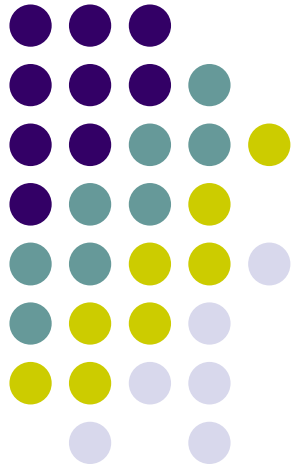
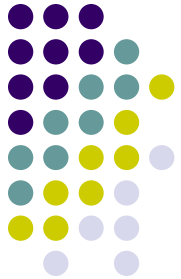
# Semester 2 Module 6 Routing and Routing Protocols



# Outline

- Introduction to Routing
- Static Routing Overview
- Dynamic Routing Overview

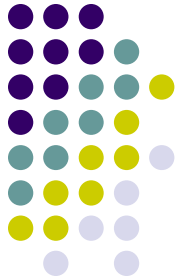
# Introducing routing



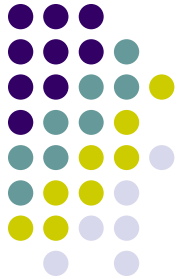
- Routing is the process that a router uses to forward packets toward the destination network.
- A router makes decisions based upon the destination IP address of a packet.
- In order to make the correct decisions, routers must learn the direction to remote networks.

# Path determination

- A router determines the path of a packet from one data link to another, using two basic functions:
  - A path determination function
  - A switching function

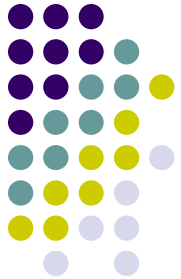


- Path determination occurs at the network layer.
- The path determination function enables a router to evaluate the paths to a destination and to establish the preferred handling of a packet.
- The router uses the routing table to determine the best path and proceeds to forward the packet using the switching function.



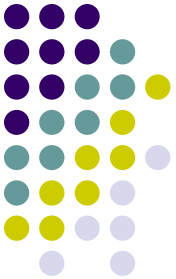
- The switching function is the internal process used by a router to accept a packet on one interface and forward it to a second interface on the same router.
- A key responsibility of the switching function of the router is to encapsulate packets in the appropriate frame type for the next data link.

# Types of Routing Protocols



- When routers use dynamic routing, this information is learned from other routers.
- When static routing is used, a network administrator configures information about remote networks manually.

# Types of Routing Protocols (cont.)



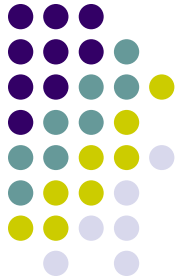
**Static**

Uses a programmed route that a network administrator enters into the router

**Dynamic**

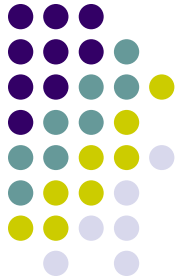
Uses a route that a routing protocol adjusts automatically for topology or traffic changes

# Routing Protocols: How to determine the best path?



- 1st Parameter: the administrative distance (AD)
  - AD is an optional parameter that gives a measure of the reliability of the route.
  - A lower value for the AD indicates the more reliable route.
  - The default AD when using next-hop address is 1, while the default AD when using the outgoing interface (connected) is 0.

# Routing Protocols: How to determine the best path? (cont.)

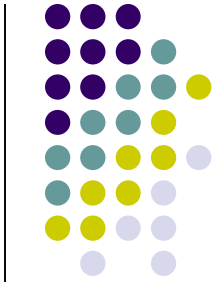


- 2nd Parameter: Metrics
  - Routing metrics are values used in determining the advantage of one route over another (often used for dynamic routing).

# AD & Metrics Table

| Protocol | | AD | Metrics | Routing Algorithm | Scalability | Classless/ Ful |
|---|---|---|---|---|---|---|
| Static Routing | Connected | 0 | | | Small | |
| | Next - hop | 1 | | | Small | |
| Dynamic Routing | EIGRP | 90 | Bandwidth, Delay, Reliability, Load, MTU | Hybrid: Distance Vector and Link state | Large | Classless |
| | OSPF | 110 | Cost = $10^8$/Bandwidth | Link state | Large | Classless |
| | IS - IS | 115 | Cost = $10^8$/Bandwidth | Link state | Large | Classless |
| | RIP v1 & v2 | 120 | Hop count | Distance vector | Small | Classful |

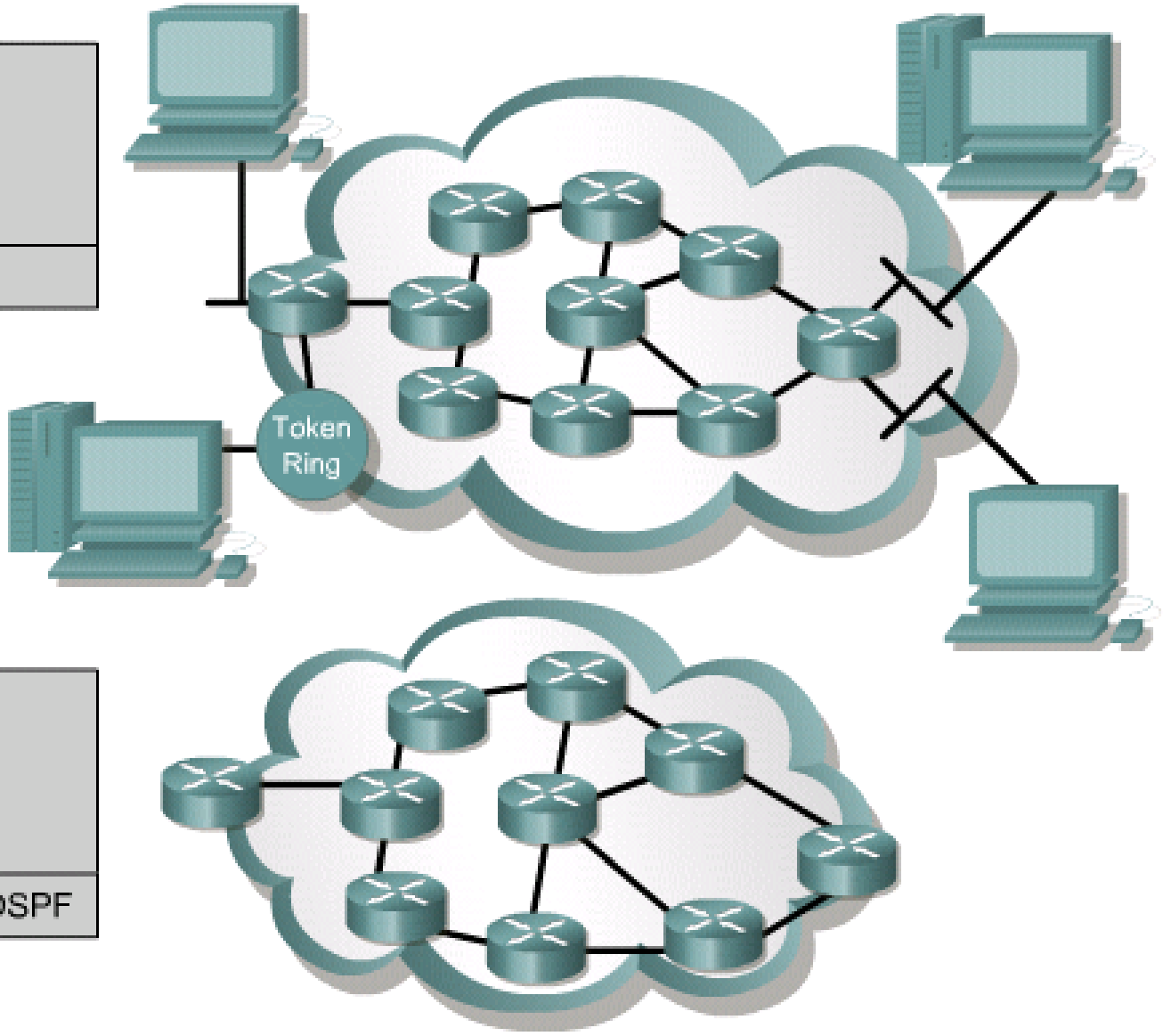
# Introduction to routing/routed protocols



- A routing protocol is the communication used between routers.
- A routed protocol is used to direct user traffic.
  - Examples of routed protocols are:
    - Internet Protocol (IP)
    - Internetwork Packet Exchange (IPX)

Routed protocol
used between
routers to direct
user traffic

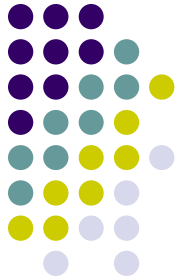
Examples: IP and IPX



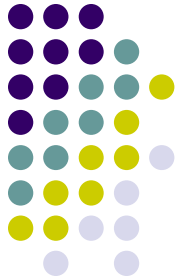

Routing protocol
used between
routers to maintain
tables

Examples: RIP, IGRP, OSPF

# Autonomous systems



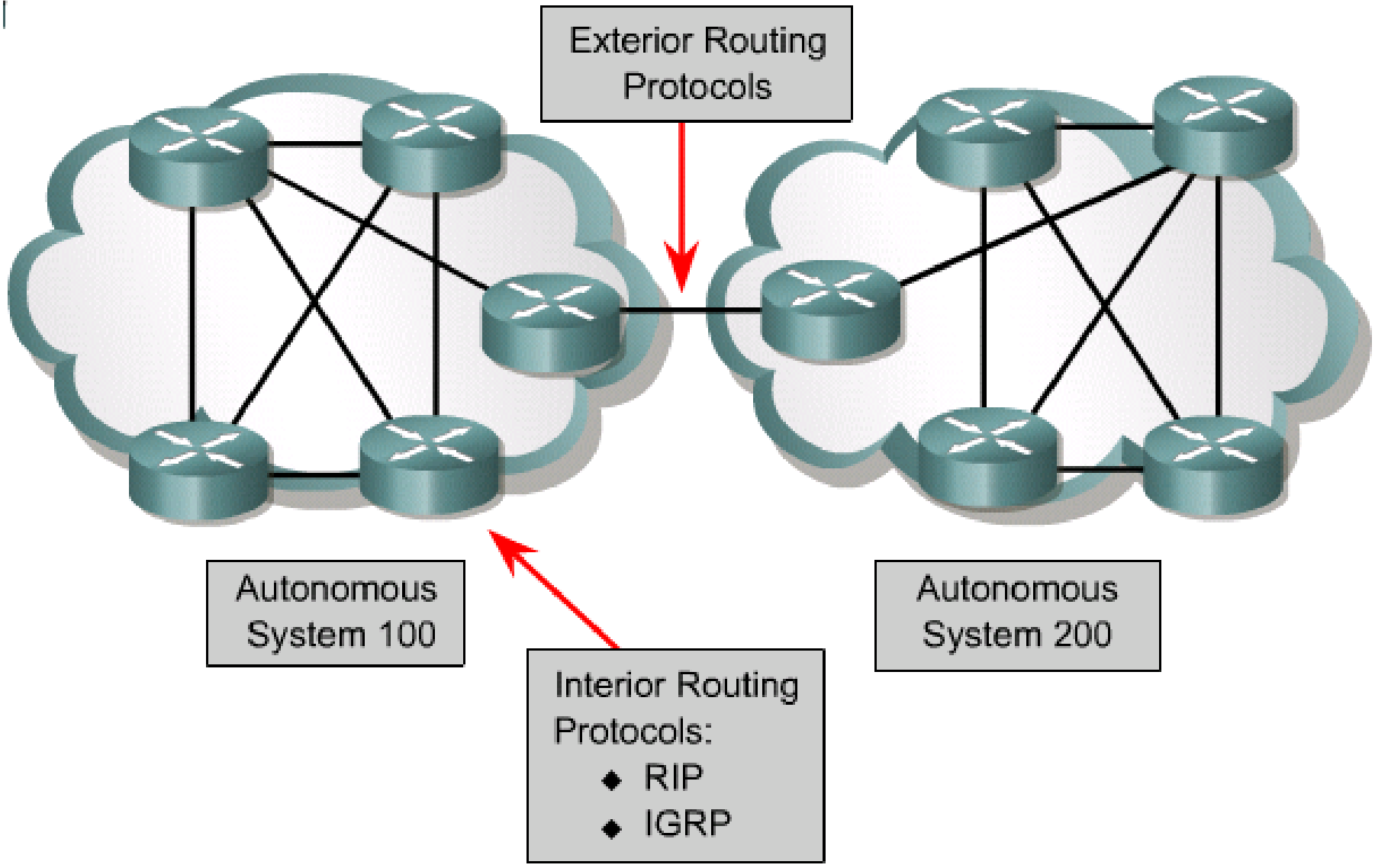
- An autonomous system (AS) is a collection of networks under a common administration sharing a common routing strategy.
- To the outside world, an AS is viewed as a single entity.



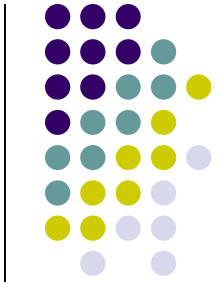
- Autonomous systems (AS) provide the division of the global internetwork into smaller and more manageable networks.
- Each AS has its own set of rules and policies and an AS number that will uniquely distinguish it from other autonomous systems throughout the world.

# Autonomous systems and IGP versus EGP

- Interior routing protocols are designed for use in a network whose parts are under the control of a single organization.
  - Examples: RIP, EIGRP, OSPF
- An exterior routing protocol is designed for use between two different networks that are under the control of two different organizations.
  - Example: BGP


Exterior Routing Protocols
Autonomous System 100
Autonomous System 200
Interior Routing Protocols:
RIP
IGRP

# Convergence



- When all routers in an internetwork are operating with the same knowledge, the internetwork is said to have converged.
- Fast convergence is desirable because it reduces the period of time in which routers would continue to make incorrect routing decisions.

# Outline

- Introduction to Routing
- Static Routing Overview
- Dynamic Routing Overview

# Static route operation

- Static route operations can be divided into these three parts:
  - Network administrator configures the route
  - Router installs the route in the routing table
  - Packets are routed using the static route
- Since a static route is manually configured, the administrator must configure the static route on the router using the **ip route** command.

# Configuring static routes

- Use the following steps to configure static routes:

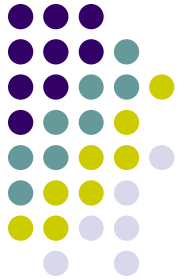
1. Determine all desired destination networks, their subnet masks, and their gateways. A gateway can be either a local interface or a next hop address that leads to the desired destination.
2. Enter global configuration mode.

   Router# configure terminal
3. Type the **ip route** command with a destination network address (Dest. Net) and subnet mask ( Dest SM) followed by their corresponding gateway from Step one. Including an administrative distance (AD) is optional.

   Router(config)# ip route {Dest. Net} {Dest. SM} {Gateway} [AD]

```
Hoboken(config)#ip route 172.16.1.0 255.255.255.0 s0
```

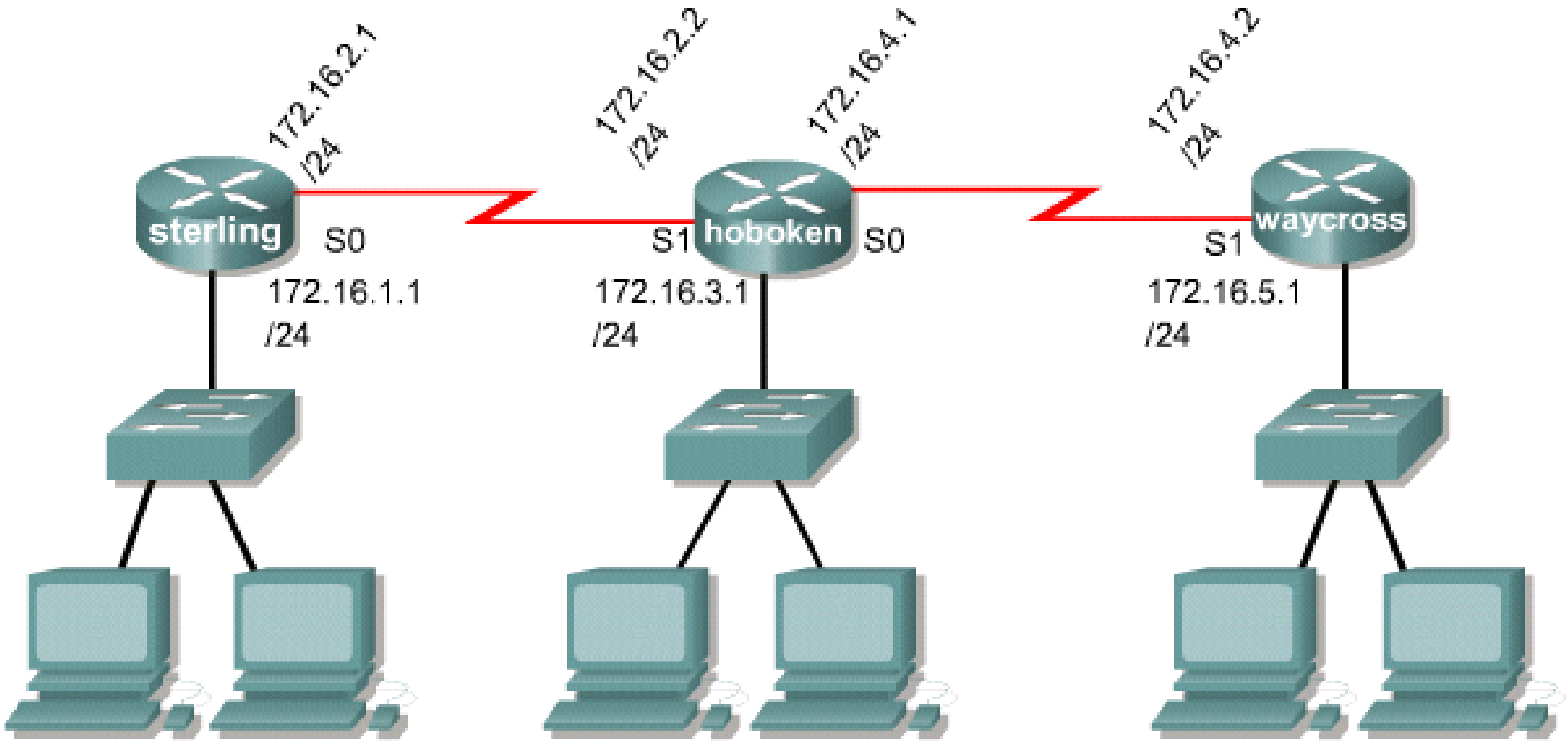
command destination net subnet mask outgoing interface



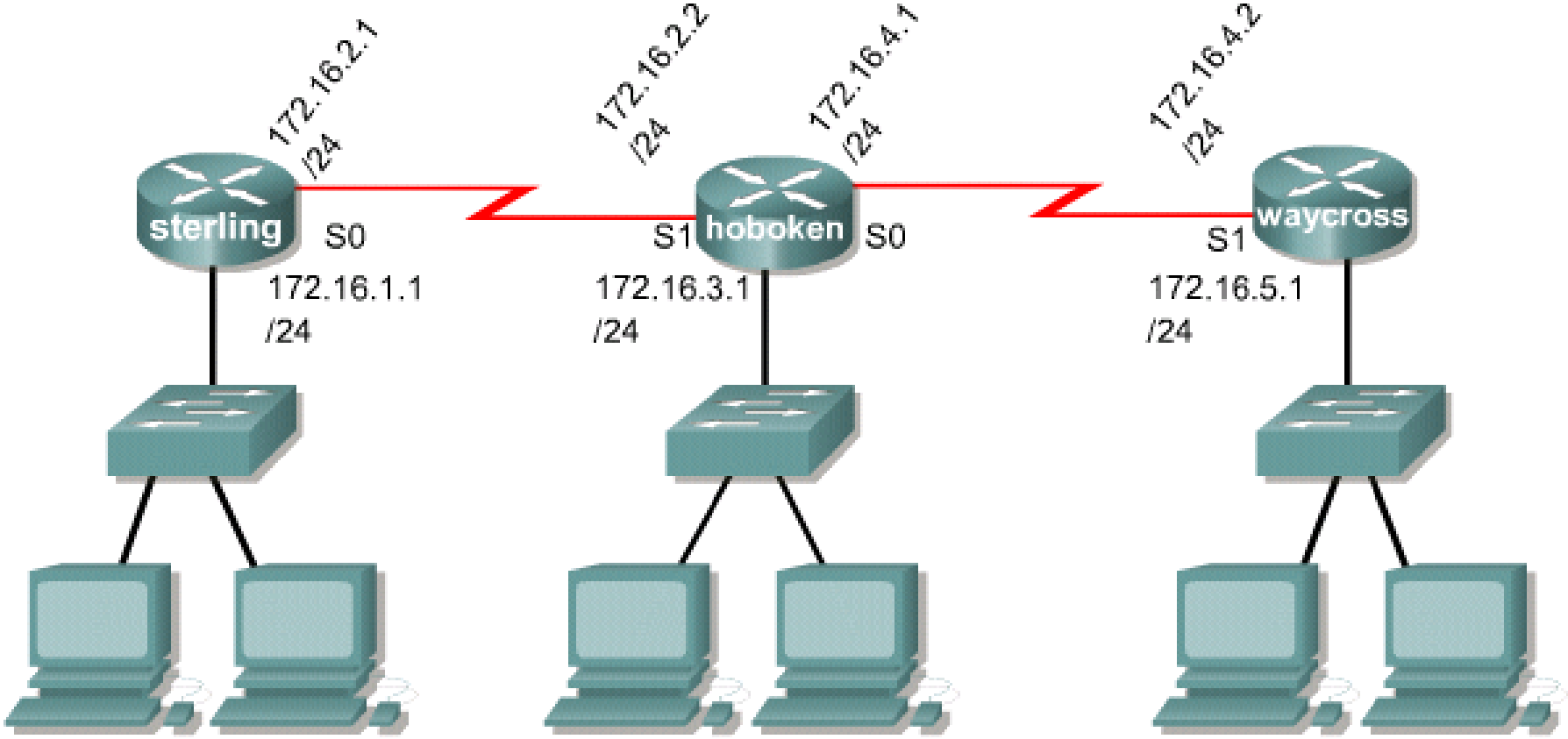
4. Repeat 3rd Step for as many destination networks as were defined in 1st Step .
5. Exit global configuration mode.

   Router(config)# exit
6. Save the active configuration to NVRAM by using the **copy running-config startup-config** command or **write memory** command

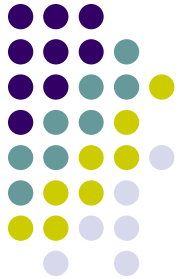
   Router# write memory




```
Hoboken(config)#ip route 172.16.1.0 255.255.255.0 s1
                   command  destination   sub mask     gateway
                            network
Hoboken(config)#ip route 172.16.5.0 255.255.255.0 s0
                   command  destination   sub mask     gateway
                            network
```

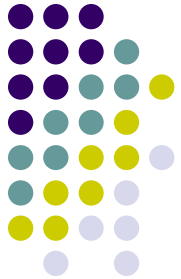



```
Hoboken(config)#ip route 172.16.1.0 255.255.255.0 172.16.2.1
                    command  destination  sub mask     gateway
                             network
Hoboken(config)#ip route 172.16.5.0 255.255.255.0 172.16.4.2
                    command  destination  sub mask     gateway
                             network
```



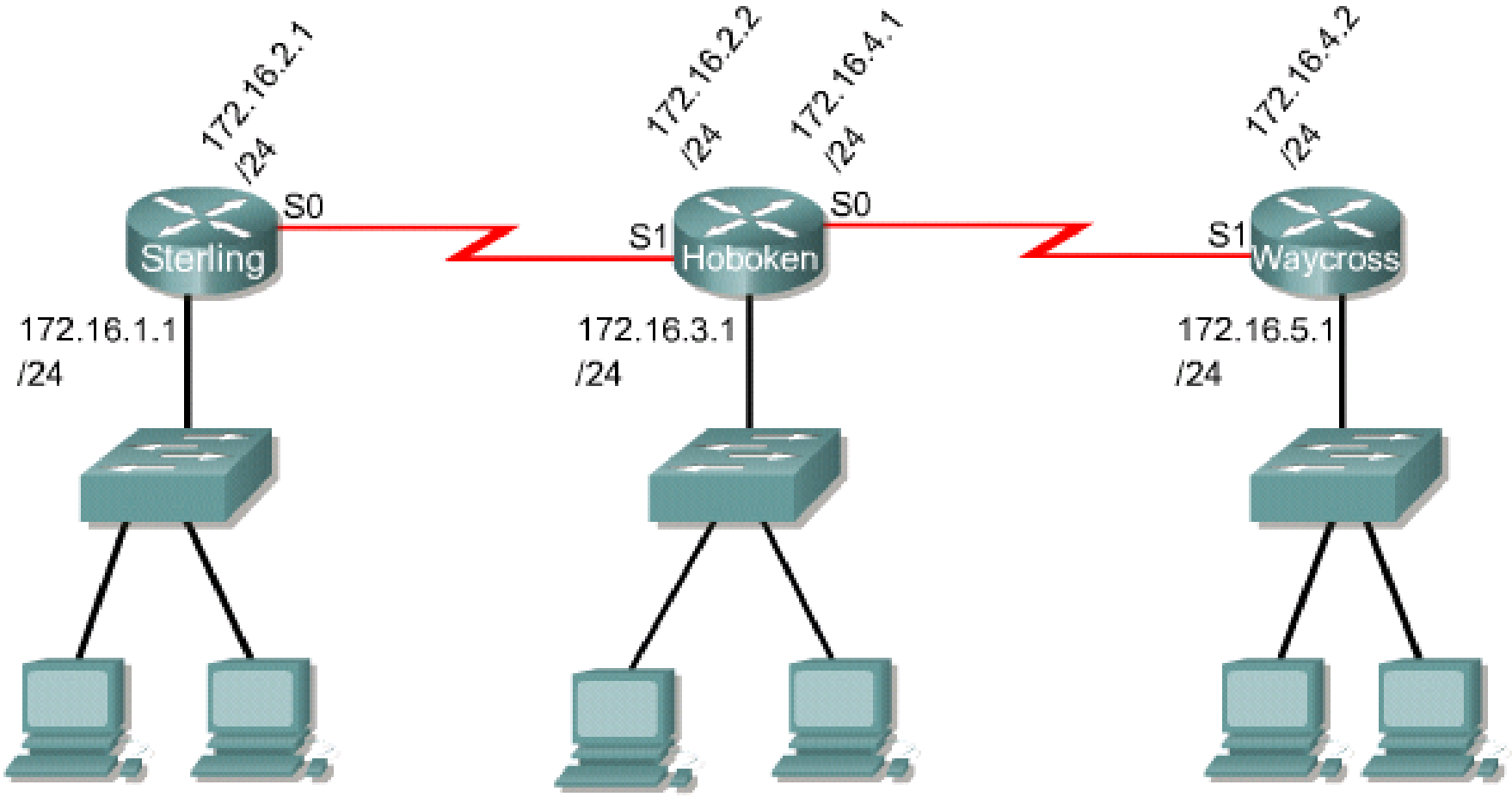
- If the router cannot reach the outgoing interface that is being used in the route, the route will not be installed in the routing table.
- This means if that interface is down, the route will not be placed in the routing table.

# Static Routing: Backup Route

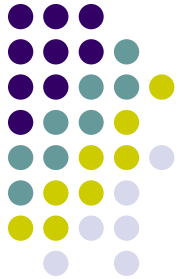


- Sometimes static routes are used for backup purposes.
- A static route can be configured on a router that will only be used when the dynamically learned route has failed.
- To use a static route in this manner, simply set the administrative distance higher than that of the dynamic routing protocol being used.

Router(config)#**ip route 172.16.3.0 255.255.255.0 172.16.4.1 130**


172.16.2.1
/24
S0
Sterling
172.16.1.1
/24
172.16.2.2
/24
172.16.4.1
/24
S1
Hoboken
S0
172.16.3.1
/24
172.16.4.2
/24
S1
Waycross
172.16.5.1
/24

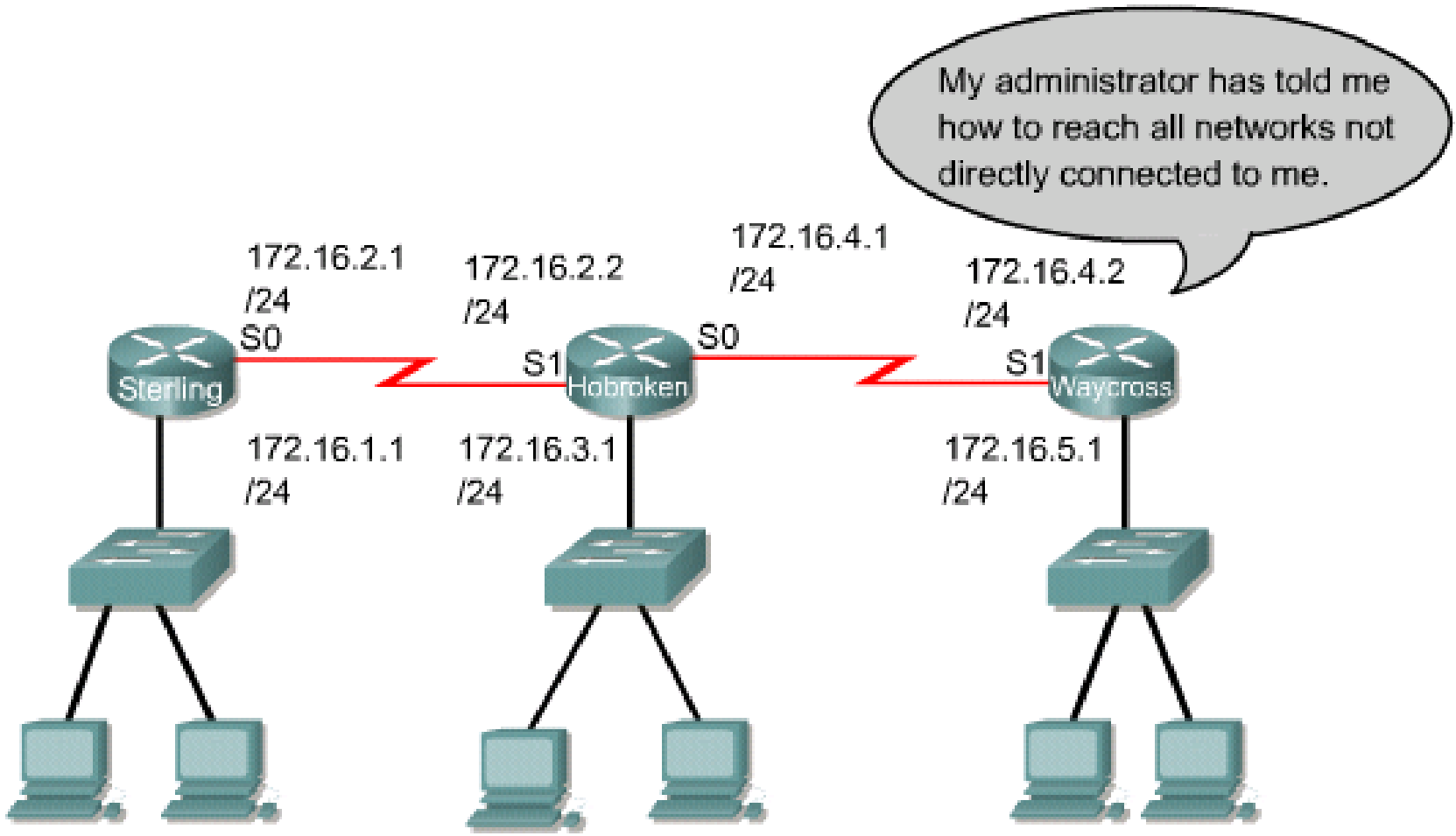
# Configuring default route forwarding



- Default routes are used to route packets with destinations that do not match any of the other routes in the routing table.
- A default route is actually a special static route that uses this format:

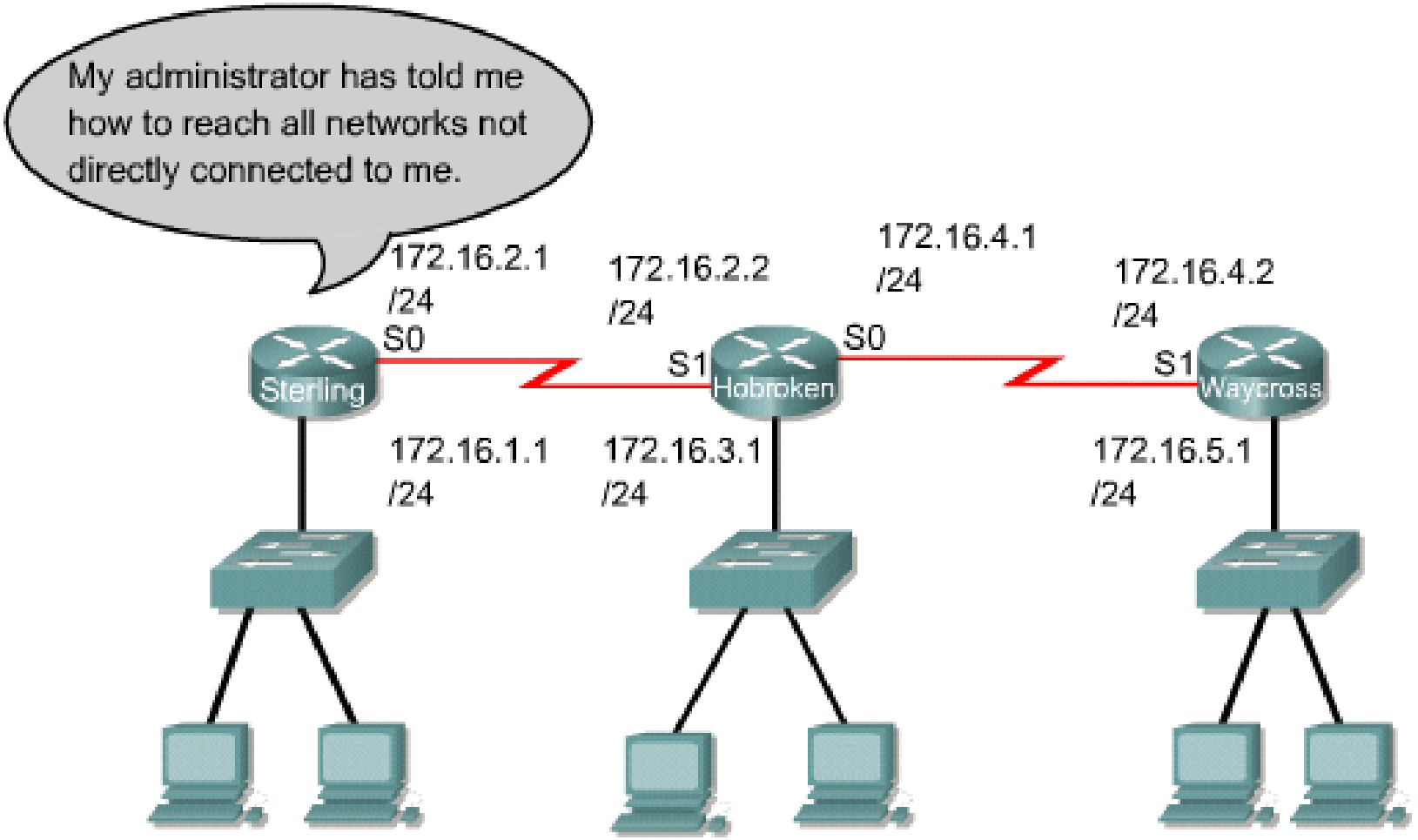
  **Router(config)# ip route 0.0.0.0 0.0.0.0**

  **[*next-hop-address* | *outgoing interface*]**




```
Waycross(config)#ip route 0.0.0.0  0.0.0.0 S1
```

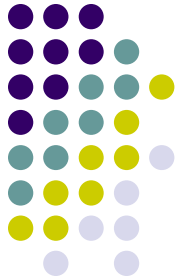
This command points to all non-directly-connected networks




```
Sterling(config)#ip route 0.0.0.0  0.0.0.0 S0
```

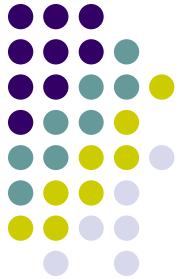
This command points to all non-directly-connected networks

# Verifying static route configuration



- Use the following steps to verify static route configuration:
  - In privileged mode enter the command **show running-config** to view the active configuration.
  - Verify that the static route has been correctly entered.
  - Enter the command **show ip route**.
  - Verify that the route that was configured is in the routing table.

# Troubleshooting static route configuration



```
Hoboken#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 type2
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, 5 subnets
C       172.16.4.0 is directly connected, Serial0
S       172.16.5.0 is directly connected, Serial0
S       172.16.1.0 is directly connected, Serial1
C       172.16.2.0 is directly connected, Serial1
```

```
Sterling#ping 172.16.5.1
Type escape sequence to abort.
Sending 5,100-byte ICMP Echos to 172.16.5.1,timeout is 2
seconds:
.....
Success rate is 0 percent (0/5)


Sterling#traceroute 172.16.5.1
Type escape sequence to abort.
Tracing the route to 172.16.5.1
  1 172.16.2.2 16 msec 16 msec 16 msec
  2 172.16.4.2 32 msec 28 msec *
  3  *  *  *
  4  *  *  *
  5  *  *  *
  6  *  *  *
```

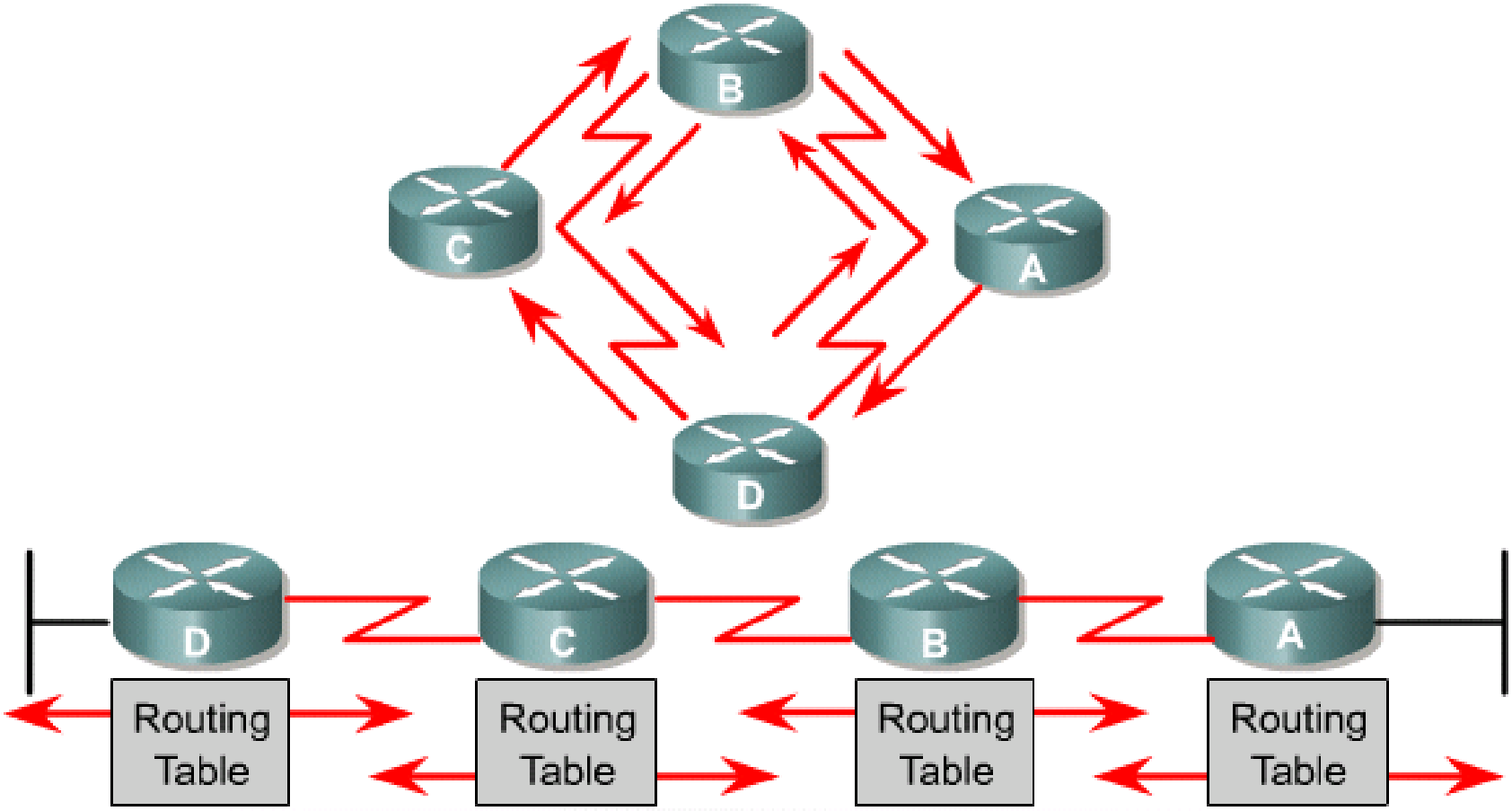
# Outline

- Introduction to Routing
- Static Routing Overview
- Dynamic Routing Overview

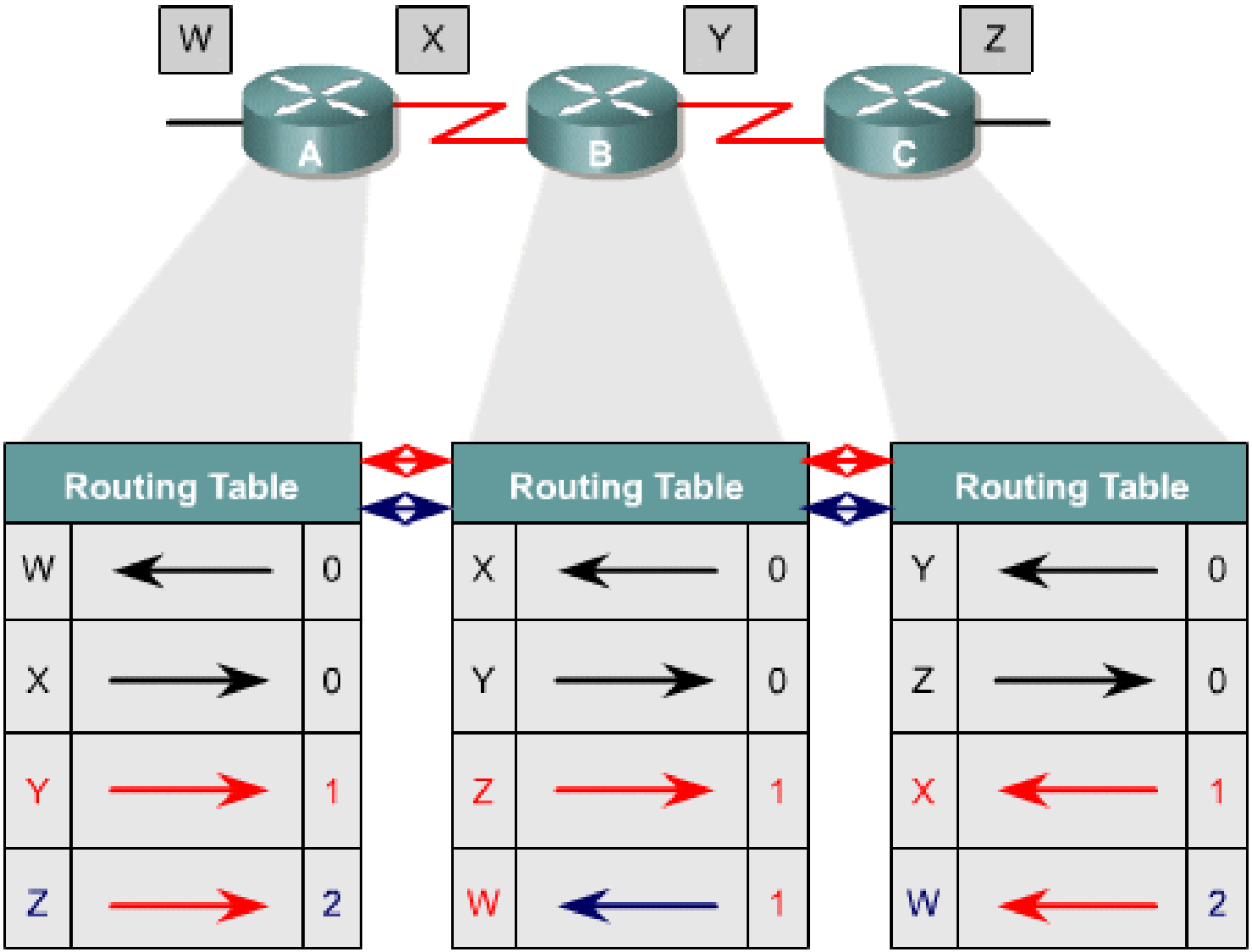
# The algorithms of dynamic routing protocols

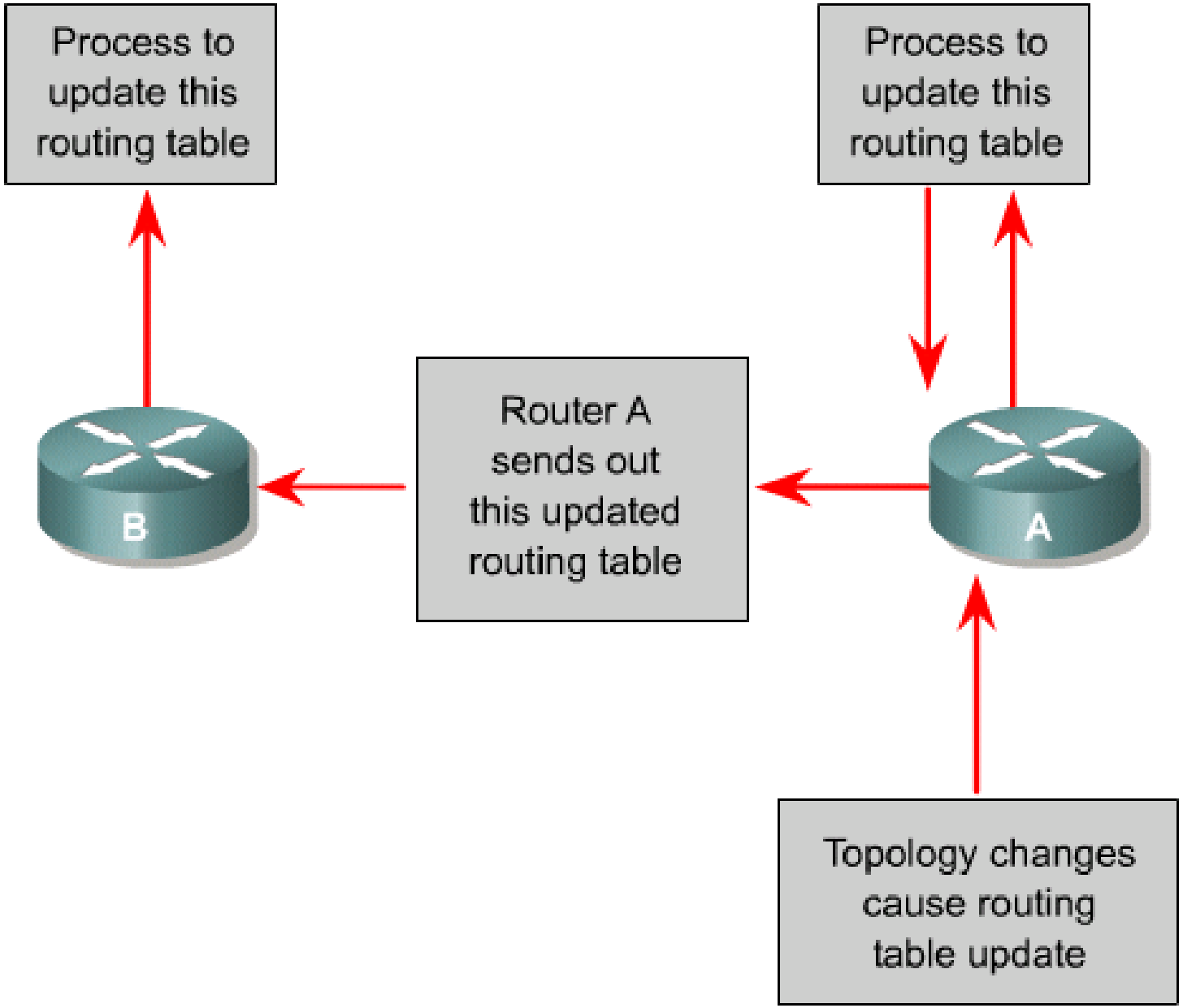
- Most routing algorithms can be classified into one of two categories:
  - distance vector (RIP, EIGRP)
  - link-state (OSPF, IS - IS)
- The distance vector routing approach determines the direction (vector) and distance to any link in the internetwork.
- The link-state approach, also called shortest path first, recreates the exact topology of the entire internetwork.

# Distance vector routing protocol features

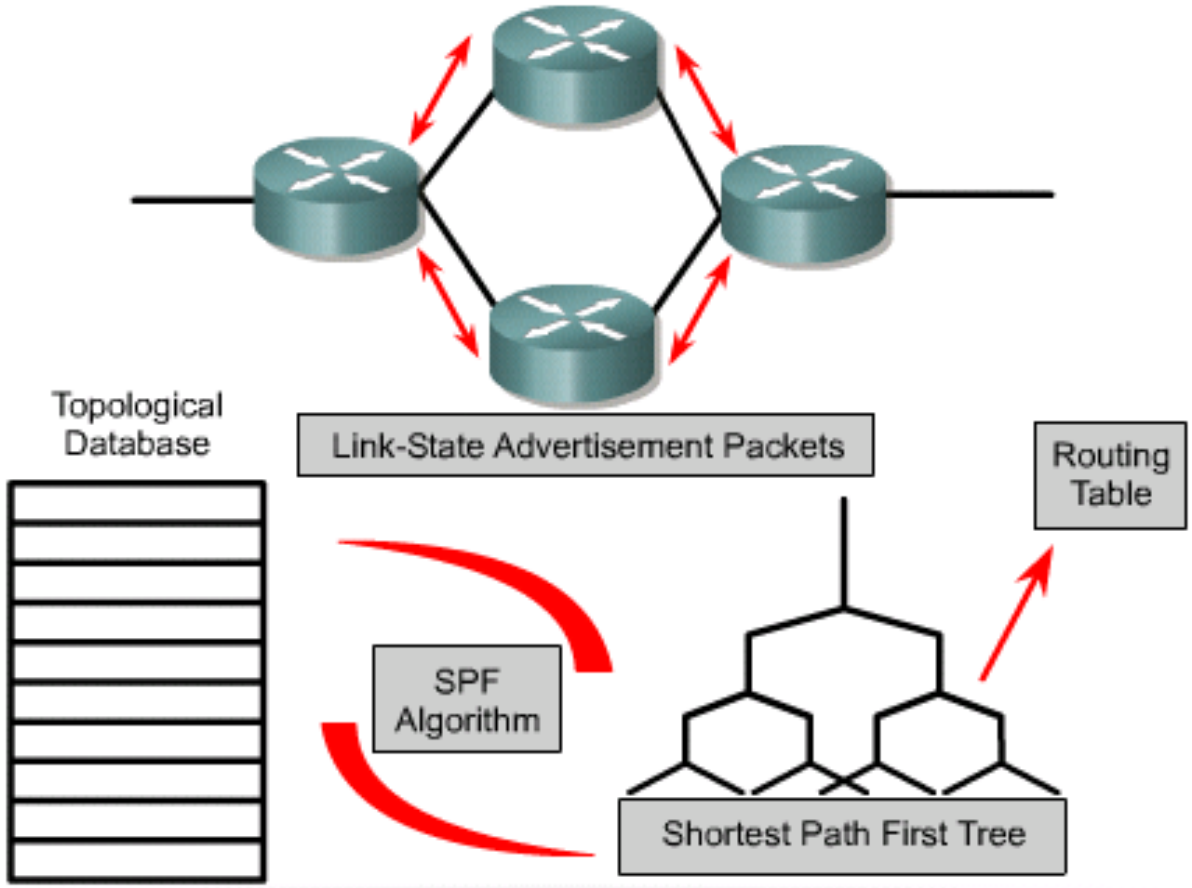



Pass periodic copies of a routing table to neighbor routers and accumulate distance vectors.

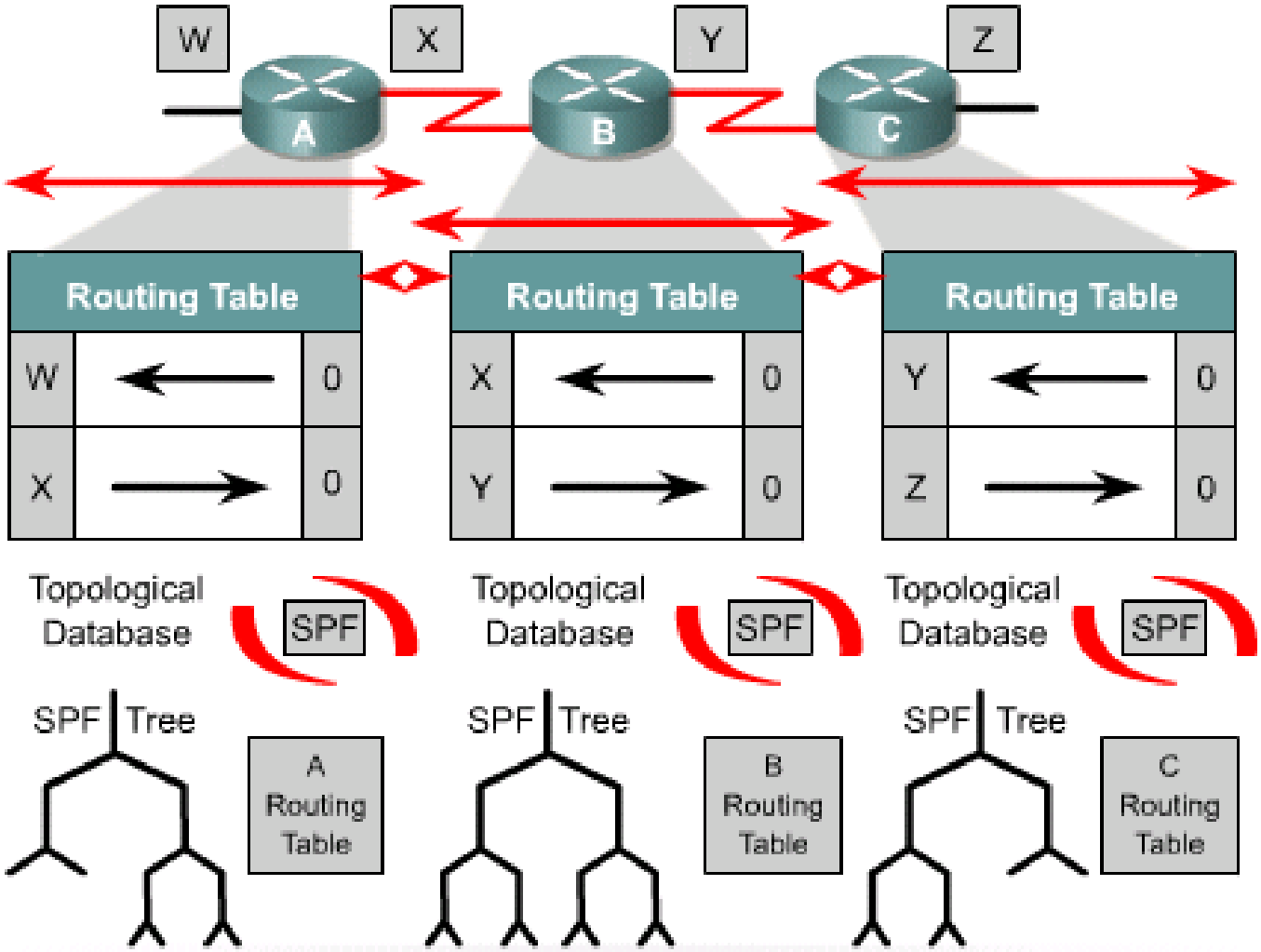

W
X
Y
Z
A
B
C
Routing Table
W 0
X 0
Y 1
Z 2
Routing Table
X 0
Y 0
Z 1
W 1
Routing Table
Y 0
Z 0
X 1
W 2


Process to update this routing table
Process to update this routing table
Router A sends out this updated routing table
B
A
Topology changes cause routing table update

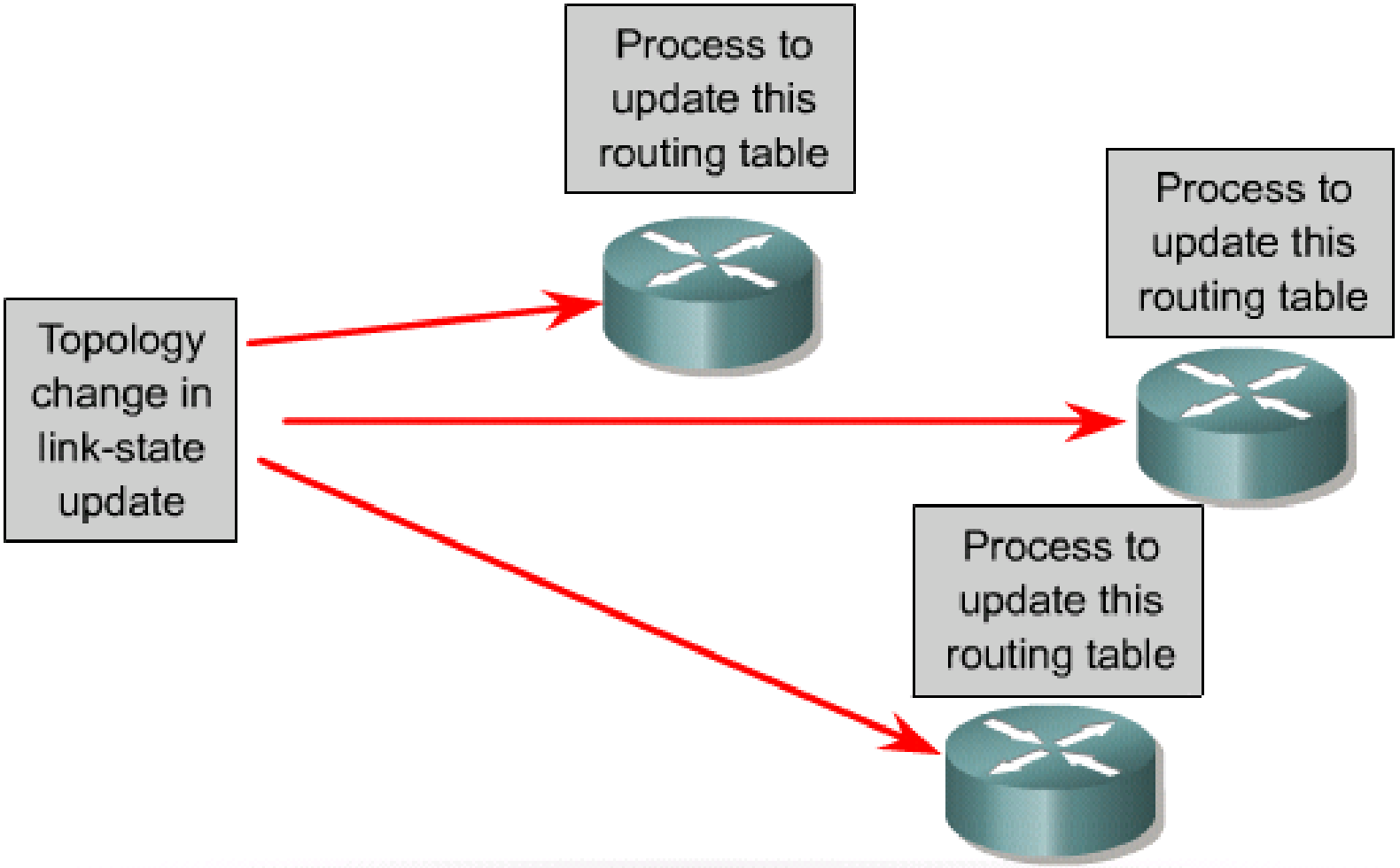
# Link-state routing protocol features



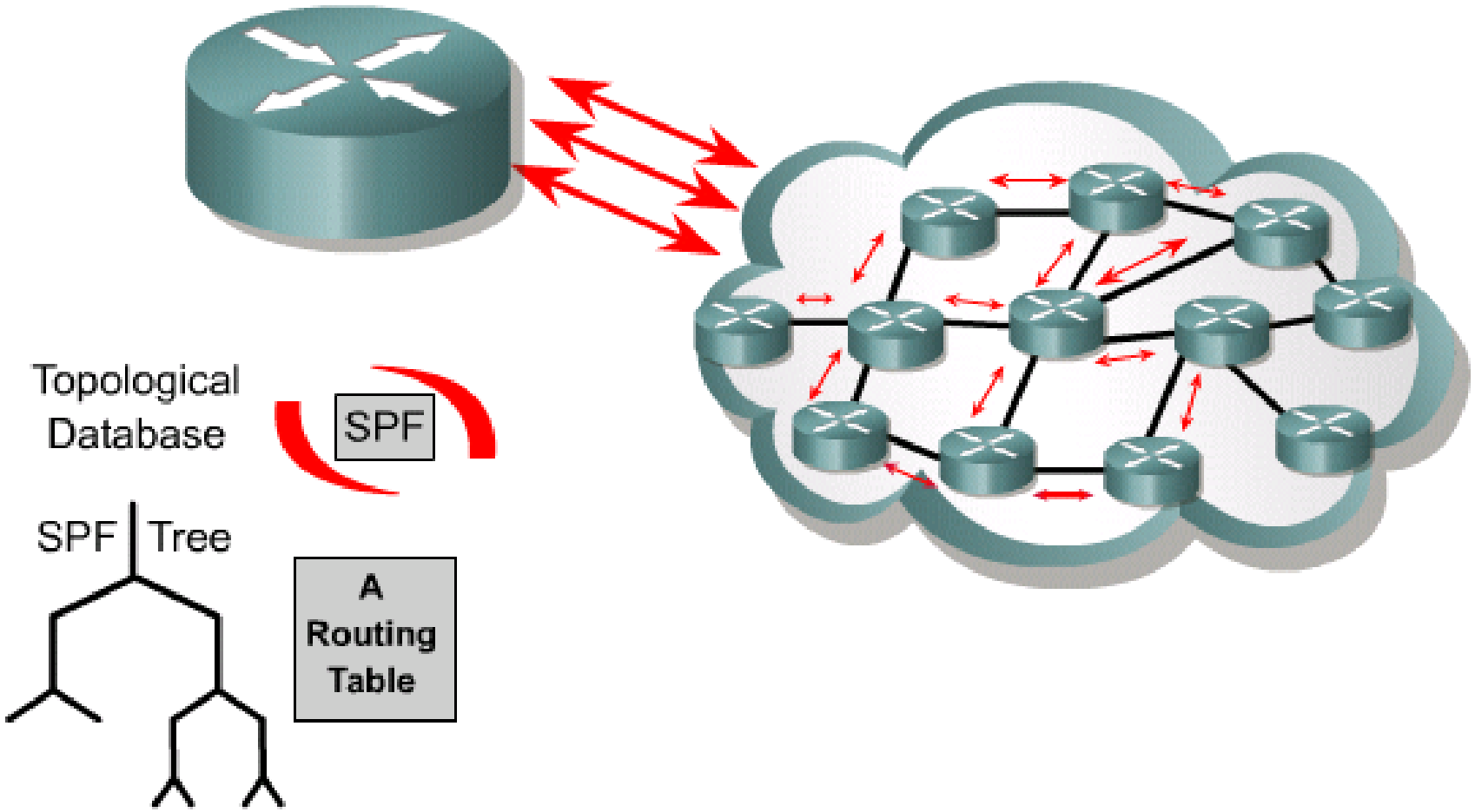

Routers send LSAs to their neighbors. The LSAs are used to build a topological database. The SPF algorithm is used to calculate the shortest path first tree in which the root is the individual router and then a routing table is created.




Each router has its own topological database on which the SPF algorithm is run.




Each router has its own topological database on which the SPF algorithm is run.

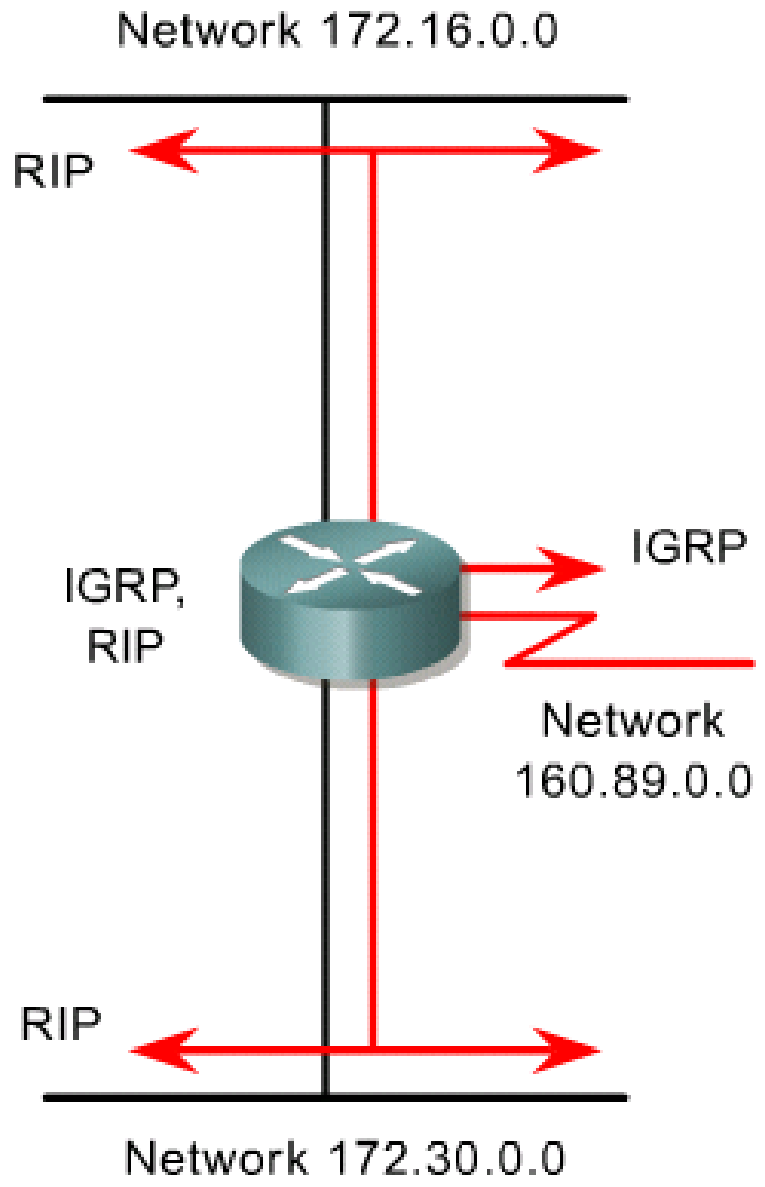



- Processing and memory requirements are increased for link-state routing.
- Bandwidth is consumed during the initial link-state flooding of LSAs.

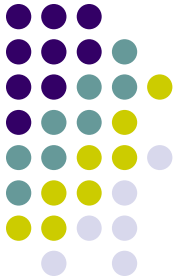
# Dynamic Routing Configuration

| Global Configuration |
| --- |
| Select routing protocol(s)<br>Specify Network(s) |

| Interface Configuration |
| --- |
| Verify address/subnet mask |



# Syntax



**Command**

```
Router(config)#router protocol {options}
```

Defines an IP routing protocol

**Command**

```
Router(config-router)#network network-number
```

The network subcommand is a mandatory configuration command for each IP routing process

| Router command | Description |
|---|---|
| `protocol` | IGRP, EIGRP, OSPF, or RIP |
| `options` | IGRP abd EIGRP require an autonomous number. OSPF requires a process ID. RIP does not require either. |

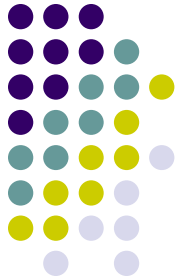
| Network command | Description |
|---|---|
| **`network`** *number* | specifies a directly connected network |

- For example: RIPv1 configuration

  GAD(config)#**router rip**

  GAD(config-router)#**network 172.16.0.0**

# RIPv1

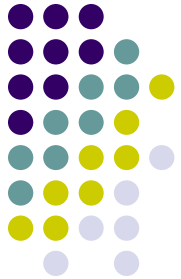


- Routing Information Protocol (RIP) was originally specified in RFC 1058.
- Its key characteristics include the following:
  - It is a distance vector routing protocol.
  - Hop count is used as the metric for path selection.
  - If the hop count is greater than 15, the packet is discarded.
  - Routing updates are broadcast every 30 seconds, by default.

# RIPv1 vs. RIPv2

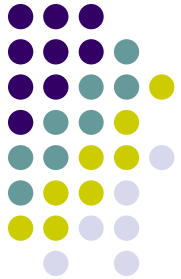
| Feature | RIP | |
|---|---|---|
| | Version 1 | Version 2 |
| **Algorithm** | Distance Vector (Bellman – Ford) | |
| **Administrative distance** | 120 | |
| **Metrics** | Hop count | |
| **Update period** | 30s | |
| **Partial Updates** | No (sending entire routing table) | |
| **Convergence speed** | Slow due to routing loop | |
| **Prevent routing loop** | Yes (using the following mechanisms):<br>• Count to infinity (Max. Count = 16)<br>• Split horizon<br>• Triggered Updates<br>• Hold-down timer (180s) | |
| **Scalability** | Small | |
| **Transport protocol** | UDP (port 520) | |
| **Authentication** | No | Yes (MD5) |
| **Communication** | Broadcasting<br>255.255.255.255 | Multicasting<br>224.0.0.9 |
| **VLSM Support** | No (not send subnet mask) | Yes (send subnet mask) |

# RIPv2 configuration example



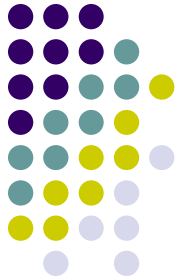
```
R1(config)# router rip
R1(config-router)# version 2
R1(config-router)# network 192.168.1.0      //LAN 1
R1(config-router)# network 192.168.1.192    //R1 – R2
R1(config-router)# network 192.168.1.204    //R1 – R4
R1(config-router)# no auto-summary
R1(config-router)# exit
R1(config)#
```

# RIPv2 & Default Route



```
R4(config)# ip route 0.0.0.0 0.0.0.0 6.9.6.9   //default route
R4(config)# router rip
R4(config-router)# version 2
R4(config-router)# network …
R4(config-router)# redistribute static          //advertise default
R4(config-router)# no auto-summary
R4(config-router)# end
R4# write memory
```

# OSPF

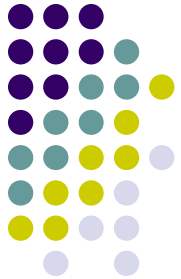


- Open Shortest Path First (OSPF) is a nonproprietary link-state routing protocol.
- The key characteristics of OSPF are as follows:
  - It is a link-state routing protocol.
  - Open standard routing protocol described in RFC 2328.
  - Uses the SPF algorithm to calculate the lowest cost to a destination.
  - Routing updates are flooded as topology changes occur.

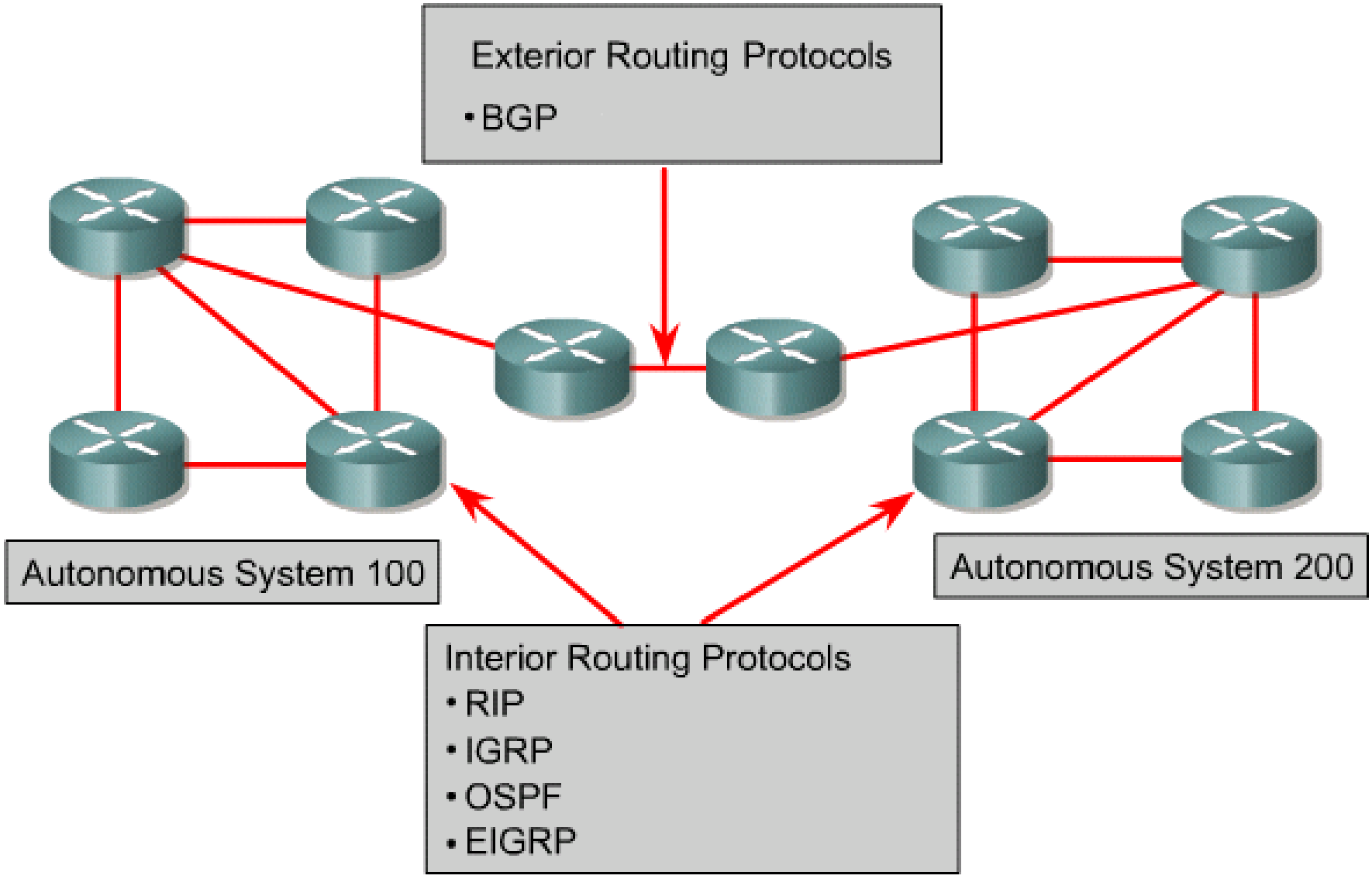
# EIGRP

- EIGRP is a Cisco proprietary enhanced distance vector routing protocol.
- The key characteristics of EIGRP are as follows:
  - It is an enhanced distance vector routing protocol.
  - Uses load balancing.
  - Uses a combination of distance vector and link-state features.
  - Uses Diffused Update Algorithm (DUAL) to calculate the shortest path.
  - Routing updates are broadcast every 90 seconds or as triggered by topology changes.

# BGP



- Border Gateway Protocol (BGP) is an exterior routing protocol.
- The key characteristics of BGP are as follows:
  - It is a distance vector exterior routing protocol.
  - Used between ISPs or ISPs and clients.
  - Used to route Internet traffic between autonomous systems.


Exterior Routing Protocols
• BGP
Autonomous System 100
Autonomous System 200
Interior Routing Protocols
• RIP
• IGRP
• OSPF
• EIGRP