The need to route

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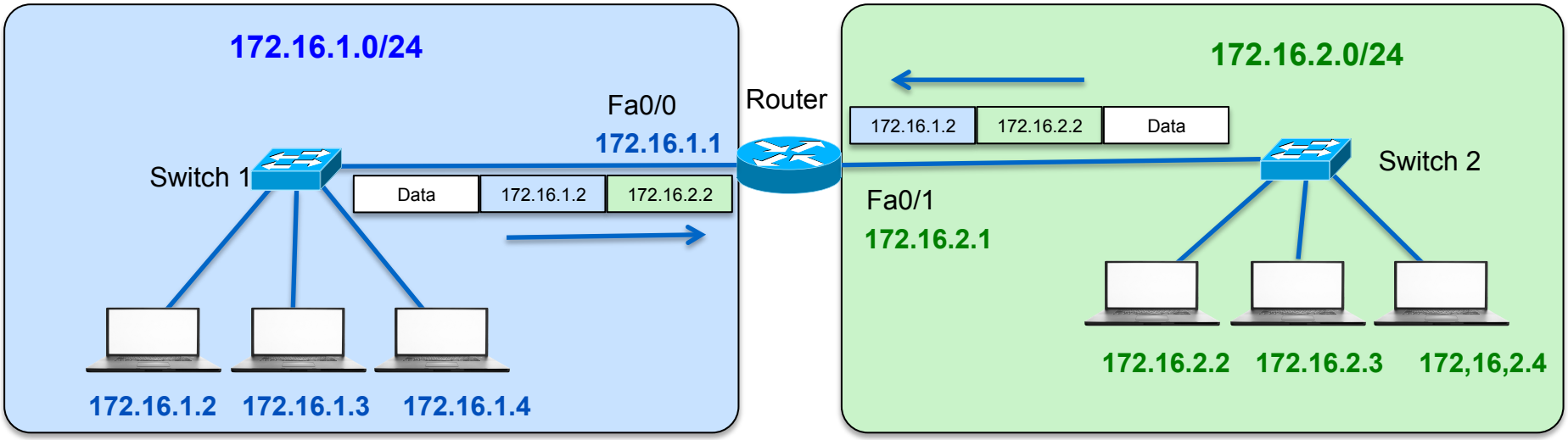
Router as a Computer

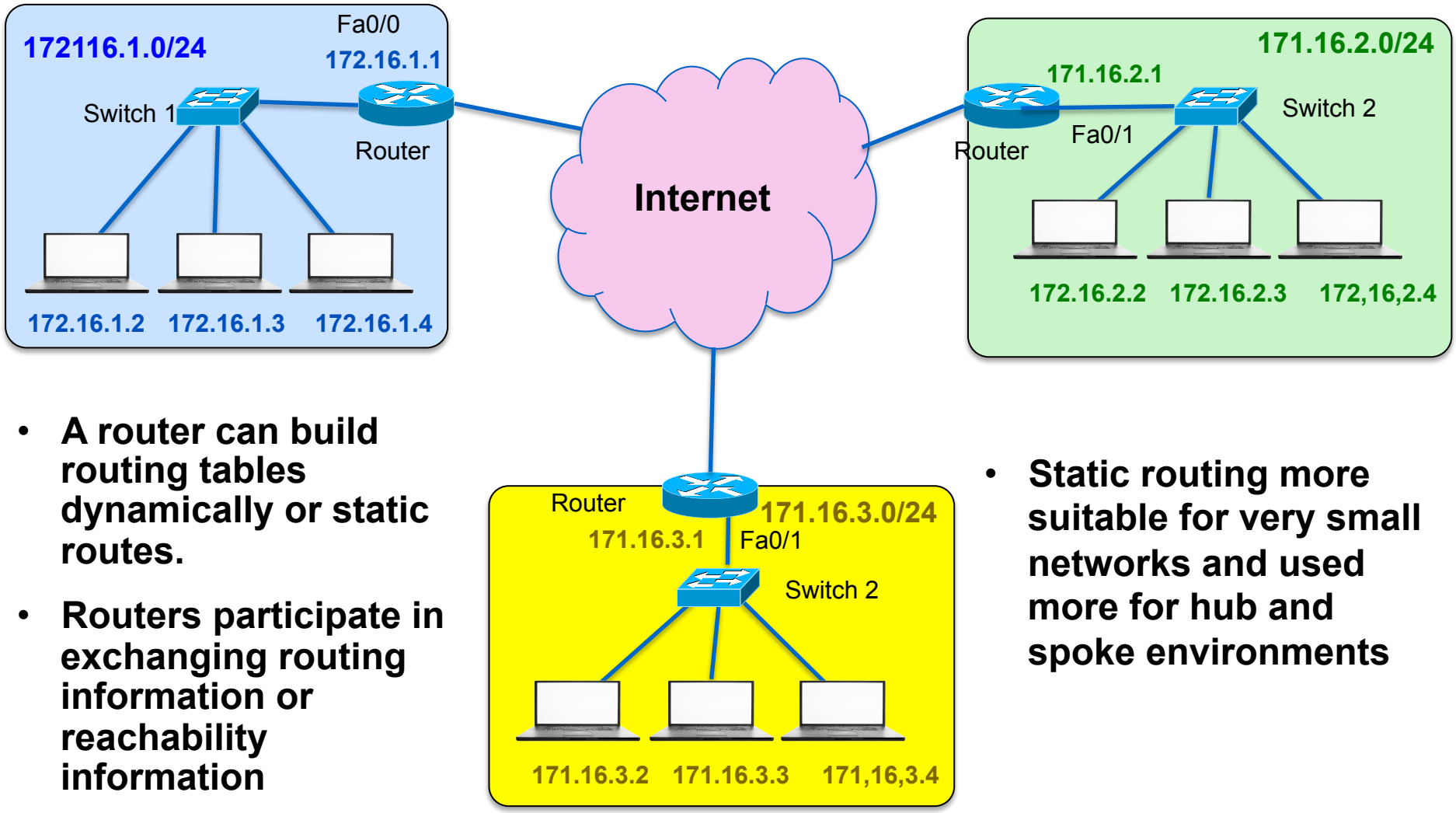
- Router Interface is a physical connector
- Each interface connects to a separate network
- Consist of socket or jack found on the outside of a router
- Types of router interfaces:
  - –-Ethernet
  - –-Fast Ethernet
  - –-Serial
  - –-DSL
  - –-ISDN
  - –-Cable

The concept of Routing



- Every IP packet originated by the hosts contains a source ip address and a destination IP address.
- The router uses this information to forward packets based on the destination IP address
- For example: Packets arriving on Fa0/0 with Source IP Address 172.16.1.2 and destination IP Address of 172.16.2.2 will be forwarded out on Fa0/1 and Vice Versa
- This technique helps to expand to multiple routers involved in routing to scale connectivity between hosts on different networks.

Scaling connectivity requires Routing



- **A router can build routing tables dynamically or static routes.**
- **Routers participate in exchanging routing information or reachability information**

- **Static routing more suitable for very small networks and used more for hub and spoke environments**

Static Routing

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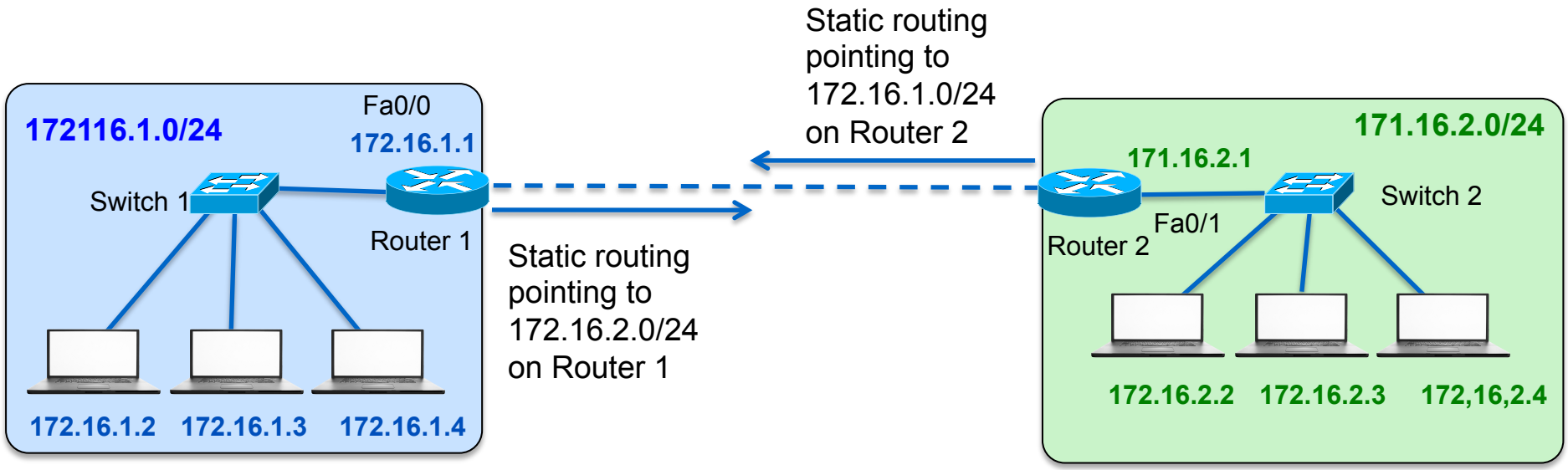
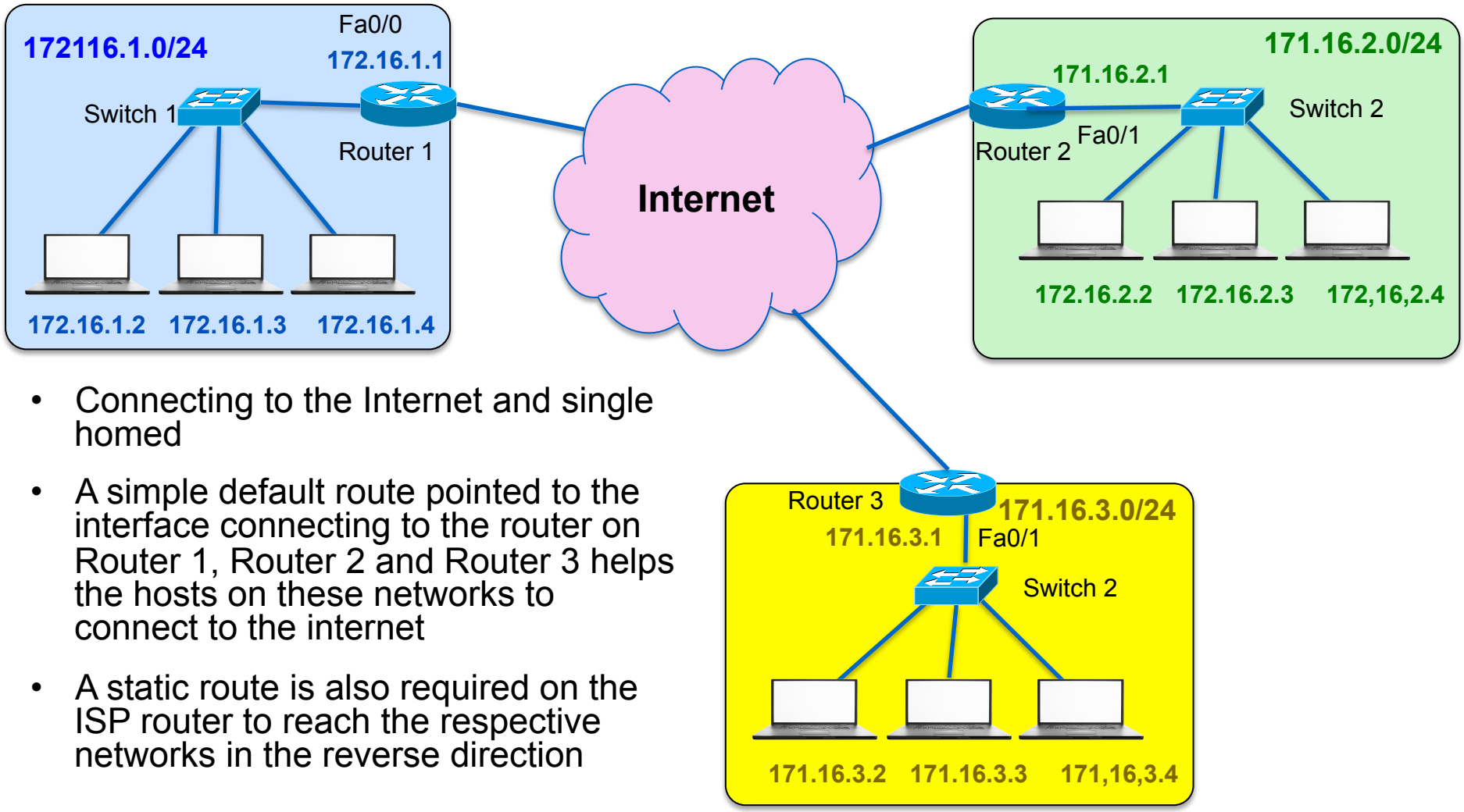
Static routing

- A manually configured route on a router to reach a specific destination network



- Useful for small networks
- Mostly used in hub and spoke networks
- Connecting to the Internet and single homed

Static Routing Scenarios



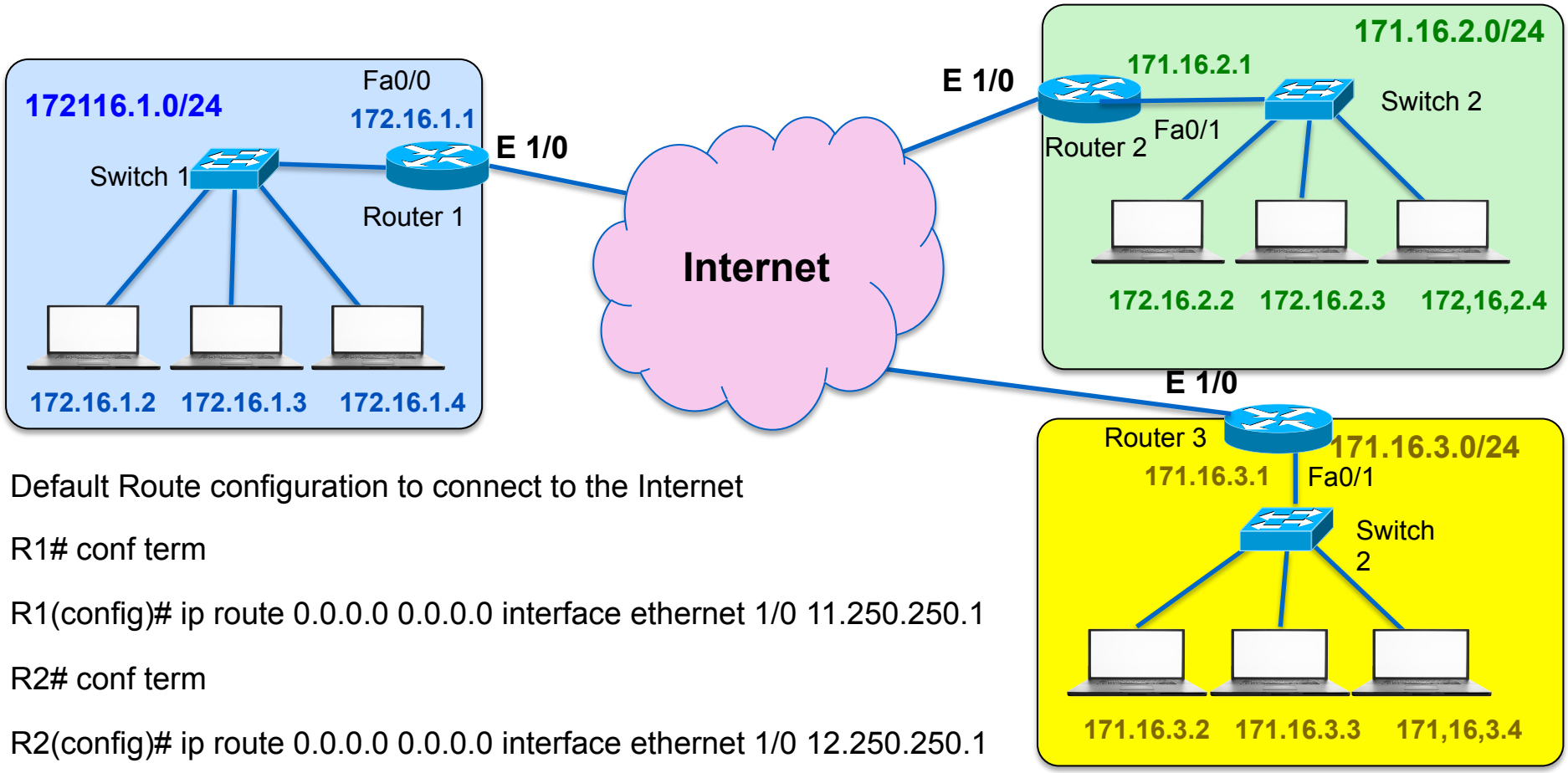
- Connecting to the Internet and single homed
- A simple default route pointed to the interface connecting to the router on Router 1, Router 2 and Router 3 helps the hosts on these networks to connect to the internet
- A static route is also required on the ISP router to reach the respective networks in the reverse direction

Static Route Configuration

```
Router(config)# ip route network-address subnet-mask
{ip-address | exit-interface }
```

Parameter	Description
network-address	Destination network address of the remote network to be added to the routing table.
subnet-mask	Subnet mask of the remote network to be added to the routing table. The subnet mask can be modified to summarize a group of networks.
ip-address	Commonly referred to as the next-hop router's IP address.
exit-interface	Outgoing interface that is used to forward packets to the destination network.

Static routing configuration Example



Default Route configuration to connect to the Internet

R1# conf term

R1(config)# ip route 0.0.0.0 0.0.0.0 interface ethernet 1/0 11.250.250.1

R2# conf term

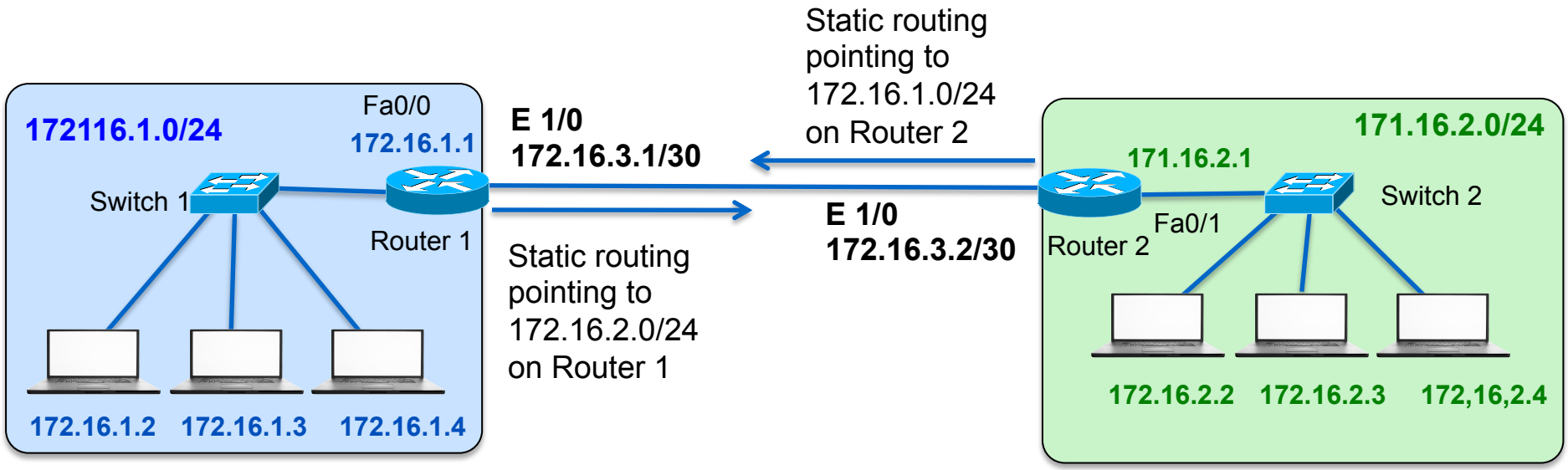
R2(config)# ip route 0.0.0.0 0.0.0.0 interface ethernet 1/0 12.250.250.1

R3# conf term

R3(config)# ip route 0.0.0.0 0.0.0.0 interface ethernet 1/0 13.250.250.1

Static routing

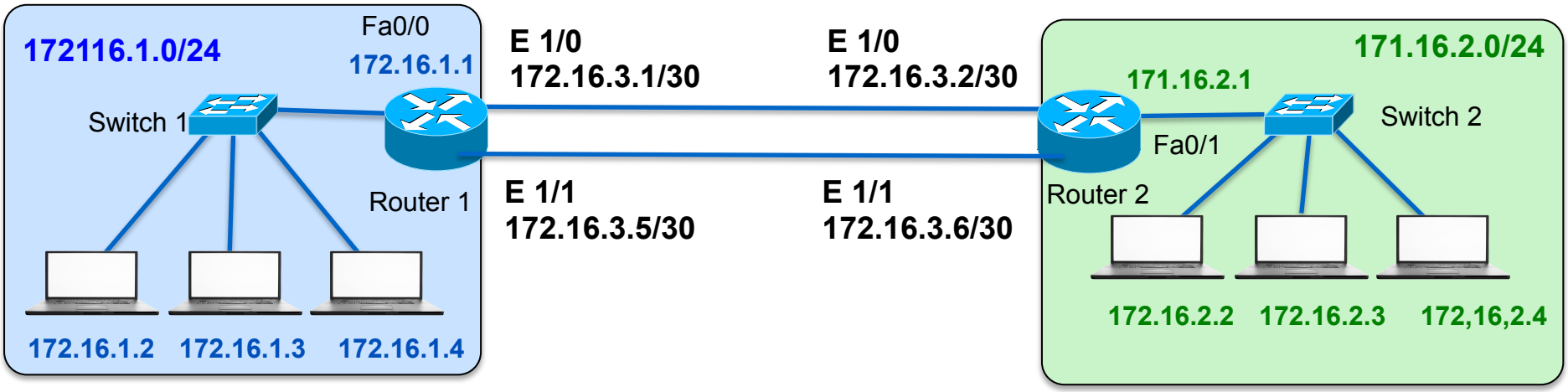
- A manually configured route on a router to reach a specific destination network



Router1# conf term
Router1(config)# ip route 172.16.2.0 255.255.255.0 ethernet 1/0 172.16.3.2

Router2# conf term
Router2(config)# ip route 172.16.1.0 255.255.255.0 ethernet 1/0 172.16.3.1

Load sharing using static routing



Router1# conf term

Router1(config)# ip route 172.16.2.0 255.255.255.0 ethernet 1/0 172.16.3.2

Router1(config)# ip route 172.16.2.0 255.255.255.0 ethernet 1/1 172.16.3.6

Router2# conf term

Router2(config)# ip route 172.16.1.0 255.255.255.0 ethernet 1/0 172.16.3.1

Router2(config)# ip route 172.16.1.0 255.255.255.0 ethernet 1/1 172.16.3.5

Pros and Cons of Static routing

- Advantages of static routing
  - It can backup multiple interfaces/networks on a router
  - Easy to configure
  - No extra resources are needed
- -More secure
- Disadvantages of static routing
  - Network changes require manual reconfiguration
  - Does not scale well in large topologies

Dynamic Routing

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Characteristics of Dynamic Routing

- Dynamic routing protocols fulfill the following functions
  - Dynamically share information between routers
  - Automatically update routing table when topology changes
  - Determine best path to a destination
- Routing protocols are grouped as either
  - Interior gateway protocols (IGP)Or
  - Exterior gateway protocols(EGP)

Terminology

- **Dynamic routing protocols** fulfill the following functions
  - –-Dynamically share information between routers
  - –-Automatically update routing table when topology changes
  - –-Determine best path to a destination
- **Routing protocols are grouped as either**
  - –-Interior gateway protocols (IGP)**Or**
  - –-Exterior gateway protocols(EGP)
- **Types of IGPs include**
  - –-Classless routing protocols - these protocols include subnet mask in routing updates
  - –-Classful routing protocols - these protocols do not include subnet mask in routing update

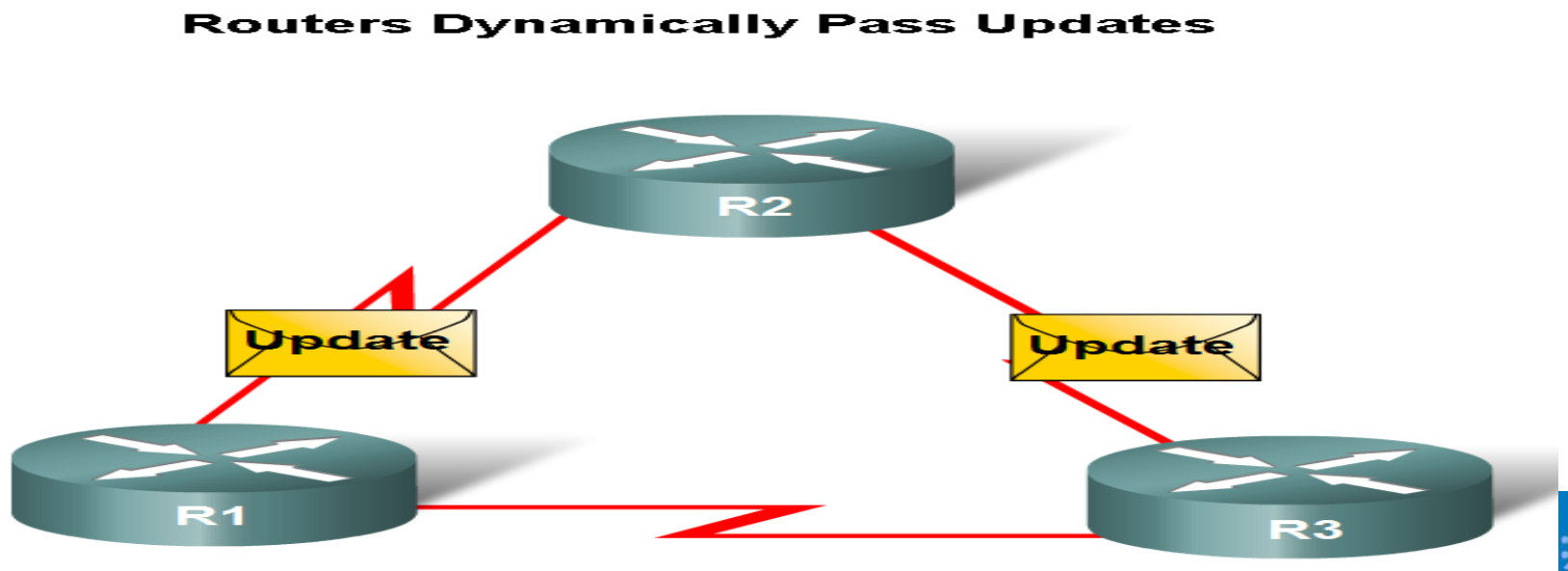
Terminology

- **Metrics** are used by dynamic routing protocols to calculate the best path to a destination.
- **Administrative distance** is the feature that routers use in order to select the best path when there are two or more different routes to the same destination from two different routing protocols. Administrative distance defines the reliability of a routing protocol. Each routing protocol is prioritized in order of most to least reliable (believable) with the help of an administrative distance value.”
- **Components of a routing table** include:
  - –-Route source
  - –-Administrative distance
  - –-Metric

Dynamic Routing Protocols

Function(s) of Dynamic Routing Protocols:

- –-Dynamically share information between routers.
- –-Automatically update routing table when topology changes.
- –-Determine best path to a destination.



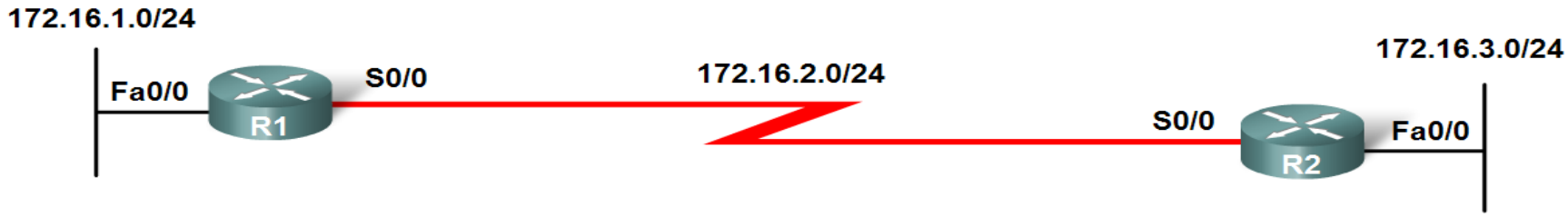
Dynamic Routing Protocols

The **purpose of a dynamic routing protocol** is to:

- –-Discover remote networks
- –-Maintaining up-to-date routing information
- –-Choosing the best path to destination networks
- –-Ability to find a new best path if the current path is no longer available

Routing Protocol Operation

Routing protocols are used to exchange routing information between the routers.



Dynamic Routing Protocols

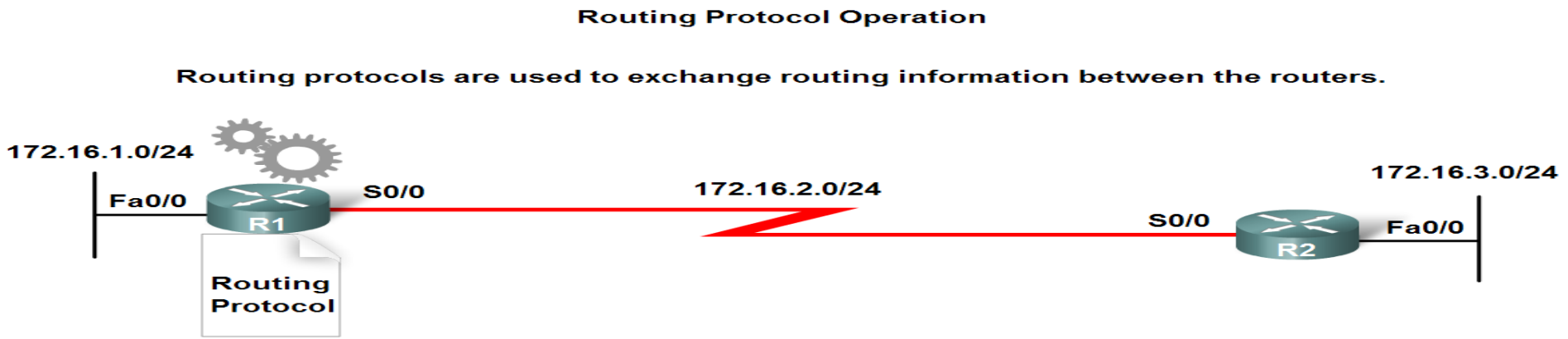
Components of a routing protocol

–Algorithm

- In the case of a routing protocol algorithms are used for facilitating routing information and best path determination

–Routing protocol messages

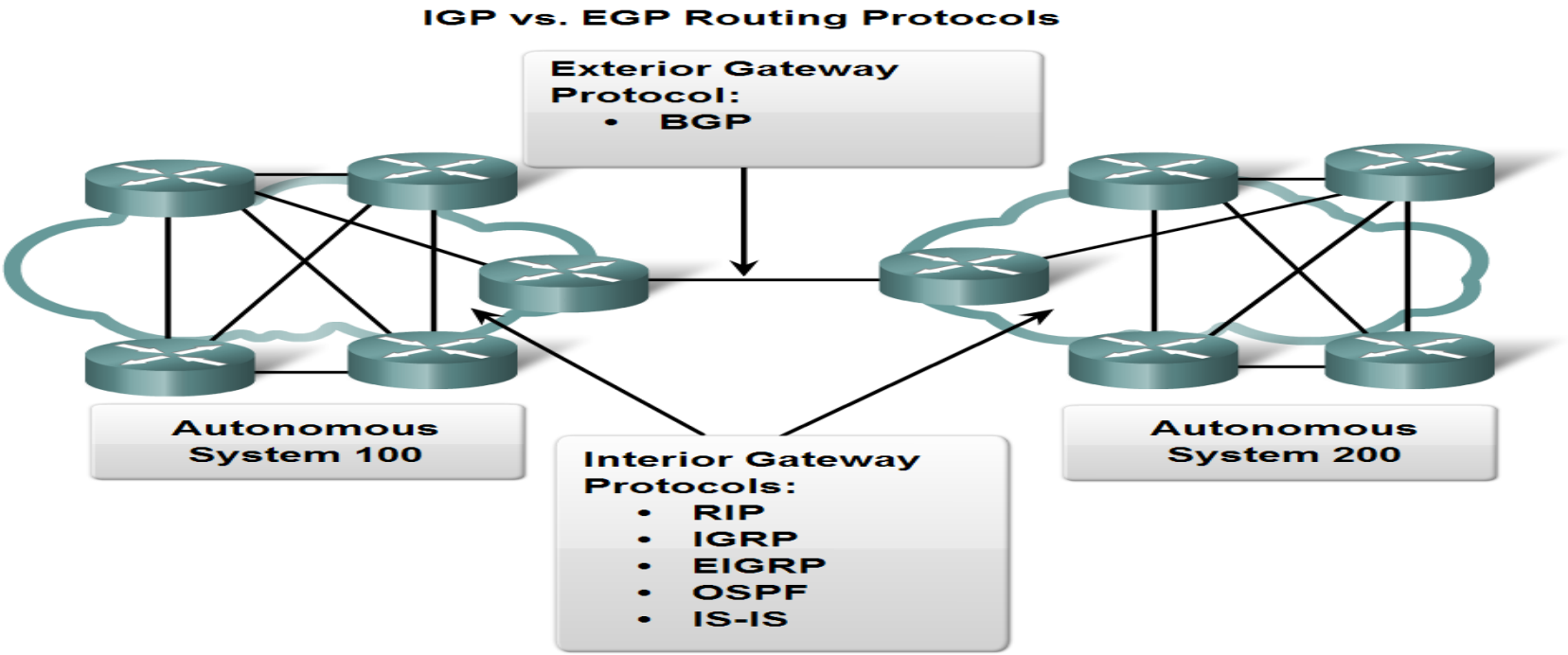
- These are messages for discovering neighbors and exchange of routing information



Classifying Routing Protocols

Types of routing protocols:

- –**Interior Gateway Protocols** (IGP)
- –**Exterior Gateway Protocols** (EGP)
- –

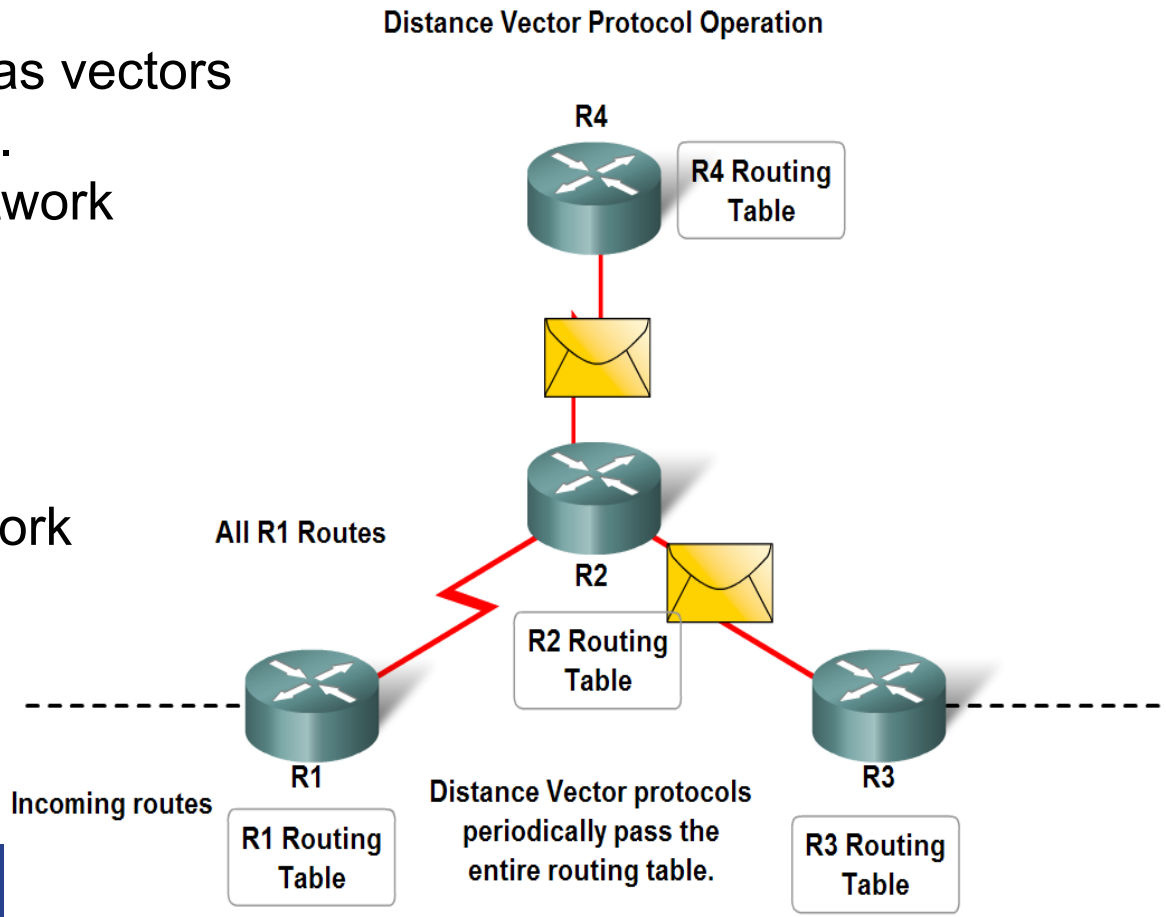


Classifying Routing Protocols

- **Interior Gateway Routing Protocols (IGP)**
  - –-Used for routing inside an autonomous system & used to route within the individual networks themselves.
  - –-Examples: RIP, EIGRP, OSPF
- **Exterior Routing Protocols (EGP)**
  - –-Used for routing between autonomous systems
  - –-Example: BGPv4

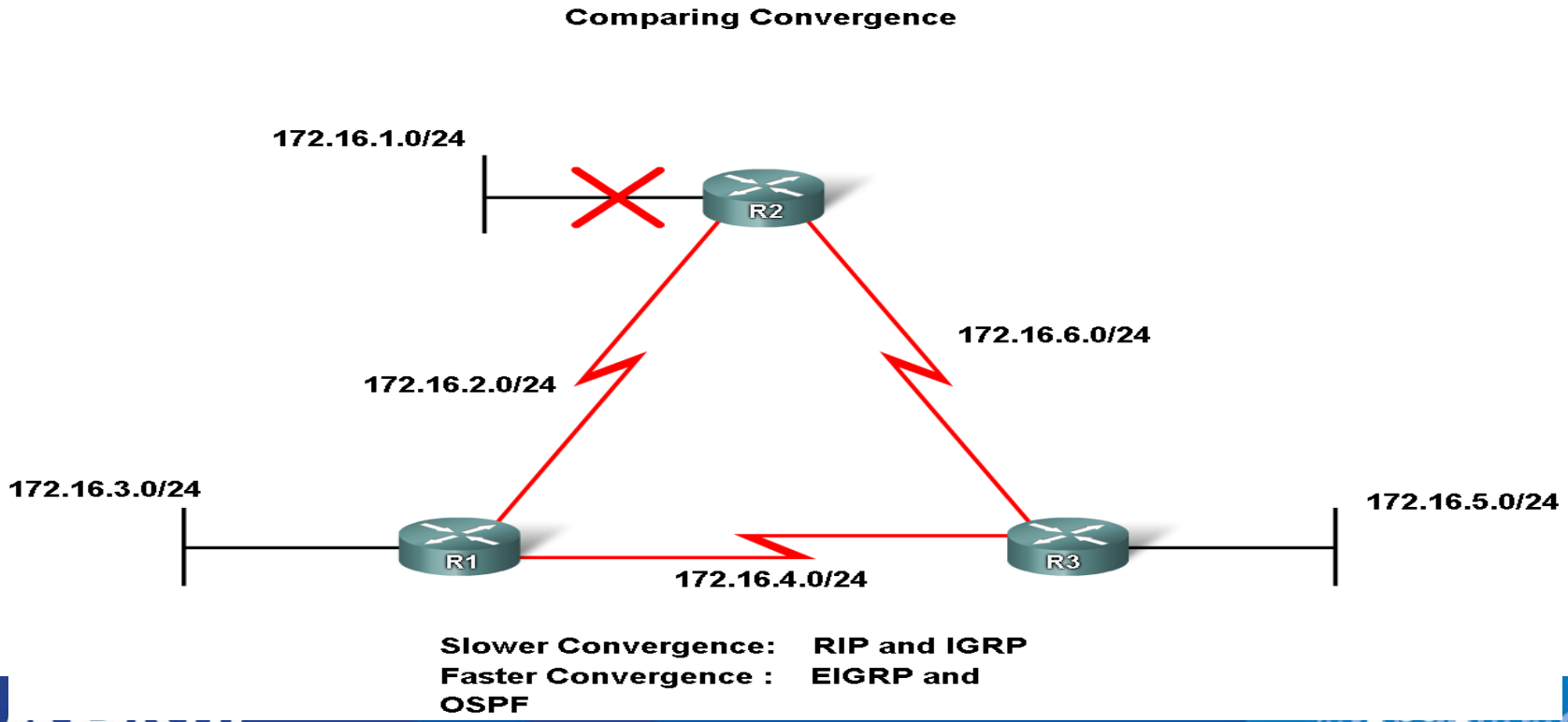
Classifying Routing Protocols

- IGP: **Comparison of Distance Vector** & **Link State** Routing Protocols
  - –**Distance vector**
  - – routes are advertised as vectors
  - – of distance & direction.
  - – incomplete view of network
  - – topology.
  - –Generally, periodic
  - – updates.
  - –**Link state**
  - – complete view of network
  - – topology is created.
  - – updates are not
  - – periodic.
  - – Faster Convergence



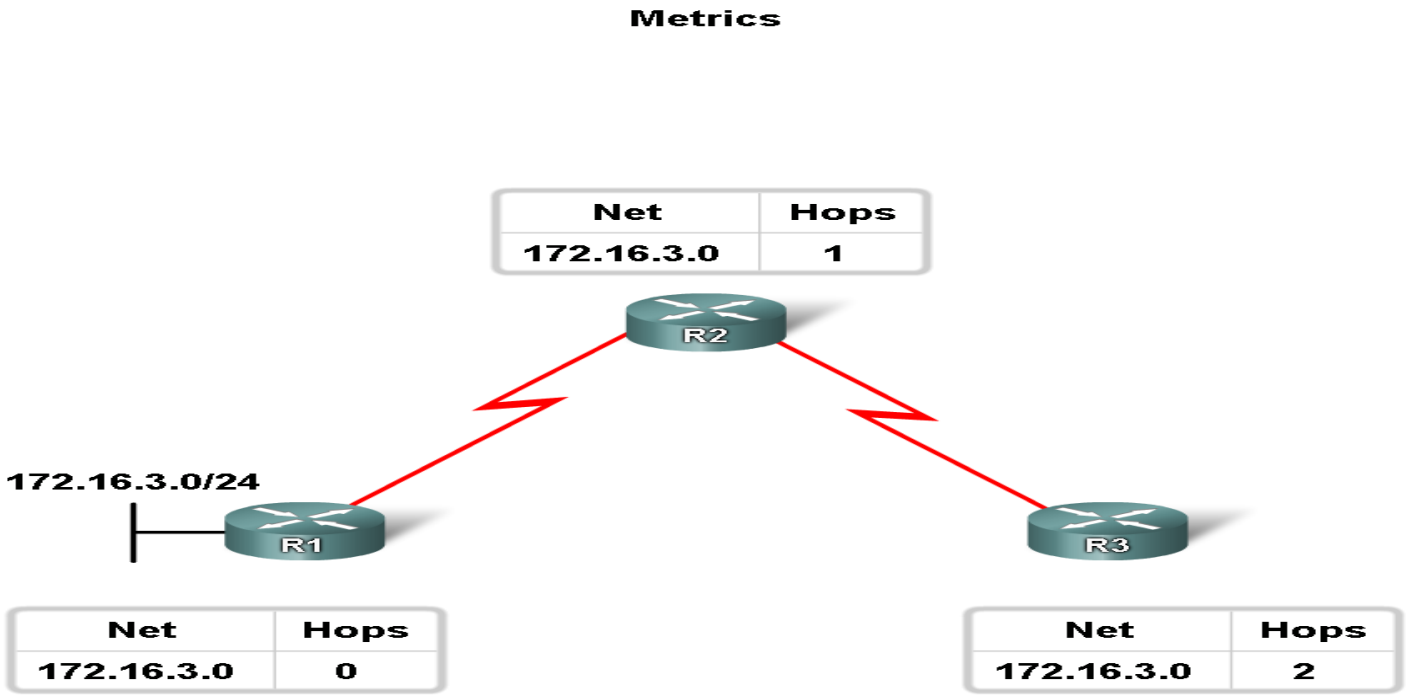
Classifying Routing Protocols

- **Convergence** is defined as: when all routers' routing tables are at a state of consistency



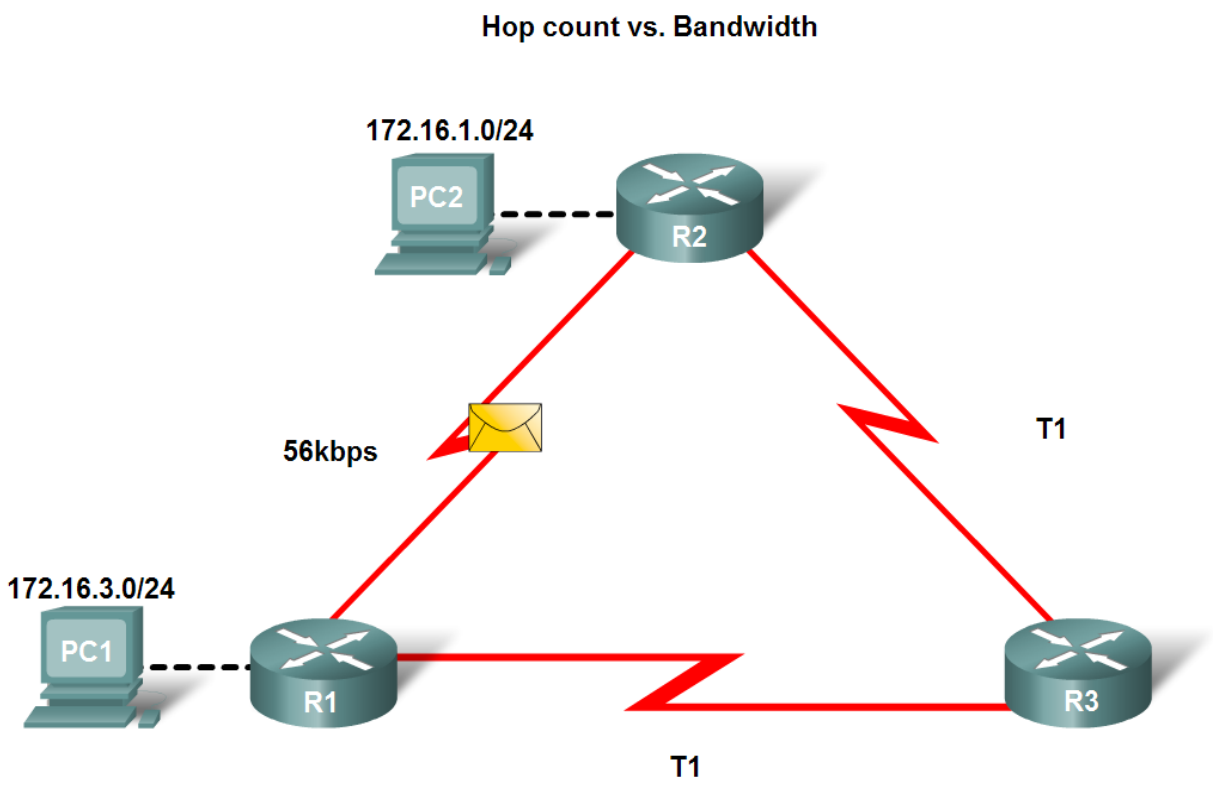
Routing Protocols Metrics

- **Metric**
  - –A value used by a routing protocol to determine which routes are better than others.



Routing Protocols Metrics

- **Metrics used in IP routing protocols**
  - –-Bandwidth
  - –-Cost
  - –-Delay
  - –-Hop count
  - –-Load
  - –-Reliability



Routing Protocols Metrics

- The Metric Field in the Routing Table
- **Metric** used for each routing protocol
  - –-RIP - hop count
  - –-IGRP & EIGRP - Bandwidth (used by default), Delay (used by default), Load, Reliability
  - –-IS-IS & OSPF – Cost, Bandwidth (Cisco's implementation)

–RIP-Routing Information Protocol

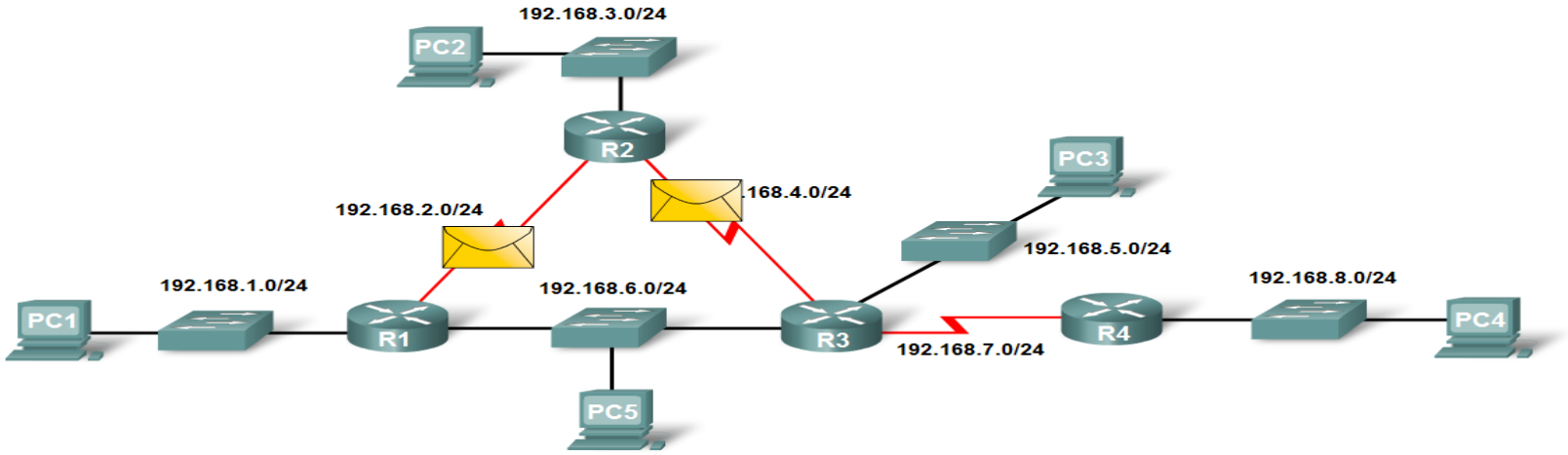
–IGRP-Interior Gateway Routing Protocol

–EIGRP-Enhanced Interior Gateway Routing Protocol

–IS-IS - Intermediate System to Intermediate System

Routing Protocols Metrics

- **Load balancing**
  - –This is the ability of a router to distribute packets among multiple same cost paths



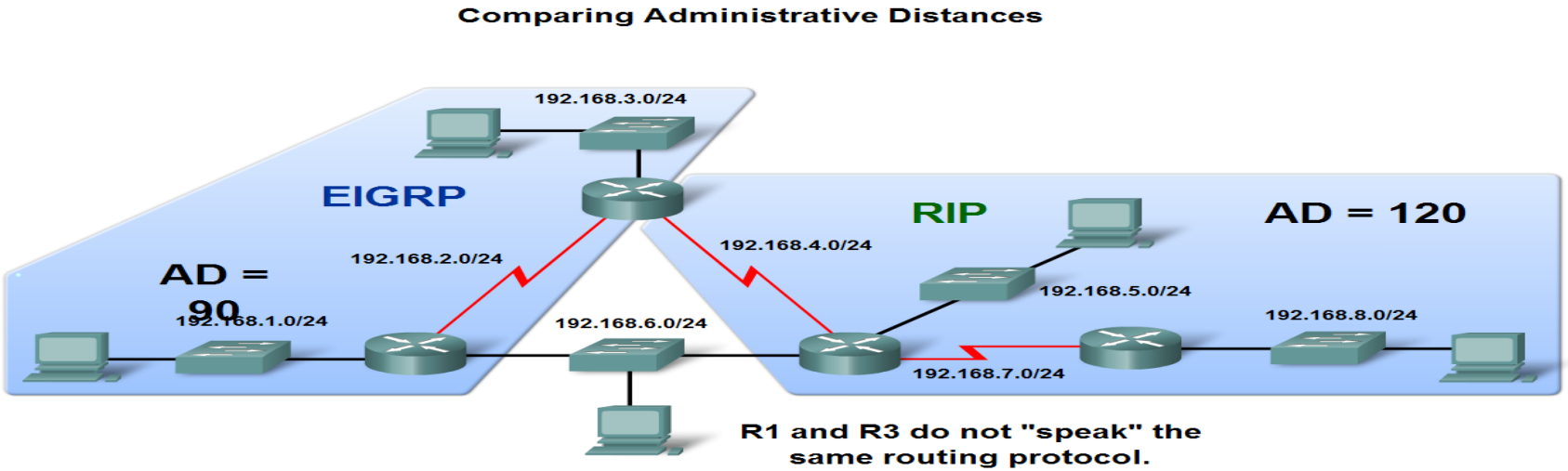

```
R2#show ip route
<output omitted>

R     192.168.6.0/24 [120/1] via 192.168.2.1, 00:00:24, Serial0/0/0
                     [120/1] via 192.168.4.1, 00:00:26, Serial0/0/1
```

Load Balancing Across Equal Cost Paths

Administrative Distance of a Route

- **Purpose of a metric**
  - –It's a calculated value used to determine the best path to a destination
- **Purpose of Administrative Distance**
  - –It's a numeric value that specifies the preference of a particular route



Administrative Distance of a Route

Identifying the Administrative Distance (AD) in a routing table

–It is the first number in the brackets in the routing table

```
R2#show ip route
<output omitted>

Gateway of last resort is not set

D     192.168.1.0/24 [90/2172416] via 192.168.2.1, 00:00:24, Serial0/0/0
C     192.168.2.0/24 is directly connected, Serial0/0/0
C     192.168.3.0/24 is directly connected, FastEthernet0/0
C     192.168.4.0/24 is directly connected, Serial0/0/1
R     192.168.5.0/24 [120/1] via 192.168.4.1, 00:00:08, Serial0/0/1
D     192.168.6.0/24 [90/2172416] via 192.168.2.1, 00:00:24, Serial0/0/0
R     192.168.7.0/24 [120/1] via 192.168.4.1, 00:00:08, Serial0/0/1
R     192.168.8.0/24 [120/2] via 192.168.4.1, 00:00:08, Serial0/0/1
```

```
R2#show ip rip database
192.168.3.0/24    directly connected, FastEthernet0/0
192.168.4.0/24    directly connected, Serial0/0/1
192.168.5.0/24
    [1] via 192.168.4.1, Serial0/0/1
192.168.6.0/24
    [1] via 192.168.4.1, Serial0/0/1
192.168.7.0/24
    [1] via 192.168.4.1, Serial0/0/1
192.168.8.0/24
    [2] via 192.168.4.1, Serial0/0/1
```

Administrative Distance of a Route

Dynamic Routing Protocols

Default Administrative Distances

Route source	Default AD
Connected interface	0
Static	1
EIGRP summary route	5
eBGP	20
EIGRP (Internal)	90
IGRP	100
OSPF	110
IS - IS	115
RIP	120
EIGRP (External)	170
iBGP	200
Unknown	255

Administrative Distance of a Route

- **Directly connected routes**
  - –Have a default **AD of 0**
- **Static Routes**
  - –Administrative distance of a static route has a **default value of 1**

```
R2#show ip route 172.16.3.0
Routing entry for 172.16.3.0/24
Known via "static", distance 1, metric 0 (connected)
  Routing Descriptor Blocks:
  * directly connected, via Serial0/0/0
      Route metric is 0, traffic share count is 1
```

Administrative Distance of a Route

Directly connected routes

–-Immediately appear in the routing table as soon as the interface is configured

```
R2#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
C       172.16.1.0 is directly connected, FastEthernet0/0
C       172.16.2.0 is directly connected, Serial0/0/0
S       172.16.3.0 is directly connected, Serial0/0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
S    192.168.2.0/24 [1/0] via 192.168.1.1
```