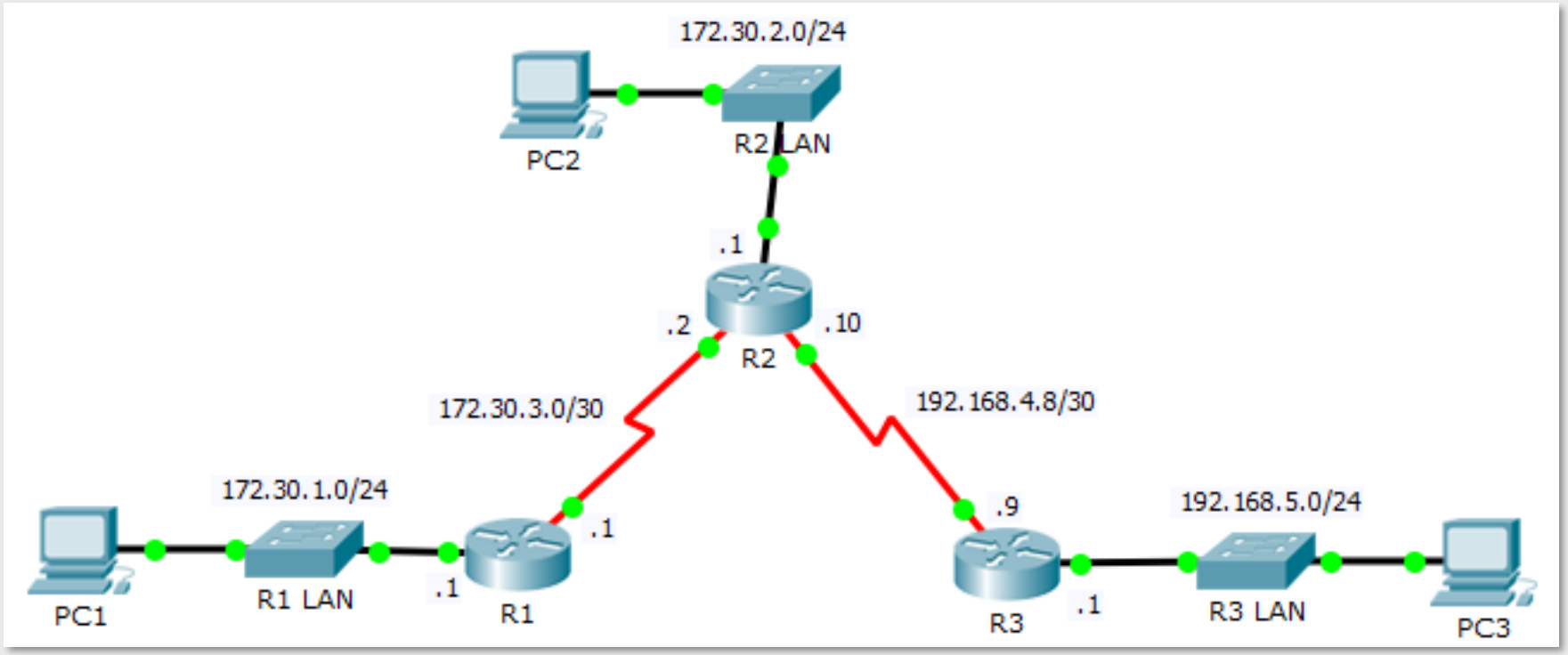
R1 sends an update out se0/0/0 including only network 192.168.1.0. Note: Split horizon is in effect!!!

R1 receives an update from R2



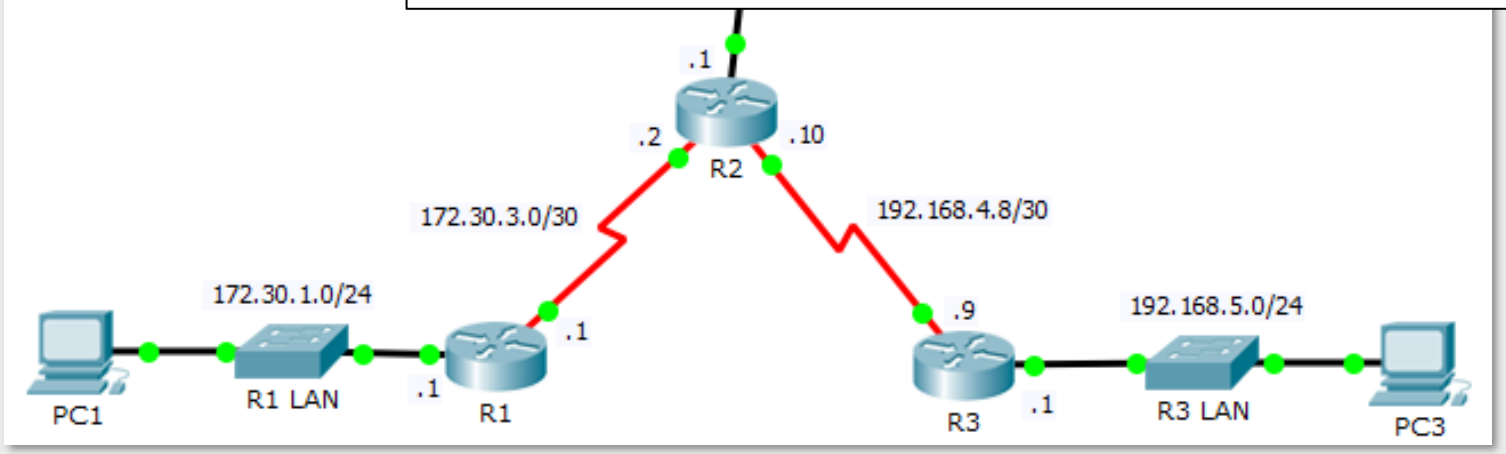
Enable RIPv2

- Reference topology



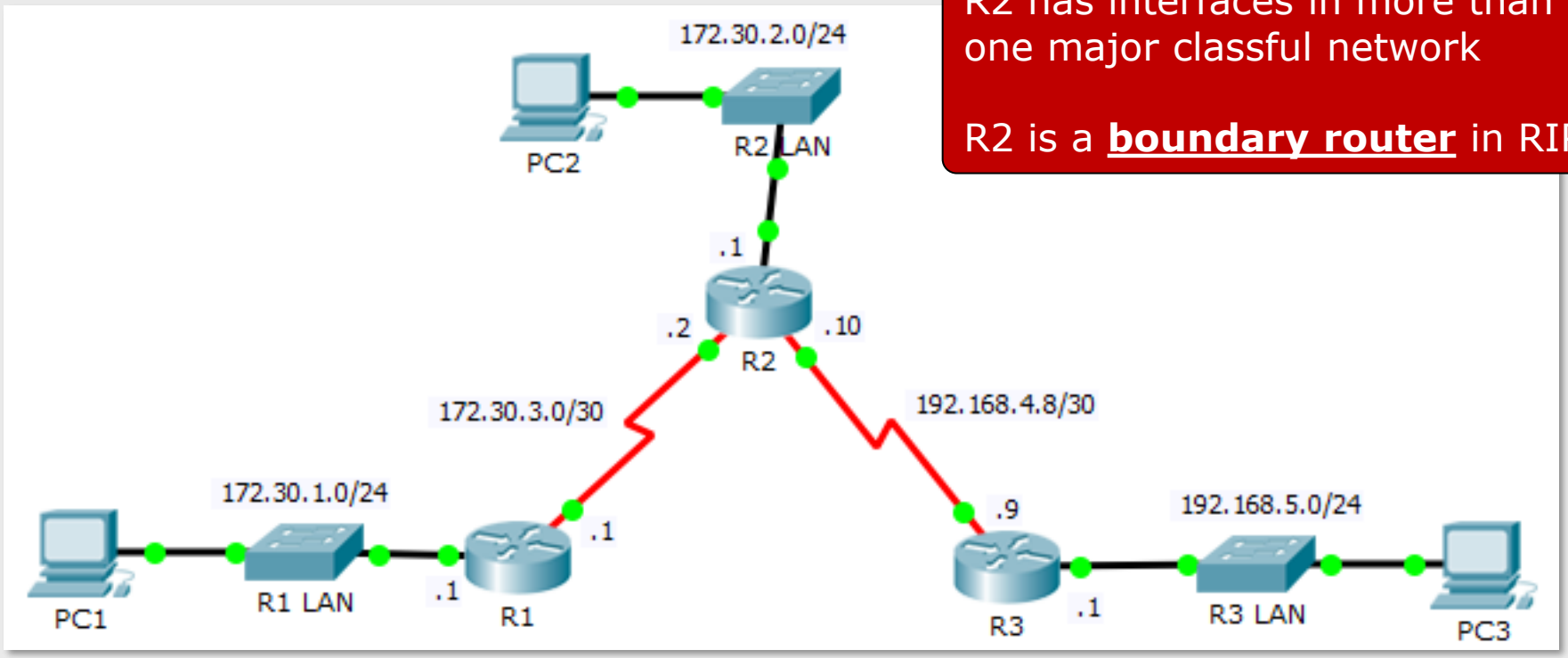
Enable RIPv2

```
R1(config)#router rip
R1(config-router)#version 2
R1(config-router)#^Z
R1#
R1#show ip protocols
(**output omitted**)

Default version control: send version 2, receive 2
  Interface              Send  Recv  Triggered RIP  Key-chain
  FastEthernet0/0        2     2
  Serial0/0/0            2     2
Automatic network summarization is in effect

(**output omitted**)
R1#
```



RIP automatic summarization

- Boundary routers automatically summarize RIP subnets across major network boundaries

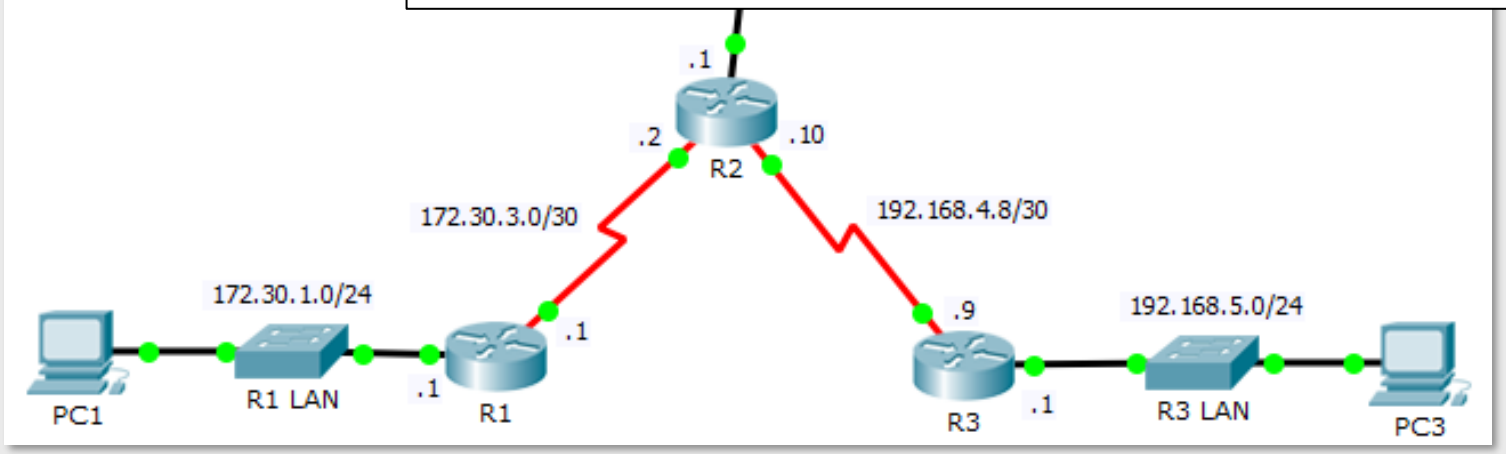


R2 has interfaces in more than one major classful network

R2 is a **boundary router** in RIP

Disable auto summarization

```
R1(config)#router rip
R1(config-router)#no auto-summary
R1(config-router)#^Z
R1#
R1#show ip protocols
(**output omitted**)

Default version control: send version 2, receive 2
  Interface              Send  Recv  Triggered RIP  Key-chain
  FastEthernet0/0        2     2
  Serial0/0/0            2     2
Automatic network summarization is not in effect

(**output omitted**)
R1#
```



Passive interfaces

- By default, RIP updates are forwarded out all RIP enabled interfaces
  - Including those not connecting to other RIP enabled routers

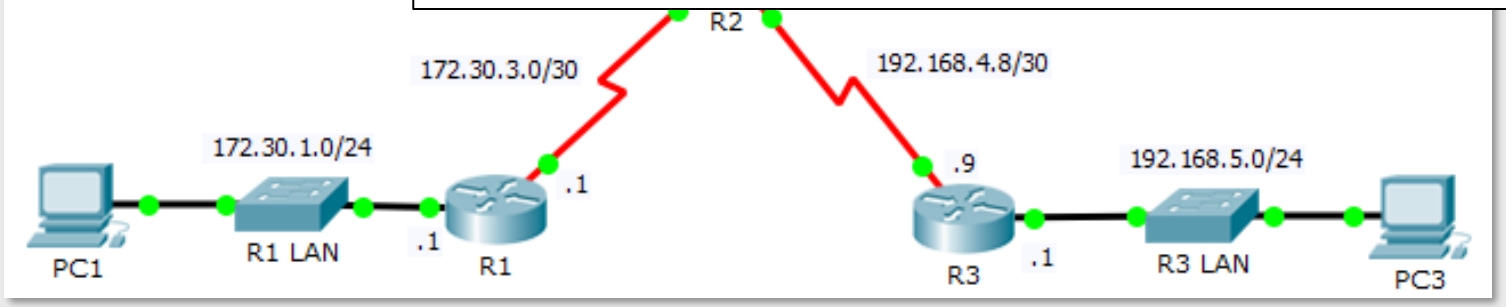
- Unnecessary RIP updates
  - Bandwidth is wasted. Because RIP updates are broadcast or multicast, switches will forward the updates out all ports.
  - All devices on the LAN must process the update up to the transport layers
  - Advertising updates on a broadcast network is a security risk

```
Router(config-router)#passive-interface interface-type interface-number
```

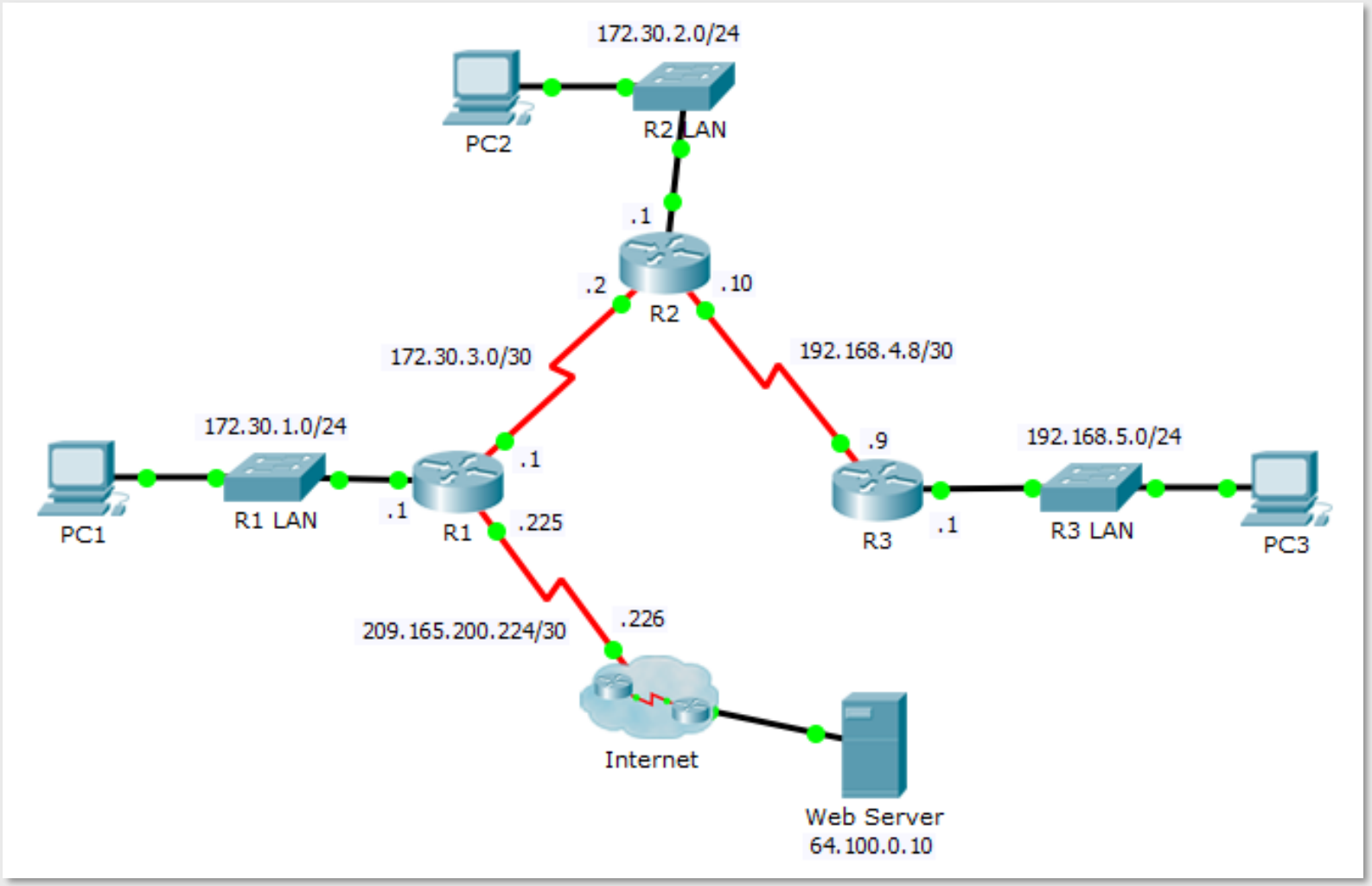
- Prevents the transmission of routing updates through a router interface but still allows that network to be advertised to other routers

Passive interfaces

```
R1(config)#router rip
R1(config-router)#passive-interface fa0/0
R1(config-router)#^Z
R1#
R1#show ip protocols
(**output omitted**)

Default version control: send version 2, receive 2
  Interface              Send  Recv  Triggered RIP  Key-chain
  Serial0/0/0            2     2
Automatic network summarization is not in effect
Maximum path: 4
Routing for Networks:
         172.30.0.0
Passive Interface(s):
         FastEthernet0/0
Routing Information Sources:
         Gateway         Distance      Last Update
         172.30.3.2           120      00:00:12
Distance: (default is 120)
```

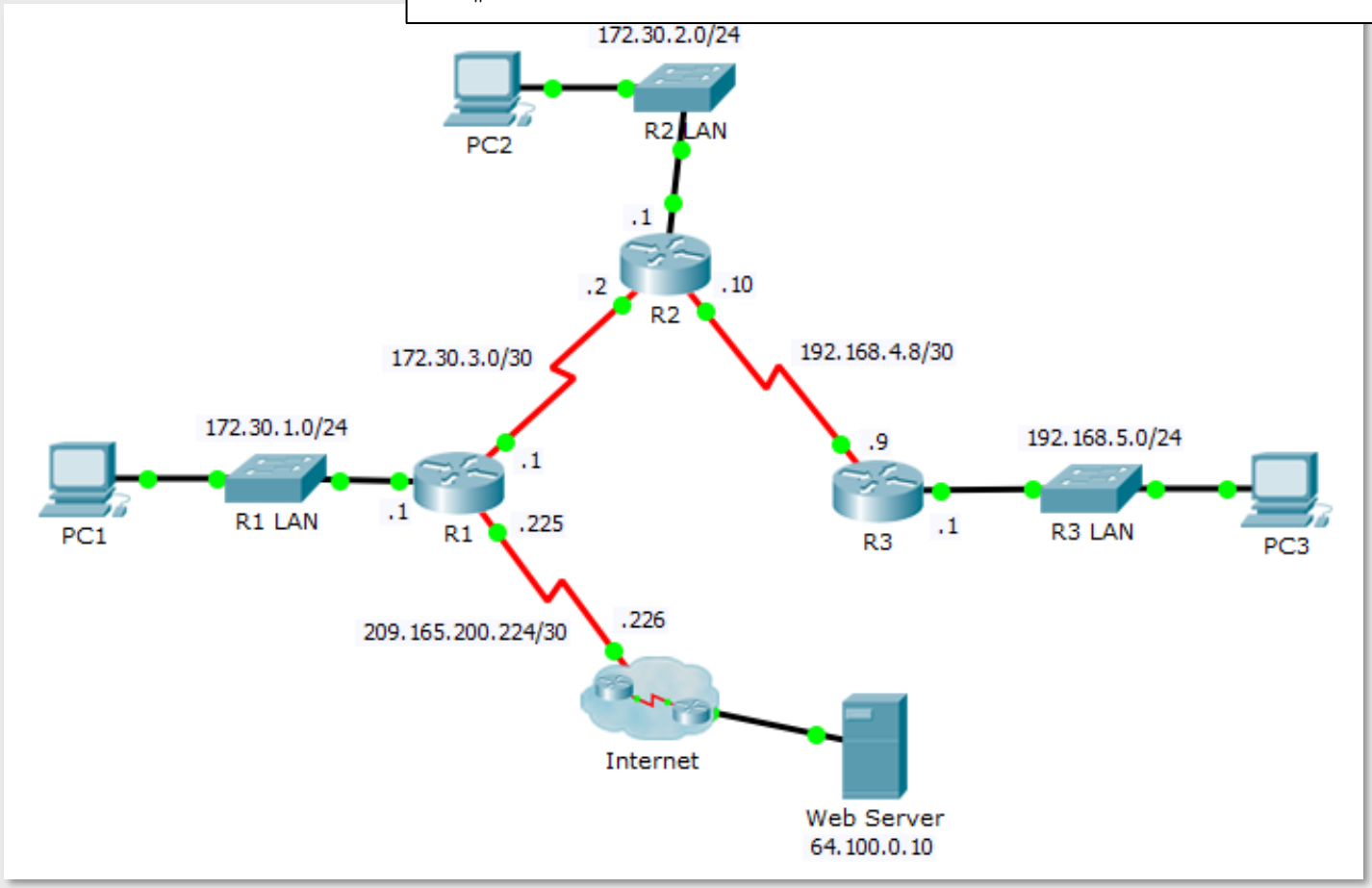


Default route propagation



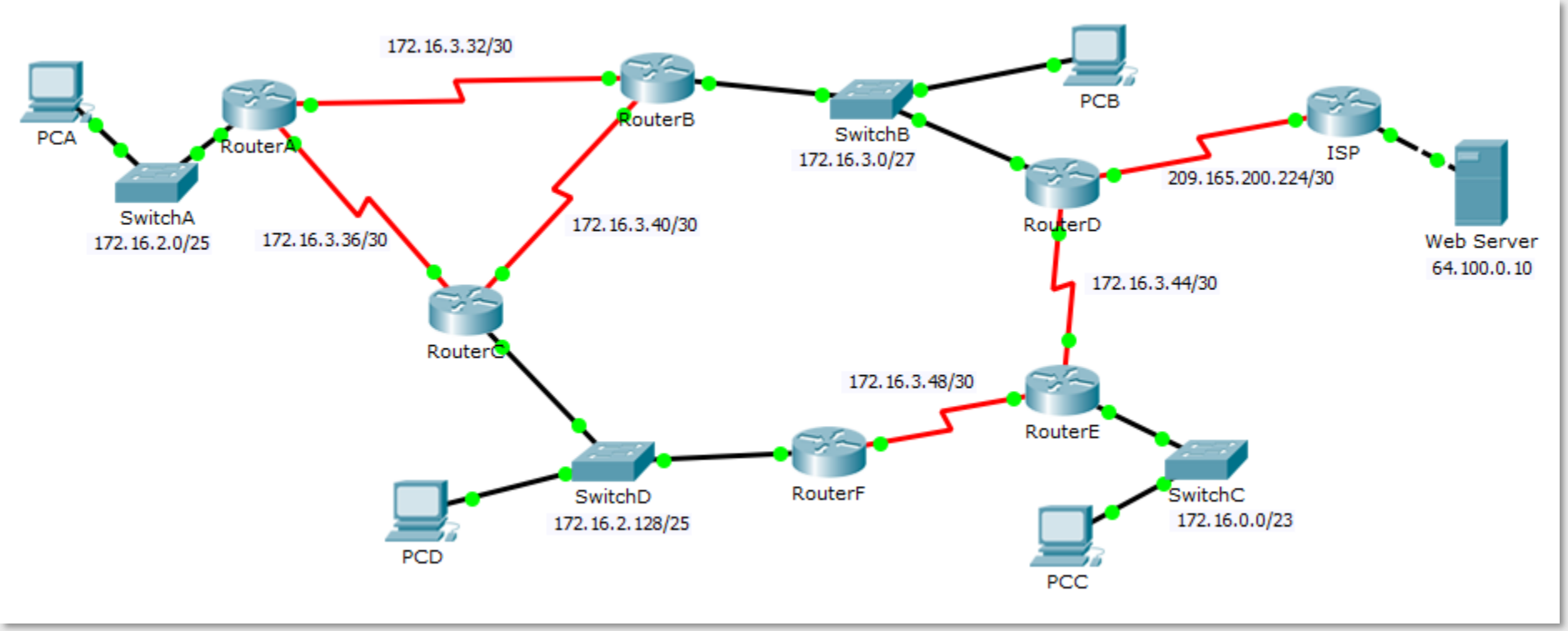
Default route propagation

```
R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.200.226
R1(config)#router rip
R1(config-router)#default-information originate
R1(config-router)#^Z
R1#
```



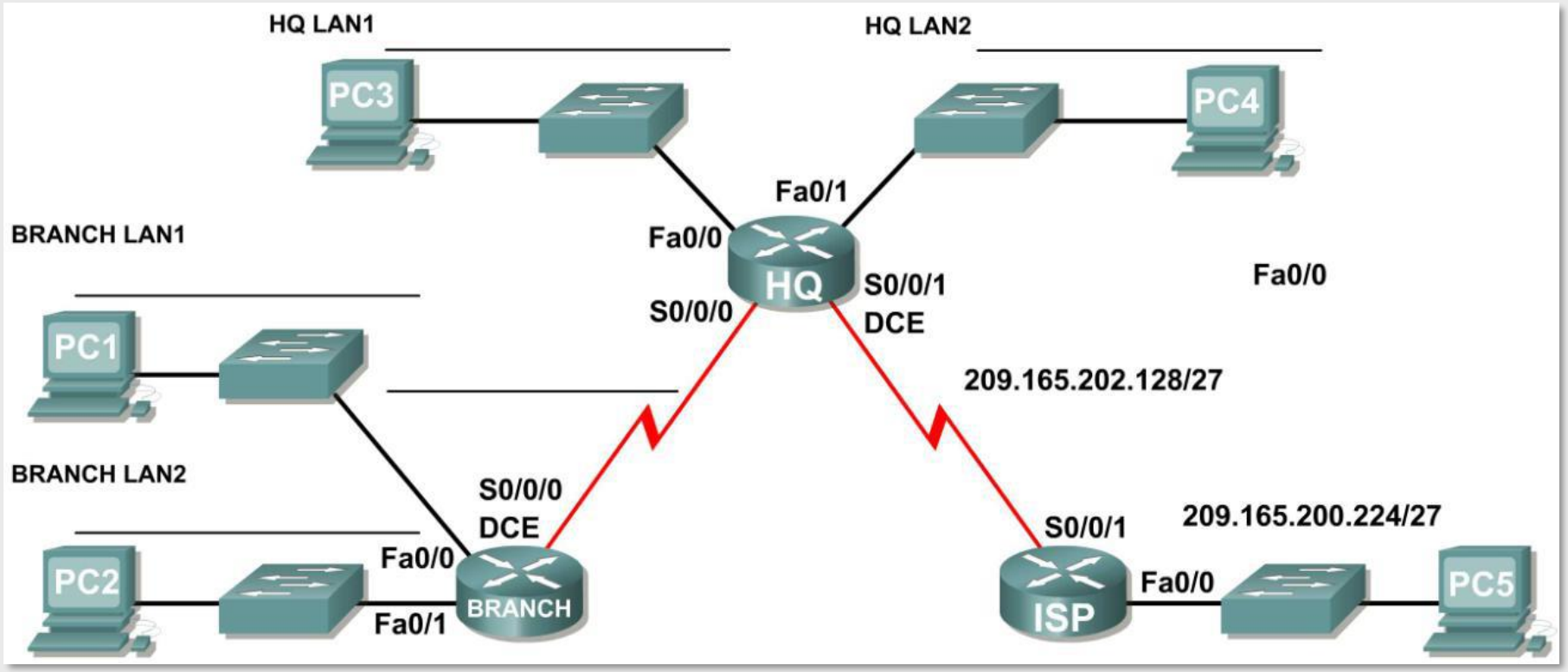
Lab activity

- Configure dynamic routing using RIPv2
- Configure on RD a default route towards the ISP



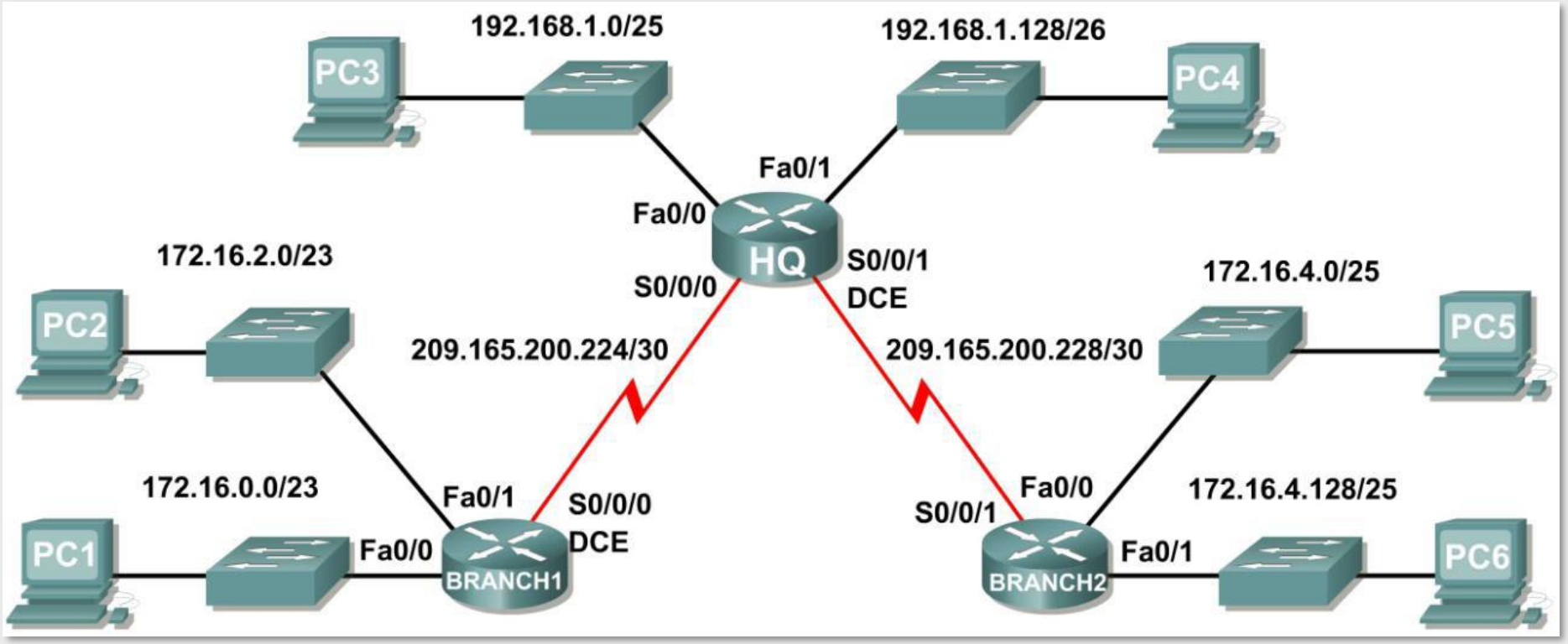
Lab activity

- RIPv2 configuration



Lab activity

- RIPv2 troubleshooting



Lab activity

- Network design and configuration