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Routing Protocols

Routing protocols

- A routing protocol provides a communication channel among routers to exchange reachability information about networks
- Routing tables are properly configured and immediately updated
- List of routing protocols:
  - ✓ Routing Information Protocol (RIP)
  - ✓ Enhanced Interior Gateway Routing Protocol (EIGRP)
  - ✓ Open Shortest Path First (OSPF)
  - ✓ Border Gateway Protocol (BGP)

Convergence

- The performance of a routing protocol is the convergence speed
- A routing protocol reaches the convergence state when all the network routers have the same network view
- A fast convergence is required since during convergence a router can have a wrong routing table (and so forwarding decisions could lead to packet loss)

Autonomous System

- An Autonomous System (AS) is a set of networks and routers managed by the same network administrator
- An AS is seen from outside as a single entity
  - An AS is identified by a single number (16 bit – AS number)
- Internet is composed of a set of ASes. Each AS manages its own set of networks:
  - There will be an independent routing protocol for the routing inside each AS
  - Routing among ASes must be the result of an agreement among ASes.

Routing protocols classification

- Routing protocol classification on the basis of functioning principles:
  - Distance vector: RIP, BGP
  - Link state: OSPF
- On the basis of use scenario:
  - Interior Gateway Protocol (IGP): intra-AS (RIP and OSPF)
  - Exterior Gateway Protocol (EGP): inter-AS (BGP)

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Distance Vector Routing protocols

Distance vector routing protocols (1/2)

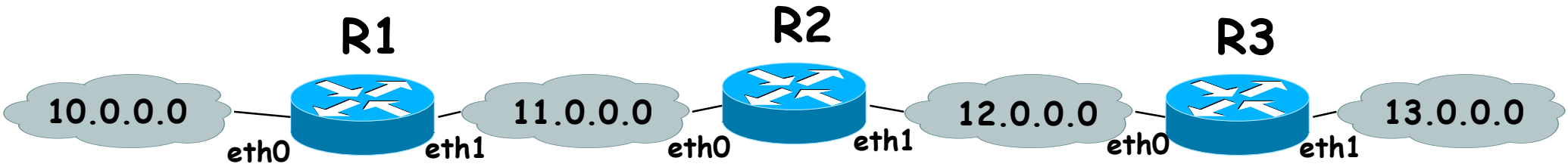
Main features of a distance vector routing protocol :

- Each router exchanges routing information only with neighbor routers
  - Two routers are neighbors if they are directly connected by means of a network
- Each router sends to the neighbors routers messages reporting its own routing table
- Routing messages are sent periodically (the time period is a protocol parameter: in the case of RIP the default value is 30 seconds)
- Each row of the routing table sent has its own distance (depends on the protocol metric: in the case of RIP the metric is the number of hops)

Distance vector routing protocols (2/2)

- In the distance vector case, a router doesn't have a global network view
- A router computes its own routing table:
  - for each route two information are stored: distance (depends on the metric) and next-hop router
  - the directly connected routes have a distance equal to 0
- When a message is received (routing table of a neighbor), an algorithm is applied (Bellmann-Ford one for RIP) to update the routing table if new better routes (on the basis of the distance) are available.

Example (1/6)



R1

Network	Next-hop	Distance

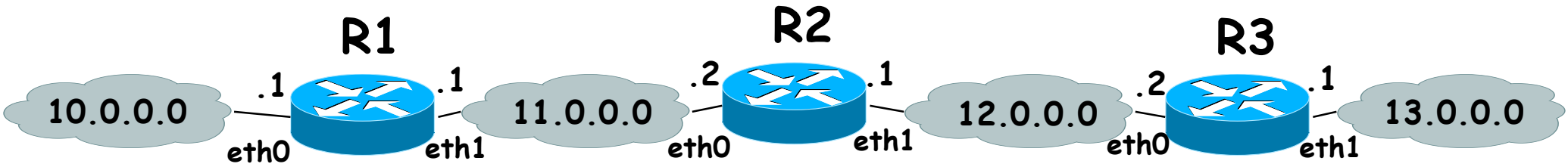
R2

Network	Next-hop	Distance

R3

Network	Next-hop	Distance

Example (2/6)



R1

Network	Next-hop	Distance
10.0.0.0	eth0	0
11.0.0.0	eth1	0

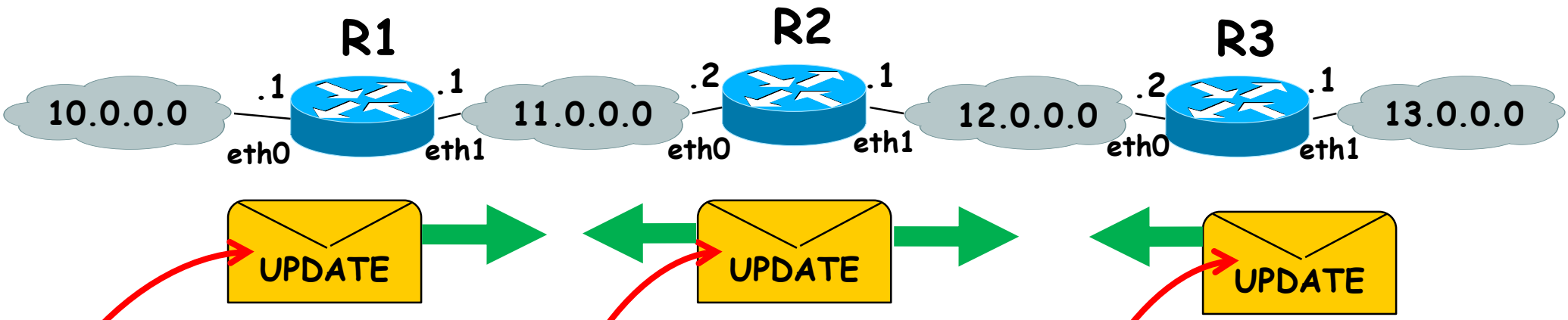
R2

Network	Next-hop	Distance
11.0.0.0	eth0	0
12.0.0.0	eth1	0

R3

Network	Next-hop	Distance
12.0.0.0	eth0	0
13.0.0.0	eth1	0

Example (3/6)



R1

Network	Next-hop	Distance
10.0.0.0	eth0	0
11.0.0.0	eth1	0

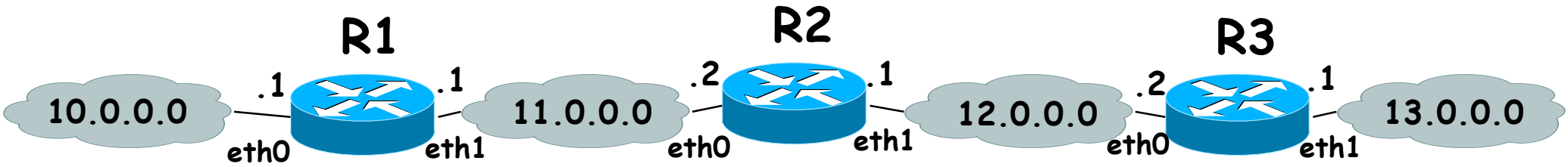
R2

Network	Next-hop	Distance
11.0.0.0	eth0	0
12.0.0.0	eth1	0

R3

Network	Next-hop	Distance
12.0.0.0	eth0	0
13.0.0.0	eth1	0

Example (4/6)



R1

Network	Next-hop	Distance
10.0.0.0	eth0	0
11.0.0.0	eth1	0
12.0.0.0	11.0.0.2	1

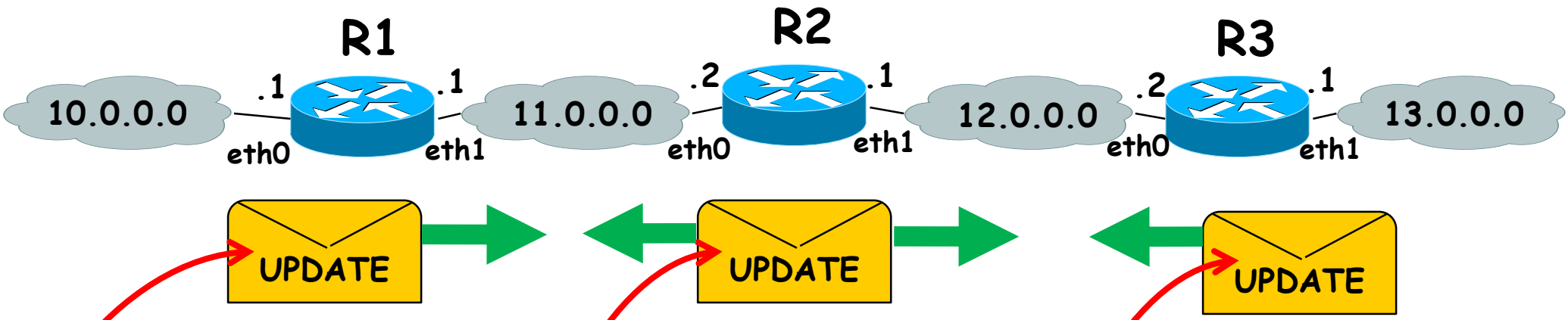
R2

Network	Next-hop	Distance
11.0.0.0	eth0	0
12.0.0.0	eth1	0
10.0.0.0	11.0.0.1	1
13.0.0.0	12.0.0.2	1

R3

Network	Next-hop	Distance
12.0.0.0	eth0	0
13.0.0.0	eth1	0
11.0.0.0	12.0.0.1	1

Example (5/6)



R1

Network	Next-hop	Distance
10.0.0.0	eth0	0
11.0.0.0	eth1	0
12.0.0.0	11.0.0.2	1

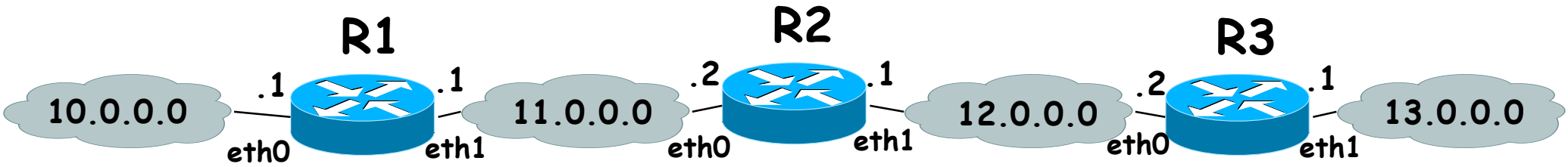
R2

Network	Next-hop	Distance
11.0.0.0	eth0	0
12.0.0.0	eth1	0
10.0.0.0	11.0.0.1	1
13.0.0.0	12.0.0.2	1

R3

Network	Next-hop	Distance
12.0.0.0	eth0	0
13.0.0.0	eth1	0
11.0.0.0	12.0.0.1	1

Example (6/6)



R1

Network	Next-hop	Distance
10.0.0.0	eth0	0
11.0.0.0	eth1	0
12.0.0.0	11.0.0.2	1
13.0.0.0	11.0.0.2	2

R2

Network	Next-hop	Distance
11.0.0.0	eth0	0
12.0.0.0	eth1	0
10.0.0.0	11.0.0.1	1
13.0.0.0	12.0.0.2	1

R3

Network	Next-hop	Distance
12.0.0.0	eth0	0
13.0.0.0	eth1	0
11.0.0.0	12.0.0.1	1
10.0.0.0	12.0.0.1	2

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Routing Information Protocol (RIP)

RIP protocol

- RIP is a distance vector routing protocol
- The number of hops (number of routers crossed) is used as distance to detect the best path
- A distance equal to 16 means destination unreachable
- Routing updates are sent in broadcast every 30 seconds
- RIP messages are encapsulated into UDP packets, with source and destination ports both equal to 520
- The administrative distance of RIP is 120

RIPv1

- RIP versions
  - Classful Routing Protocol (RIP v1)
  - Classless Routing Protocol (RIP v2)
- In the RIPv1 messages the subnet mask is not provided.
- How to choose the subnet mask?:
  - Using the default one on the basis of the classful approach (classes A,B or C)
  - The subnet mask of the network connected to the RIP message incoming interface is used
- RIPv1 is defined classful but it works even if subnetting is used IF
  - subnetting is performed with fixed subnet length AND
  - the subnetted networks are contiguous.

RIPv1 configuration (1/2)

- The "router rip" command enables RIP
- The command "network" is used to define the interfaces running RIP:
  - the interfaces running RIP will send and receive RIP messages
  - the networks (directly) connected to interfaces running RIP will be inserted (as routes) in the RIP messages sent

Configurazione del protocollo RIPv1 (2/2)

- If the network address is "wrong" the router is able to perform the correction

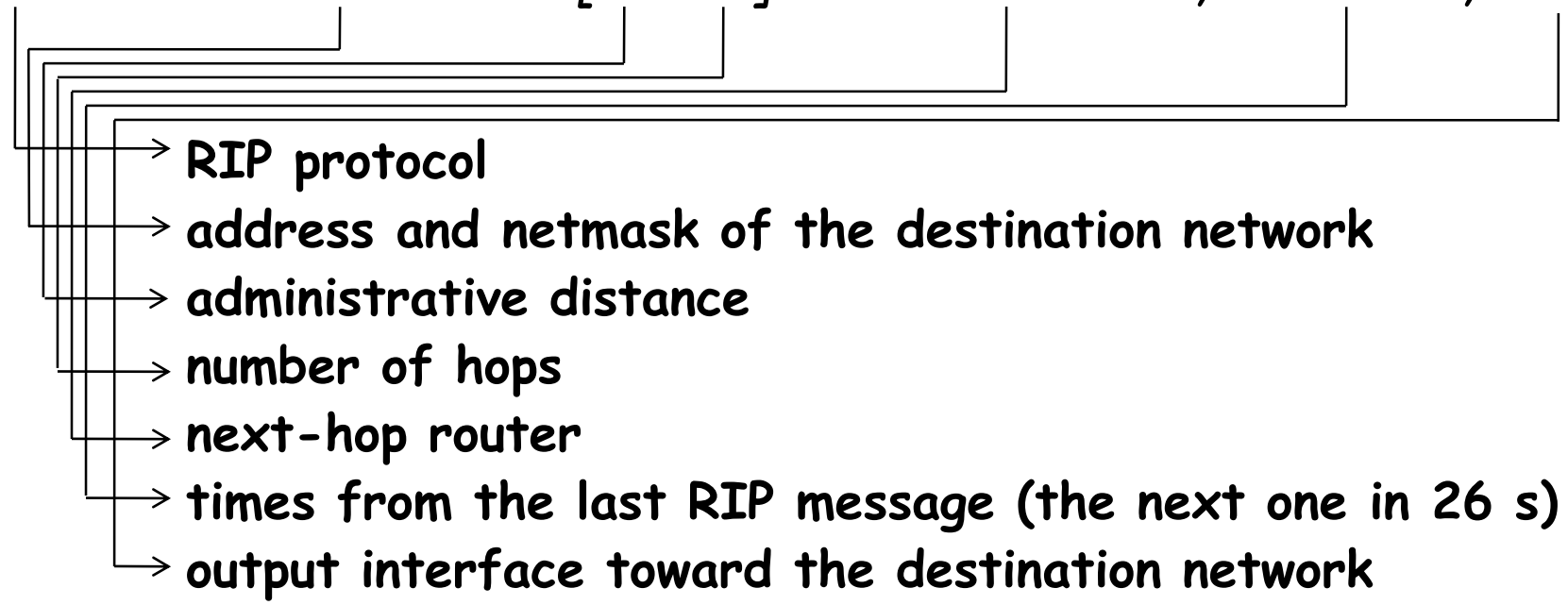
```
R3(config)#router rip
R3(config-router)#network 192.168.4.0
R3(config-router)#network 192.168.5.1

R3#show running-config
!
router rip
network 192.168.4.0
network 192.168.5.0
!
```

RIP and the routing table

- RIP route in the routing table (*show ip route*)

R 192.168.205.0/24 [120/3] via 151.100.37.8, 00:00:04, Eth0



RIP timers

- **Invalid timer**. If a route is not updated after "invalid timer" seconds (default value 180 s), it is flagged as invalid and its distance is set to 16.
- **Flush timer**. If a router is not updated after "flush timer" seconds (default value 240 s), it is removed from the routing table.

show ip protocols

```
R2#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 23 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         1 2
    Serial0/0/0              1         1 2
    Serial0/0/1              1         1 2
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    192.168.2.0
    192.168.3.0
    192.168.4.0
```

Passive-interface

- The command *passive-interface* is used to avoid sending RIP messages through a specific interface (and so into a network)
- The router still inserts the network connected to the passive interface in the RIP messages.

```
Default version control: send version 1, receive any version
    Interface              Send  Recv  Triggered RIP  Key-chain
    Serial0/0/0            1     1 2
    Serial0/0/1            1     1 2
Automatic network summarization is in effect
Routing for Networks:
    192.168.2.0
    192.168.3.0
    192.168.4.0
Passive Interface(s):
   FastEthernet0/0
```

RIP debug

```
R2#debug ip rip
RIP protocol debugging is on
RIP: received v1 update from 192.168.2.1 on Serial0/0/0
      192.168.1.0 in 1 hops
RIP: received v1 update from 192.168.4.1 on Serial0/0/1
      192.168.5.0 in 1 hops
RIP: sending  v1 update to 255.255.255.255 via FastEthernet0/0 (192.168.3.1)
RIP: build update entries
      network 192.168.1.0 metric 2
      network 192.168.2.0 metric 1
      network 192.168.4.0 metric 1
      network 192.168.5.0 metric 2
RIP: sending  v1 update to 255.255.255.255 via Serial0/0/1 (192.168.4.2)
RIP: build update entries
      network 192.168.1.0 metric 2
      network 192.168.2.0 metric 1
      network 192.168.3.0 metric 1
```

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RIPv2

RIPv1

- RIP v1: Classful Routing Protocol

- In RIPv1 the subnet mask of destination networks is not specified in the RIP messages:
  1) **How to detect the subnet mask?**
  2) **How to face subnetting?**

- Major Network concept: class A, B o C address associated to an IP address.

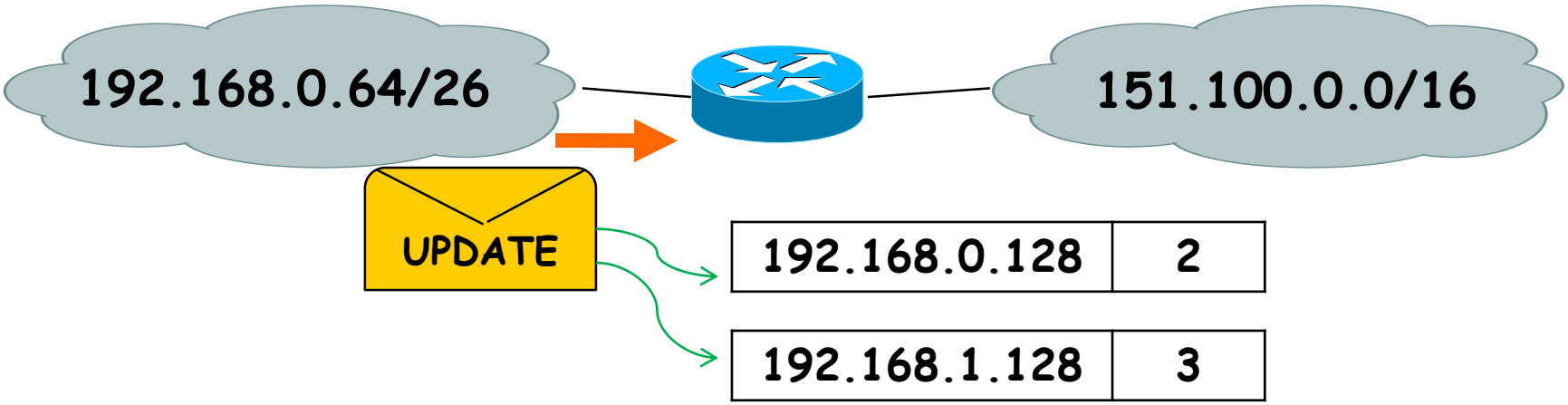
  Example: major network of 192.168.0.128/25 is 192.168.0.0/24

RIP messages processing

- If a router receives an Update (RIP message) containing a destination network with IP address A.B.C.D, it associates the subnet mask following two rules:

  1) If the destination network has a major network different than the one of the network directly connected to the received interface, then the classful subnet mask is used.

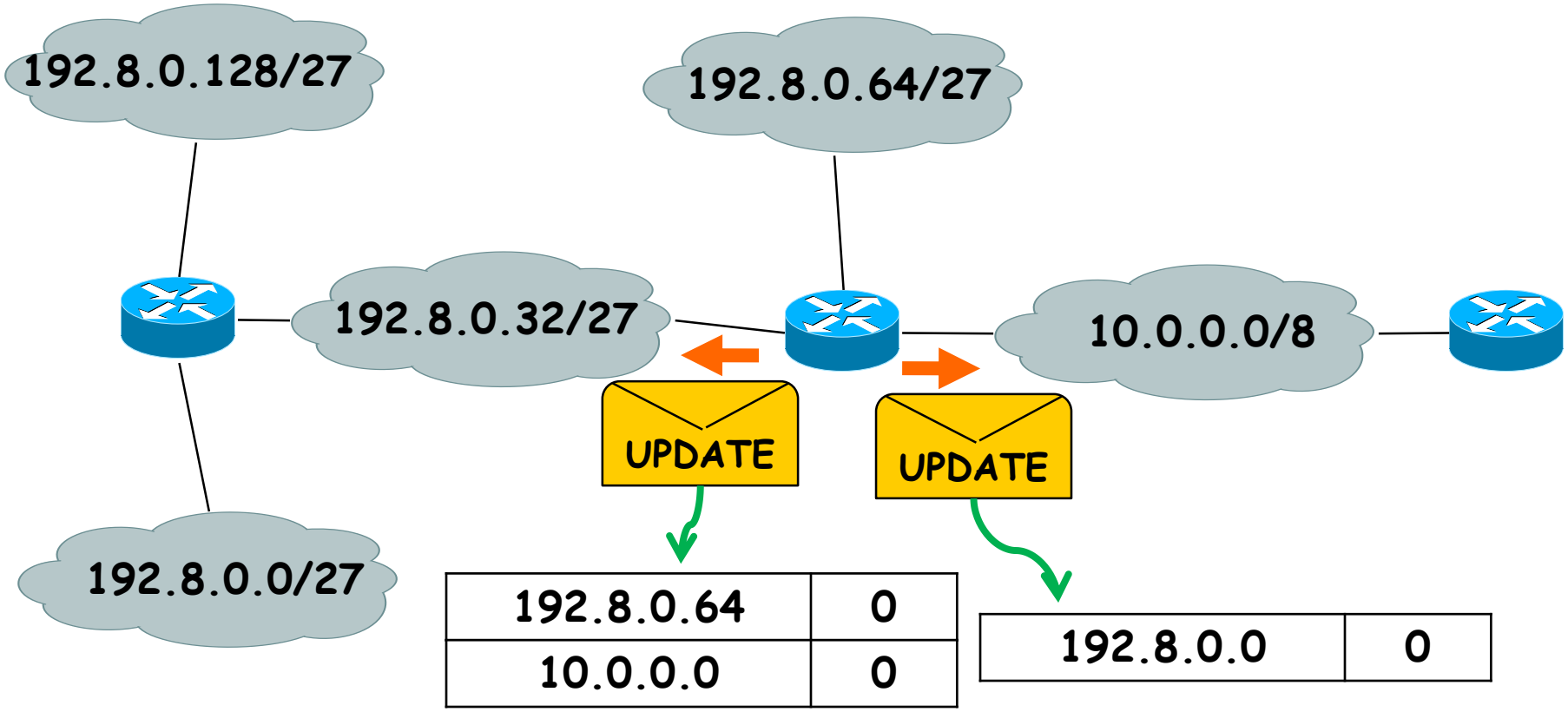
  2) If the destination network has a major network equal to the one of the network directly connected to the received interface, then the same subnet mask of the interface is used.



RIP messages generation

- If a router has to send a RIP message through an outgoing interface and the destination IP address is obtained by subnetting:
  1) If the destination address has a major network different than the one of the network directly connected to the interface, then the IP address of the major network is used: **summarization**
  2) If the destination network has a major network equal to the one of the network directly connected to the interface, then the same subnet mask of the interface is used.

Summarization: example



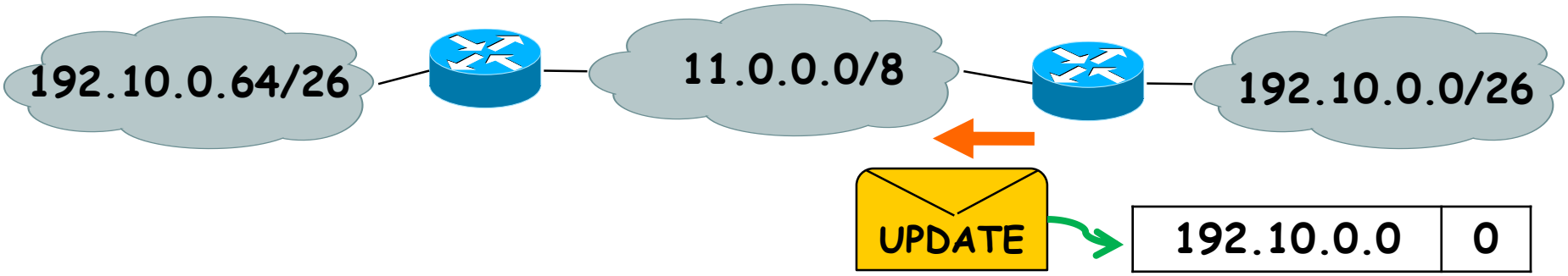
Summarization

Advantages:

- Low number of RIP Messages
- Shorter routing table

Weak aspects:

- Subnetting with variable mask length is not possible
- Networks with same major network must be contiguous



RIPv2

- RIP v2: Classless Routing Protocol
- In the RIPv2 messages the subnet mask field is present:
- The configuration commands:

R3(config)# router rip

R3(config-router)# version 2

- In the case of variable or discontinuous subnetting, RIPv2 doesn't work!

WHY?

RIPv2: auto-summary

- Let's take a look to show ip protocols

```
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 2, receive version 2
    Interface              Send  Recv  Triggered RIP  Key-chain
    FastEthernet0/0        2     2
    FastEthernet0/1        2     2
    Serial0/1/0            2     2
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    172.30.0.0
```

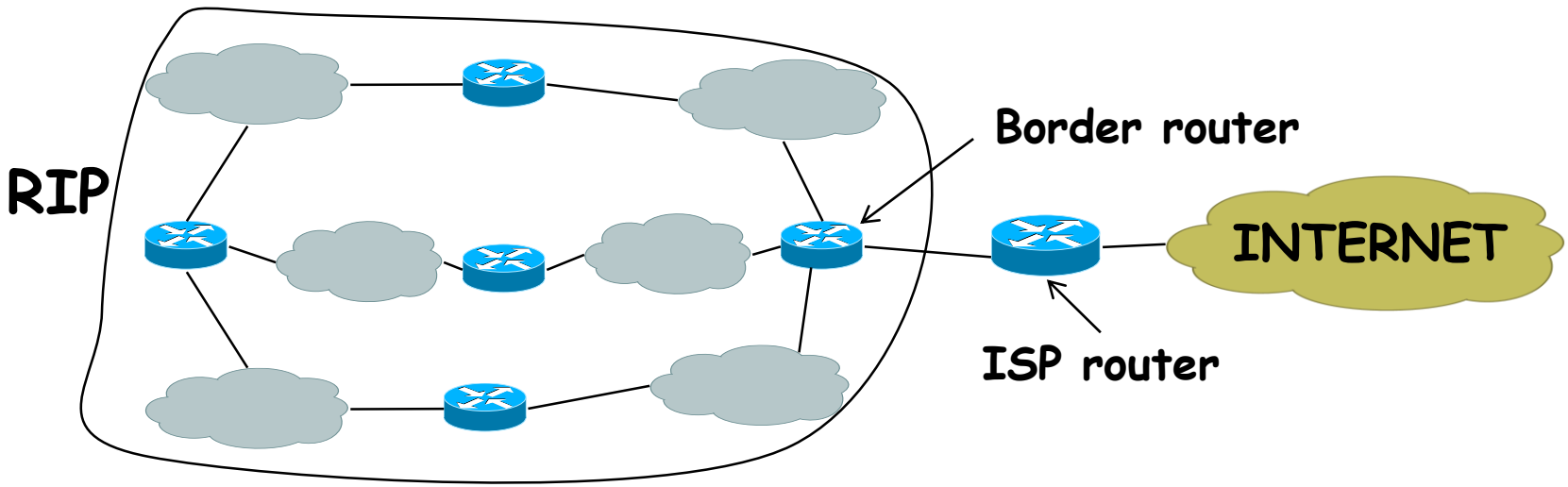
- The option *Automatic network summarization* is automatically enabled: RIPv2 acts as RIPv1.
- In the case of variable or discontinuous subnetting, it must be deactivated:

R3(config-router)# no auto-summary

Default router distribution

- It is possible to configure the default router only on the border router and then "to distribute" it to remaining routers using RIP:

Router (config-router)# default-information originate



- Command to distribute static routes:

Router (config-router)# redistribute static