Introduction to Dynamic Routing Protocol

Routing Protocols and Concepts – Chapter 3

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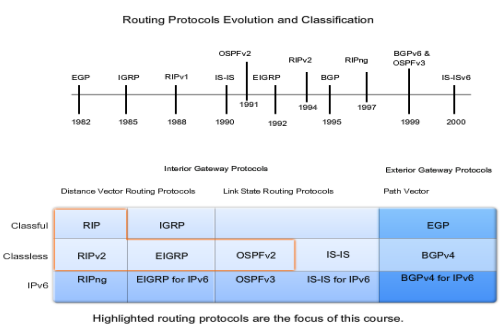
Objectives

- 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 of the routing table.

Protocol Evolution

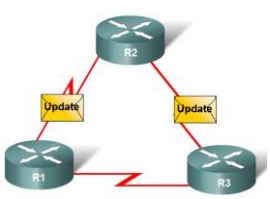


Highlighted routing protocols are the focus of this course.

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.

Routers Dynamically Pass Updates

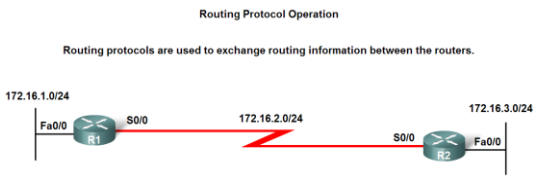


Dynamic Routing Overview

- Compared to static routing, dynamic routing protocols require less administrative overhead.
- However, the expense of using dynamic routing protocols is dedicating part of a router's resources for protocol operation including CPU time and network link bandwidth.
- Despite the benefits of dynamic routing, static routing still has its place. There are times when static routing is more appropriate and other times when dynamic routing is the better choice.
- More often than not, you will find a combination of both types of routing in any network that has a moderate level of complexity

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



Dynamic Routing Protocols

- **Components of a routing protocol**

1. Data structures - Some routing protocols use tables and/or databases for its operations. This information is kept in RAM.
2. 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.
3. Routing protocol messages - Routing protocols use various types of messages to discover neighbouring routers, exchange routing information, and other tasks to learn and maintain accurate information about the network.

Dynamic Routing Protocols

- 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 Operation

- The operations of a dynamic routing protocol vary depending upon the type of routing protocol and the routing protocol itself. In general, the operations of a dynamic routing protocol can be described as follows:

1. The router sends and receives routing messages on its interfaces.
2. The router shares routing messages and routing information with other routers that are using the same routing protocol.
3. Routers exchange routing information to learn about remote networks.
4. When a router detects a topology change the routing protocol can advertise this change to other routers.

Dynamic vs. Static

Dynamic versus Static Routing

	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

Dynamic Routing Advantages + Disadvantages

- Dynamic routing advantages:

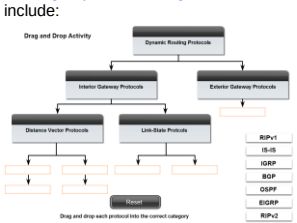
1. Administrator has less work maintaining the configuration when adding or deleting networks.
2. Protocols automatically react to the topology changes.
3. Configuration is less error-prone.
4. More scalable, growing the network usually does not present a problem.

- Dynamic routing disadvantages:

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

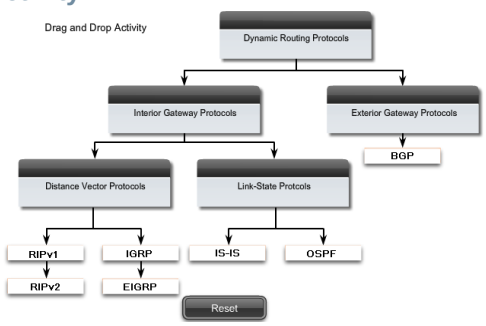
Classifying Routing Protocols

- **Dynamic routing protocols** are grouped according to characteristics. Examples include:
  - -RIP
  - -IGRP
  - -EIGRP
  - -OSPF
  - -IS-IS
  - -BGP



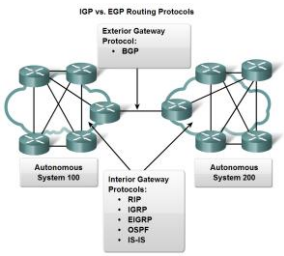
- **Autonomous System** is a group of routers under the control of a single authority.

Activity



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.
  - -For example, CENIC operates an autonomous system comprised of California schools, colleges and universities. CENIC uses an IGP to route within its autonomous system in order to interconnect all of these institutions.
  - -Each of the educational institutions also uses an IGP of their own choosing to route within its own individual network.
  - -The IGP used by each entity provides best path determination within its own routing domains, just as the IGP used by CENIC provides best path routes within the autonomous system itself.
  - - Examples: RIP, EIGRP, OSPF
- **Exterior Routing Protocols (EGP)**
  - -Used for routing between autonomous systems. BGP is the only currently-viable EGP and is the routing protocol used by the Internet.
  - -Example: BGPv4

Classifying Routing Protocols

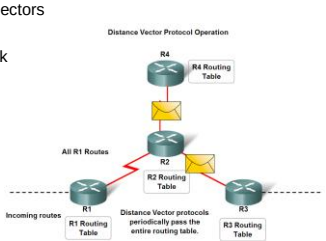
- IGP: **Comparison of Distance Vector** & **Link State** Routing Protocols

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.



Distance Vector

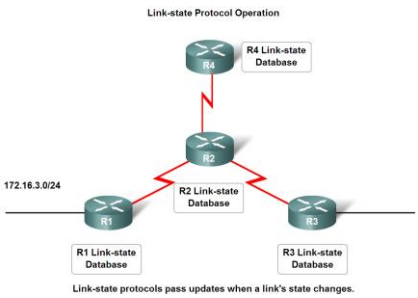
- **Distance vector protocols work best in situations where**:

1. The network is simple and flat and does not require a special hierarchical design.
2. The administrators do not have enough knowledge to configure and troubleshoot link-state protocols.
3. Specific types of networks, such as hub-and-spoke networks, are being implemented.
4. Worst-case convergence times in a network are not a concern.

Link-state protocols work best in situations where:

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

Classifying Routing Protocols



Classifying Routing Protocols

- **Classful routing protocols**

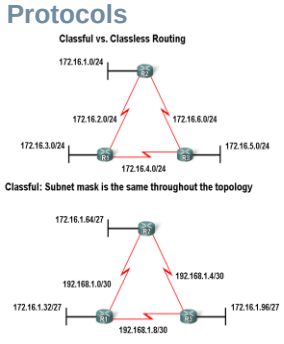
  Do NOT send subnet mask in routing updates

  Classful routing protocols include RIPv1 and IGRP.

- **Classless routing protocols**

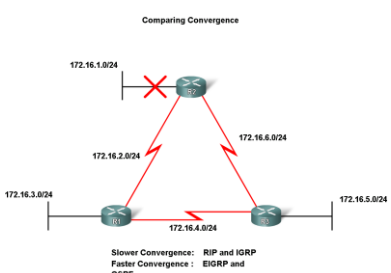
  Do send subnet mask in routing updates.

  Classless routing protocols are RIPv2, EIGRP, OSPF, IS-IS, BGP.



Classifying Routing Protocols

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



Convergence

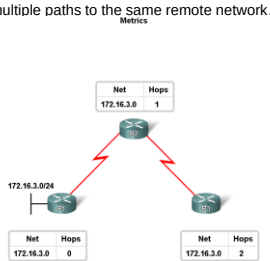
- Convergence is when all routers' routing tables are at a **state of consistency**. The network has converged when all routers have complete and accurate information about the network.
- Convergence time is the time it takes routers to share information, calculate best paths, and update their routing tables.
- **A network is not completely operable** until the network has converged; therefore, most networks require short convergence times. Convergence is both collaborative and independent.
- The routers share information with each other but must independently calculate the impacts of the topology change on their own routes. Because they develop an agreement with the new topology independently, they are said to converge on this consensus.
- Convergence properties include the **speed of propagation** of routing information and the **calculation of optimal paths**. Routing protocols can be rated based on the speed to convergence; the faster the convergence, the better the routing protocol.
- Generally, RIP and IGRP are slow to converge, whereas EIGRP and OSPF are faster to converge.

Routing Protocols Metrics

- **Metric**

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

  The metric is used to determine which path is most preferable when there are multiple paths to the same remote network.



Metrics

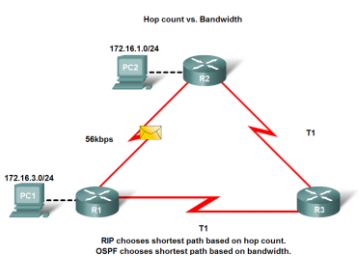
- Metrics used in IP routing protocols include:

1. **Hop count** - A simple metric that counts the number of routers a packet must traverse
2. **Bandwidth** - Influences path selection by preferring the path with the highest bandwidth
3. **Load** - Considers the traffic utilization of a certain link
4. **Delay** - Considers the time a packet takes to traverse a path
5. **Reliability** - Assesses the probability of a link failure, calculated from the interface error count or previous link failures
6. **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.

Routing Protocols Metrics

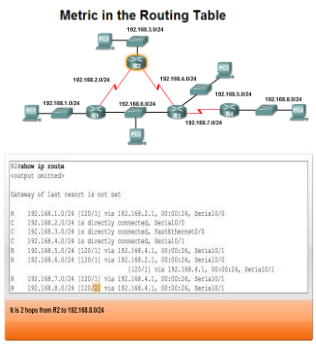
- **Metrics used in IP routing protocols**

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



Routing Protocols Metrics

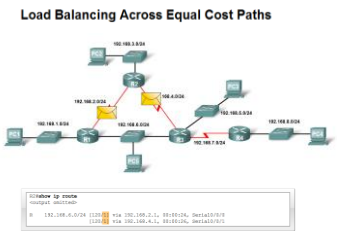
- The Metric Field in the Routing Table
- **Metric** used for each routing protocol
  - -RIP - hop count
  - -IGRP & EIGRP - Bandwidth (used by default), Delay (used by default), Load, Reliability
  - -IS-IS & OSPF – Cost, Bandwidth (Cisco's implementation)



Routing Protocols Metrics

- **Load balancing**

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

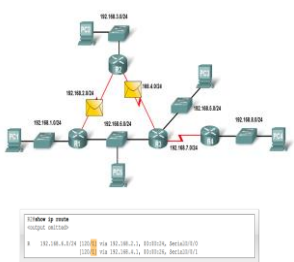


Load Balancing

- We have discussed that individual routing protocols use metrics to determine the best route to reach remote networks.
- But what happens when two or more routes to the same destination have identical metric values?
- How will the router decide which path to use for packet forwarding?
- In this case, the router does not choose only one route. Instead, the router "**load balances**" between these equal cost paths. The packets are forwarded using all equal-cost paths.
- To see whether load balancing is in effect, check the routing table. **Load balancing is in effect if two or more routes are associated with the same destination.**

Example

- R2 load balances traffic to PC5 over two equal cost paths.
- The show ip route command reveals that the destination network 192.168.6.0 is available through 192.168.2.1 (Serial 0/0/0) and 192.168.4.1 (Serial 0/0/1).
- 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



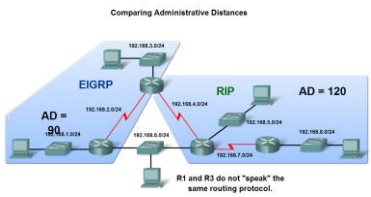
Administrative Distance of a Route

- **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



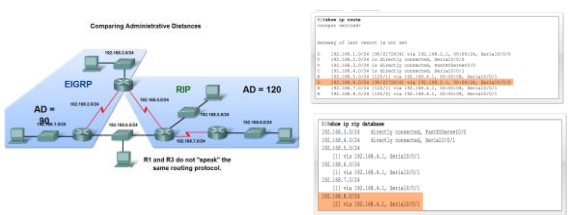
Administrative Distance

- Administrative distance (AD) defines the preference of a routing source.
- Each routing source - including specific routing protocols, static routes, and even directly connected networks - is prioritized in order of **most- to least-preferable using an administrative distance value**.
- Cisco routers use the AD feature to select the best path when it learns about the same destination network from two or more different routing sources.
- **Administrative distance is an integer value from 0 to 255**.
- The lower the value the more preferred the route source.
- **An administrative distance of 0 is the most preferred**.
- Only a directly connected network has an administrative distance of 0, which cannot be changed.
- **An administrative distance of 255 means the router will not believe the source of that route and it will not be installed in the routing table**.

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



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
```


Misconception

- The static route to **172.16.3.0** is listed as directly connected.
- However, there is no information on what the AD value is. It is a common misconception to assume that the AD value of this route must be 0 because it states "directly connected."
- However, that is a false assumption. **The default AD of any static route, including those configured with an exit interface is 1.**
- Remember, only a directly connected network can have an AD of 0.
- This can be verified by extending the show ip route command with the [route] option. Specifying the [route] reveals detailed information about the route, including its distance, or AD value.

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
```


Exercise

```
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
```

Router	Router Source	AD	Metric
10.4.0.0/16			
172.16.2.0/24			
172.16.1.0/24			
172.16.3.0/24			
192.168.1.0/24			
192.168.100.0/24			
192.168.110.0/24			
192.168.120.0/24			

EIGRP	1
RIP	65
OSPF	0
ODR	110
BGP	90
Static	120
Connected	2172416

Reset

Routing Table Entries

```
     10.0.0.0/16 is subnetted, 1 subnets
S       10.4.0.0 is directly connected, Serial0/0
     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
```

```
D       172.16.3.0 [90/2172416] via 172.16.2.1, 00:00:18, Serial0/0
C    192.168.1.0/24 is directly connected, Serial0/1
O    192.168.100.0/24 [110/65] via 172.16.2.1, 00:00:03, Serial0/0
O    192.168.110.0/24 [110/65] via 172.16.2.1, 00:00:03, Serial0/0
R    192.168.120.0/24 [120/1] via 172.16.2.1, 00:00:18, Serial0/0
```


Answers

Router	Router 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

EIGRP	1
RIP	65
OSPF	0
ODR	110
BGP	90
Static	120
Connected	2172416

Reset

Summary

- **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

Summary

- **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