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Applied Advanced Routing Routing and Routing Protocols Olga Torstensson

Routed Versus Routing Protocol

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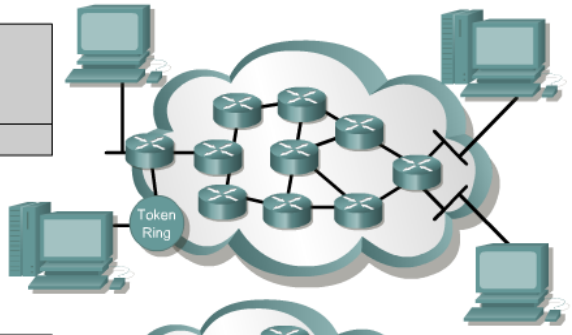
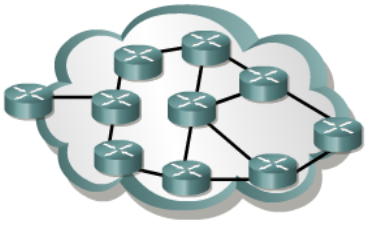
Routed protocol used between routers to direct user traffic

Examples: IP and IPX



Routing protocol used between routers to maintain tables

Examples: RIP, IGRP, OSPF



Route Types

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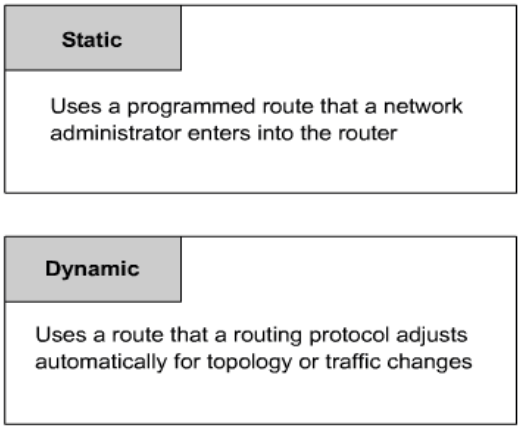

Zinin's 3 routing principles

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- **Principle 1:**

"Every router makes its decision alone, based on the information it has in its own routing table."

- **Principle 2:**

"The fact that one router has certain information in its routing table does not mean that other routers have the same information."

- **Principle 3:**

"Routing information about a path from one network to another does not provide routing information about the reverse, or return path."

Static route

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- **Static routing is useful in networks that have a single path to any destination network.**
- **Static routing reduces the memory and processing burdens on a router.**
- **Secure operation.**

Specifying Outgoing Interface

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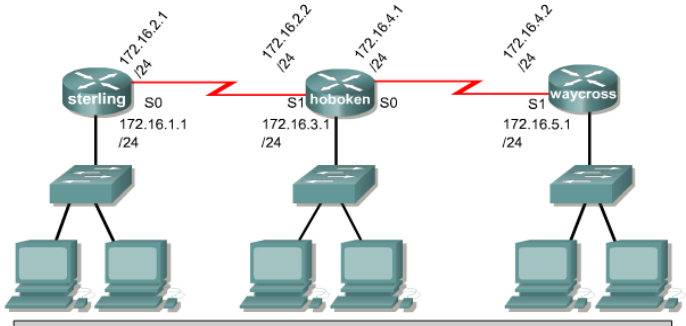


```
Hoboken(config)#ip route 172.16.1.0 255.255.255.0 s1
                   command  destination  sub mask    gateway
                            network
Hoboken(config)#ip route 172.16.5.0 255.255.255.0 s0
                   command  destination  sub mask    gateway
                            network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

Specifying the Next-hop IP Address

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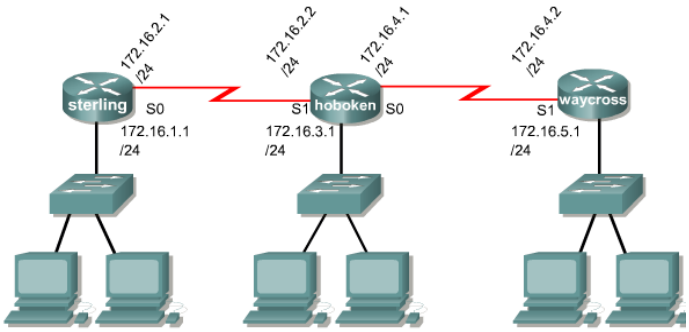


```
Hoboken(config)#ip route 172.16.1.0 255.255.255.0 172.16.2.1
                     command  destination  sub mask   gateway
                              network
Hoboken(config)#ip route 172.16.5.0 255.255.255.0 172.16.4.2
                     command  destination  sub mask   gateway
            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


Non-directly Connected Networks

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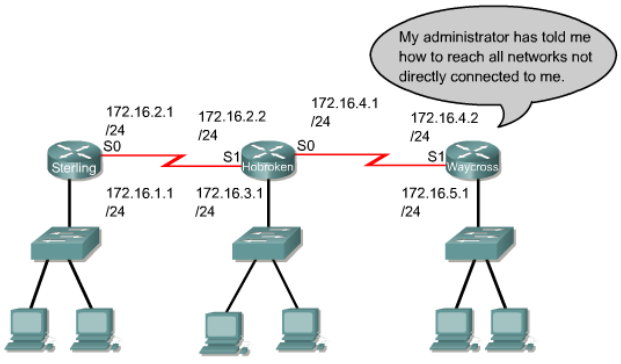


```
Waycross(config)#ip route 0.0.0.0  0.0.0.0 S1
This command points to all non-directly-connected networks
```

Verifying Route Configuration

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- The command **show running-config** is used to view the active configuration in RAM to verify that the static route was entered correctly.
- The **show ip route** command is used to make sure that the static route is present in the routing table

The show ip route Command Output

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```
Router#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
```

Troubleshooting Route Configuration

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- The **`show interfaces`** command
- The **`ping`** command
- The **`traceroute`** command

The `ping` and `traceroute` Commands

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```
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  *  *  *
```

Static routing

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- **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 Protocols

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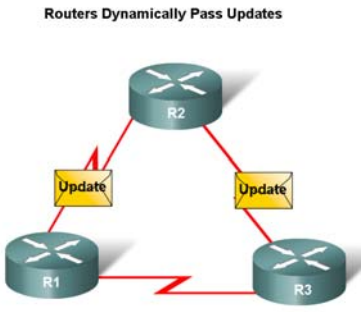
- **Functions of Dynamic Routing Protocols:**
  - **-Dynamically share information between routers.**
  - **-Automatically update routing table when topology changes.**
  - **-Determine best path to a destination.**



Dynamic Routing Protocols

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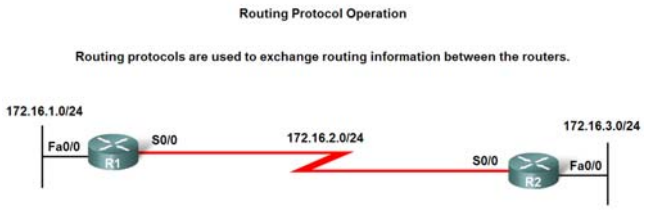
- The purpose of a dynamic routing protocol is to:
  - -Discover remote networks
  - -Maintaining up-to-date routing information
  - -Choosing the best path to destination networks
  - -Ability to find a new best path if the current path is no longer available



Dynamic Routing Protocols

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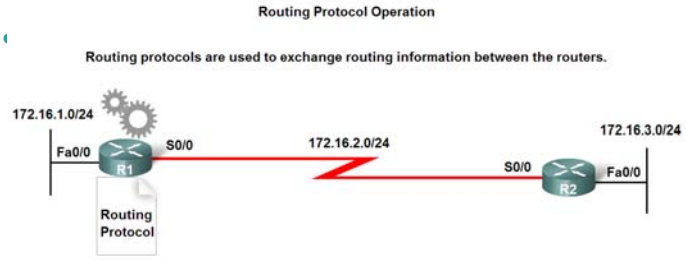
- Algorithm
  - In the case of a routing protocol algorithms are used for facilitating routing information and best path determination



Classifying Routing Protocols

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- Types of routing protocols:
  - -Interior Gateway Protocols (IGP)
  - -Exterior Gateway Protocols (EGP)
- 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

Autonomous Systems

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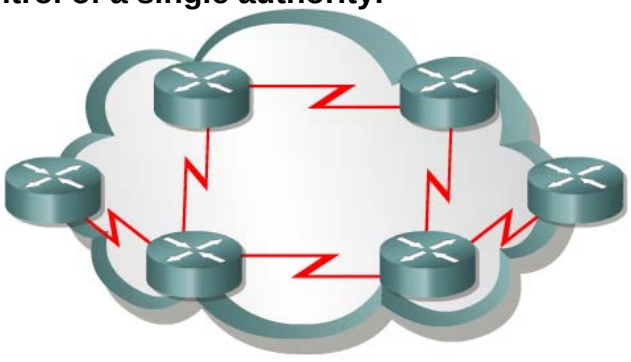
Autonomous System is a group of routers under the control of a single authority.



Routers under a common administration

Routing Protocols

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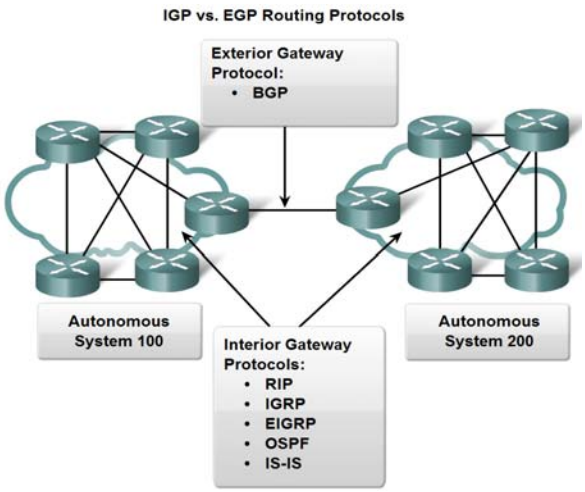

Classifying Routing Protocols

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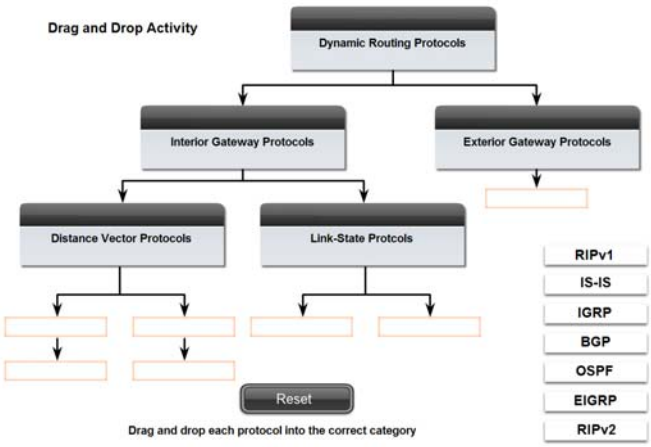

Dynamic Routing Operations

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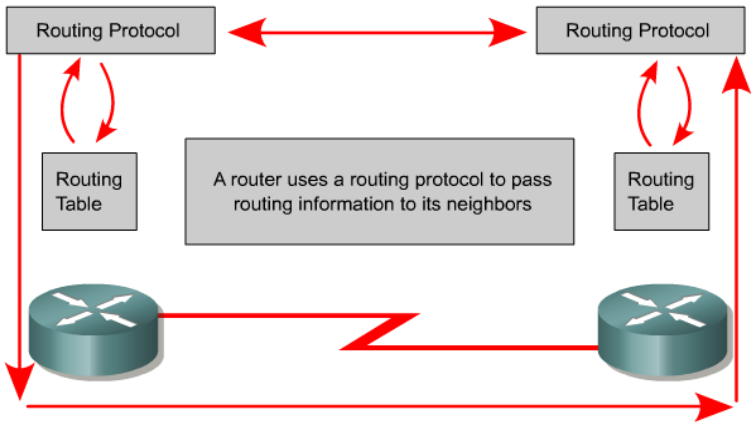

The Initiation of Routing Updates

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- Routing protocols can instruct a router to update neighbors after a specific amount of time has passed, after a certain event has occurred, or both.
- Time-driven routing protocols wait for the update timer to expire and then send an update.
- Protocols that are event-driven do not require the router to update neighbors until the router detects a change in the network topology.
- Routing protocols that are exclusively time-driven react poorly to topology changes.
- Routing protocols that are exclusively event-driven could go for extended periods of time without sending updates.

Route Calculation Fundamentals

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The capability of a routing protocol to update and calculate routes efficiently is based on several factors:

- **Whether the protocol calculates and stores multiple routes to each destination.**
- **The manner in which routing updates are initiated.**
- **The metrics used to calculate distances or costs.**

Routing Protocols Metrics

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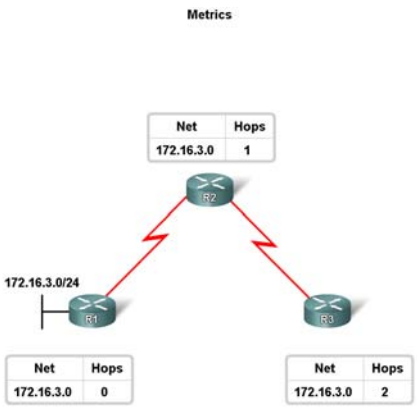
- **Metric :**

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



Routing Protocols Metrics

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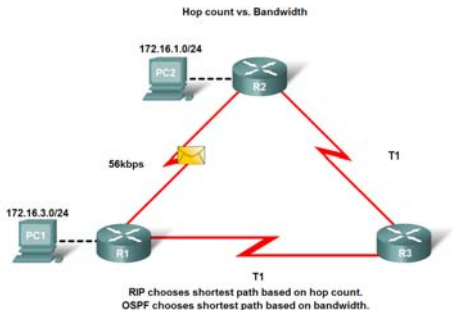
Metrics used in IP routing protocols

- -Bandwidth
- -Cost
- -Delay
- -Hop count
- -Load
- -Reliability



Routing Metric Components

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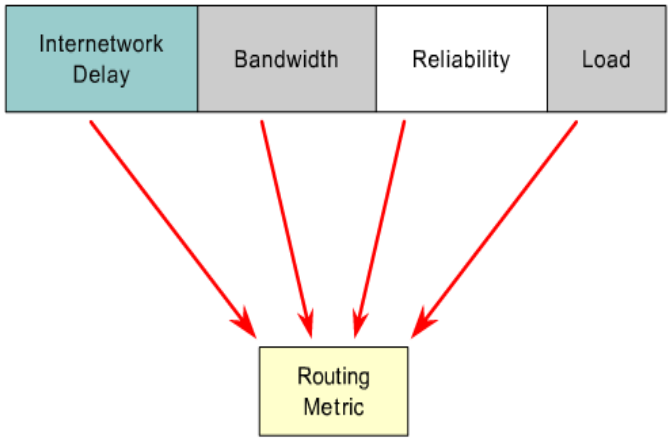
- **A routing metric is a value that measures desirability.**



Routing Metrics

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- Some routing protocols use only one factor to calculate a metric while others base their metric on two or more factors, including hop count, bandwidth, delay, load, reliability, and maximum transmission unit (MTU).
- Bandwidth and delay are static.
- Load and reliability are dynamic and calculated for each interface in real time by the router.
- The more factors that make up a metric, the greater the ability is to adapt network operation to meet specific needs.

Routing Protocols Metrics

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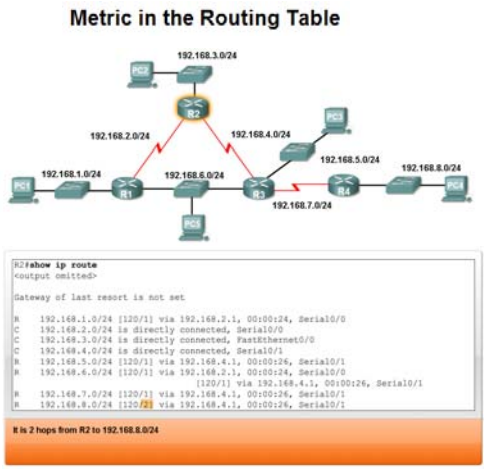
- The Metric Field in the Routing Table
- Metric used for each routing protocol
  - -RIP - hop count
  - -IGRP & EIGRP - Bandwidth (used by default), Delay (used by default), Load, Reliability
  - -IS-IS & OSPF – Cost, Bandwidth



Routing Protocols Metrics

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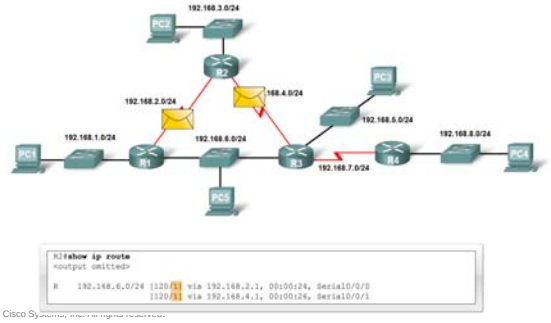
- **Load balancing**

  This is the ability of a router to distribute packets among multiple same cost paths

Load Balancing Across Equal 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, 00:00:24, Serial0/0/1
```


Convergence

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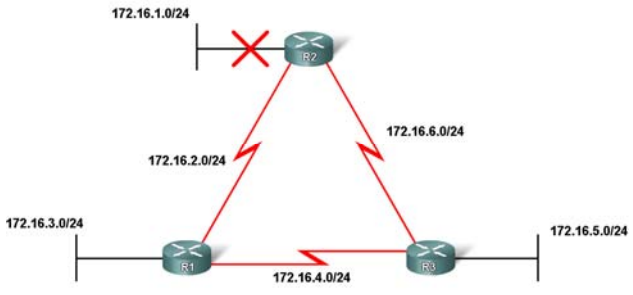
- **Convergence is defined as when all routers' routing tables are at a state of consistency**

Comparing Convergence



Slower Convergence: RIP and IGRP
Faster Convergence : EIGRP and OSPF

Convergence Issues

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- **Factors affecting the convergence time include the following:**
  - **Routing protocol used**
  - **Distance of the router, or the number of hops from the point of change**
  - **Number of routers in the network that use dynamic routing protocols**
  - **Bandwidth and traffic load on communications links**
  - **Load on the router**
  - **Traffic patterns in relation to the topology change**

Administrative Distance of a Route

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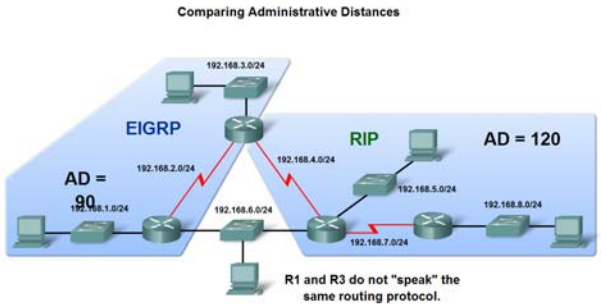
- **Purpose of a metric**
  - **It's a calculated value used to determine the best path to a destination**
- **Purpose of Administrative Distance**
  - **It's a numeric value that specifies the preference of a particular route**



Administrative Distance of a Route

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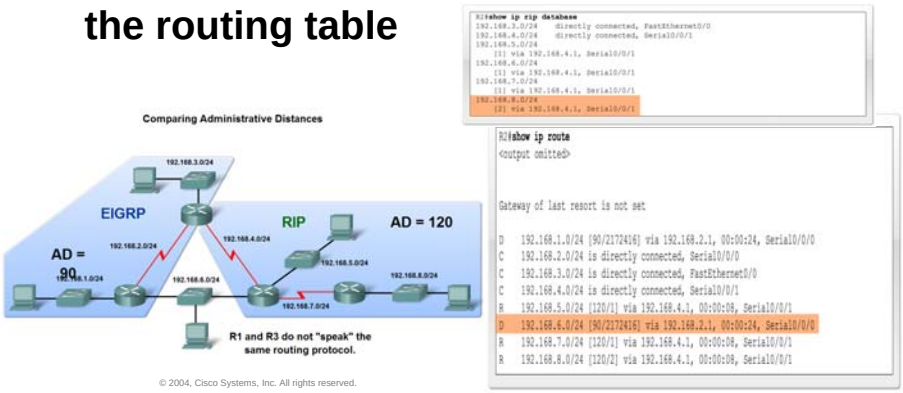
- **Identifying the Administrative Distance (AD) in a routing table**
- **It is the first number in the brackets in the routing table**



Administrative Distance of a Route

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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

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- **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

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Directly connected routes

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

-Has a default AD of 0

```
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
```

Configuring Dynamic Routing

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- **Dynamic routing of TCP/IP can be implemented using one or more protocols which are often grouped according to where they are used.**
- **Protocols can be further categorized as either distance vector or link-state routing protocols, depending on their method of operation.**

Classes of Routing Protocols

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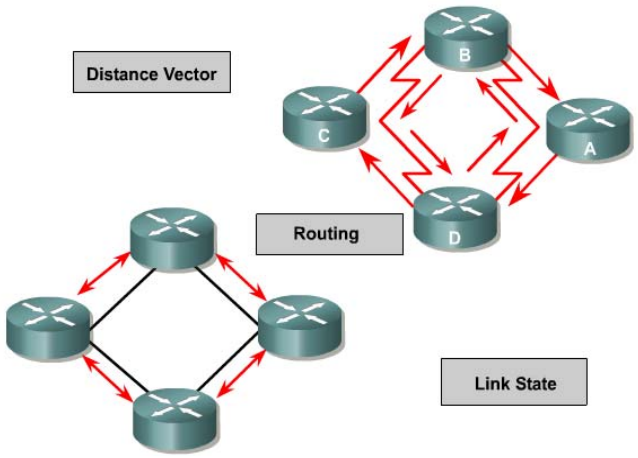
These classifications describe the algorithm, or formula, that routers use to calculate and exchange routing information.



Distance Vector Routing Protocols

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Distance vector routing protocols are based on the Bellman-Ford algorithm.

Distance vector routing protocols are concerned with the distance and vector, or direction, of destination networks.

Distance Vector Concepts

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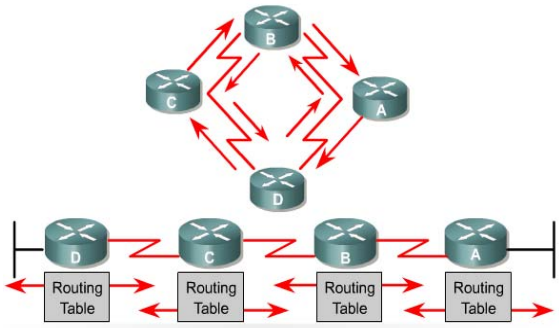
- **Sharing knowledge about the entire AS.**
- **Sharing only with neighbors.**
- **Sharing at regular intervals.(RIP- 30 s)**



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

Distance Vector Network Discovery

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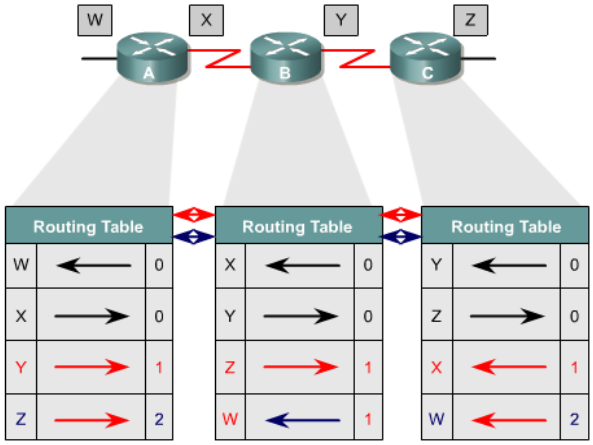

Distance Vector Routing Protocols

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- **Simple distance vector routing protocols offer two primary advantages over link-state protocols.**
  - **Relatively easy to configure.**
  - **Generally use less memory and processing power.**

Link-State Concepts

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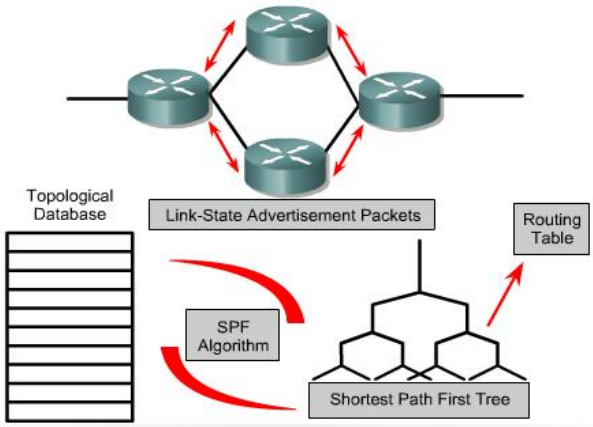

Routers send LSAs to their neighbors. The LSAs are used to build a topological database. The SPF algorithm is used to calculate the shortest path first tree in which the root is the individual router. A routing table is then created.

Link-State Concepts

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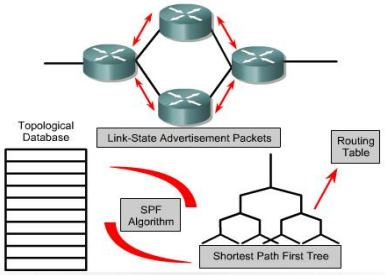
- **Sharing knowledge about the neighborhood.**
- **Sharing with every other router.**
- **Sharing when there is a change.**



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Link-State Network Discovery

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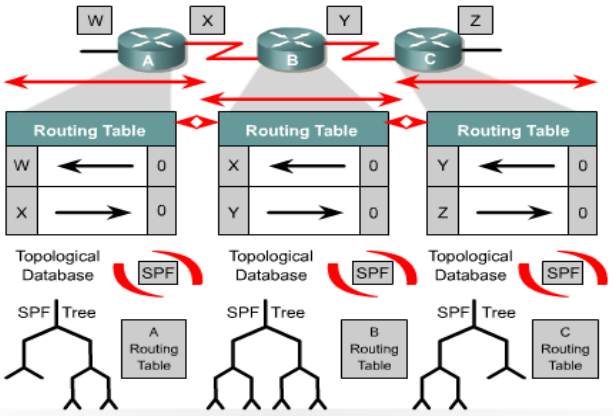

Each router has its own topological database on which the SPF algorithm is run.

Link-State Topology Changes

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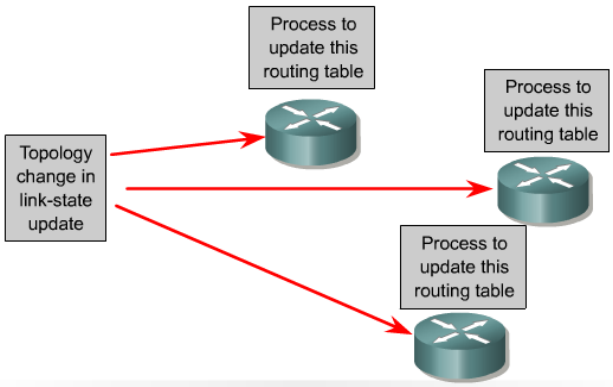

Each router has its own topological database on which the SPF algorithm is run.

Link-State Concerns

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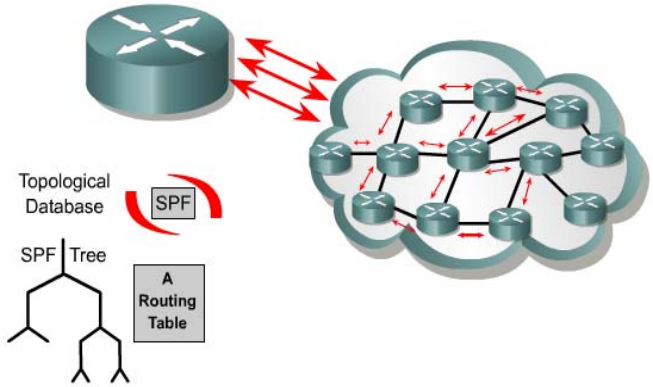

- Processing and memory requirements are increased for link-state routing.
- Bandwidth is consumed during the initial link-state flooding of LSAs.

Link-state Routing Protocols

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- **Based on Dijkstra's algorithm.**
- **Builds a complete database of all the link states of every router in its area.**
- **Benefits include faster convergence and improved bandwidth utilization over distance vector protocols.**

Link-state Routing Protocols

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- Offer greater scalability and faster convergence than distance vector protocols.
- Require more memory and processing power from the router.
- May overtax low-end hardware.
- Require complex administration.

Routing protocols

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Routing Protocols	Method of Operation
AppleTalk RTMP	Distance vector protocol
EIGRP	Advanced distance vector protocol (sometimes referred to as a "hybrid" protocol)
IGRP	Distance vector protocol
IPX RIP	Distance vector protocol
IS-IS	Link-state protocol
Netware NLSP	Link-state protocol
OSPF	Link-state protocol
RIP v1	Distance vector protocol
RIP v2	Distance vector protocol

IP Routing Configuration Tasks

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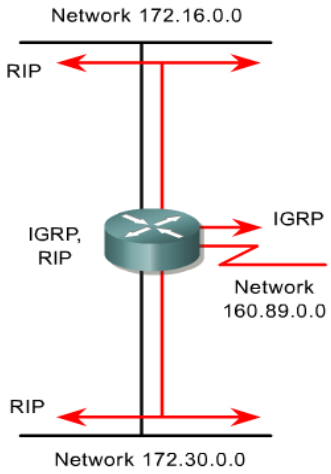
Global Configuration
Select routing protocol(s) Specify Network(s)

Interface Configuration
Verify address/subnet mask



Using the `router` and `network` Commands

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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