Cisco Network Academy
CCNA Exploration Course Two
Routers and protocols

Lesson 2-3
Introduction to Dynamic Routing Protocols

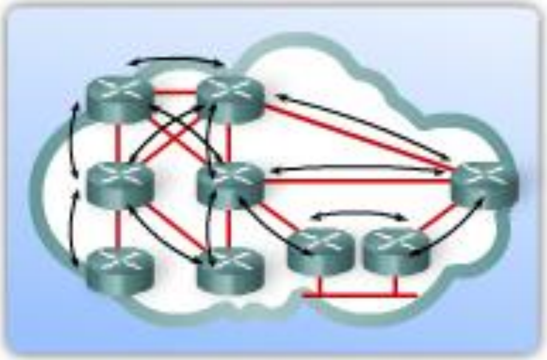
Frank Schneemann, MS Edtech

3.0.1 Chapter Introduction …

Dynamic Routing Scales to Larger Networks

Static Routing

Dynamic Routing

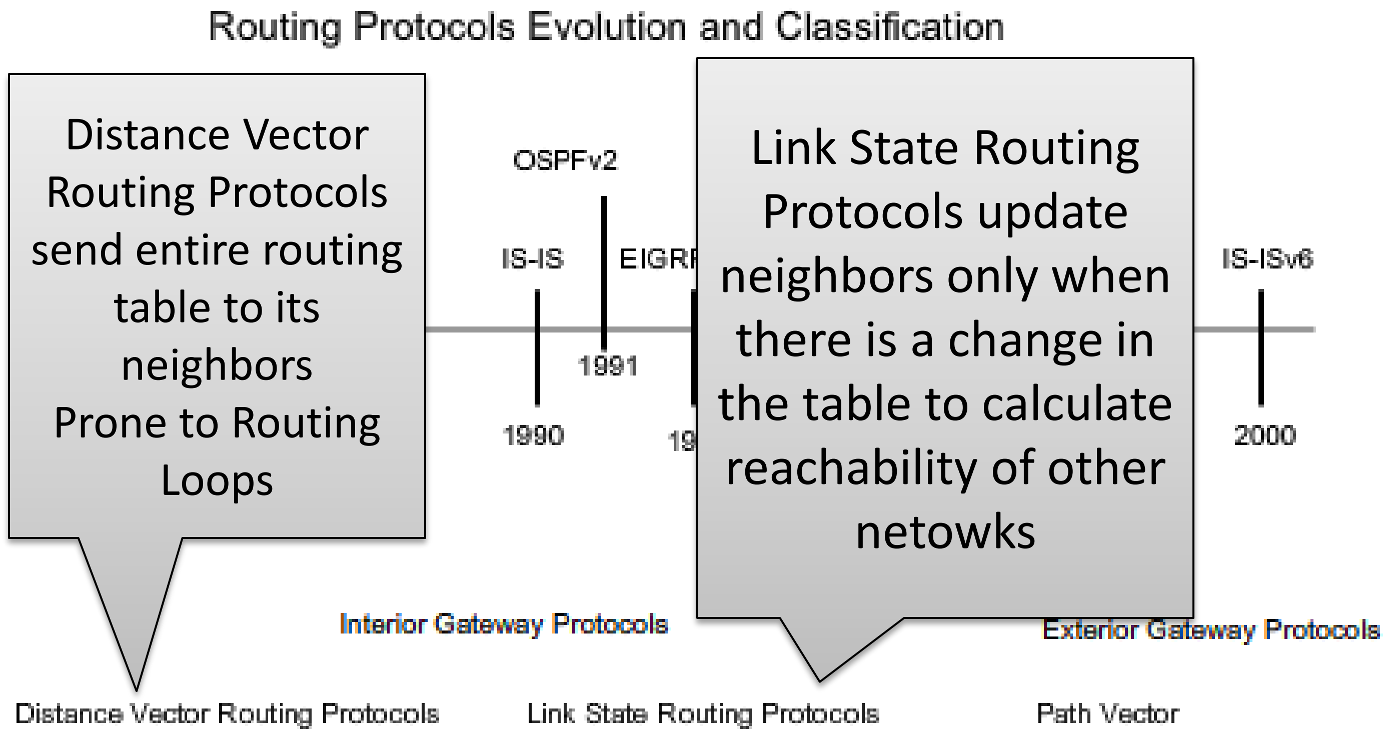


In this chapter, you will learn to:

- Describe the role of dynamic routing protocols and place these protocols in the context of modern network design.
- Identify several ways to classify routing protocols.
- Describe how metrics are used by routing protocols, and identify the metric types used by dynamic routing protocols.
- Determine the administrative distance of a route and describe its importance in the routing process.
- Identify the different elements in the routing table.
- Given realistic constraints, devise and apply subnetting schemes.

3.1.1 Perspective and Background …

- RIP AND RIP v2 do not scale well to large networks
- EIGRP AND OSPF do scale well to larger networks



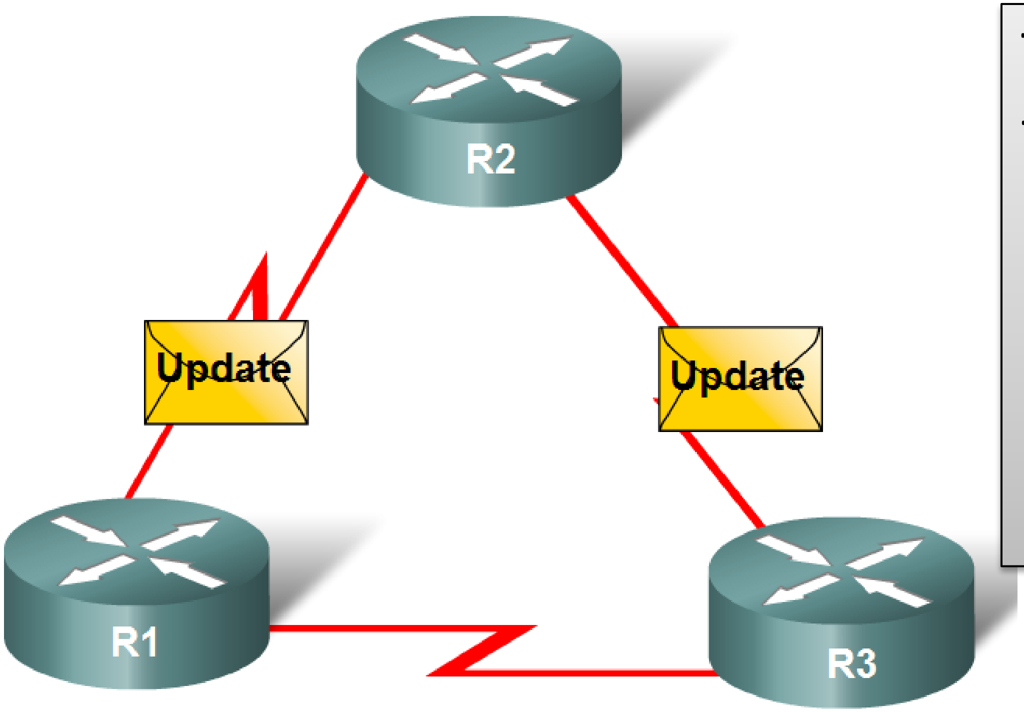
Classful	RIP	IGRP			EGP
Classless	RIPv2	EIGRP	OSPFv2	IS-IS	BGPv4
IPv6	RIPng	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	BGPv4 for IPv6

Highlighted routing protocols are the focus of this course.

3.1.1 Perspective and Background

Function(s) of Dynamic Routing Protocols:
- -Dynamically share information between routers.
- -Automatically update routing table when topology changes.
- -Determine best path to a destination.

Routers Dynamically Pass Updates



This exchange allows routers to:

- automatically learn about new networks
- find alternate paths when there is a link failure to a current network.

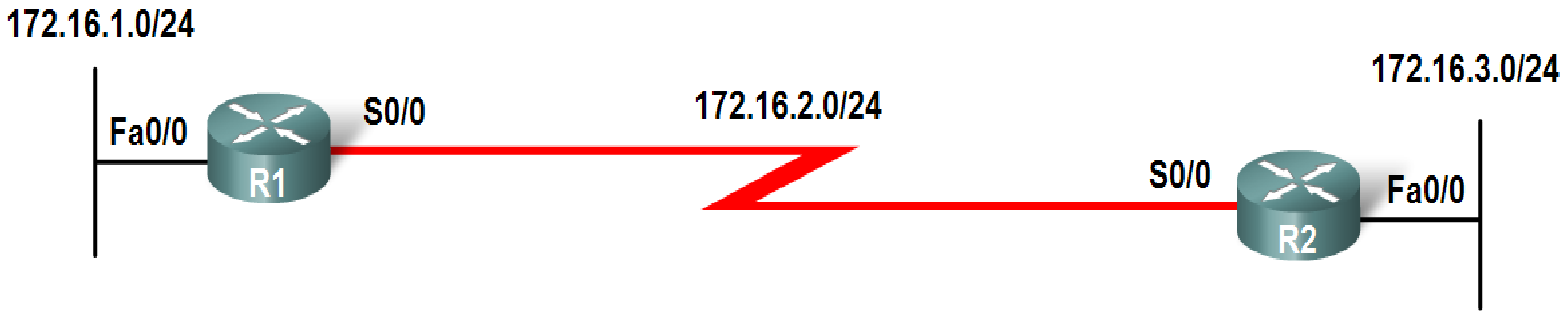
3.1.2 Network Discovery and Routing Table Maintenance

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

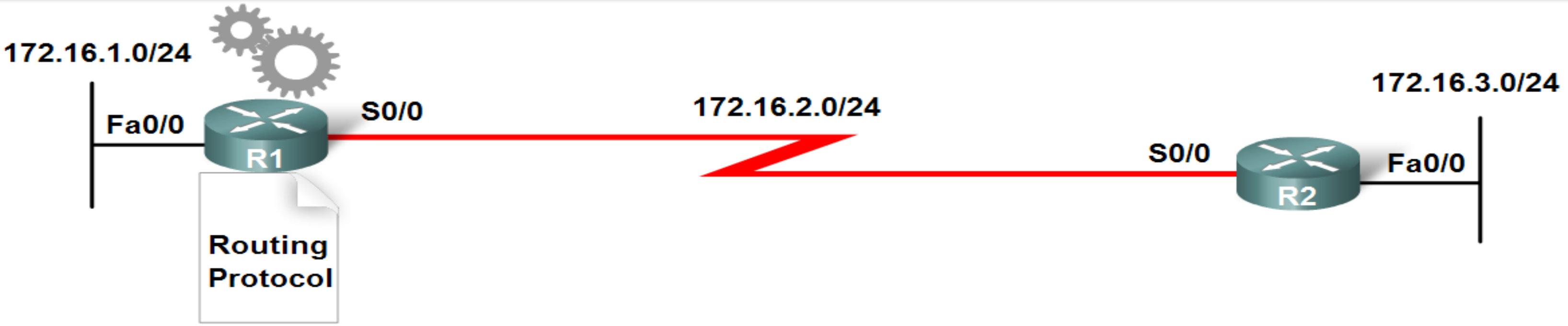
Routing protocols are used to exchange routing information between the routers.



3.1.2 Network Discovery and Routing Table Maintenance

Components of a routing protocol

- Data structures - Some routing protocols use tables and/or databases for its operations. This information is kept in RAM.
- Algorithm - An algorithm is a finite list of steps used in accomplishing a task. Routing protocols use algorithms for facilitating routing information and for best path determination.
- Routing protocol messages - Routing protocols use various types of messages to discover neighboring routers, exchange routing information, and other tasks to learn and maintain accurate information about the network.



3.1.3 Advantages

	Dynamic routing	Static routing
Configuration Complexity	Generally independent of the network size	Increases with network size
Required administrator knowledge	Advanced knowledge required	No extra knowledge required
Topology changes	Automatically adapts to topology changes	Administrator intervention required
Scaling	Suitable for simple and complex topologies	Suitable for simple topologies
Security	Less secure	More secure
Resource usage	Uses CPU, memory, link bandwith	No extra resources needed
Predictability	Route depends on the current topology	Route to destination is always the same

3.1.3 Advantages

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

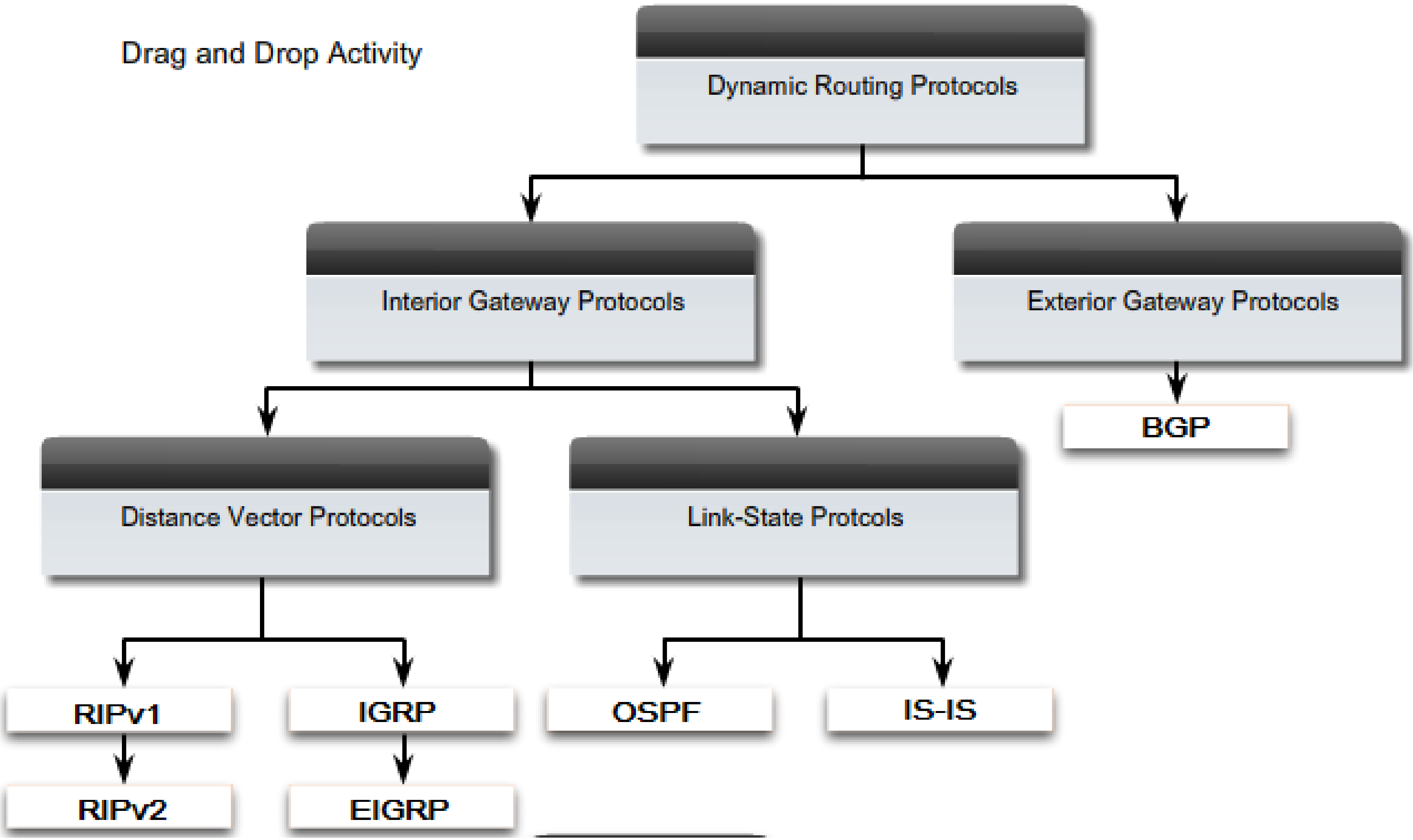
Dynamic routing advantages:

- Administrator has less work maintaining the configuration when adding or deleting networks.
- Protocols automatically react to the topology changes.
- Configuration is less error-prone.
- More scalable, growing the network usually does not present a problem.

Dynamic routing disadvantages:

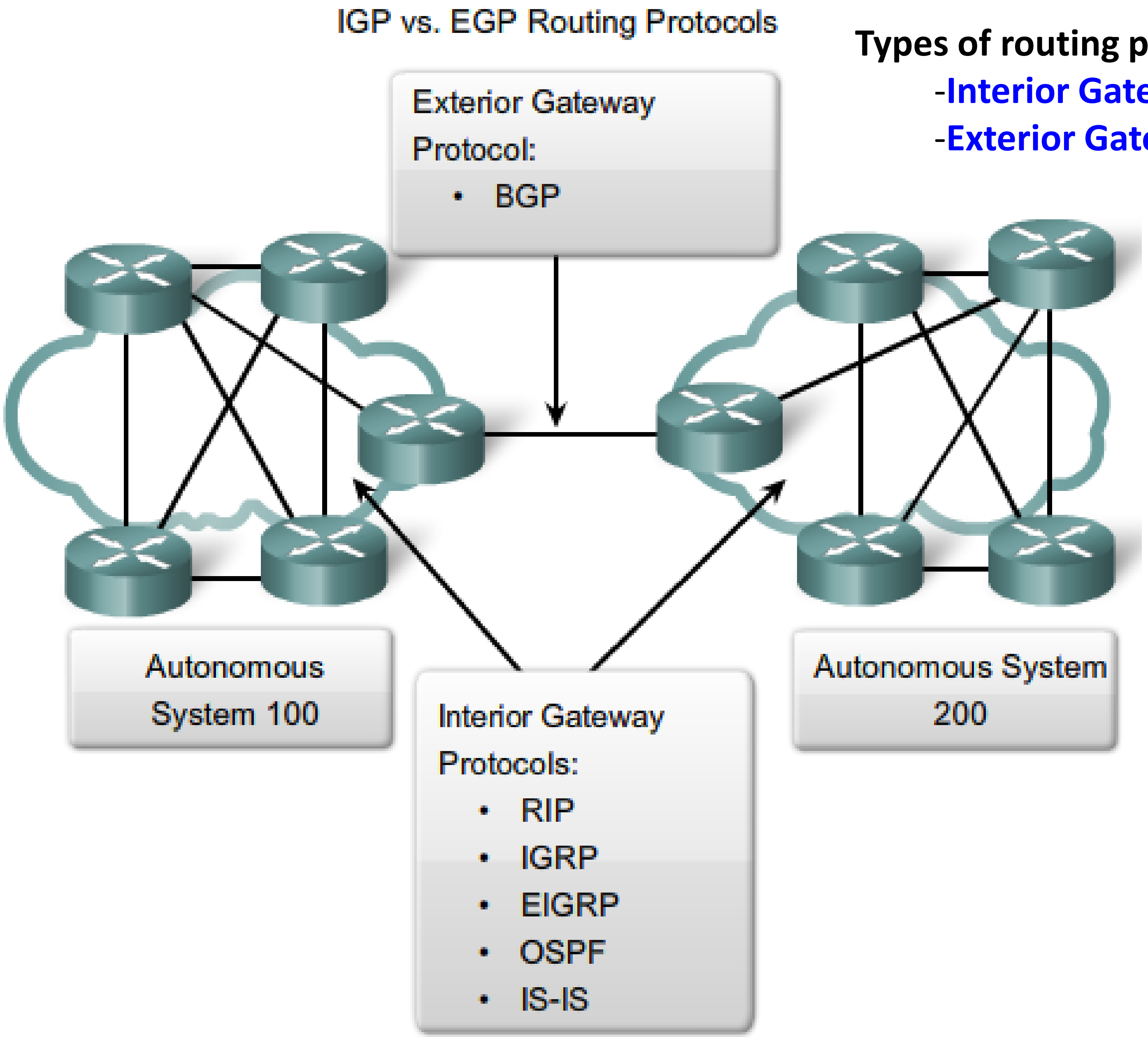
- Router resources are used (CPU cycles, memory and link bandwidth).
- More administrator knowledge is required for configuration, verification, and troubleshooting

3.2.1 Dynamic Routing Overview …



Autonomous System is a group of routers under the control of a single authority.

3.2.2 IGP EGP …



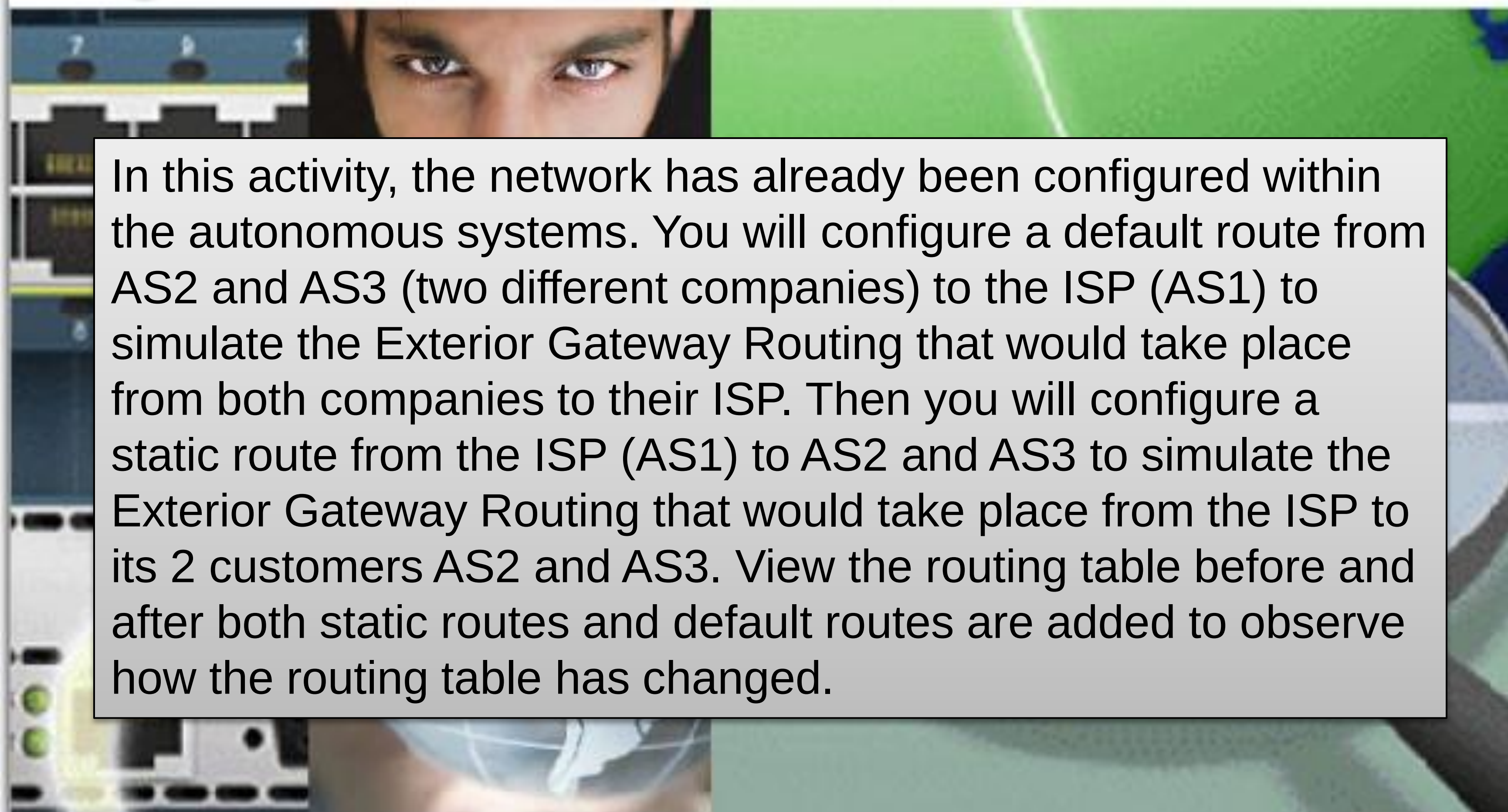
Types of routing protocols:

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

3.2.2 IGP EGP

Packet Tracer Exploration:

Characteristics of IGP and EGP Routing Protocols



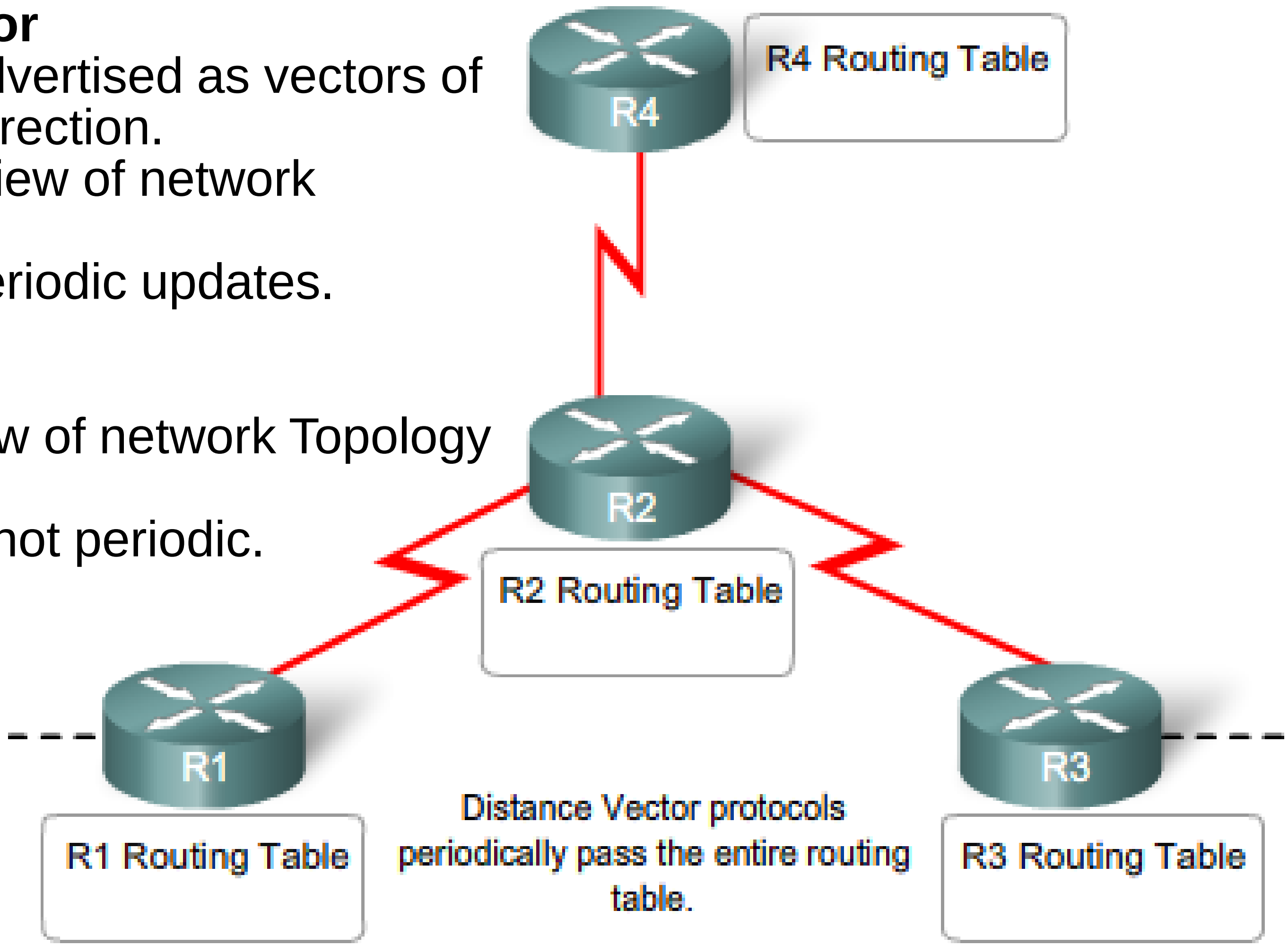
In this activity, the network has already been configured within the autonomous systems. You will configure a default route from AS2 and AS3 (two different companies) to the ISP (AS1) to simulate the Exterior Gateway Routing that would take place from both companies to their ISP. Then you will configure a static route from the ISP (AS1) to AS2 and AS3 to simulate the Exterior Gateway Routing that would take place from the ISP to its 2 customers AS2 and AS3. View the routing table before and after both static routes and default routes are added to observe how the routing table has changed.

3.2.3 Distance Vector and Link State …

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.

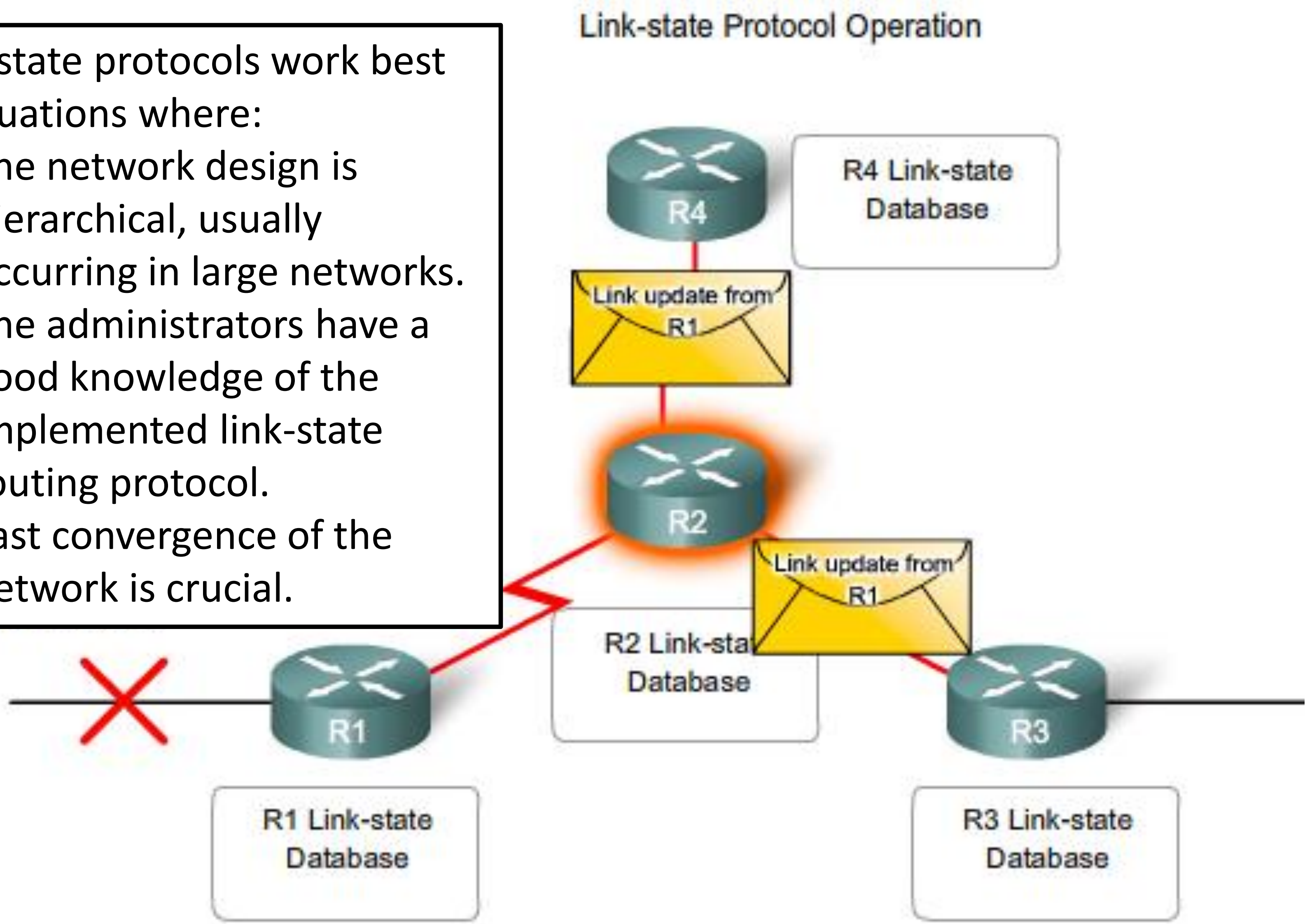
Link state
- complete view of network Topology is created.
- updates are not periodic.



3.2.3 Distance Vector and Link State

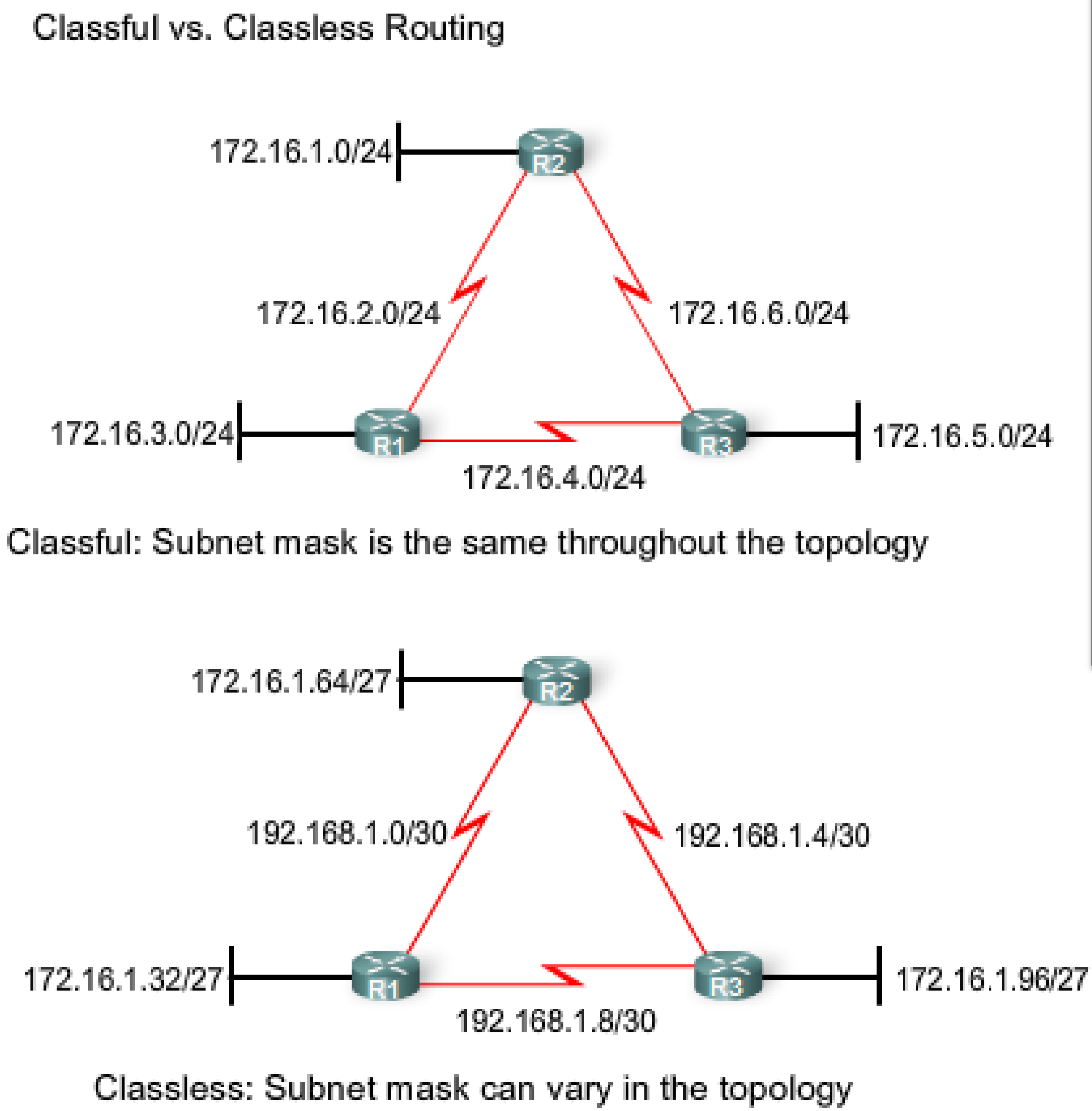
Link-state protocols work best in situations where:

- The network design is hierarchical, usually occurring in large networks.
- The administrators have a good knowledge of the implemented link-state routing protocol.
- Fast convergence of the network is crucial.



Link-state protocols pass updates when a link's state changes.

3.2.4 Classful and Classless Routing Protocols …



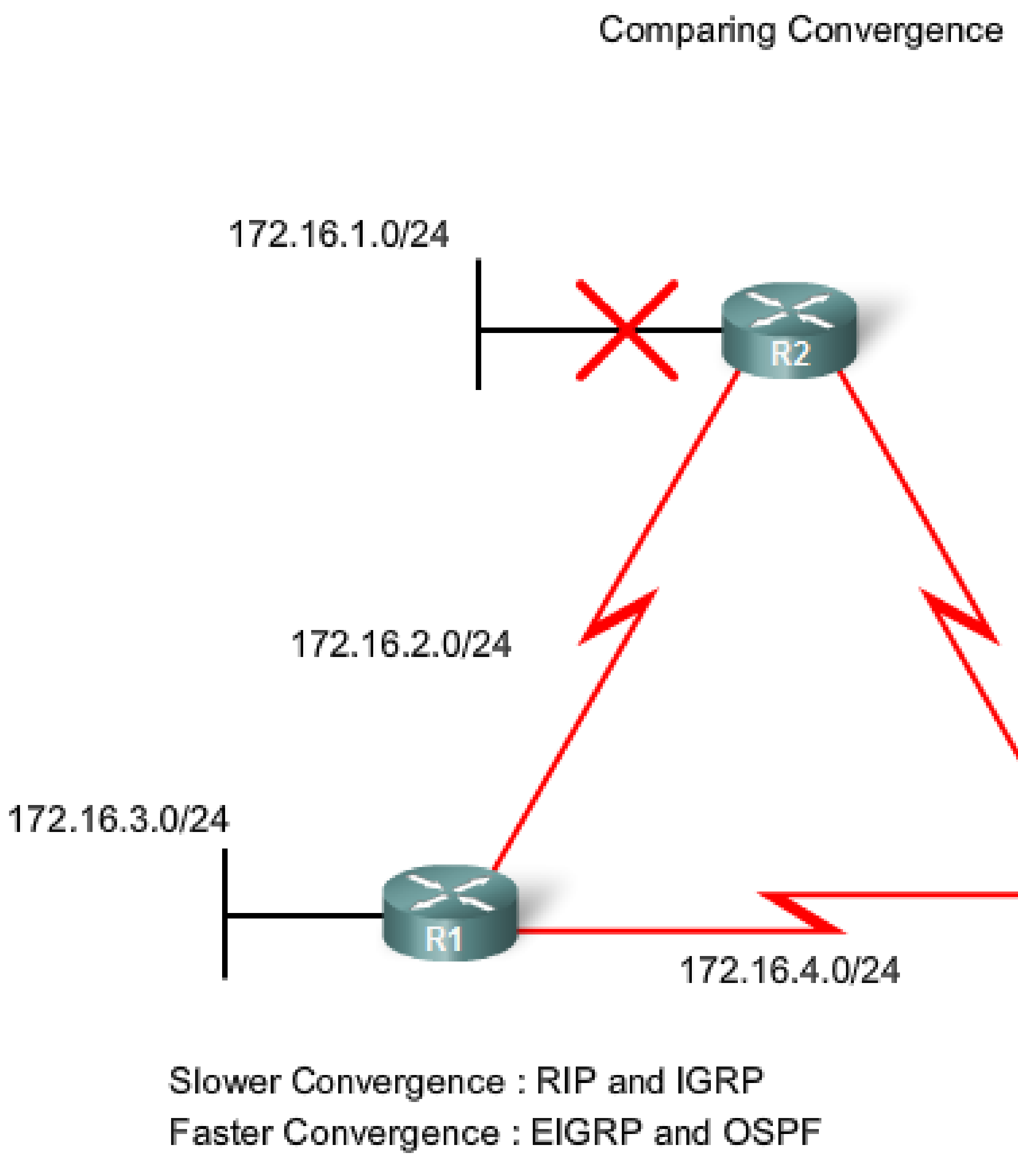
Classful routing protocols

Do NOT send subnet mask in routing updates

Classless routing protocols

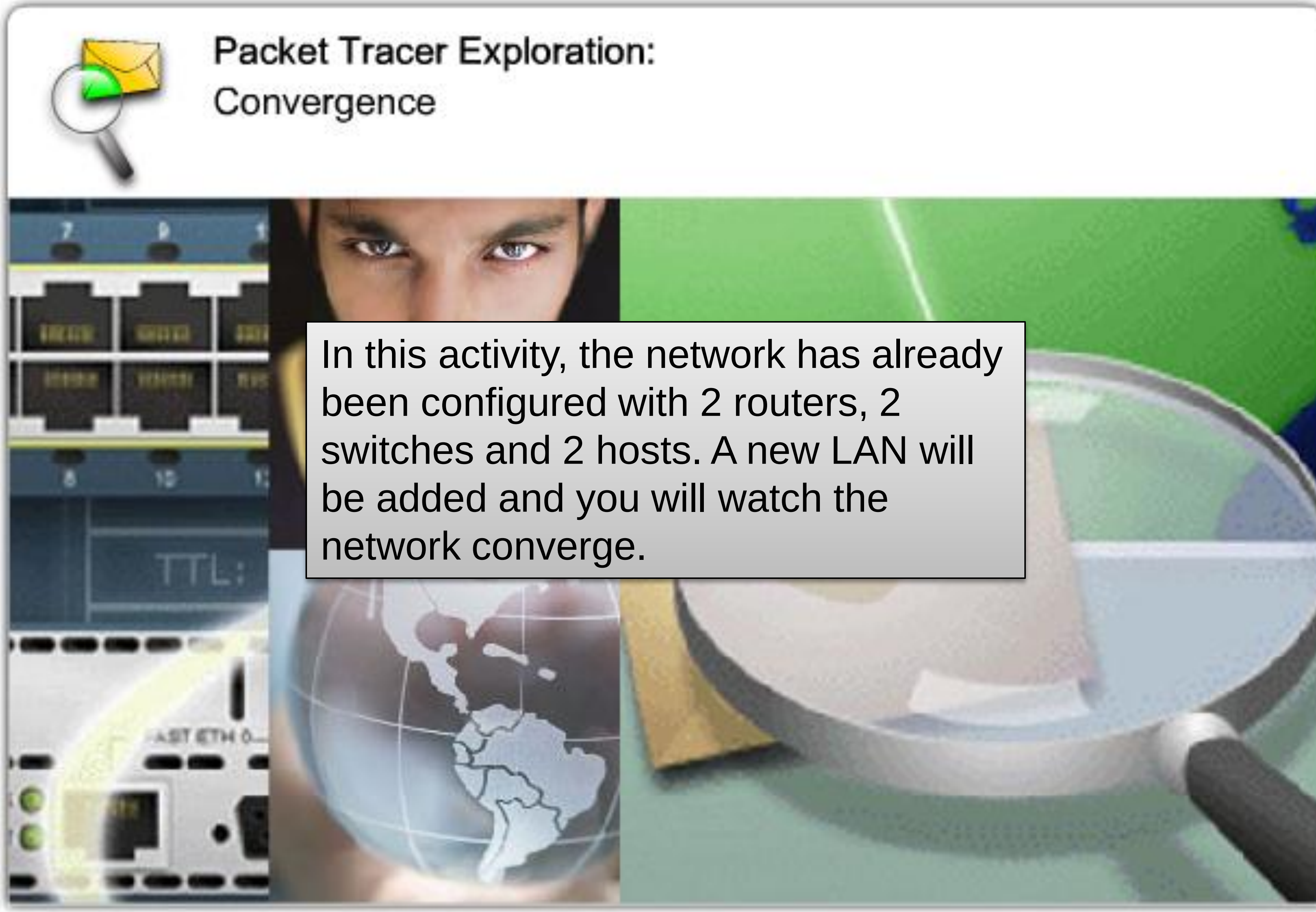
Do send subnet mask in routing updates.

3.2.5 Convergence



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

3.2.5 Convergence

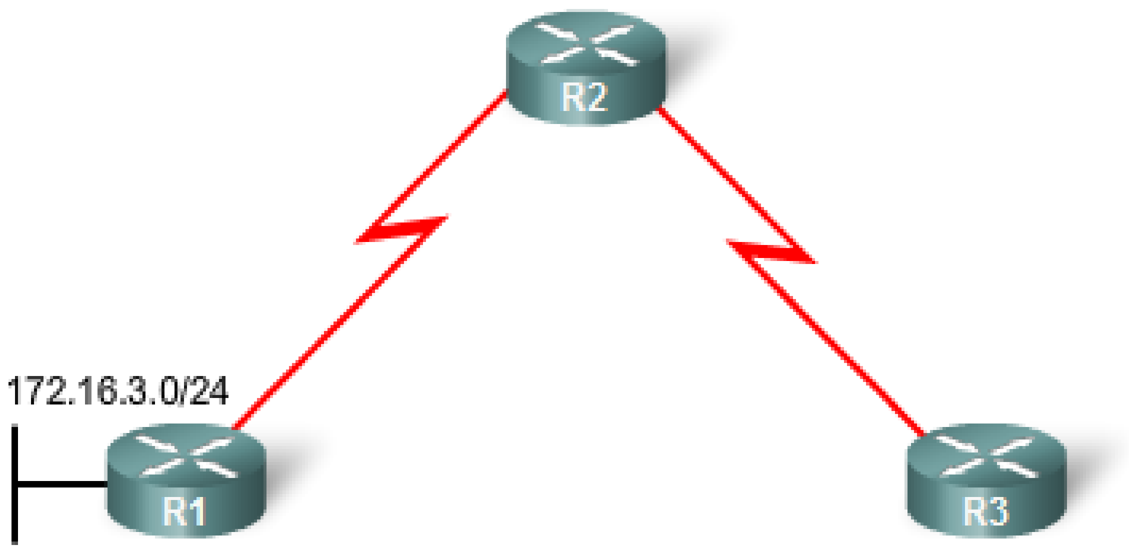


In this activity, the network has already been configured with 2 routers, 2 switches and 2 hosts. A new LAN will be added and you will watch the network converge.

3.3.1 Purpose of a Metric

Each routing protocol uses its own metric. For example, **RIP** uses hop count, **EIGRP** uses a combination of bandwidth and delay, and Cisco's implementation of **OSPF** uses bandwidth

Net	Hops
172.16.3.0	1



Net	Hops
172.16.3.0	0

Net	Hops
172.16.3.0	2

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

3.3.2 Metrics and Routing Protocols

Metrics used in IP routing protocols include:

Hop count - A simple metric that counts the number of routers a packet must traverse

Bandwidth - Influences path selection by preferring the path with the highest bandwidth

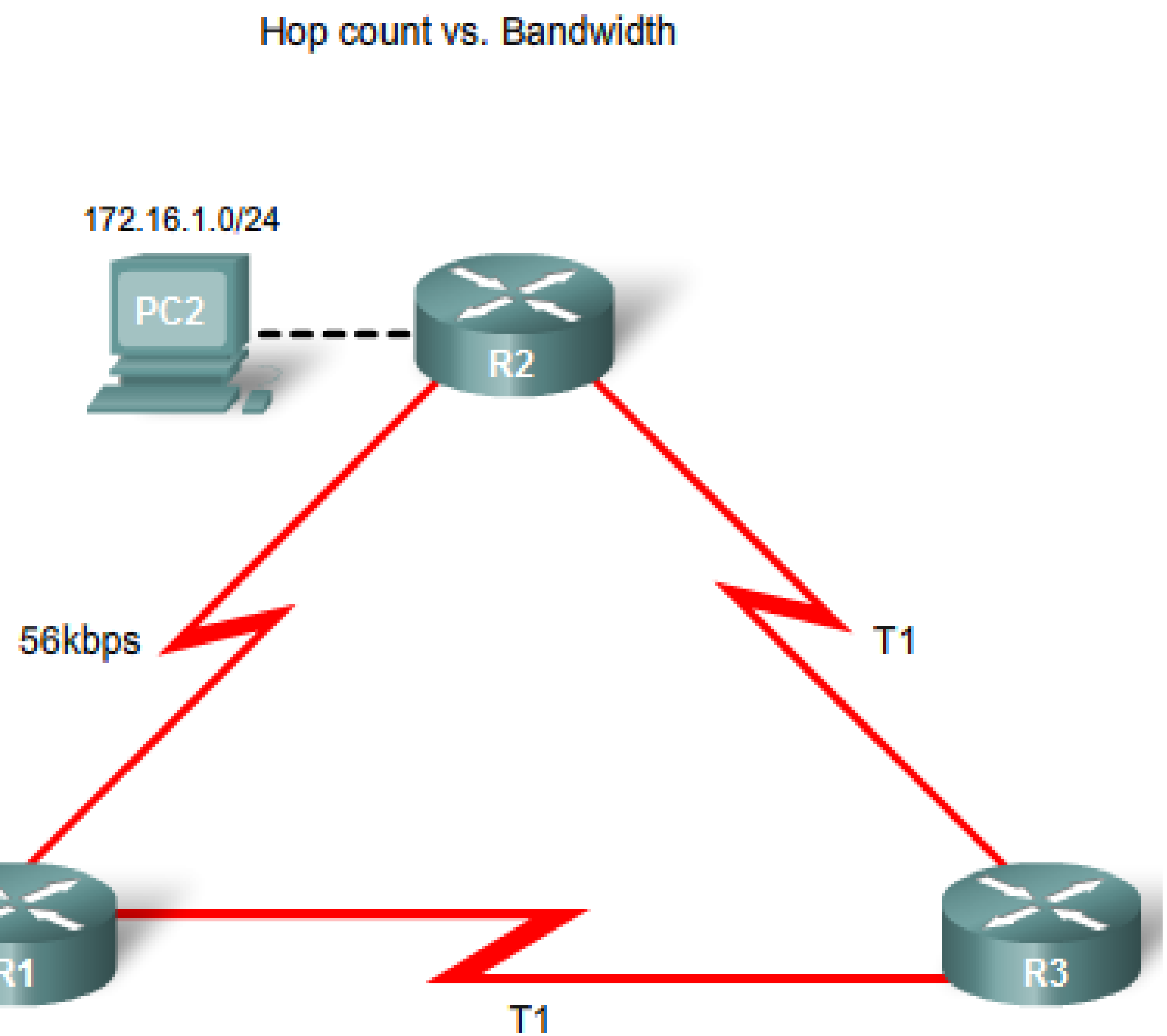
Load - Considers the traffic utilization of a certain link

Delay - Considers the time a packet takes to traverse a path

Reliability - Assesses the probability of a link failure, calculated from the interface error count or previous link failures

Cost - A value determined either by the IOS or by the network administrator to indicate preference for a route. Cost can represent a metric, a combination of metrics or a policy.

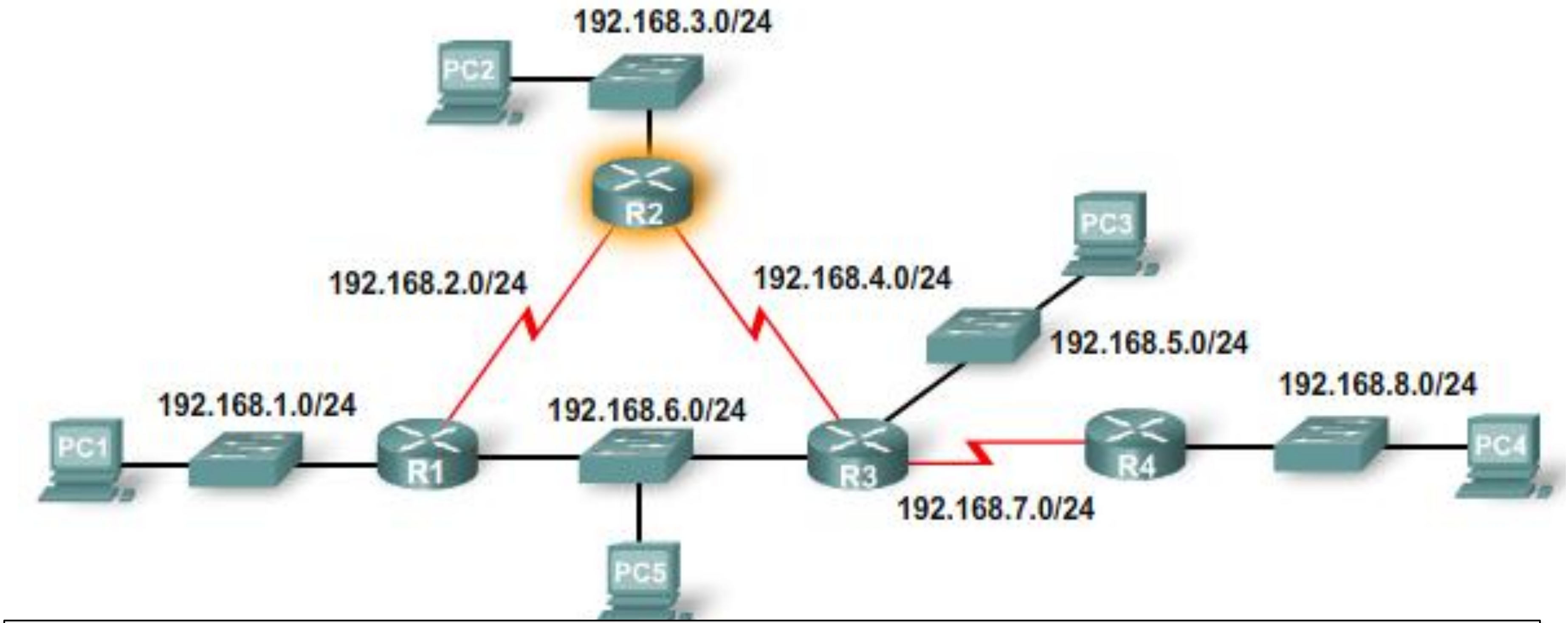
3.3.2 Metrics and Routing Protocols



RIP chooses shortest path based on hop count.

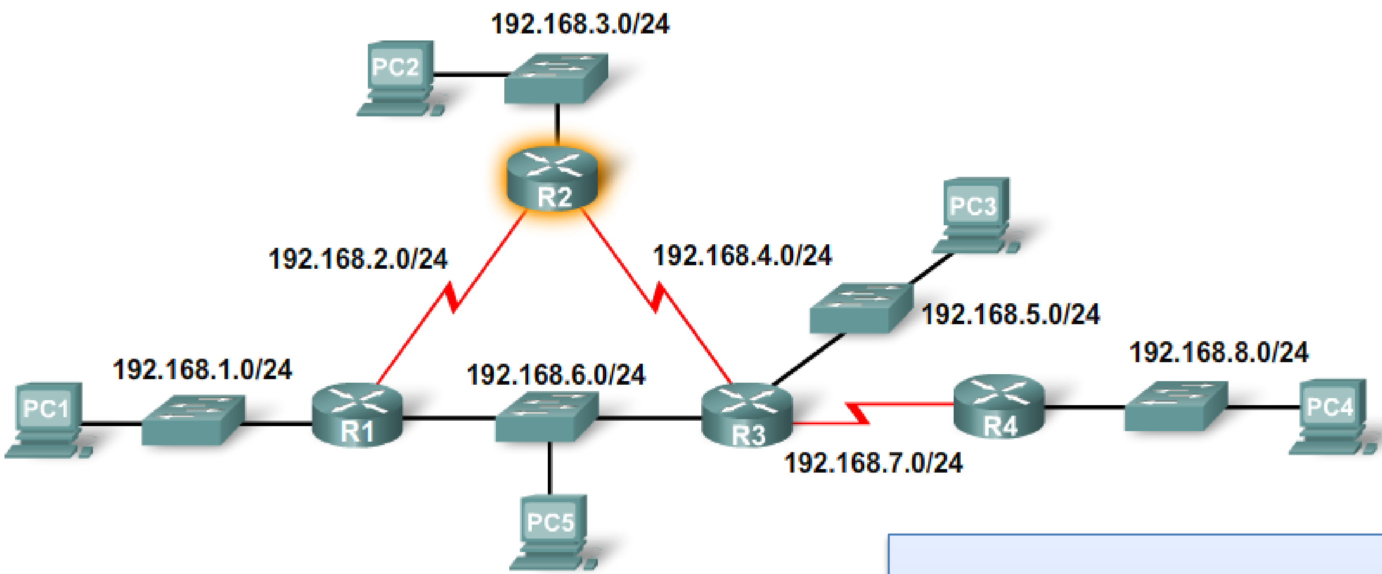
OSPF chooses shortest path based on bandwidth.

3.3.2 Metrics and Routing Protocols



RIP: Hop count
IGRP and EIGRP: Bandwidth, Delay, Reliability, and Load - Best path is chosen by the route with the smallest composite metric value calculated from these multiple parameters. By default, only bandwidth and delay are used.
IS-IS and OSPF: Cost - Best path is chosen by the route with the lowest cost. . Cisco's implementation of OSPF uses bandwidth. IS-IS is discussed in CCNP.

3.3.2 Metrics and Routing Protocols

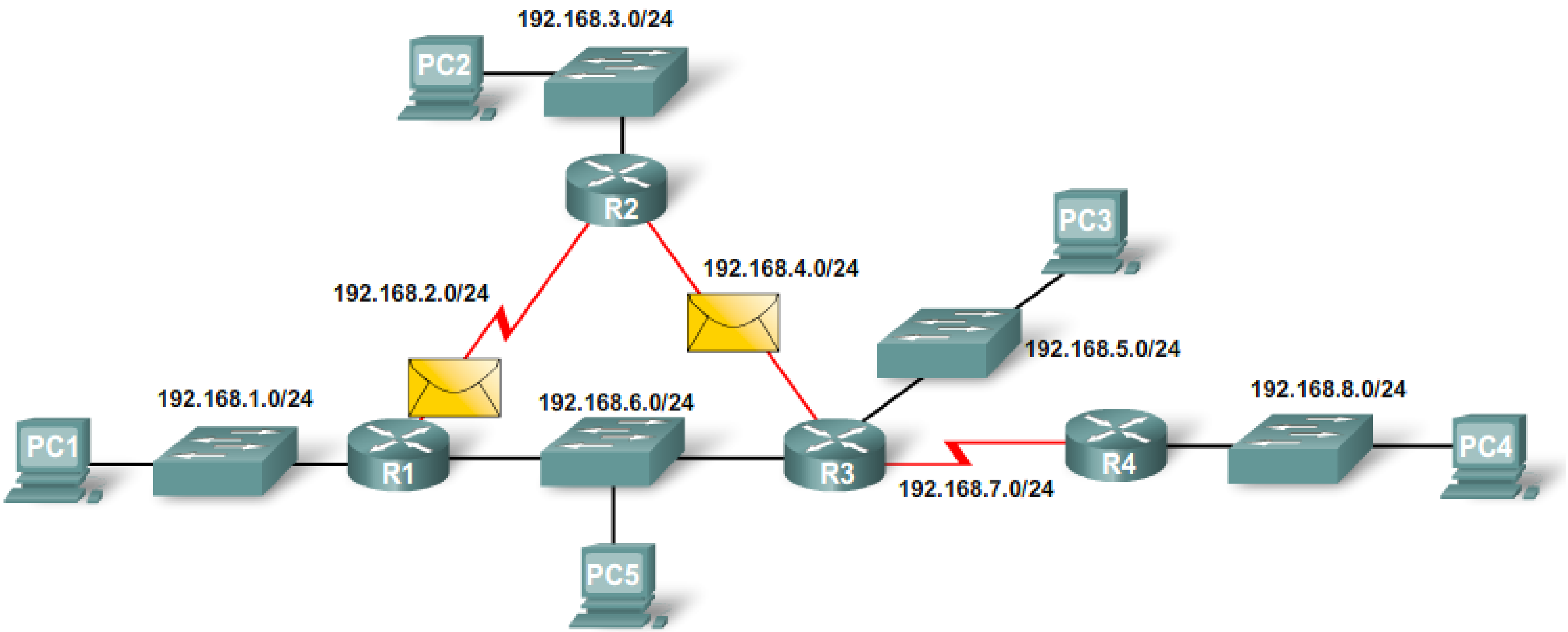



```
R2#show ip route
(**output omitted**)

Gateway of last resort is not set

R    192.168.1.0/24 [120/1] via 192.168.2.1, 00:00:24, Ser
C    192.168.2.0/24 is directly connected, Serial0/0
C    192.168.3.0/24 is directly connected, FastEthernet0/0
C    192.168.4.0/24 is directly connected, Serial0/1
R    192.168.5.0/24 [120/1] via 192.168.4.1, 00:00:
R    192.168.6.0/24 [120/1] via 192.168.2.1,
                                [120
R    192.168.7.0/24 [120/1] via
R    192.168.8.0/24 [120/2] via 192.168.4.1, 00:00:26, Ser
```

The routers are using the RIP routing protocol. The metric associated with a certain route can be best viewed using the show ip route command. The metric value is the second value in the brackets for a routing table entry. In the figure, R2 has a route to the 192.168.8.0/24 network that is 2 hops away

It is 2 hops from R2 to 192.168.8.0/24

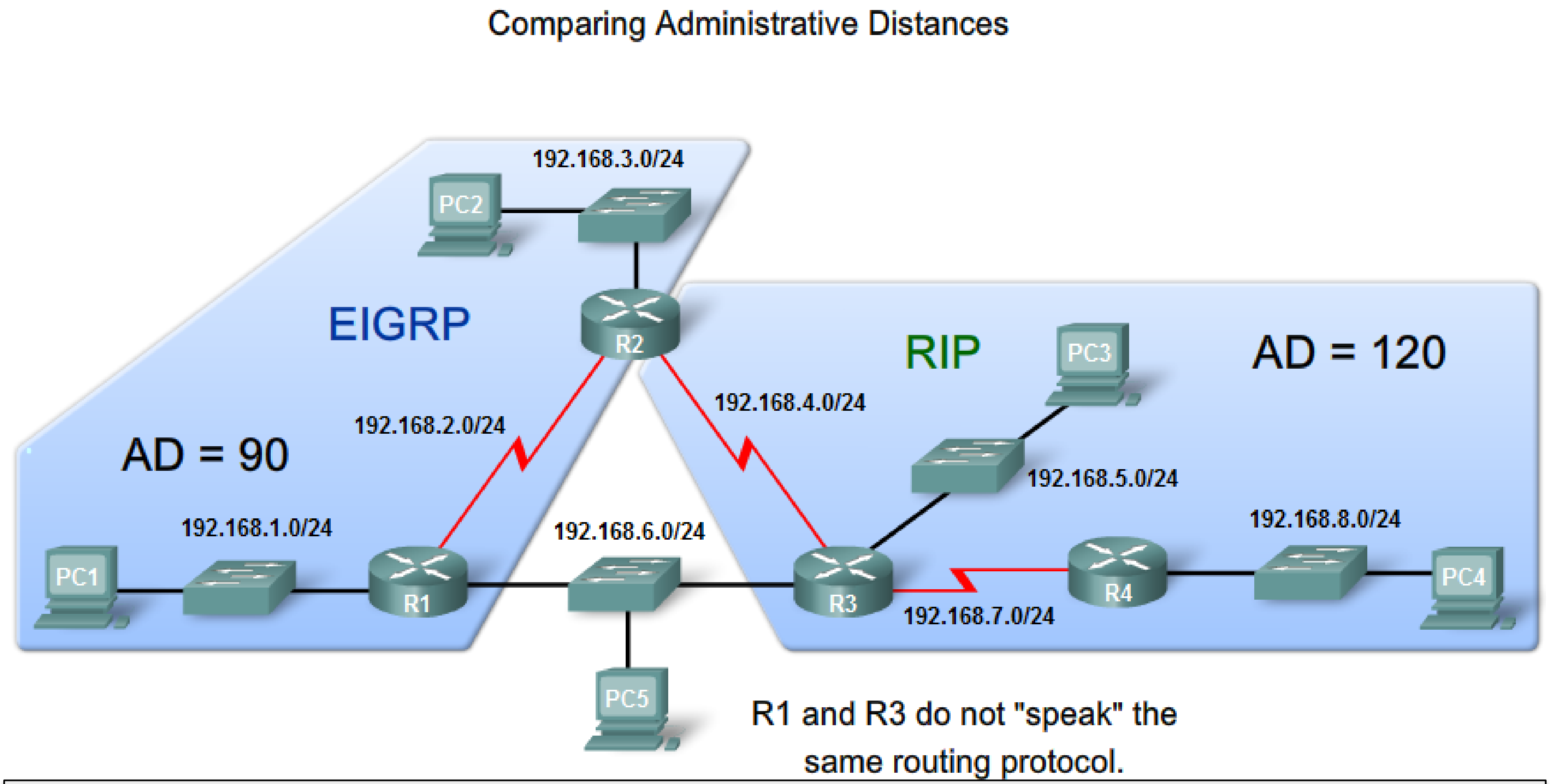
Load Balancing Across Equal Cost Paths



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
```

3.4.1 Purpose of Administrative Distance …



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

3.4.1 Purpose of Administrative Distance

```
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:
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
```

AD=90

Administrative Distance is the first number in the brackets in the routing table

```
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
```

show ip rip database command. This command shows all RIP routes learned by R2, whether or not the RIP route is installed in the routing table.

3.4.2 Dynamic Routing Protocols

Default Administrative Distances

Route Source	Administrative Distance
Connected	0
Static	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
RIP	120
External EIGRP	170
Internal BGP	200

3.4.3 Static Routes

```
R2#show ip 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
```

```
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
```

Directly connected routes

Have a default AD of 0

Static Routes

Administrative distance of a static route has a default value of 1

3.4.4 Directly Connected Networks …

Administrative Distance and Directly Connected Networks

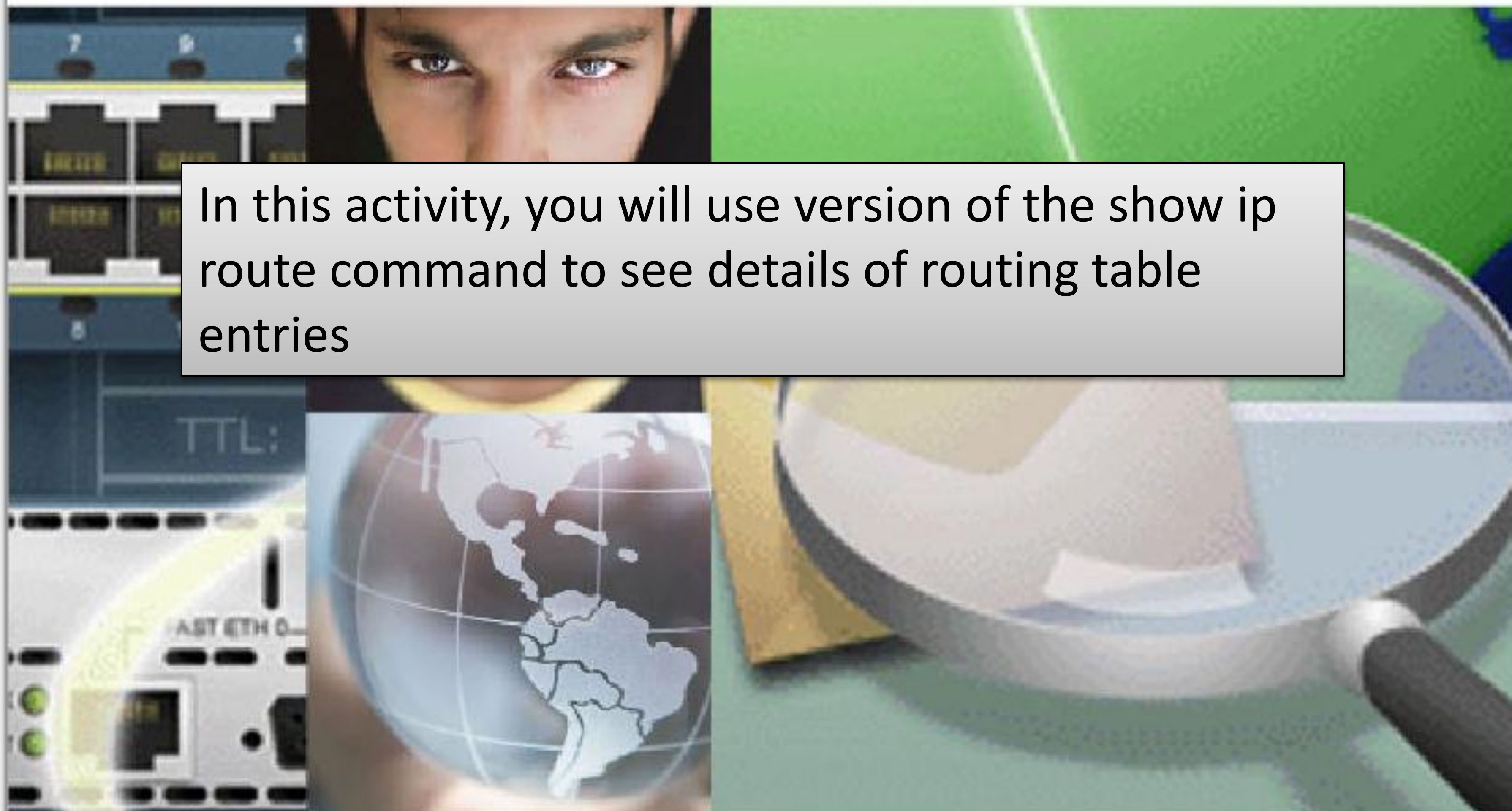
```
R2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       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
```

Directly connected routes

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

Packet Tracer Exploration:

Viewing Routing Table Information - `show ip route`



In this activity, you will use version of the show ip route command to see details of routing table entries

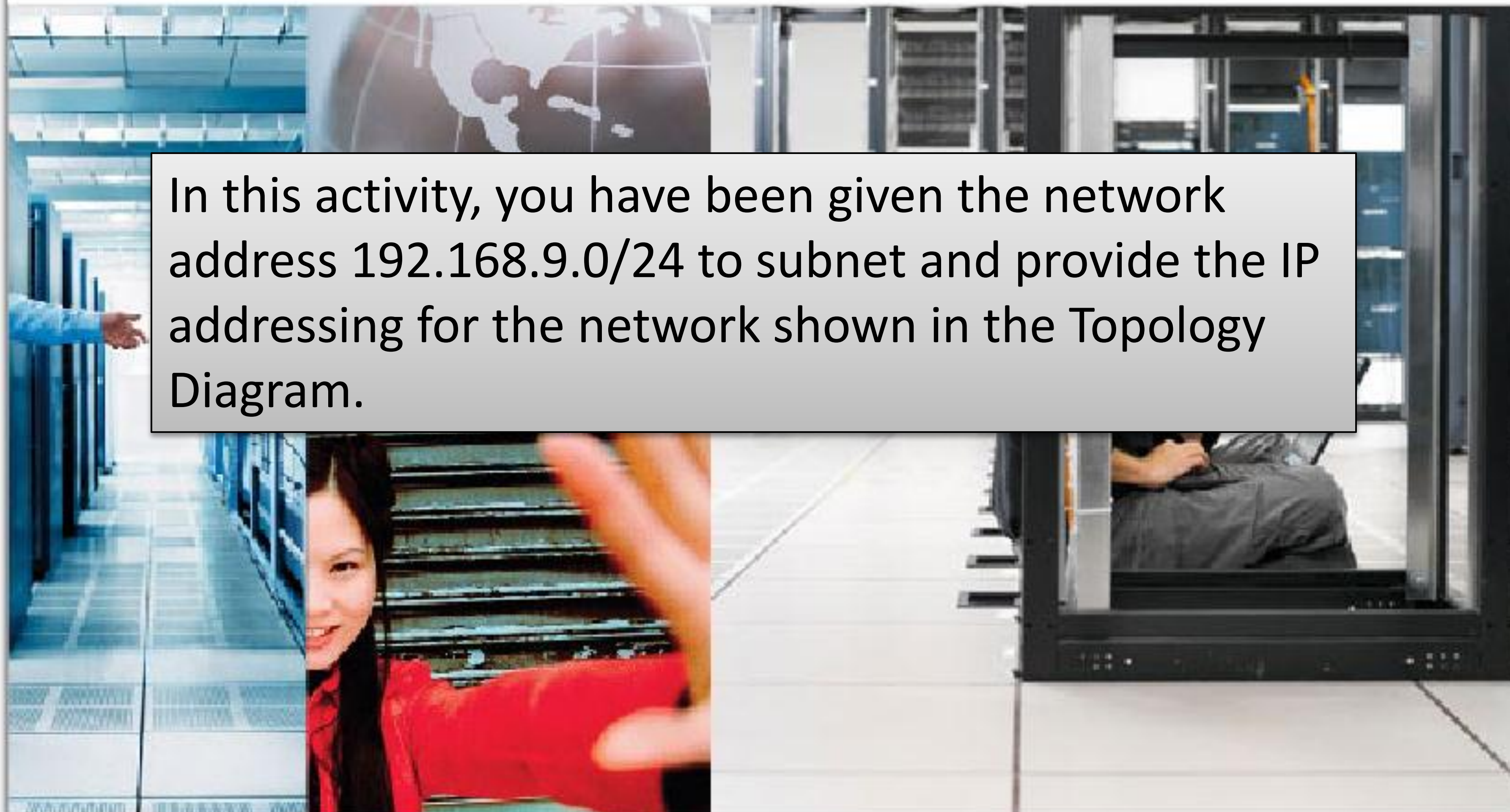
3.5.1 Identifying Elements of the Routing Table

Route	Route Source	AD	Metric
10.4.0.0/16	Static	1	0
172.16.2.0/24	Connected	0	0
172.16.1.0/24	Connected	0	0
172.16.3.0/24	EIGRP	90	2172416
192.168.1.0/24	Connected	0	0
192.168.100.0/24	OSPF	110	65
192.168.110.0/24	OSPF	110	65
192.168.120.0/24	RIP	120	1

The output is not common for most routing tables. Running more than one routing protocol on the same router is rare. Running three, as shown here, is more of an academic exercise and has value in that it will help you learn to interpret the routing table output.

3.5.2 Subnetting Scenario 1

Hands-on Lab:
Subnetting Scenario 1



In this activity, you have been given the network address 192.168.9.0/24 to subnet and provide the IP addressing for the network shown in the Topology Diagram.

3.5.2 Subnetting Scenario 1

Packet Tracer Exploration:

Subnetting Scenario 1

3.5.3 Subnetting Scenario 2

Hands-on Lab:
Subnetting Scenario 2

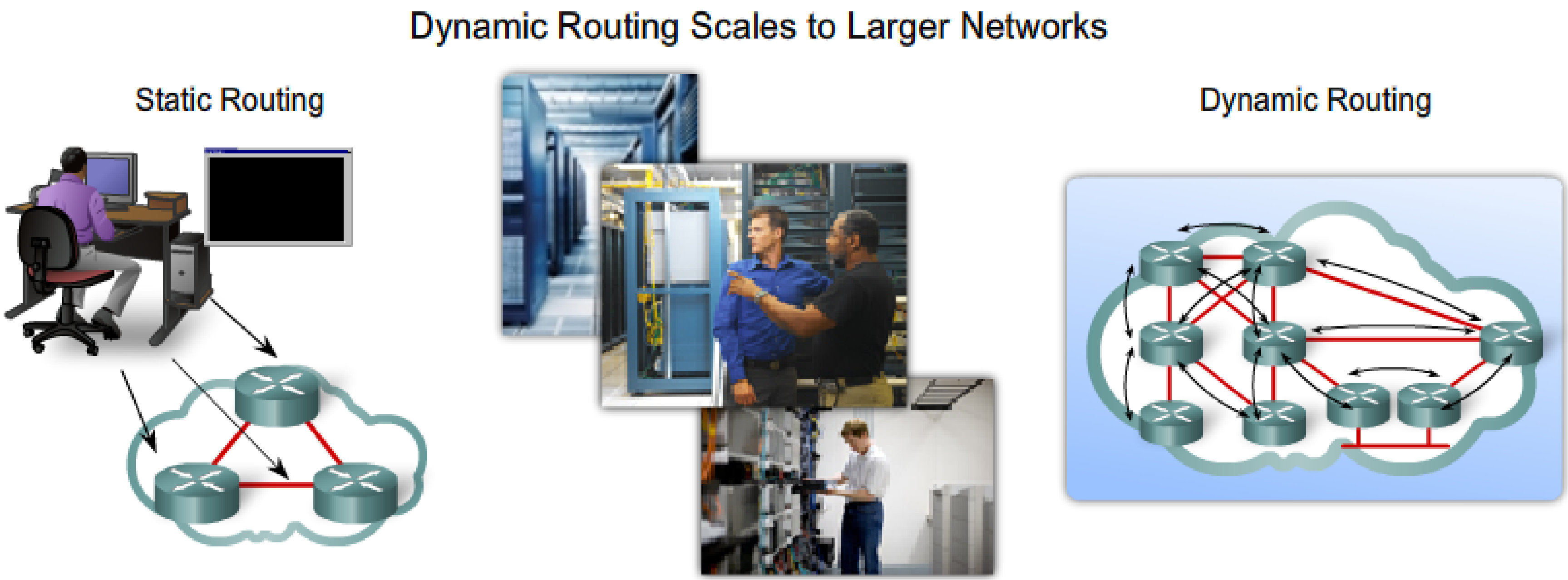
Packet Tracer Exploration:
Subnetting Scenario 2

3.5.4 Subnetting Scenario 3

Hands-on Lab:
Subnetting Scenario 3

Packet Tracer Exploration:
Subnetting Scenario 3

3.6.1 Summary and Review



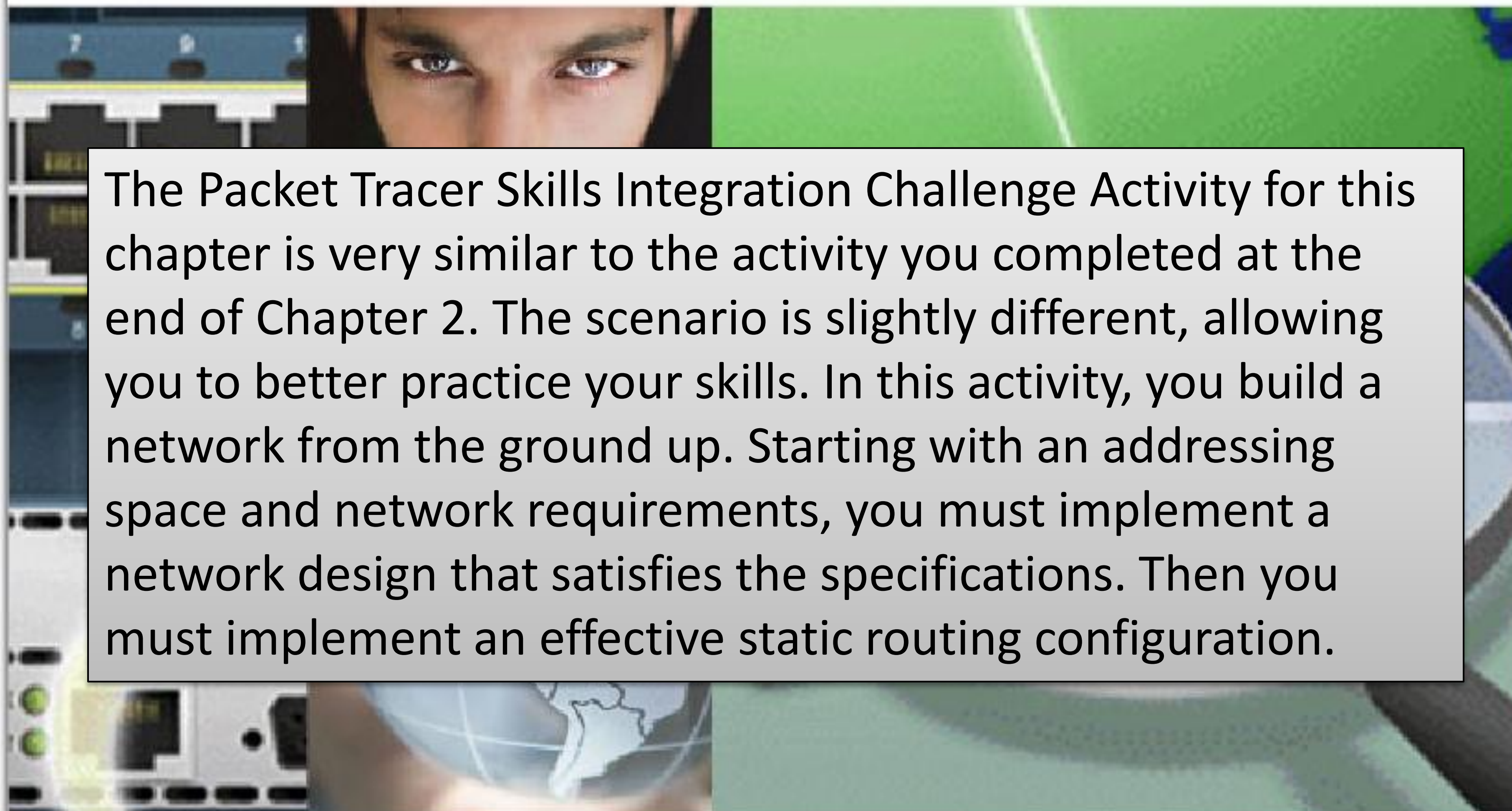
In this chapter, you have learned to:

- Describe the role of dynamic routing protocols and place these protocols in the context of modern network design.
- Identify several ways to classify routing protocols.
- Describe how metrics are used by routing protocols, and identify the metric types used by dynamic routing protocols.
- Determine the administrative distance of a route and describe its importance in the routing process.
- Identify the different elements in the routing table.
- Given realistic constraints, devise and apply subnetting schemes.

3.6.1 Summary and Review

Packet Tracer Exploration:

Ch3 - Packet Tracer Skills Integration Challenge



The Packet Tracer Skills Integration Challenge Activity for this chapter is very similar to the activity you completed at the end of Chapter 2. The scenario is slightly different, allowing you to better practice your skills. In this activity, you build a network from the ground up. Starting with an addressing space and network requirements, you must implement a network design that satisfies the specifications. Then you must implement an effective static routing configuration.

3.6.1 Summary and Review

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

Metrics are used by dynamic routing protocols to calculate the best path to a destination.

Administrative distance is an integer value that is used to indicate a router's "trustworthiness"

Components of a routing table include:

-Route source

-Administrative distance

-Metric

THANKS FOR YOUR ATTENTION