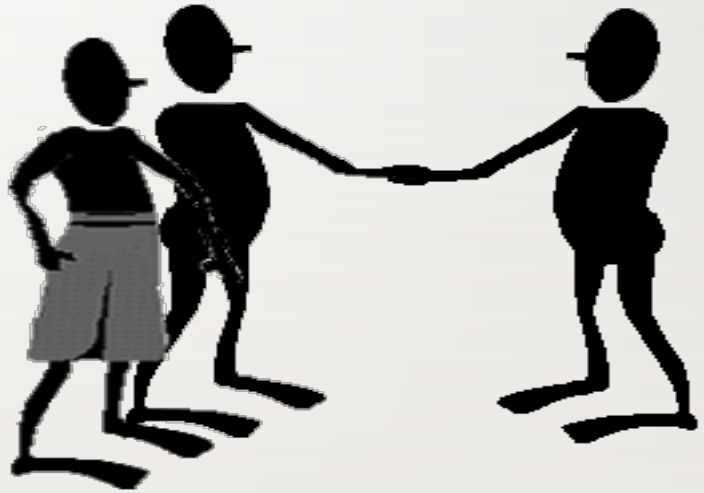
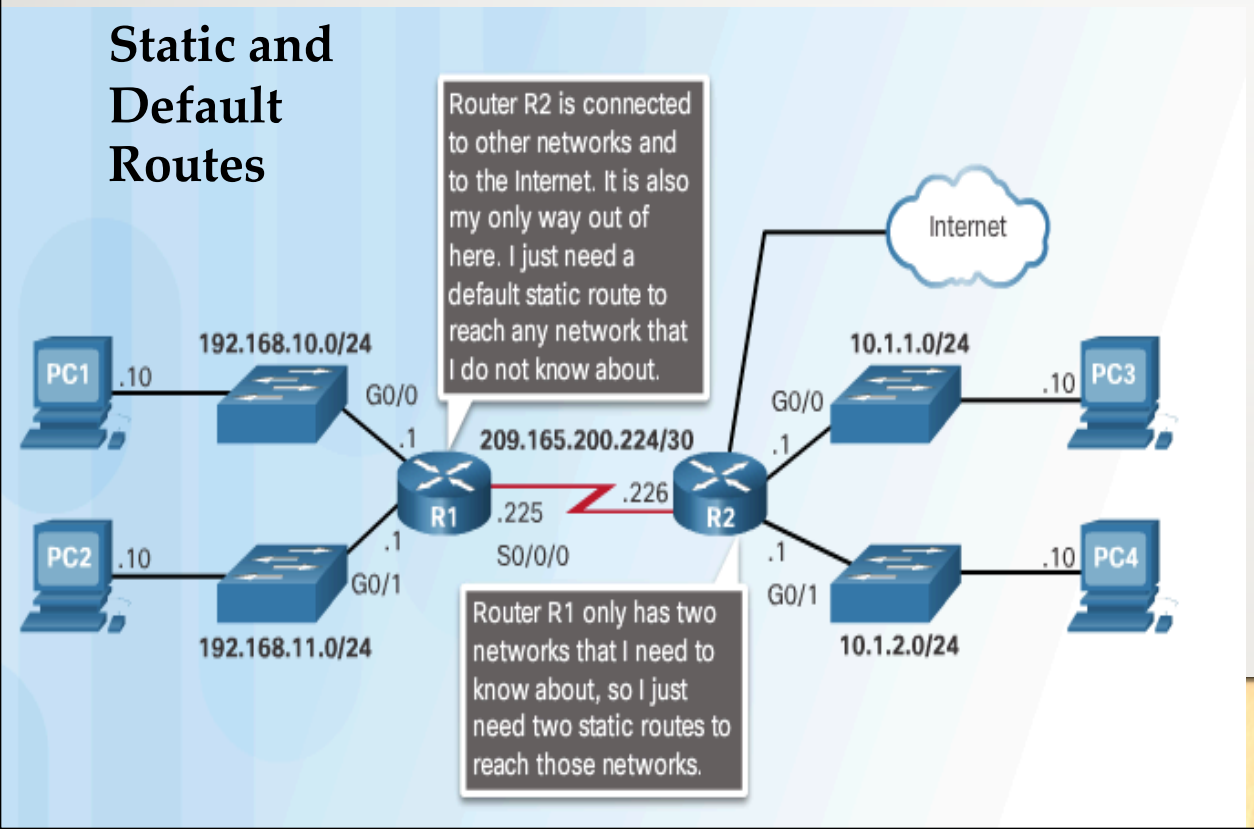
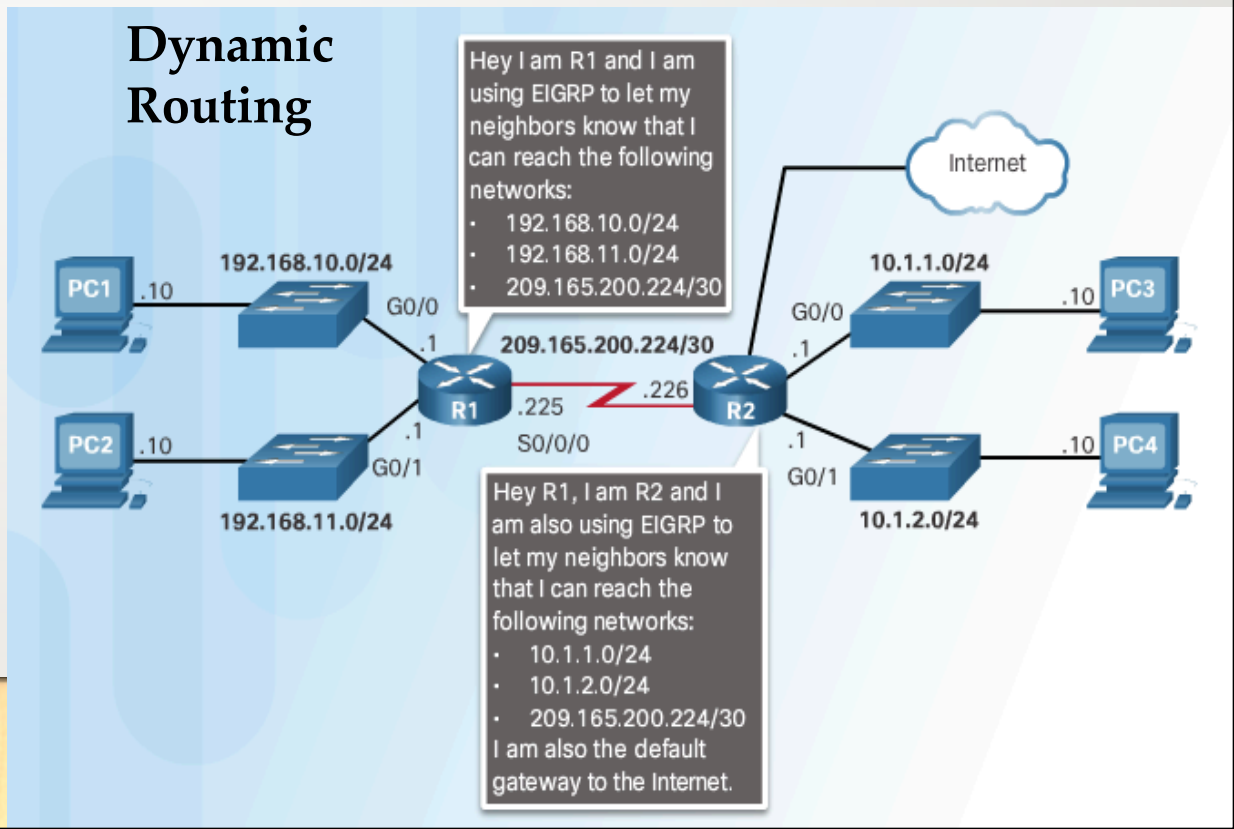
Chapter – 4
Layer -3 Protocols



Reach Remote Networks

- A router learns about remote networks in two ways:
  - **Manually entered into the route table using static routes**
    - Static routes are not automatically updated and must be reconfigured when topology changes
  - **Dynamically (Automatically) learned using a routing protocol**

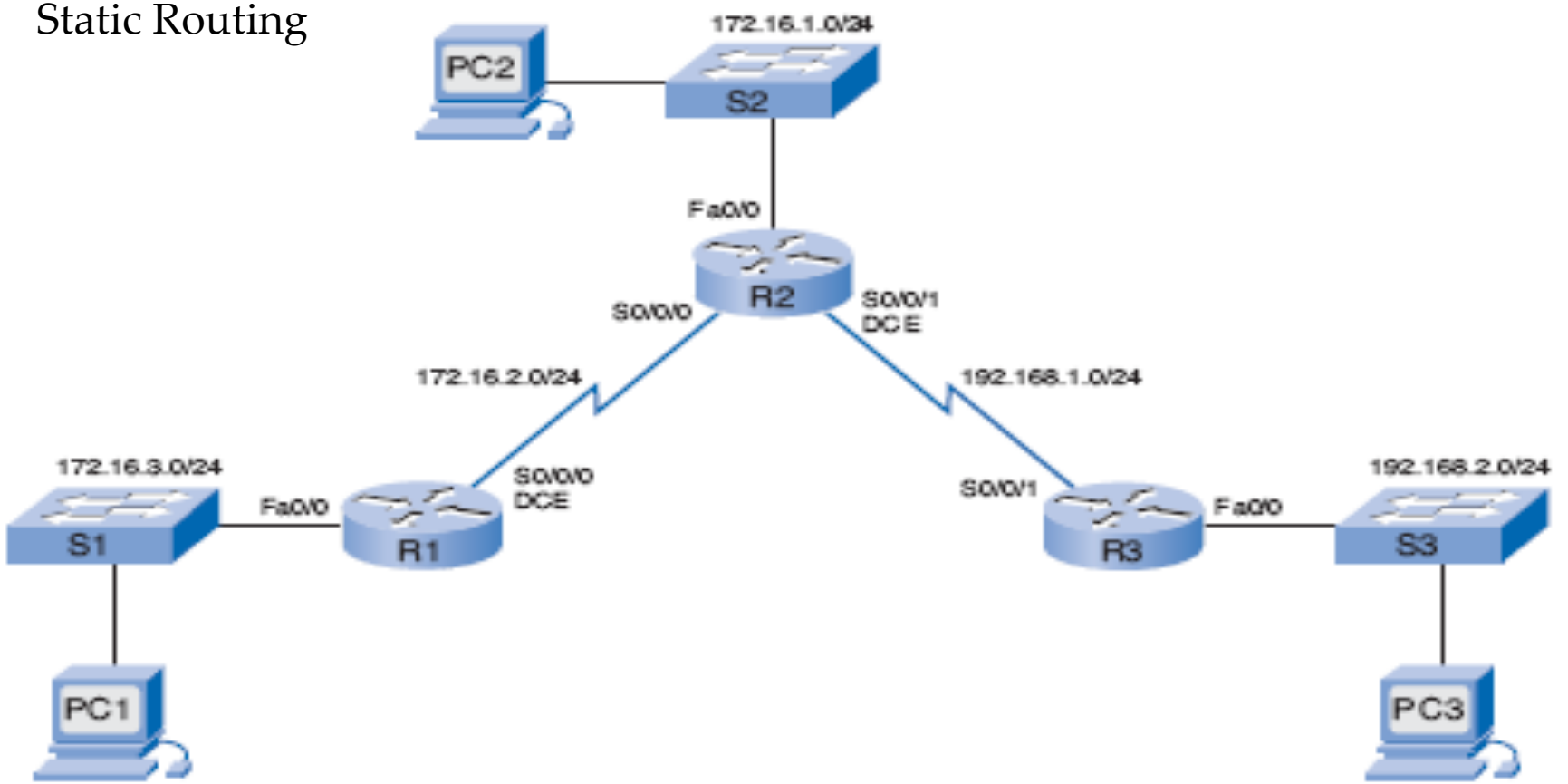




Dynamic Routing Versus Static Routing

	Dynamic Routing	Static Routing
Configuration Complexity	Generally independent of the network size	Increases with network size
Topology Changes	Automatically adapts to topology changes	Administration intervention required
Scaling	Suitable for simple and complex topologies	Suitable for simple topologies
Security	Less secure	More secure
Resource Usage	Uses CPU, memory, and link bandwidth	No extra resources required

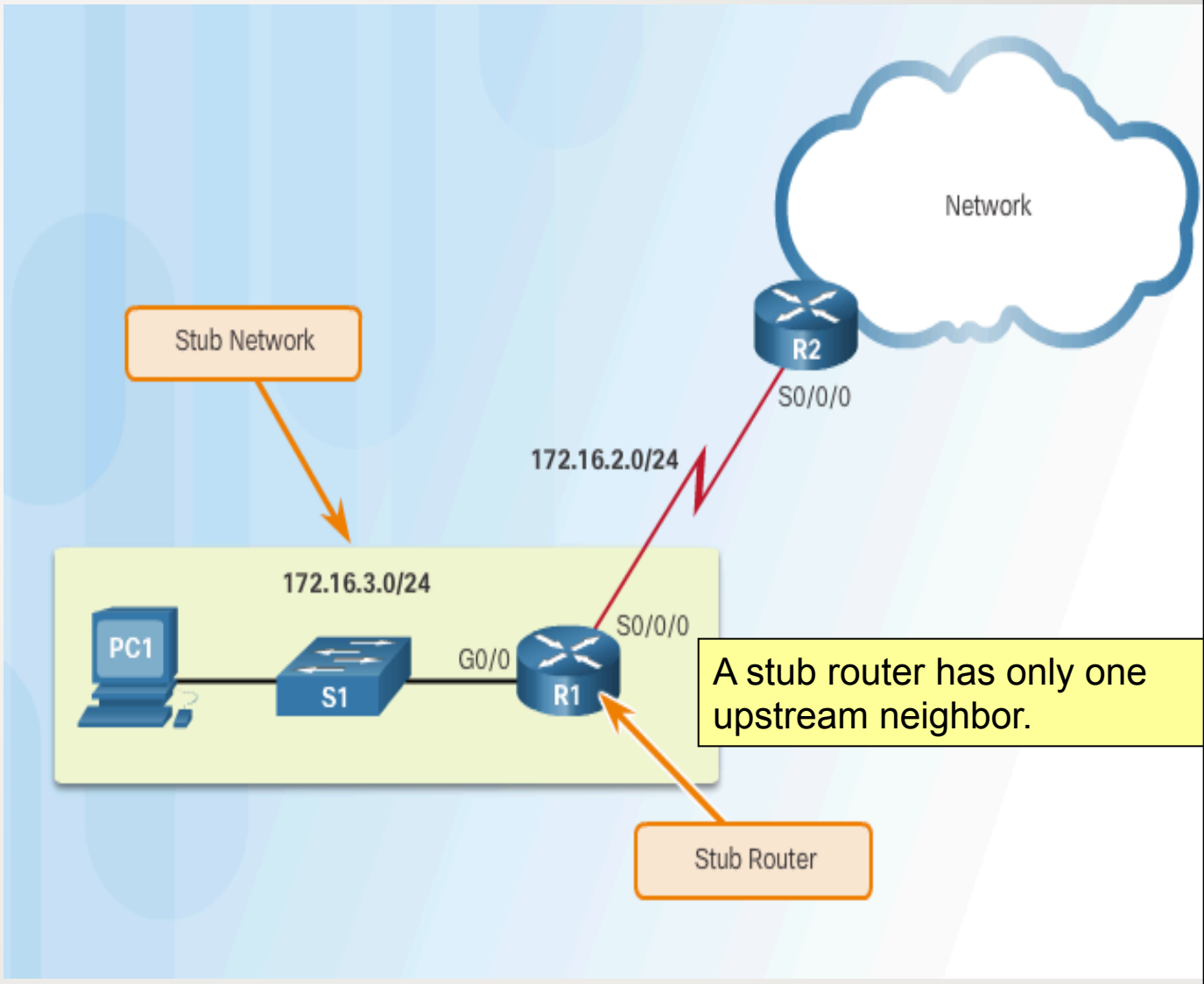
Static Routing




```
R1(config)# ip route 172.16.1.0 255.255.255.0 172.16.2.2
R1(config)# ip route 192.168.1.0 255.255.255.0 172.16.2.2
R1(config)# ip route 192.168.2.0 255.255.255.0 172.16.2.2
R2(config)# ip route 172.16.3.0 255.255.255.0 172.16.2.1
R2(config)# ip route 192.168.2.0 255.255.255.0 192.168.1.1
R3(config)# ip route 172.16.1.0 255.255.255.0 192.168.1.2
R3(config)# ip route 172.16.2.0 255.255.255.0 192.168.1.2
R3(config)# ip route 172.16.3.0 255.255.255.0 192.168.1.2
```

When to Use Static Routes

- In small networks that are not expected to grow significantly.
- To route traffic to and from stub networks.
- A single default route to represent a path to any network not found in the routing table
  - Use default route on R1 to point to R2 for all other networks

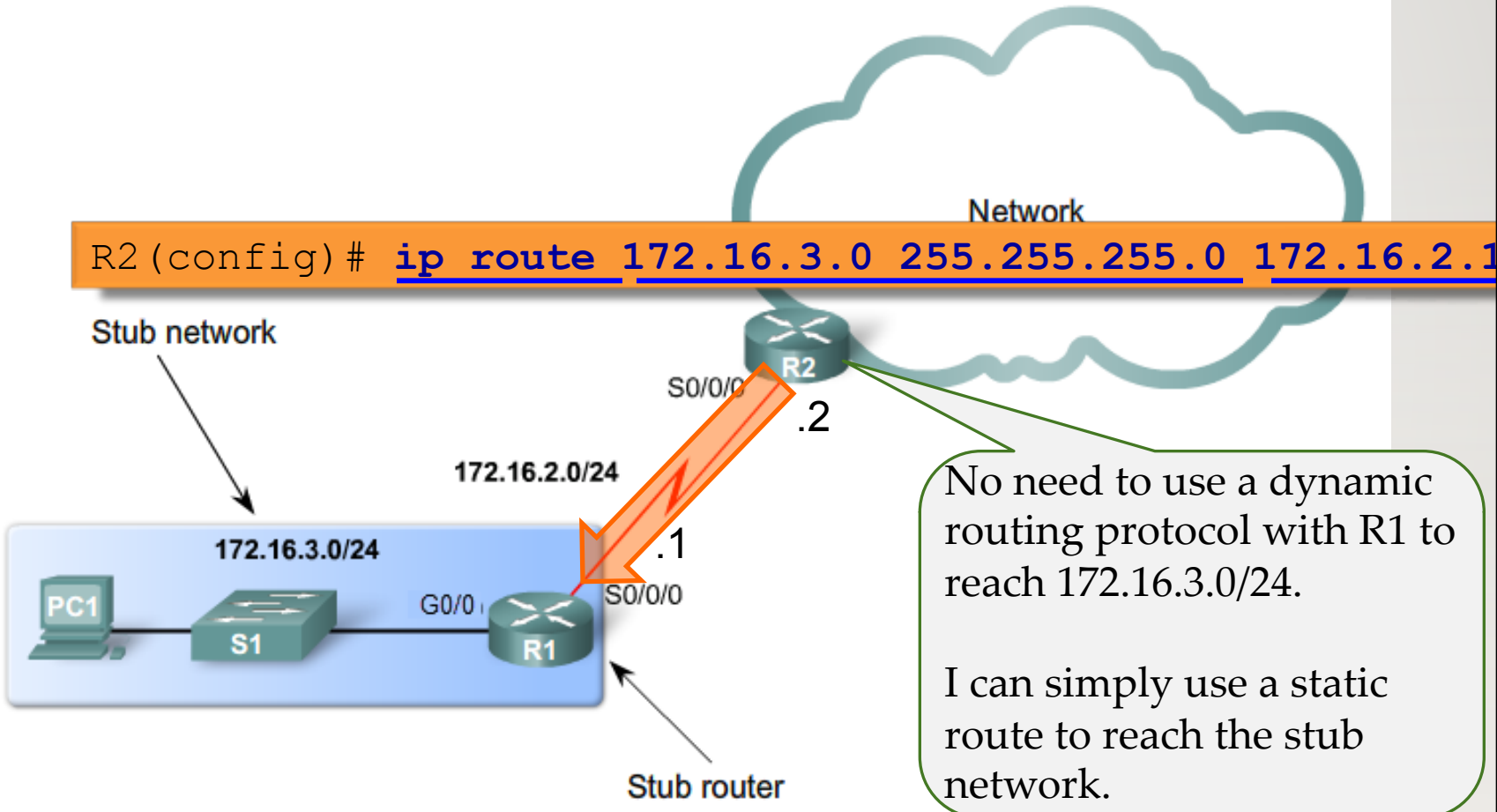


Types of Static Routes

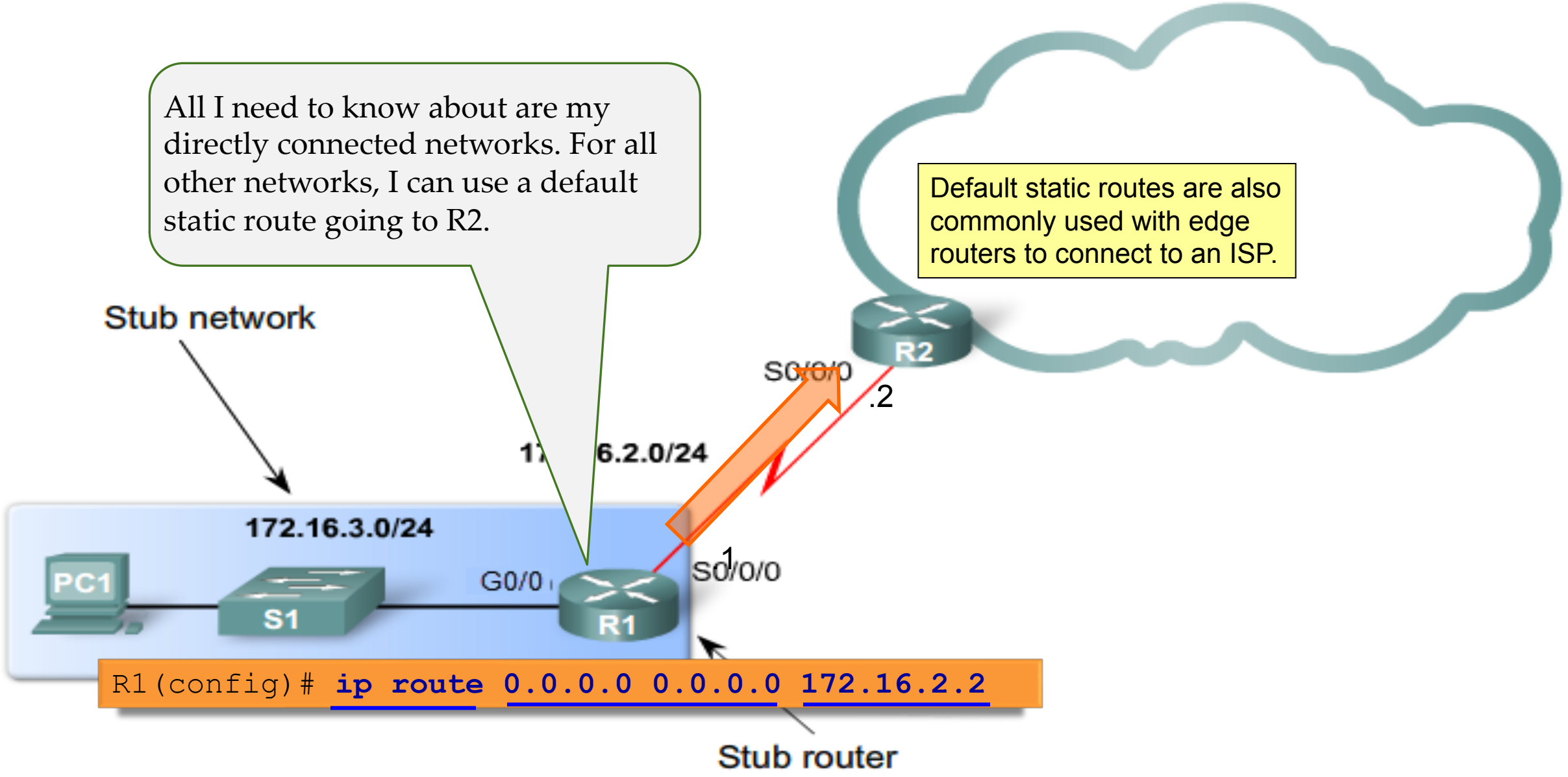
- **Standard static route**
- **Default static route**
- **Summary static route**
- **Floating static route**

Standard Static Route

- Standard static routes are useful when connecting to a specific remote network.

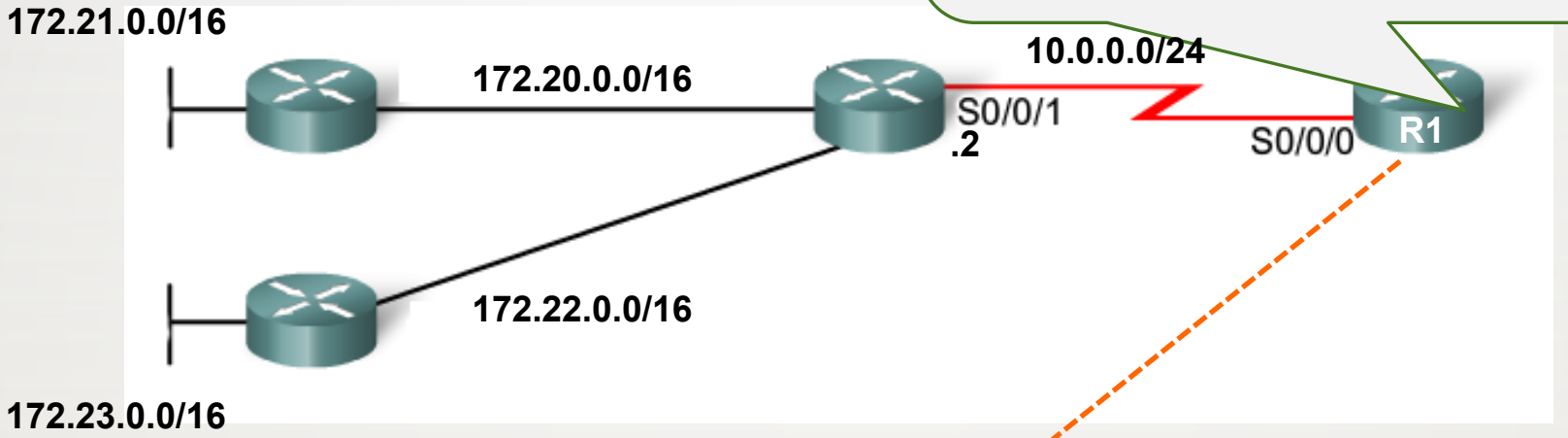


Default Static Route Example



Summary Static Route

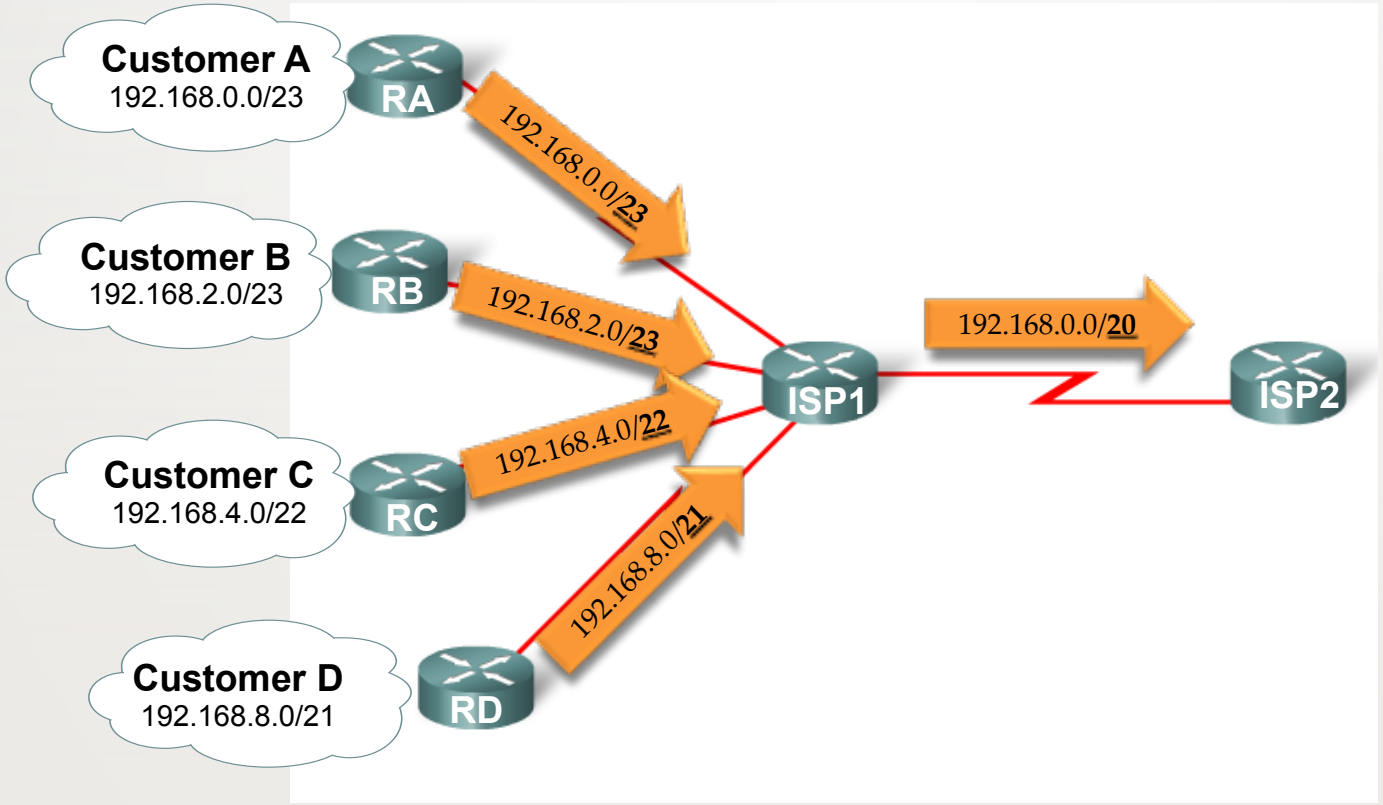
I have four static routes to reach the remote networks 172.20.0.0/16 - 172.23.0.0/16.
But to reduce the size of my routing table, I will replace those four static routes with one summary static route using a /14 subnet mask




```
R1(config)# no ip route 172.20.0.0 255.255.0.0 10.0.0.2
R1(config)# no ip route 172.21.0.0 255.255.0.0 10.0.0.2
R1(config)# no ip route 172.22.0.0 255.255.0.0 10.0.0.2
R1(config)# no ip route 172.23.0.0 255.255.0.0 10.0.0.2
R1(config)#
R1(config)# ip route 172.20.0.0 255.252.0.0 10.0.0.20
```

Summarizing Supernet Routes

- The address space of the four customers can be summarized into one advertisement to ISP2 (192.168.0.0/20)
  - This type of route is known as a **supernet** route.



Calculating a Summary Route

1. List the networks in binary format.
2. Count the number of far left matching bits.
   - This identifies the prefix length or subnet mask for the summarized route.
3. Copy the matching bits and then add zero bits to the rest of the address to determine subnet prefix.

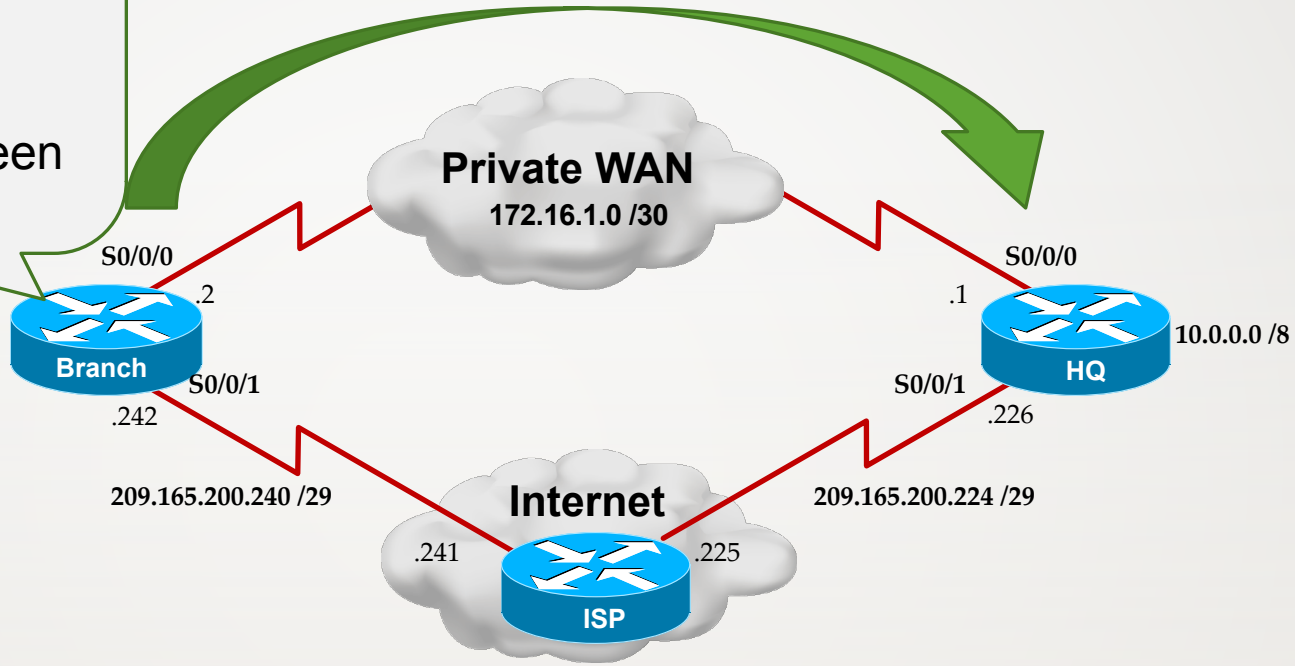
Customer A (192.168.**0**.0): 11000000.10101000.00000000.00000000
Customer B (192.168.**2**.0): 11000000.10101000.00000010.00000000
Customer C (192.168.**4**.0) :11000000.10101000.00000100.00000000
Customer D (192.168.**8**.0): 11000000.10101000.00001000.00000000

11000000.10101000.00000000.00000000 /20

Floating Static Route

I can reach the HQ router 10.0.0.0/8 LAN using the private WAN link.

I'm using EIGRP to exchange routes between sites.



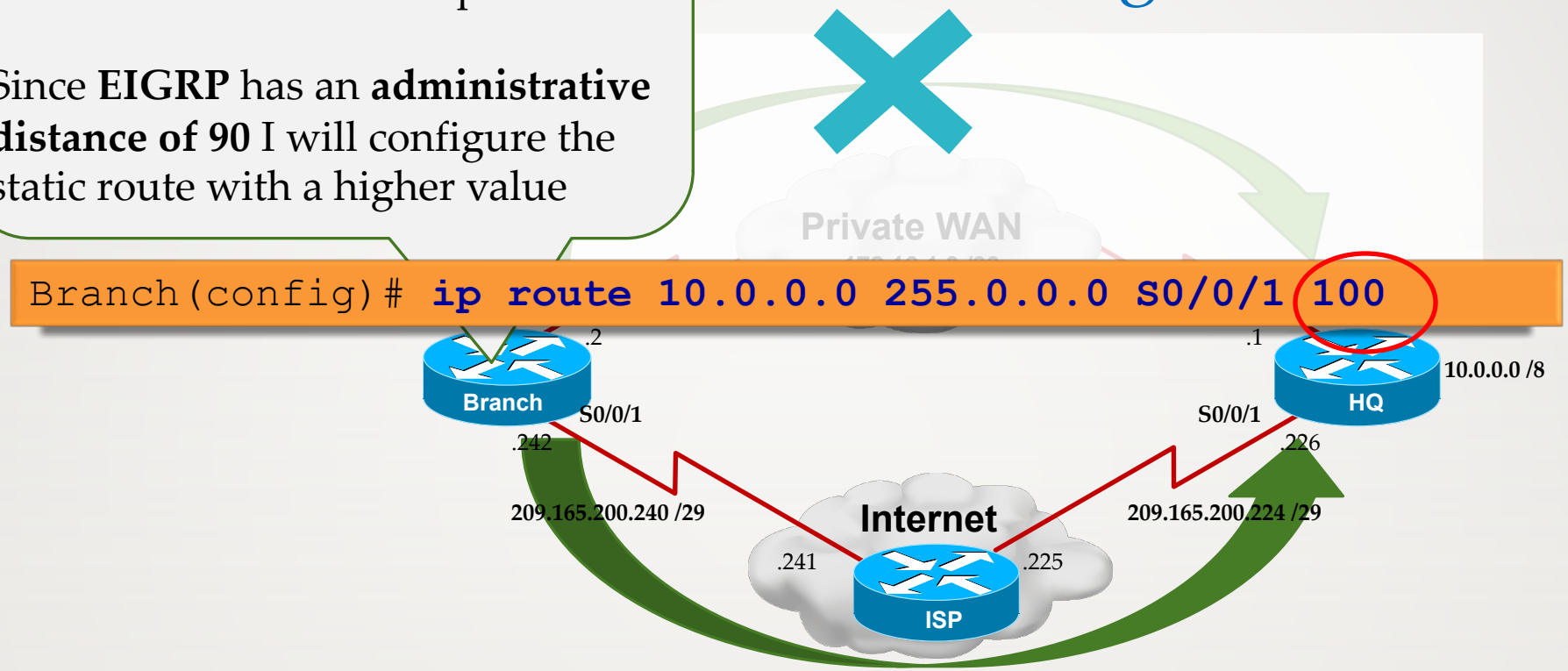
Floating static routes are static routes used to provide a backup path to a primary static or dynamic route, in the event of a link failure.

- The floating static route is only used when the primary route is not available.

Floating Static Route

However, if that link ever fails, I will use a floating static route connecting to the Internet as a backup.

Since **EIGRP** has an **administrative distance of 90** I will configure the static route with a higher value



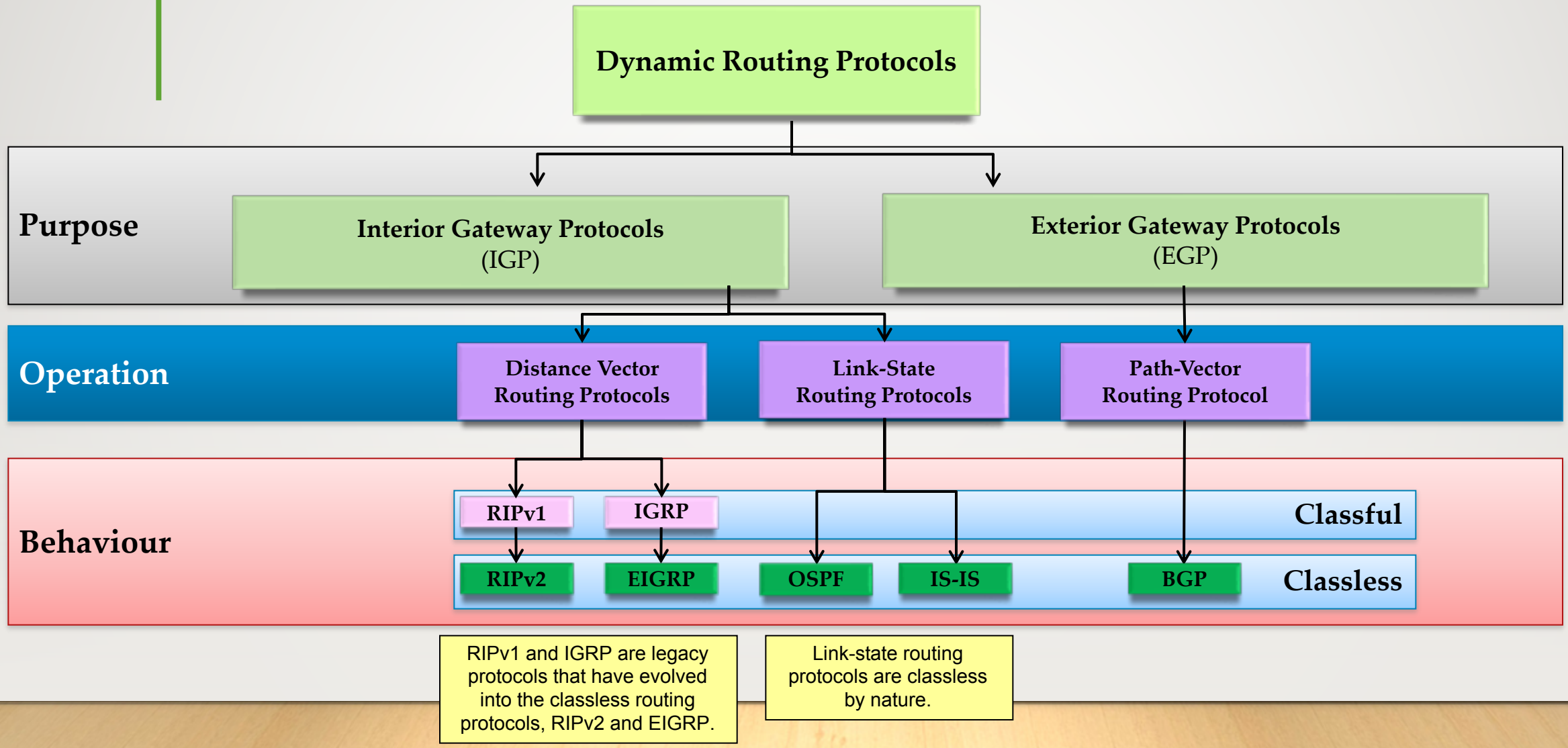
Accomplished by configuring the static route with a higher administrative distance than the primary route.

Administrative distance represents the trustworthiness of a route.

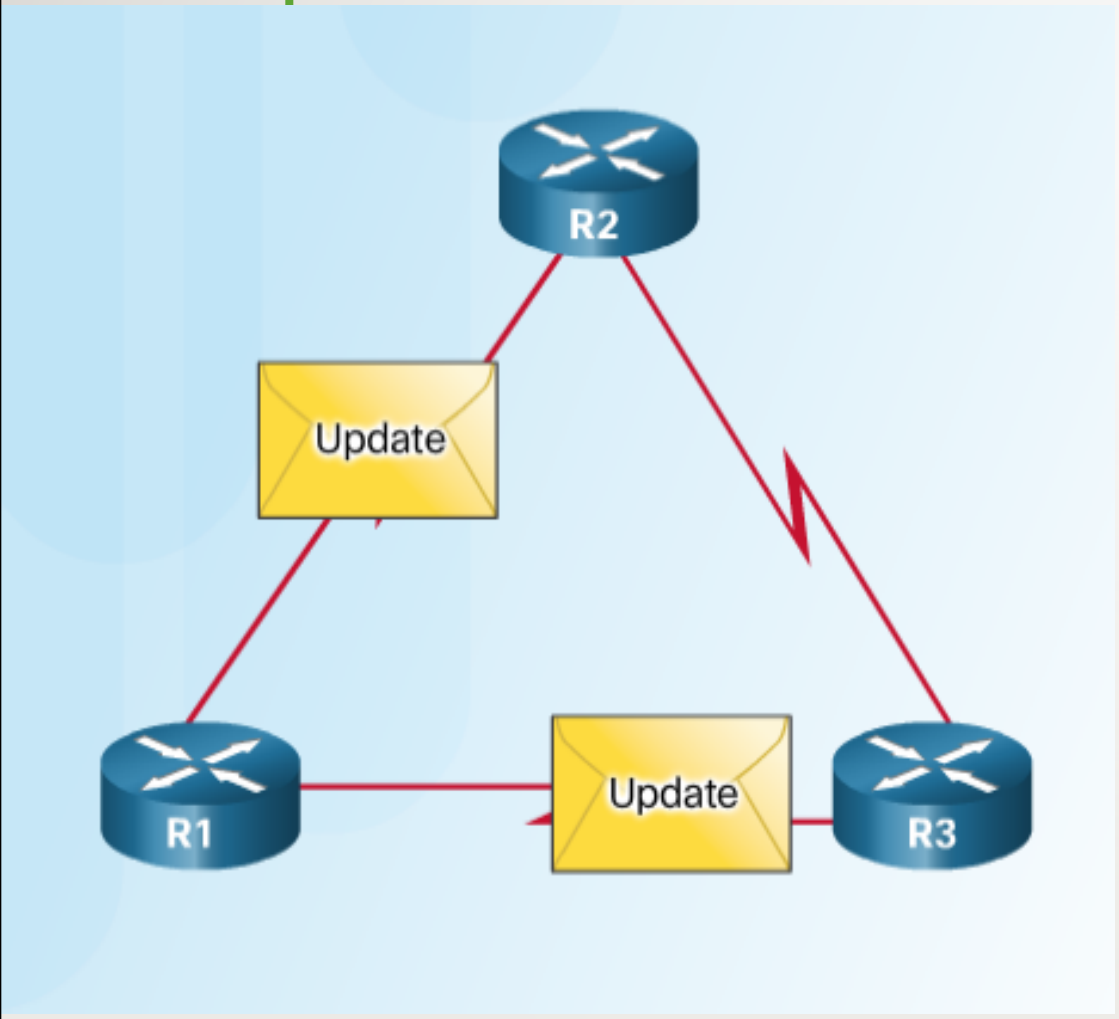
- If multiple paths to the destination exist, the router will choose the path with the lowest administrative distance.

Dynamic Routing Protocols

Classifying Routing Protocols

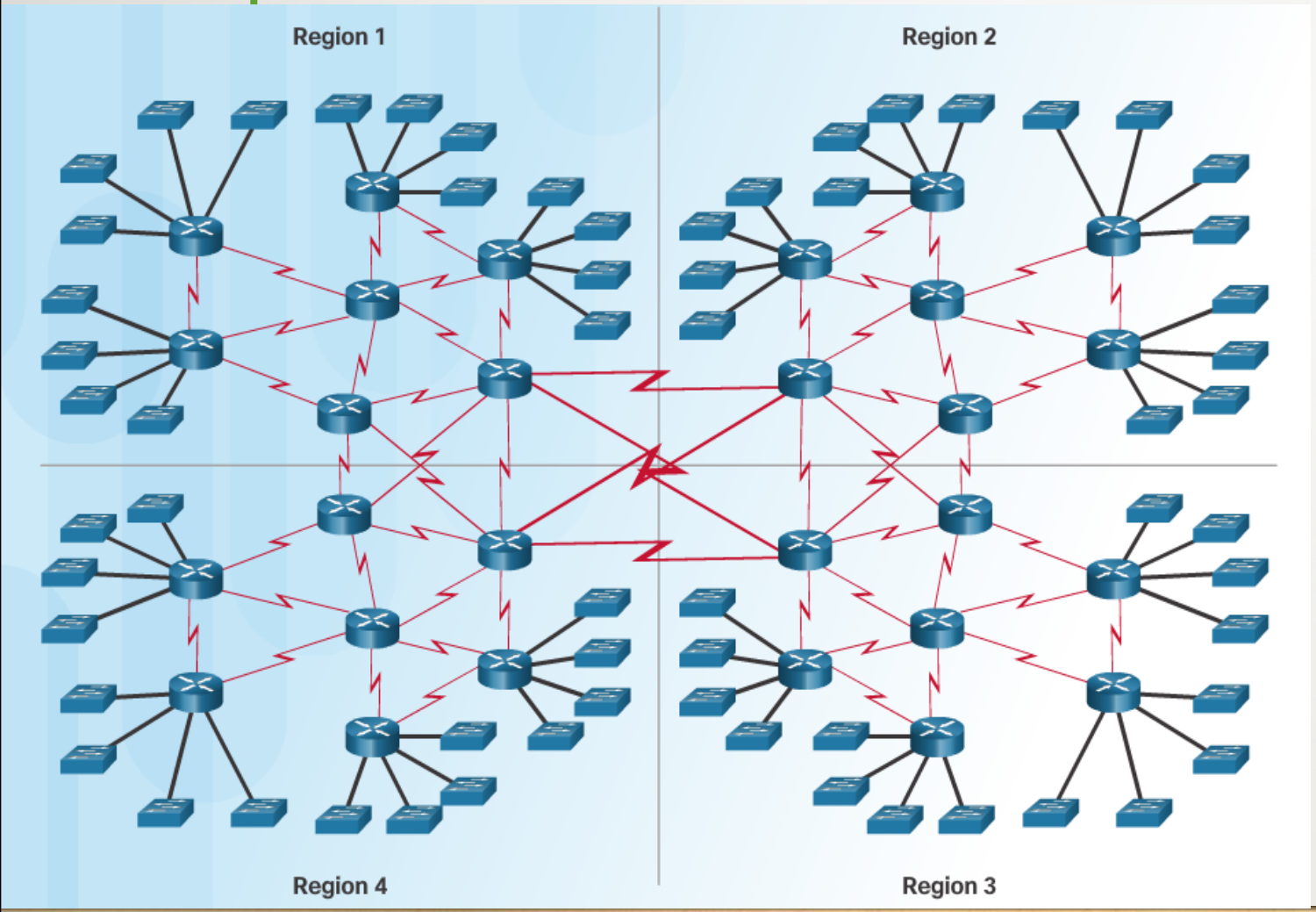


Dynamic Routing Protocol Components



- Purpose of dynamic routing protocols includes:
  - Discovery of 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
- **The main components of dynamic routing protocols include:**
  - Data structures - tables or databases kept in RAM.
  - Routing protocol messages - to discover neighboring routers, exchange routing information, and maintain accurate information about the network.
  - Algorithms – to facilitate learning routing information and for best path determination.

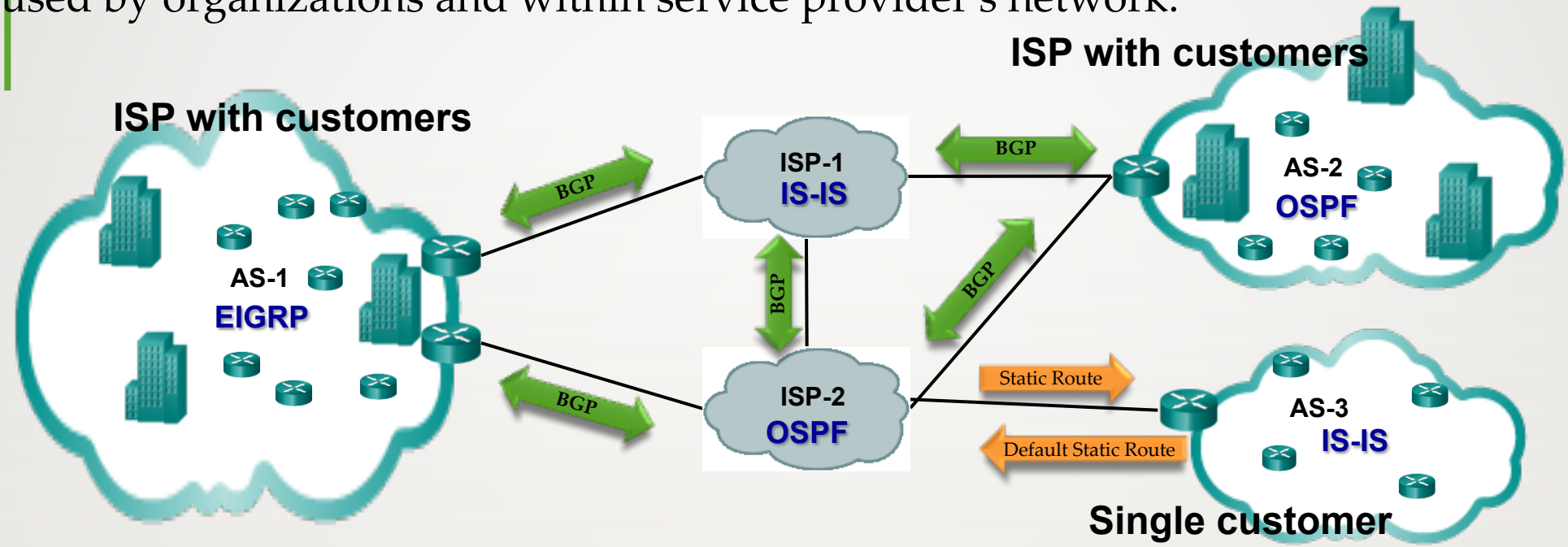
Dynamic Routing Protocols Uses



- Dynamic routing is the best choice for large networks
- Dynamic routing protocols help the network administrator manage the network:
  - Providing redundant paths
  - Automatically implementing the alternate path when a link goes down.

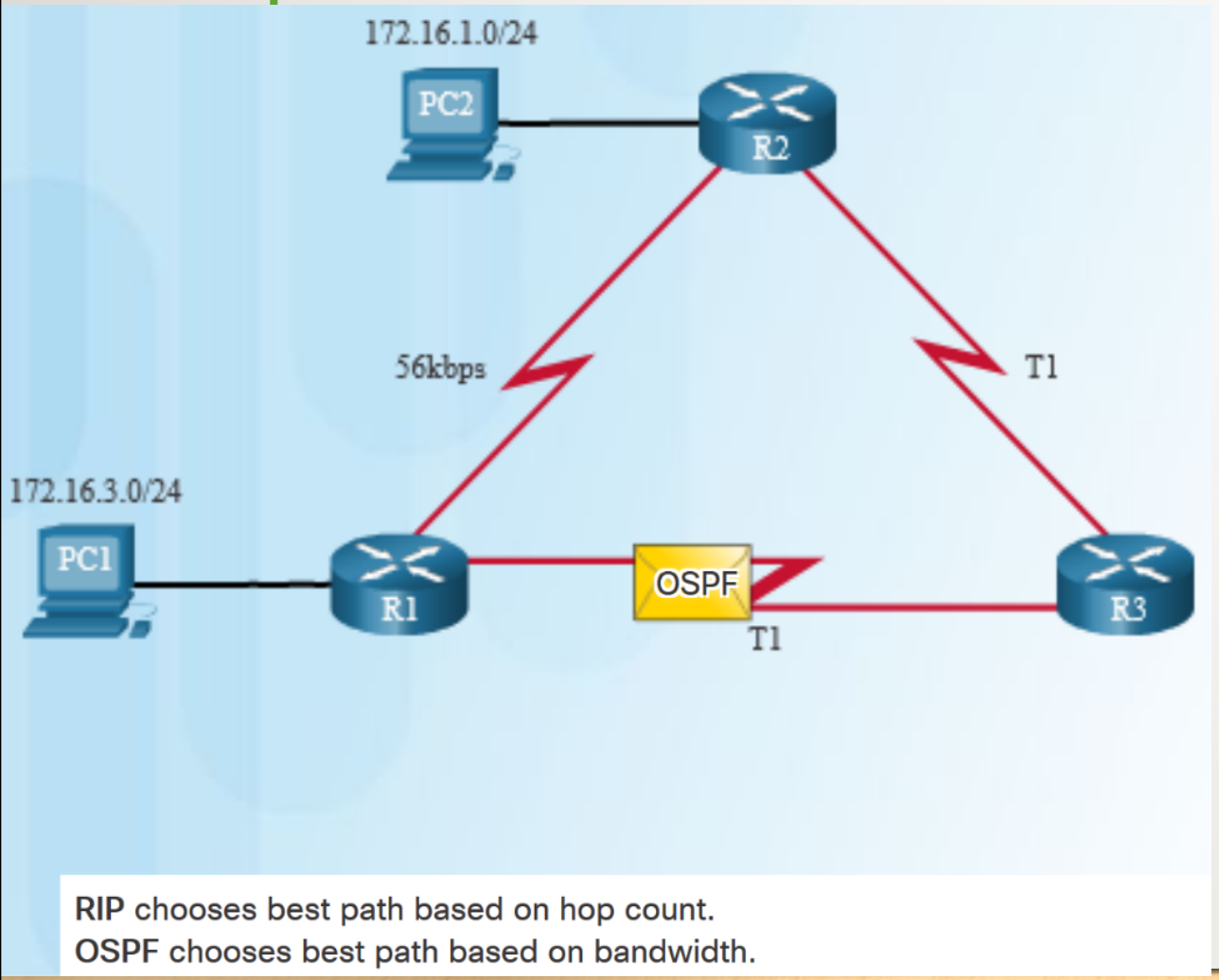
IGP versus EGP Routing Protocols

- IGPs are used by organizations and within service provider's network.



- BGP could be used to interconnect large organizations to service providers and in between various service providers.
- Smaller organizations would typically connect using static routes but could also use BGP.

Routing Protocol Metrics

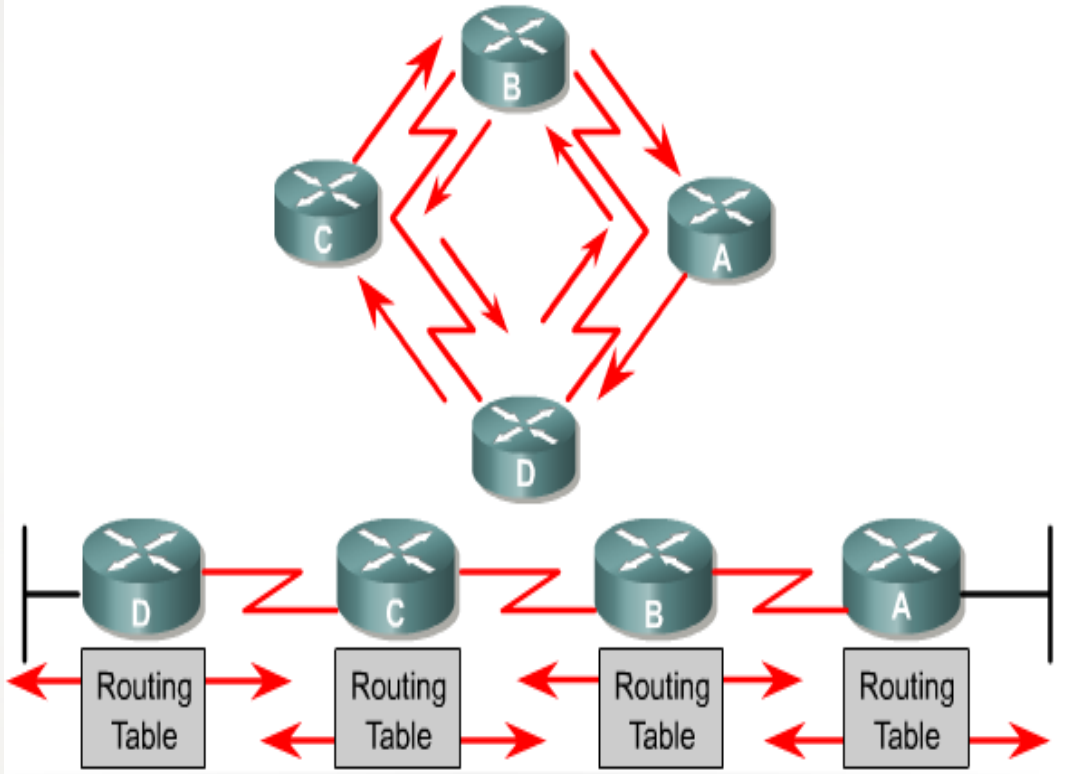


RIP chooses best path based on hop count.
OSPF chooses best path based on bandwidth.

- A metric is a measurable value that is assigned by the routing protocol to different routes based on the usefulness of that route.
- Routing metrics are used to determine the overall "cost" of a path from source to destination.
- Best path is route with the lowest cost.
- Metrics used by various dynamic protocols:
  - RIP – Use Hop counts as its metric.
  - OSPF – Cost based on cumulative bandwidth
  - EIGRP - **Bandwidth, delay**, load, and reliability.

Distance Vector Concepts

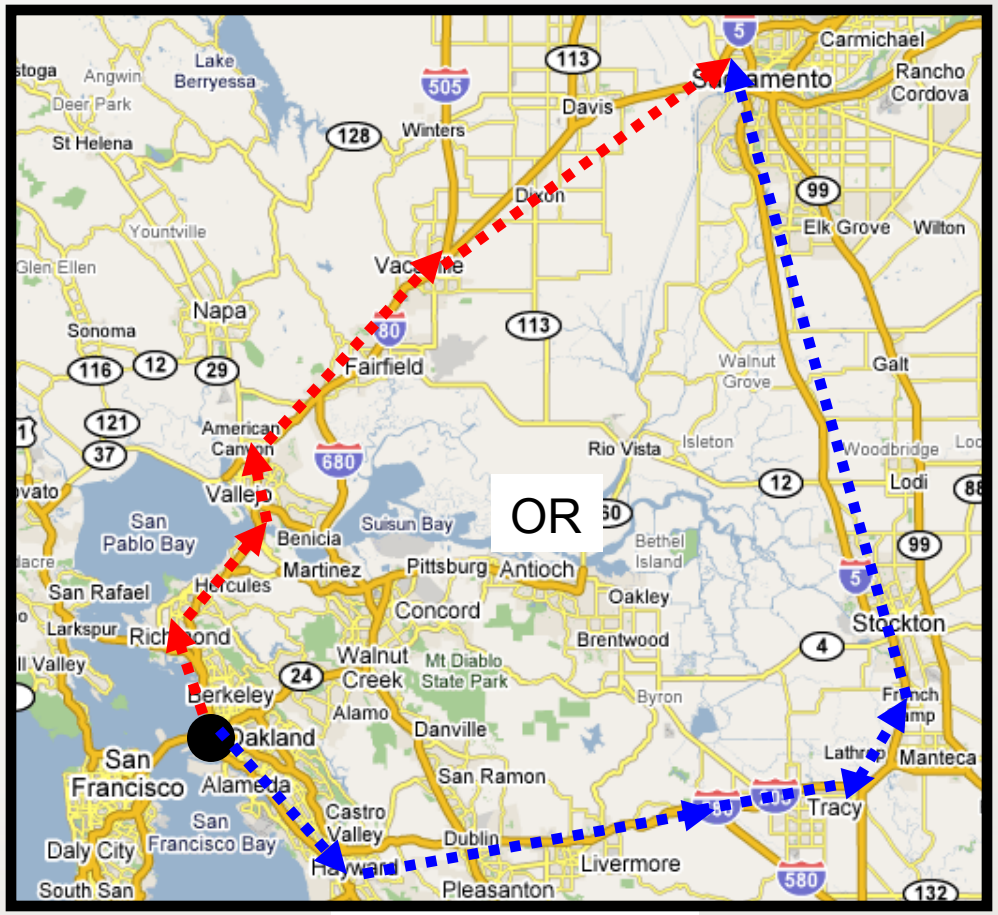
- Distance vector routing protocols share updates between neighbors.
- Routers using distance vector routing are not aware of the network topology.
- Some distance vector routing protocols send periodic updates.
  - RIPv1 sends updates as broadcasts 255.255.255.255.
  - RIPv2 and EIGRP can use multicast addresses to reach only specific neighbor routers.
  - EIGRP can use a unicast message to reach a specific neighbor router.
  - EIGRP only sends updates when needed, not periodically.



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

Link-State Protocol Operation

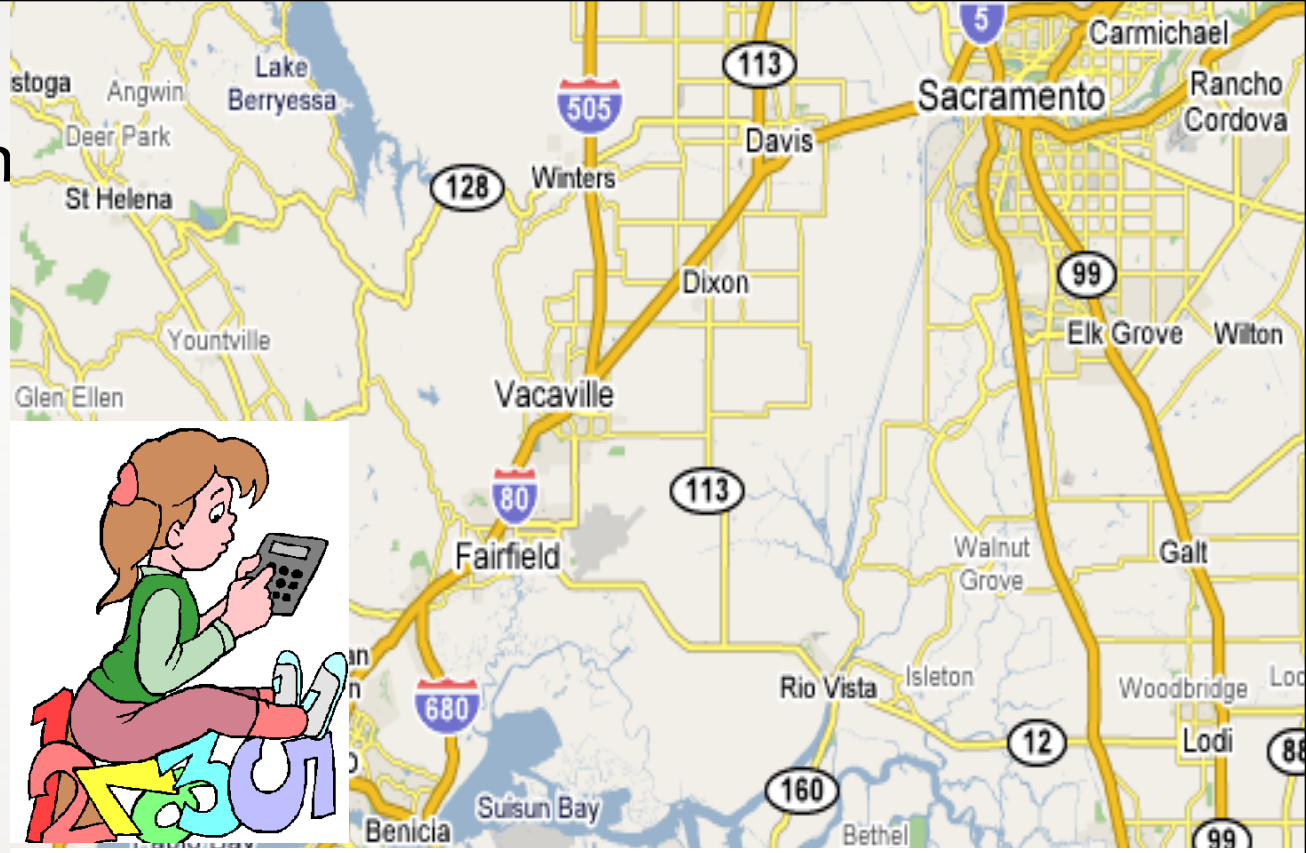
- ***Link-state*** routing protocol can create a "complete view," or topology, of the network.
- Link-state protocols are associated with Shortest Path First (SPF) calculations.
- A ***link-state router*** uses the link-state information to:
  - Create a topology map
  - Select the best path to all destination networks in the topology.
  - Each router makes the decision!



Link State routing protocols is like having a complete map of the network topology

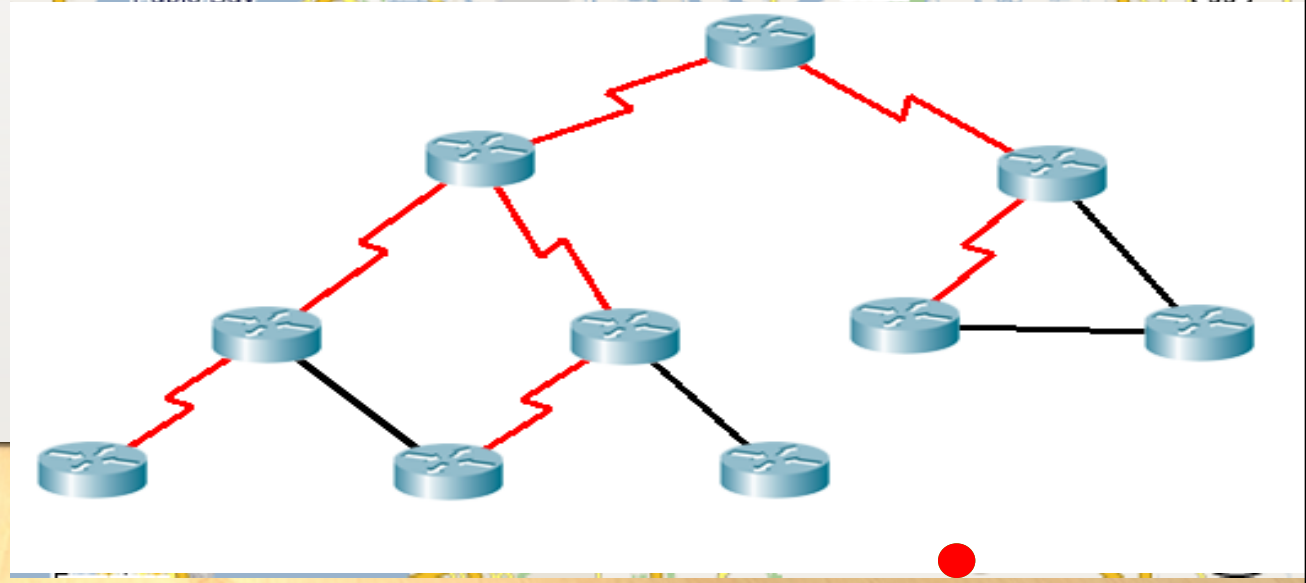
Link-State Protocol Operation

- **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.



Type of link-State protocols

- **Open Shortest Path First (OSPF)**
  - Popular standards based routing protocol
- **Intermediate System-to-Intermediate System (IS-IS)**
  - Popular in provider networks



Purpose of Administrative Distance

- What if a router learns about a remote network from two different routing sources.
- What if RIP advertises the network as 10 hops away but OSPF advertises it as a cumulative bandwidth of 100,000.
- Which is better RIP or OSPF?
  - Can't tell
  - Can't compare apples and oranges.
  - Note: This is not common.
- ***Administrative distance (AD)*** is:
  - Used to determine <u>which routing source takes precedence</u>.
  - Used when there are multiple routing sources for the same destination network address.
- **Lower the AD** the <u>more preferred</u> the routing source.

Route Source	AD
Connected	0
Static	1
EIGRP summary route	5
E	20
I	90
IGRP	100
OSPF	110
IS-IS	115
	120
	170
Internal BGP	200

So, which one would be preferred RIP or OSPF? OSPF

Which route would be preferred, OSPF or a Static Route to the same network? Static Route

Purpose of Administrative Distance

- Cisco uses Administrative distance (AD) to define the preference of a routing source.
- Routing sources:
  - **Directly connected networks**
  - **Static routes**
  - **Specific routing protocols**

Note

- The term ***trustworthiness*** is commonly used when defining administrative distance.
- *The lower the administrative distance value, the more trustworthy the route.*

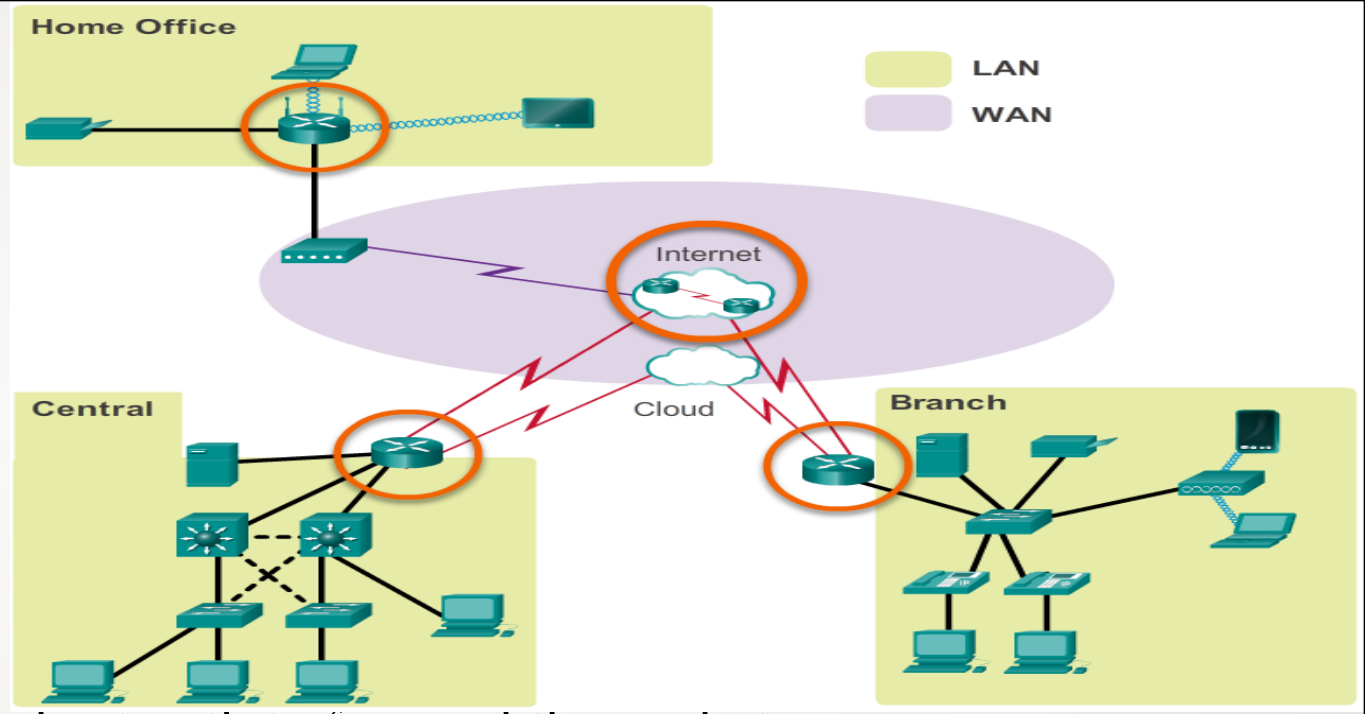
Route Source	AD
Connected	0
Static	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
RIP	120
External EIGRP	170
Internal BGP	200

Purpose of Administrative Distance

- AD: 0 to 255.
- The lower the value, the more preferred the route source.
- **AD of 0** is the most preferred.
  - *Only a directly connected network has an administrative distance of 0, which cannot be changed.*
  - No better route to a network than being directly connected to that network.
- **AD of 255** means the router will not believe the source of that route
  - Route will not be installed in the routing table.

Route Source	AD
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

Path Decisions



- The router uses its routing table to determine the best path to forward the packet.
  - When the router receives a packet, it examines its destination IP address and searches for the best network address match in the routing table.
  - The routing table entries also includes the interface to be used to forward the packet.
  - Once a match is found, the router encapsulates the IP packet into the data link frame of the outgoing o exit interface.
  - The packet is then forwarded toward its destination.

Path Decisions

- **How does a Router choose a path when multiple paths exist?**

- The three attributes for Route Preference are the **Route Specificity (Longest match**), the **Administrative Distance**, and the **Metric**.

End of Chapter 4