Chapter 7: Routing Dynamically

Routing Protocols
Chapter 7

7.1 Dynamic Routing Protocols
7.2 Distance Vector Dynamic Routing
7.3 RIP and RIPng Routing
7.4 Link-State Dynamic Routing
7.5 The Routing Table
7.6 Summary
Chapter 7: Objectives

- Explain the basic operation of dynamic routing protocols.
- Compare and contrast dynamic and static routing.
- Determine which networks are available during an initial network discovery phase.
- Define the different categories of routing protocols.
- Describe the process by which distance vector routing protocols learn about other networks.
- Identify the types of distance-vector routing protocols.
- Configure the RIP routing protocol.
- Configure the RIPng routing protocol.
- Explain the process by which link-state routing protocols learn about other networks.
Chapter 7: Objectives (continued)

- Describe the information sent in a link-state update.
- Describe advantages and disadvantages of using link-state routing protocols.
- Identify protocols that use the link-state routing process. (OSPF, IS-IS)
- Determine the route source, administrative distance, and metric for a given route.
- Explain the concept of a parent/child relationship in a dynamically built routing table.
- Compare the IPv4 classless route lookup process and the IPv6 lookup process.
- Analyze a routing table to determine which route will be used to forward a packet.
Dynamic Routing Protocols
Dynamic Routing Protocol Operation

The Evolution of Dynamic Routing Protocols

- Dynamic routing protocols used in networks since the late 1980s
- Newer versions support the communication based on IPv6

Routing Protocols Classification

<table>
<thead>
<tr>
<th>Interior Gateway Protocols</th>
<th>Link-State</th>
<th>Path Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance Vector</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPv4</td>
<td>RIPv2</td>
<td>OSPFv2</td>
</tr>
<tr>
<td>IPv6</td>
<td>RIPng</td>
<td>OSPFv3</td>
</tr>
<tr>
<td>EIGRP</td>
<td>IS-IS</td>
<td>IS-IS for IPv6</td>
</tr>
<tr>
<td>EIGRP for IPv6</td>
<td>BGP-4</td>
<td>BGP-MP</td>
</tr>
</tbody>
</table>
Dynamic Routing Protocol Operation

Purpose of Dynamic Routing Protocols

- **Routing Protocols**
  - Used to facilitate the exchange of routing information between routers

- **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
Main components of dynamic routing protocols include:

- **Data structures** - Routing protocols typically use tables or databases for its operations. This information is kept in RAM.

- **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.

- **Algorithm** - Routing protocols use algorithms for facilitating routing information for best path determination.
Dynamic Routing Protocol Operation

Purpose of Dynamic Routing Protocols

Components of Routing Protocols

Routing protocols create and maintain data structures:
- EIGRP creates and maintains the:
  - Neighbor table
  - Topology table

Routing protocols exchange messages:
- EIGRP Hello
- EIGRP Update
- EIGRP Query
- EIGRP Reply
- EIGRP Acknowledge

Routing protocols use routing algorithms to identify the best route(s):
- I will use the EIGRP DUAL algorithm to identify what the best routes are and submit the best route(s) to the routing table.
Dynamic Routing Protocol Operation

The Role of Dynamic Routing Protocols

- Advantages of dynamic routing
  - Automatically share information about remote networks
  - Determine the best path to each network and add this information to their routing tables
  - Compared to static routing, dynamic routing protocols require less administrative overhead
  - Help the network administrator manage the time-consuming process of configuring and maintaining static routes

- Disadvantages of dynamic routing
  - Dedicate part of a router's resources for protocol operation, including CPU time and network link bandwidth

- Times when static routing is more appropriate

Do animation on 7.1.1.3
Dynamic Routing Protocol Operation
The Role of Dynamic Routing Protocols

Activity - Part 1: Identify Components of a Routing Protocol - EIGRP

In this activity, you will focus on the operation of EIGRP, a distance vector routing protocol.

Read the statement at the top of the matrix. Next, drag a blue checkmark to the field (or fields) next to the items which accurately complete the statement. More than one of the items may be selected. Click Check to verify your answers. If correct, move to Part 2 of this activity. If incorrect, please Reset and try again.

In the area of data structure, EIGRP creates and maintains the __________.

- Topology table
- Neighbor table
- Update table
- Best path(s) in the routing table

Do activities on buttons 1 - 3 on 7.1.1.4 in class
Dynamic verses Static Routing
Using Static Routing

- Networks typically use a combination of both static and dynamic routing

- Static routing has several primary uses
  - Providing ease of routing table maintenance in smaller networks that are not expected to grow significantly
  - Routing to and from a stub network
    - a network with only one default route out and no knowledge of any remote networks
  - Accessing a single default router
    - used to represent a path to any network that does not have a match in the routing table
Dynamic verses Static Routing

Using Static Routing

Router R2 is connected to other networks and to the Internet. It is also my only way out of here. I just use a default static route to reach any network I do not know about.

Router R1 only has two networks that I need to know about so I just use two static routes to reach those networks.
### Dynamic verses Static Routing

#### Static Routing Scorecard

#### Static Routing Advantages and Disadvantages

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to implement in a small network.</td>
<td>Suitable only for simple topologies or for special purposes such as a default static route. Configuration complexity increases dramatically as network grows.</td>
</tr>
<tr>
<td>Very secure. No advertisements are sent as compared to dynamic routing protocols.</td>
<td></td>
</tr>
<tr>
<td>Route to destination is always the same.</td>
<td>Manual intervention required to re-route traffic.</td>
</tr>
<tr>
<td>No routing algorithm or update mechanism required; therefore, extra resources (CPU or RAM) are not required.</td>
<td></td>
</tr>
</tbody>
</table>
## Dynamic Routing Scorecard

### Dynamic Routing Advantages and Disadvantages

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitable in all topologies where multiple routers are required.</td>
<td>Can be more complex to implement.</td>
</tr>
<tr>
<td>Generally independent of the network size.</td>
<td>Less secure. Additional configuration settings are required to secure.</td>
</tr>
<tr>
<td>Automatically adapts topology to reroute traffic if possible.</td>
<td>Route depends on the current topology.</td>
</tr>
<tr>
<td></td>
<td>Requires additional CPU, RAM, and link bandwidth.</td>
</tr>
</tbody>
</table>
Routing Protocol Operating Fundamentals

Dynamic Routing Protocol Operation

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.

Do animation on 7.1.3.1
Routing Protocol Operating Fundamentals
Cold Start

- R1 adds the 10.1.0.0 network available through interface FastEthernet 0/0 and 10.2.0.0 is available through interface Serial 0/0/0.
- R2 adds the 10.2.0.0 network available through interface Serial 0/0/0 and 10.3.0.0 is available through interface Serial 0/0/1.
- R3 adds the 10.3.0.0 network available through interface Serial 0/0/1 and 10.4.0.0 is available through interface FastEthernet 0/0.

Routers running RIPv2

<table>
<thead>
<tr>
<th>Network</th>
<th>Interface</th>
<th>Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1.0.0</td>
<td>Fa0/0</td>
<td>0</td>
</tr>
<tr>
<td>10.2.0.0</td>
<td>S0/0/0</td>
<td>0</td>
</tr>
<tr>
<td>10.3.0.0</td>
<td>S0/0/1</td>
<td>0</td>
</tr>
<tr>
<td>10.4.0.0</td>
<td>Fa0/0</td>
<td>0</td>
</tr>
</tbody>
</table>

Do animation on 7.1.3.2
Routing Protocol Operating Fundamentals

Network Discovery

R1:
- Sends an update about network 10.1.0.0 out the Serial0/0/0 interface
- Sends an update about network 10.2.0.0 out the FastEthernet0/0 interface
- Receives update from R2 about network 10.3.0.0 with a metric of 1
- Stores network 10.3.0.0 in the routing table with a metric of 1

Routers running RIPv2

Do animation on 7.1.3.3
Routing Protocol Operating Fundamentals
Network Discovery

R2:
- Sends an update about network 10.3.0.0 out the Serial 0/0/0 interface
- Sends an update about network 10.2.0.0 out the Serial 0/0/1 interface
- Receives an update from R1 about network 10.1.0.0 with a metric of 1
- Stores network 10.1.0.0 in the routing table with a metric of 1
- Receives an update from R3 about network 10.4.0.0 with a metric of 1
- Stores network 10.4.0.0 in the routing table with a metric of 1
R3:
- Sends an update about network 10.4.0.0 out the Serial 0/0/1 interface
- Sends an update about network 10.3.0.0 out the FastEthernet0/0
- Receives an update from R2 about network 10.2.0.0 with a metric of 1
- Stores network 10.2.0.0 in the routing table with a metric of 1

Routers running RIPv2
Routing Protocol Operating Fundamentals
Exchanging the Routing Information

R1:
- Sends an update about network 10.1.0.0 out the Serial 0/0/0 interface
- Sends an update about networks 10.2.0.0 and 10.3.0.0 out the FastEthernet0/0 interface
- Receives an update from R2 about network 10.4.0.0 with a metric of 2
- Stores network 10.4.0.0 in the routing table with a metric of 2
- Same update from R2 contains information about network 10.3.0.0 with a metric of 1. There is no change; therefore, the routing information remains the same

Routing Information Table:

<table>
<thead>
<tr>
<th>Network</th>
<th>Interface</th>
<th>Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1.0.0</td>
<td>Fa0/0</td>
<td>0</td>
</tr>
<tr>
<td>10.2.0.0</td>
<td>S0/0/0</td>
<td>0</td>
</tr>
<tr>
<td>10.3.0.0</td>
<td>S0/0/1</td>
<td>0</td>
</tr>
<tr>
<td>10.4.0.0</td>
<td>S0/0/0</td>
<td>2</td>
</tr>
</tbody>
</table>

Routers running RIPv2

Do animation on 7.1.3.4
R2:

- Sends an update about networks 10.3.0.0 and 10.4.0.0 out of Serial 0/0/0 interface
- Sends an update about networks 10.1.0.0 and 10.2.0.0 out of Serial 0/0/1 interface
- Receives an update from R1 about network 10.1.0.0. There is no change; therefore, the routing information remains the same.
- Receives an update from R3 about network 10.4.0.0. There is no change; therefore, the routing information remains the same.
Exchanging the Routing Information

R3:
- Sends an update about network 10.4.0.0 out the Serial 0/0/0/1 interface
- Sends an update about networks 10.2.0.0 and 10.3.0.0 out the FastEthernet0/0 interface
- Receives an update from R2 about network 10.1.0.0 with a metric of 2
- Stores network 10.1.0.0 in the routing table with a metric of 2
- Same update from R2 contains information about network 10.2.0.0 with a metric of 1. There is no change; therefore, the routing information remains the same.

Routers running RIPv2
Routing Protocol Operating Fundamentals

Achieving Convergence

- Network converged when all routers have complete and accurate information about the entire 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.

- Convergence properties include the speed of propagation of routing information and the calculation of optimal paths. The speed of propagation refers to the amount of time it takes for routers within the network to forward routing information.

- Generally, older protocols, such as RIP, are slow to converge, whereas modern protocols, such as EIGRP and OSPF, converge more quickly.
Types of Routing Protocols

Classifying Routing Protocols

Routing Protocols Classification

- **Dynamic Routing Protocols**
  - **Interior Gateway Protocols (IGPs)**
    - **Distance Vector Routing Protocols**
      - RIPv1
      - RIPv2
      - EIGRP
      - OSPF
      - IS-IS
    - **Link-State Routing Protocols**
    - **Path-Vector Routing Protocol**
  - **Exterior Gateway Protocols (EGPs)**

Do buttons on 7.1.4.1
Types of Routing Protocols
IGP and EGP Routing Protocols

Interior Gateway Protocols (IGP) -
- Used for routing within an AS
- Include RIP, EIGRP, OSPF, and IS-IS

Exterior Gateway Protocols (EGP) -
- Used for routing between AS
- Official routing protocol used by the Internet
Types of Routing Protocols

Distance Vector Routing Protocols

- **Distance vector IPv4 IGPs:**
  - **RIPv1** - First generation legacy protocol
  - **RIPv2** - Simple distance vector routing protocol
  - **IGRP** - First generation Cisco proprietary protocol (obsolete)
  - **EIGRP** - Advanced version of distance vector routing

For R1, 172.16.3.0/24 is one hop away (distance) it can be reached through R2 (vector)
Types of Routing Protocols

Distance Vector or Link-State Routing Protocols

Distance vector protocols use routers as sign posts along the path to the final destination.

A link-state routing protocol is like having a complete map of the network topology. The sign posts along the way from source to destination are not necessary, because all link-state routers are using an identical map of the network. A link-state router uses the link-state information to create a topology map and to select the best path to all destination networks in the topology.
Types of Routing Protocols

Link-State Routing Protocols

Link-state IPv4 IGPs:
- **OSPF** - Popular standards based routing protocol
- **IS-IS** - Popular in provider networks.

Link-state protocols forward updates when the state of a link changes.
Classful Routing Protocols

- Classful routing protocols do not send subnet mask information in their routing updates
  - Only RIPv1 and IGRP are classful
  - Created when network addresses were allocated based on classes (class A, B, or C)
  - Cannot provide variable length subnet masks (VLSMs) and classless interdomain routing (CIDR)
  - Create problems in discontiguous networks
Types of Routing Protocols

Classless Routing Protocols

- Classless routing protocols include subnet mask information in the routing updates
  - RIPv2, EIGRP, OSPF, and IS-IS
  - Support VLSM and CIDR
  - IPv6 routing protocols
### Types of Routing Protocols

#### Routing Protocol Characteristics

<table>
<thead>
<tr>
<th>Feature</th>
<th>Distance Vector</th>
<th>Link State</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RIPv1</td>
<td>RIPv2</td>
</tr>
<tr>
<td>Speed Convergence</td>
<td>Slow</td>
<td>Slow</td>
</tr>
<tr>
<td>Scalability - Size of Network</td>
<td>Small</td>
<td>Small</td>
</tr>
<tr>
<td>Use of VLSM</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Resource Usage</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Implementation and Maintenance</td>
<td>Simple</td>
<td>Simple</td>
</tr>
</tbody>
</table>

7.1.4.7
Types of Routing Protocols

Routing Protocol Metrics

A metric is a measurable value that is assigned by the routing protocol to different routes based on the usefulness of that route:

- Used to determine the overall “cost” of a path from source to destination
- Routing protocols determine the best path based on the route with the lowest cost
Types of Routing Protocols

7.1.4.9 Activity - Classify Dynamic Routing Protocols

Do activities on buttons 1, 2, 3 for 7.1.4.9 in class
Types of Routing Protocols
7.1.4.10 Activity - Compare Routing Protocols

Do activities on buttons for 7.1.4.10 in class
# Types of Routing Protocols

## 7.1.4.11 Activity - Match the Metric to the Protocol

Check the protocol which best matches the metric described.

<table>
<thead>
<tr>
<th>Metric Description</th>
<th>EIGRP</th>
<th>OSPF</th>
<th>RIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric based on hop counts.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uses cost (cumulative link bandwidths) as its metric.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metric based on delay (packet delivery time) and bandwidth.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metric can be based additionally on load (amount of link traffic) and reliability (probability of link failure).</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Do activities on buttons for 7.1.4.11 in class**
Distance Vector Dynamic Routing
Distance Vector Routing Protocol Operation

Distance Vector Technologies

**Distance vector routing protocols**
- Share updates between neighbors
- Not aware of the network topology
- Some send periodic updates to broadcast IP 255.255.255.255 even if topology has not changed
- Updates consume bandwidth and network device CPU resources
- RIPv2 and EIGRP use multicast addresses
- EIGRP will only send an update when topology has changed
Distance Vector Routing Protocol Operation

Distance Vector Algorithm

Purpose of Routing Algorithms

- Sending and receiving updates
- Calculate best path and install route
- Detect and react to topology changes

RIP uses the Bellman-Ford algorithm as its routing algorithm

IGRP and EIGRP use the Diffusing Update Algorithm (DUAL) routing algorithm developed by Cisco
### Types of Routing Protocols

#### 7.2.1.3 Activity - Identify Distance Vector Terminology

Drag the term that best matches the distance vector routing protocol description to the field provided.

<table>
<thead>
<tr>
<th>Term</th>
<th>Distance Vector Routing Protocol Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bellman-Ford</td>
<td>A timing process where updates are sent to neighboring routers at regular intervals.</td>
</tr>
<tr>
<td>Broadcast Updates</td>
<td>A process where neighbor routers receive network updates at a specific network address.</td>
</tr>
<tr>
<td>Neighbors</td>
<td>Process which calculates the best paths to networks.</td>
</tr>
<tr>
<td>Periodic Updates</td>
<td>EIGRP and IGRP use this algorithm process as developed by Cisco.</td>
</tr>
<tr>
<td>Algorithm</td>
<td>RIP uses this algorithm process.</td>
</tr>
<tr>
<td>DUAL</td>
<td>Describes routers which share a link and the same routing protocol.</td>
</tr>
</tbody>
</table>

Do activities on buttons for 7.2.1.3 in class
Types of Distance Vector Routing Protocols

Routing Information Protocol

RIPv1 versus RIPv2

<table>
<thead>
<tr>
<th>Characteristics and Features</th>
<th>RIPv1</th>
<th>RIPv2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric</td>
<td>Both use hop count as a simple metric. The maximum number of hops is 15.</td>
<td></td>
</tr>
<tr>
<td>Updates Forwarded to Address</td>
<td>255.255.255.255</td>
<td>224.0.0.9</td>
</tr>
<tr>
<td>Supports VLSM</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Supports CIDR</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Supports Summarization</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Supports Authentication</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>

Routing updates broadcasted every 30 seconds

Updates use UDP port 520

RIPng is based on RIPv2 with a 15 hop limitation and the administrative distance of 120
## Types of Distance Vector Routing Protocols

### Enhanced Interior-Gateway Routing Protocol

#### EIGRP
- Bounded triggered updates
- Hello keepalives mechanism
- Maintains a topology table
- Rapid convergence
- Multiple network layer protocol support

### IGRP versus EIGRP

<table>
<thead>
<tr>
<th>Characteristics and Features</th>
<th>IGRP</th>
<th>EIGRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric</td>
<td></td>
<td>Both use a composite metric consisting of bandwidth and delay. Reliability and load can also be included in the metric calculation.</td>
</tr>
<tr>
<td>Updates Forwarded to Address</td>
<td>255.255.255.255</td>
<td>224.0.0.10</td>
</tr>
<tr>
<td>Supports VLSM</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Supports CIDR</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Supports Summarization</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Supports Authentication</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>

7.2.2.2
## Types of Distance Vector Routing Protocols

### 7.2.2.3 Activity - Compare RIP and EIGRP

#### Activity - Part 1: Compare RIP and EIGRP

Drag the distance vector routing protocol that matches each description to the field provided. Click Button 2 to continue the activity.

<table>
<thead>
<tr>
<th>distance vector Routing Protocol Description</th>
<th>RIP OR EIGRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sends hello packets</td>
<td></td>
</tr>
<tr>
<td>Version 2 supports VLSM and classless routing</td>
<td></td>
</tr>
<tr>
<td>Maximum limit of 255 hops</td>
<td></td>
</tr>
<tr>
<td>Maximum limit of 15 hops</td>
<td></td>
</tr>
<tr>
<td>Forms neighbor adjacencies</td>
<td></td>
</tr>
</tbody>
</table>

**Buttons:**
- RIP
- EIGRP

**Buttons:**
- Check
- Reset

**Do activities on buttons for 7.2.2.3 in class**
Types of Distance Vector Routing Protocols

7.2.2.4 Packet Tracer - Comparing RIP and EIGRP Path Selection

Show Packet Tracer 7.2.2.4 in class Simulation mode
PC pings 64.103.0.1
RIP and RIPng Routing
Configuring the RIP Protocol

Router RIP Configuration Mode

Advertising Networks

R1\# conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)# router rip
R1(config-router)#

Advertising the R1 Networks

R1(config)# router rip
R1(config-router)# network 192.168.1.0
R1(config-router)# network 192.168.2.0
R1(config-router)#

Do buttons on 7.3.1.1
Configuring the RIP Protocol

Advertising Networks

```
R1(config)# router rip
R1(config-router)# network 192.168.1.0
R1(config-router)# network 192.168.2.0
```

Do buttons on 7.3.1.2
Students do button 2 in class
Configuring the RIP Protocol
Examining Default RIP Settings

Verifying RIP Settings on R1

```
R1# show ip protocols
*** IP Routing is NSF aware ***
Routing Protocol is "rip"
   Outgoing update filter list for all interfaces is not set
   Incoming update filter list for all interfaces is not set
   Sending updates every 30 seconds, next due in 16 seconds
   Invalid after 180 seconds, hold down 180, flushed after 240
   Redistributing: rip

   Default version control: send version 1, receive any version
   Interface    Send    Recv   Triggered RIP   Key-chain
   GigabitEthernet0/0  1      1      2
   Serial0/0/0         1      1      2

   Automatic network summarization is in effect
   Maximum path: 4
   Routing for Networks:
   192.168.1.0
   192.168.2.0

   Routing Information Sources:
   Gateway          Distance  Last Update
   192.168.2.2      120        00:00:15

   Distance: (default is 120)
```

Verifying RIP Routes on R1

```
R1# show ip route | begin Gateway
Gateway of last resort is not set

   192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
   C  192.168.1.0/24 is directly connected, GigabitEthernet0/0
   L  192.168.1.1/32 is directly connected, GigabitEthernet0/0
   192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
   C  192.168.2.0/24 is directly connected, Serial0/0/0
   L  192.168.2.1/32 is directly connected, Serial0/0/0
   R  192.168.3.0/24 [120/1] via 192.168.2.2, 00:00:24, Serial0/0/0
   R  192.168.4.0/24 [120/1] via 192.168.2.2, 00:00:24, Serial0/0/0
   R  192.168.5.0/24 [120/2] via 192.168.2.2, 00:00:24, Serial0/0/0

```

Do buttons on 7.3.1.3
Students do button 3 in class
Configuring the RIP Protocol
Enabling RIPv2

Verifying RIP Settings on R1

R1# show ip protocols
*** IP Routing is NSF aware ***

Routing Protocol is "rip"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Sending updates every 30 seconds, next due in 16 seconds
Invalid after 180 seconds, hold down 180, flushed after 240

Redistributing: rip

Default version control: send version 1, receive any version

<table>
<thead>
<tr>
<th>Interface</th>
<th>Send</th>
<th>Recv</th>
<th>Triggered RIP</th>
<th>Key-chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>GigabitEthernet0/0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Serial0/0/0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
192.168.1.0
192.168.2.0
Routing Information Sources:
Gateway  Distance  Last Update

Enable and Verify RIPv2 on R1

R1(config) # router rip
R1(config-router) # version 2
R1(config-router) # ^Z

R1# show ip protocols | section Default

Default version control: send version 2, receive version 2

<table>
<thead>
<tr>
<th>Interface</th>
<th>Send</th>
<th>Recv</th>
<th>Triggered RIP</th>
<th>Key-chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>GigabitEthernet0/0</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serial0/0/0</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do buttons on 7.3.1.4
Students do button 4 in class

7.3.1.4
Configuring the RIP Protocol

Disabling Auto Summarization

Disable Automatic Summarization on R1

R1(config)# router rip
R1(config-router)# no auto-summary
R1(config-router)# end
R1#

*Mar 10 14:11:49.659: %SYS-5-CONFIG_I: Configured from console by console
R1# show ip protocols | section Automatic
  Automatic network summarization is not in effect
R1#

7.3.1.5

Do buttons on 7.3.1.5
Students do button 3 in class
Configuring the RIP Protocol

Configuring Passive Interfaces

Sending out unneeded updates on a LAN impacts the network in three ways:

- **Wasted Bandwidth**
- **Wasted Resources**
- **Security Risk**

---

**7.3.1.6**

Do buttons on 7.3.1.6

Students do button 3 in class
Configuring the RIP Protocol

Propagating a Default Route

Do buttons on 7.3.1.7
Students do button 3 in class
Configuring the RIPng Protocol
Advertising IPv6 Networks

7.3.2.1
Students do button 2 in class
Configuring the RIPng Protocol

Examining the RIPng Configuration

Verifying RIP Settings on R1

R1# show ipv6 protocols
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "rip RIP-AS"

Interfaces:
Serial0/0/0
GigabitEthernet0/0

Redistribution:
None

R1$

Verifying Routes on R1

R1# show ipv6 route
IPv6 Routing Table - default - 8 entries
Codes: C = Connected, L = Local, S = Static, U = Per-user
Static route
B = BGP, R = RIP, I1 = ISIS L1, I2 = ISIS L2
IA = ISIS interarea, IS = ISIS summary, D = EIGRP,
EX = EIGRP external, ND = ND Default,
NDp = ND Prefix, DCE = Destination, NDr = Redirect,
O = OSPF Intra, OI = OSPF Inter, OE1 = OSPF ext 1,
OE2 = OSPF ext 2, ON1 = OSPF NSSA ext 1,
ON2 = OSPF NSSA ext 2

C 2001:DB8:CAFE::1/64 [0/0]
   via GigabitEthernet0/0, directly connected
L 2001:DB8:CAFE:1::1/128 [0/0]
   via GigabitEthernet0/0, receive
R 2001:DB8:CAFE:2::/64 [120/2]
   via FE80::FE99:47FF:FE71:78A0, Serial0/0/0
R 2001:DB8:CAFE:3::/64 [120/3]
   via FE80::FE99:47FF:FE71:78A0, Serial0/0/0
C 2001:DB8:CAFE:A001::/64 [0/0]
   via Serial0/0/0, directly connected
L 2001:DB8:CAFE:A001::1/128 [0/0]
   via Serial0/0/0, receive
R 2001:DB8:CAFE:A002::/64 [120/2]

Do buttons on 7.3.2.2
Configuring the RIPng Protocol

Examining the RIPng Configuration

Verifying RIPng Routes on R1

```
R1# show ipv6 route rip
IPv6 Routing Table - default  - 8 entries
Codes: C  - Connected, L  - Local, S  - Static, U  - Per-user
Static route
  B  - BGP, R  - RIP, I1  - ISIS L1, I2  - ISIS L2
  IA  - ISIS interarea, IS  - ISIS summary, D  - EIGRP,
  EX  - EIGRP external, ND  - ND Default,
  NDr  - ND Prefix, DCE  - Destination, NDp  - Redirect,
  O  - OSPF Intra, OI  - OSPF Inter, OE1  - OSPF ext 1,
  OE2  - OSPF ext 2, ON1  - OSPF NSSA ext 1,
  ON2  - OSPF NSSA ext 2
R  2001:DB8:CAFE:2::/64 [120/2]  
  via FE80::FE99:47FF:FE71:78A0, Serial0/0/0
R  2001:DB8:CAFE:3::/64 [120/3]  
  via FE80::FE99:47FF:FE71:78A0, Serial0/0/0
R  2001:DB8:CAFE:A002::/64 [120/2]  
  via FE80::FE99:47FF:FE71:78A0, Serial0/0/0
R1#
```
Link-State Dynamic Routing
Link-State Routing Protocol Operation

Shortest Path First Protocols

Interior Gateway Protocols (IGP)

Distance Vector Routing Protocols
- RIPv1
- IGRP

Link-State Routing Protocols
- RIPv2
- EIGRP
- OSPF
- IS-IS
Link-State Routing Protocol Operation

Dijkstra’s Algorithm

Dijkstra's Shortest Path First Algorithm

Shortest Path for host on R2 LAN to reach host on R3 LAN:
R2 to R1 (20) + R1 to R3 (5) + R3 to LAN (2) = 27
Link-State Updates

Link-State Routing Process

- Each router learns about each of its own directly connected networks.
- Each router is responsible for "saying hello" to its neighbors on directly connected networks.
- Each router builds a Link State Packet (LSP) containing the state of each directly connected link.
- Each router floods the LSP to all neighbors who then store all LSP's received in a database.
- Each router uses the database to construct a complete map of the topology and computers the best path to each destination networks.
Link-State Updates

Link and Link-State

The first step in the link-state routing process is that each router learns about its own links, its own directly connected networks.

Link-State of Interface Fa0/0

Link-State of Interface S0/0/0

<table>
<thead>
<tr>
<th>Link 1</th>
<th>Link 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Network: 10.1.0.0/16</td>
<td>- Network: 10.2.0.0/16</td>
</tr>
<tr>
<td>- IP address: 10.1.0.1</td>
<td>- IP address: 10.2.0.1</td>
</tr>
<tr>
<td>- Type of network: Ethernet</td>
<td>- Type of network: Serial</td>
</tr>
<tr>
<td>- Cost of that link: 2</td>
<td>- Cost of that link: 20</td>
</tr>
<tr>
<td>- Neighbors: None</td>
<td>- Neighbors: R2</td>
</tr>
</tbody>
</table>

Do buttons on 7.4.2.2
Link-State Updates

Say Hello

The second step in the link-state routing process is that each router is responsible for meeting its neighbors on directly connected networks.
Link-State Updates

The third step in the link-state routing process is that each router builds a link-state packet (LSP) containing the state of each directly connected link.

1. R1; Ethernet network
   10.1.0.0/16; Cost 2
2. R1 -> R2; Serial point-to-point network;
   10.2.0.0/16; Cost 20
3. R1 -> R3; Serial point-to-point network;
   10.7.0.0/16; Cost 5
4. R1 -> R4; Serial point-to-point network;
   10.4.0.0/16; Cost 20
Link-State Updates
Flooding the LSP

The fourth step in the link-state routing process is that each router floods the LSP to all neighbors, who then store all LSPs received in a database.
Link-State Updates

Building the Link-State Database

The final step in the link-state routing process is that each router uses the database to construct a complete map of the topology and computes the best path to each destination network.

### Contents of the Link-State Database

<table>
<thead>
<tr>
<th>Link-State Database</th>
<th>Link-states:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R1</strong></td>
<td>Connected to network 10.1.0.0/16, cost = 2</td>
</tr>
<tr>
<td></td>
<td>Connected to R2 on network 10.2.0.0/16, cost = 20</td>
</tr>
<tr>
<td></td>
<td>Connected to R3 on network 10.3.0.0/16, cost = 5</td>
</tr>
<tr>
<td></td>
<td>Connected to R4 on network 10.4.0.0/16, cost = 20</td>
</tr>
<tr>
<td><strong>R2</strong></td>
<td>Connected to network 10.5.0.0/16, cost = 2</td>
</tr>
<tr>
<td></td>
<td>Connected to R1 on network 10.2.0.0/16, cost = 20</td>
</tr>
<tr>
<td></td>
<td>Connected to R5 on network 10.9.0.0/16, cost = 10</td>
</tr>
<tr>
<td><strong>R3</strong></td>
<td>Connected to network 10.6.0.0/16, cost = 2</td>
</tr>
<tr>
<td></td>
<td>Connected to R1 on network 10.3.0.0/16, cost = 5</td>
</tr>
<tr>
<td></td>
<td>Connected to R4 on network 10.7.0.0/16, cost = 10</td>
</tr>
<tr>
<td><strong>R4</strong></td>
<td>Connected to network 10.8.0.0/16, cost = 2</td>
</tr>
<tr>
<td></td>
<td>Connected to R1 on network 10.4.0.0/16, cost = 20</td>
</tr>
<tr>
<td></td>
<td>Connected to R3 on network 10.7.0.0/16, cost = 10</td>
</tr>
<tr>
<td></td>
<td>Connected to R5 on network 10.10.0.0/16, cost = 10</td>
</tr>
<tr>
<td><strong>R5</strong></td>
<td>Connected to network 10.11.0.0/16, cost = 2</td>
</tr>
<tr>
<td></td>
<td>Connected to R2 on network 10.9.0.0/16, cost = 10</td>
</tr>
<tr>
<td></td>
<td>Connected to R4 on network 10.10.0.0/16, cost = 10</td>
</tr>
</tbody>
</table>
# Link-State Updates

## Building the SPF Tree

### Identify the Directly Connected Networks

<table>
<thead>
<tr>
<th>R1 Link-State Database</th>
<th>SPF Tree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R1 Link-states:</strong></td>
<td></td>
</tr>
<tr>
<td>- Connected to network 10.1.0.0/16, cost = 2</td>
<td></td>
</tr>
<tr>
<td>- Connected to R2 on network 10.2.0.0/16, cost = 20</td>
<td></td>
</tr>
<tr>
<td>- Connected to R3 on network 10.3.0.0/16, cost = 5</td>
<td></td>
</tr>
<tr>
<td>- Connected to R4 on network 10.4.0.0/16, cost = 20</td>
<td></td>
</tr>
</tbody>
</table>

| R2 Link-states:       |          |
| - Connected to network 10.5.0.0/16, cost = 2 |
| - Connected to R1 on network 10.2.0.0/16, cost = 20 |
| - Connected to R5 on network 10.9.0.0/16, cost = 10 |

| R3 Link-states:       |          |
| - Connected to network 10.6.0.0/16, cost = 2 |
| - Connected to R1 on network 10.3.0.0/16, cost = 5 |
| - Connected to R4 on network 10.7.0.0/16, cost = 10 |

| R4 Link-states:       |          |
| - Connected to network 10.8.0.0/16, cost = 2 |
| - Connected to R1 on network 10.4.0.0/16, cost = 20 |
| - Connected to R3 on network 10.7.0.0/16, cost = 10 |
| - Connected to R5 on network 10.10.0.0/16, cost = 10 |

| R5 Link-states:       |          |
| - Connected to network 10.11.0.0/16, cost = 2 |
| - Connected to R2 on network 10.9.0.0/16, cost = 10 |
| - Connected to R4 on network 10.10.0.0/16, cost = 10 |
### Link-State Updates

#### Building the SPF Tree

**Resulting SPF Tree of R1**

<table>
<thead>
<tr>
<th>Destination</th>
<th>Shortest Path</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.5.0.0/16</td>
<td>R1 → R2</td>
<td>22</td>
</tr>
<tr>
<td>10.6.0.0/16</td>
<td>R1 → R3</td>
<td>7</td>
</tr>
<tr>
<td>10.7.0.0/16</td>
<td>R1 → R3</td>
<td>15</td>
</tr>
<tr>
<td>10.8.0.0/16</td>
<td>R1 → R3 → R4</td>
<td>17</td>
</tr>
<tr>
<td>10.9.0.0/16</td>
<td>R1 → R2</td>
<td>30</td>
</tr>
<tr>
<td>10.10.0.0/16</td>
<td>R1 → R3 → R4</td>
<td>25</td>
</tr>
<tr>
<td>10.11.0.0/16</td>
<td>R1 → R3 → R4 → R5</td>
<td>27</td>
</tr>
</tbody>
</table>
### Link-State Updates

#### Adding OSPF Routes to the Routing Table

#### Populate the Routing Table

<table>
<thead>
<tr>
<th>Destination</th>
<th>Shortest Path</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.5.0.0/16</td>
<td>R1 → R2</td>
<td>22</td>
</tr>
<tr>
<td>10.6.0.0/16</td>
<td>R1 → R3</td>
<td>7</td>
</tr>
<tr>
<td>10.7.0.0/16</td>
<td>R1 → R3</td>
<td>15</td>
</tr>
<tr>
<td>10.8.0.0/16</td>
<td>R1 → R3 → R4</td>
<td>17</td>
</tr>
<tr>
<td>10.9.0.0/16</td>
<td>R1 → R2</td>
<td>30</td>
</tr>
<tr>
<td>10.10.0.0/16</td>
<td>R1 → R3 → R4</td>
<td>25</td>
</tr>
<tr>
<td>10.11.0.0/16</td>
<td>R1 → R3 → R4 → R5</td>
<td>27</td>
</tr>
</tbody>
</table>

#### R1 Routing Table

**Directly Connected Networks**
- 10.1.0.0/16 Directly Connected Network
- 10.2.0.0/16 Directly Connected Network
- 10.3.0.0/16 Directly Connected Network
- 10.4.0.0/16 Directly Connected Network

**Remote Networks**
- 10.5.0.0/16 via R2 serial 0/0/0, cost=22
- 10.6.0.0/16 via R3 serial 0/0/1, cost=7
- 10.7.0.0/16 via R3 serial 0/0/1, cost=15
- 10.8.0.0/16 via R3 serial 0/0/1, cost=17
- 10.9.0.0/16 via R2 serial 0/0/0, cost=30
- 10.10.0.0/16 via R3 serial 0/0/1, cost=25
- 10.11.0.0/16 via R3 serial 0/0/1, cost=27
Link-State Updates
7.4.2.9 Activity - Building the Link-State Database and SPF Tree

Do activities on buttons for 7.4.2.9 in class
Why Use Link-State Routing Protocols

Why Use Link-State Protocols?

---

**Advantages of Link-State Routing Protocols**

- Each router builds its own topological map of the network to determine the shortest path.
- Immediate flooding of LSPs achieves faster convergence.
- LSPs are sent only when there is a change in the topology and contain only the information regarding that change.
- Hierarchical design used when implementing multiple areas.

---

**Disadvantages compared to distance vector routing protocols:**

- Memory Requirements
- Processing Requirements
- Bandwidth Requirements
Why Use Link-State Routing Protocols

Disadvantages of Link-State Protocols

Create Areas to Minimize Router Resource Usage

LSP not flooded to these areas. SPF algorithm does not have to be rerun in these areas.

Area 0

Area 1

Area 51

LSP flooded only within this area

Rerun SPF algorithm
Why Use Link-State Routing Protocols

Protocols that Use Link-State

Only two link-state routing protocols:

- Open Shortest Path First (OSPF) most popular
  - began in 1987
  - two current versions
  - OSPFv2 - OSPF for IPv4 networks
  - OSPFv3 - OSPF for IPv6 networks

- IS-IS was designed by International Organization for Standardization (ISO)
The Routing Table
Parts of an IPv4 Route Entry

Routing Table Entries

Routing Table of R1

```
R1#show ip route | begin Gateway
Gateway of last resort is 209.165.200.234 to network 0.0.0.0
S* 0.0.0.0/0 [1/0] via 209.165.200.234, Serial0/0/1
    is directly connected, Serial0/0/1
    172.16.0.0/16 is variably subnetted, 5 subnets, 3 masks
C  172.16.1.0/24 is directly connected, GigabitEthernet0/0
L  172.16.1.1/32 is directly connected, GigabitEthernet0/0
R  172.16.2.0/24 [120/1] via 209.165.200.226, 00:00:12, Serial0/0/0
R  172.16.3.0/24 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
R  172.16.4.0/28 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
R  192.168.0.0/16 [192/2] via 209.165.200.226, 00:00:03, Serial0/0/0
    209.165.200.0/24 is variably subnetted, 5 subnets, 2 masks
C  209.165.200.224/30 is directly connected, Serial0/0/0
L  209.165.200.225/32 is directly connected, Serial0/0/0
R  209.165.200.228/30 [120/1] via 209.165.200.226, 00:00:12,
    Serial0/0/0
C  209.165.200.232/30 is directly connected, Serial0/0/1
L  209.165.200.233/30 is directly connected, Serial0/0/1
```
Parts of an IPv4 Route Entry

Directly Connected Entries

Directly Connected Interfaces of R1

```
R1#show ip route | begin Gateway
Gateway of last resort is 209.165.200.234 to network 0.0.0.0
S* 0.0.0.0/0 [1/0] via 209.165.200.234, Serial0/0/1
     is directly connected, Serial0/0/1
R 172.16.0.0/16 is variably subnetted, 5 subnets, 3 masks
    C 172.16.1.0/24 is directly connected, GigabitEthernet0/0
    L 172.16.1.1/32 is directly connected, GigabitEthernet0/0
R 172.16.2.0/24 [120/1] via 209.165.200.226, 00:00:12, Serial0/0/0
R 172.16.3.0/24 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
R 172.16.4.0/28 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
R 192.168.0.0/16 [120/2] via 209.165.200.226, 00:00:03, Serial0/0/0
    209.165.200.24 is variably subnetted, 5 subnets, 2 masks
    C 209.165.200.224/30 is directly connected, Serial0/0/0
    L 209.165.200.225/32 is directly connected, Serial0/0/0
R 209.165.200.228/30 [120/1] via 209.165.200.226, 00:00:12, Serial0/0/0
C 209.165.200.232/30 is directly connected, Serial0/0/1
L 209.165.200.233/32 is directly connected, Serial0/0/1
R1#
```
Parts of an IPv4 Route Entry

Remote Network Entries

Route source

Administrative distance

Next-hop

Outgoing interface

R 172.16.4.0/28 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0

Destination network

Metric

Route timestamp
Routing Dynamically

7.5.1.4 Activity - Identify Parts of an IPv4 Routing Table Entry

Gateway of last resort is not set
10.0.0.0/16 is subnetted, 1 subnets
S 10.4.0.0 is directly connected, Serial0/0/0
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, Serial0/0/0
D 172.16.3.0 [90/2172416] via 172.16.2.1, 00:00:18, Serial0/0/0
C 192.168.1.0/24 is directly connected, Serial0/0/1
O 192.168.100.0/24 [110/65] via 172.16.2.1, 00:00:03, Serial0/0/0
O 192.168.110.0/24 [110/65] via 172.16.2.1, 00:00:03, Serial0/0/0
R 192.168.120.0/24 [120/1] via 172.16.2.1, 00:00:18, Serial0/0/0

Do activities on buttons for 7.5.1.4 in class
Dynamically Learned IPv4 Routes
Routing Table Terms

Routes are discussed in terms of:
- Ultimate route
- Level 1 route
- Level 1 parent route
- Level 2 child routes
Dynamically Learned IPv4 Routes

Ultimate Route

An ultimate route is a routing table entry that contains either a next-hop IP address or an exit interface.

- directly connected
- dynamically learned
- link local routes are ultimate routes.

It’s “ultimately” going somewhere
Dynamically Learned IPv4 Routes

Level 1 Route

Sources of Level 1 Routes

Level 1 Routes

- Network
- Supernet
- Default

Next-hop IP address and/or exit interface

- Ultimate Route: 192.168.1.0/24
- Ultimate Route: 192.168.0.0/16
- Ultimate Route: 0.0.0.0/0

Path/Interface

Do buttons on 7.5.2.3
Dynamically Learned IPv4 Routes
Level 1 Parent Route

Level 1 Parent Routes of R1

```
R1#show ip route | begin Gateway
Gateway of last resort is 209.165.200.234 to network 0.0.0.0
S* 0.0.0.0/0 [1/0] via 209.165.200.234, Serial0/0/1
   is directly connected, Serial0/0/1
172.16.0.0/16 is variably subnetted, 5 subnets, 3 masks
   C 172.16.1.0/24 is directly connected, GigabitEthernet0/0
   L 172.16.1.1/32 is directly connected, GigabitEthernet0/0
   R 172.16.2.0/24 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
   R 172.16.3.0/24 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
   R 172.16.4.0/28 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
   R 192.168.0.0/16 [120/2] via 209.165.200.226, 00:00:03, Serial0/0/0
   209.165.200.0/24 is variably subnetted, 5 subnets, 2 masks
      C 209.165.200.224/30 is directly connected, Serial0/0/0
```
Dynamically Learned IPv4 Routes
Level 2 Child Route

Example of Level 2 Child Routes

```
R1#show ip route | begin Gateway
Gateway of last resort is 209.165.200.234 to network 0.0.0.0
S*  0.0.0.0/0 [1/0] via 209.165.200.234, Serial0/0/1
    is directly connected, Serial0/0/1
    172.16.0.0/16 is variably subnetted, 5 subnets, 3 masks
    C    172.16.1.0/24 is directly connected,
    GigabitEthernet0/0
    L    172.16.1.1/32 is directly connected,
    GigabitEthernet0/0
    R    172.16.2.0/24 [120/1] via 209.165.200.226,
        00:00:12, Serial0/0/0
    R    172.16.3.0/24 [120/2] via 209.165.200.226,
        00:00:12, Serial0/0/0
    R    172.16.4.0/28 [120/2] via 209.165.200.226,
        00:00:12, Serial0/0/0
    R    192.168.0.0/16 [120/2] via 209.165.200.226, 00:00:03,
        Serial0/0/0
    209.165.200.0/24 is variably subnetted, 5 subnets, 2 masks
    C    209.165.200.224/30 is directly connected,
    Serial0/0/0
```
Dynamically Learned IPv4 Routes

7.5.2.6 Activity - Identify Parent and Child IPv4 Routes

Using the routing table below; locate the networks listed in the chart. Determine whether the networks are classified as Level 1, Level 1 Parent, or Level 2 Child routes. Drag the appropriate term to the Route Type field provided.

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

- 192.0.2.0/24 is variably subnetted, 2 subnets, 2 masks
- C 192.0.2.0/30 is directly connected, Serial0/0/1
- C 192.0.2.64/26 is directly connected, FastEthernet0/1
- D 192.168.1.0/24 [90/2172416] via 192.168.2.1, 00:01:36, Serial0/0/0
- C 192.168.2.0/24 is directly connected, Serial0/0/0
- C 192.168.3.0/24 is directly connected, FastEthernet0/0
- D 192.168.5.0/24 [90/2172416] via 192.168.2.1, 00:01:36, Serial0/0/0
- S 0.0.0.0/8 is directly connected, Serial0/0/0

<table>
<thead>
<tr>
<th>Specified Network</th>
<th>Route Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0.0</td>
<td></td>
</tr>
<tr>
<td>192.168.3.0/24</td>
<td></td>
</tr>
<tr>
<td>192.0.2.64/26</td>
<td></td>
</tr>
<tr>
<td>192.0.2.0/30</td>
<td></td>
</tr>
<tr>
<td>192.0.2.0/24</td>
<td></td>
</tr>
</tbody>
</table>

Do Activity on 7.5.2.6
The IPv4 Route Lookup Process

**Best Route = Longest Match**

Matches for Packet Destined to 172.16.0.10

<table>
<thead>
<tr>
<th>IP Packet Destination</th>
<th>172.16.0.10</th>
<th>10101100.00010000.00000000.00001010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route 1</td>
<td>172.16.0.0/12</td>
<td>10101100.00010000.00000000.00000000</td>
</tr>
<tr>
<td>Route 2</td>
<td>172.16.0.0/18</td>
<td>10101100.00010000.00000000.00000000</td>
</tr>
<tr>
<td>Route 3</td>
<td>172.16.0.0/26</td>
<td>10101100.00010000.00000000.00000000</td>
</tr>
</tbody>
</table>

Longest Match to IP Packet Destination
The IPv4 Route Lookup Process

7.5.3.3 Activity - Determine the Longest Match Route

<table>
<thead>
<tr>
<th>Address</th>
<th>Prefix Length</th>
<th>Network Address</th>
<th>Subnet Mask</th>
</tr>
</thead>
<tbody>
<tr>
<td>172.17.128.0/17</td>
<td>16</td>
<td>10101100.00010001.10000000.00000000</td>
<td>10101100.00010001.10000000.00000000</td>
</tr>
<tr>
<td>172.17.128.0/19</td>
<td>14</td>
<td>10101100.00010001.10000000.00000000</td>
<td>10101100.00010001.10000000.00000000</td>
</tr>
<tr>
<td>172.17.160.0/19</td>
<td>16</td>
<td>10101100.00010001.10100000.00000000</td>
<td>10101100.00010001.10100000.00000000</td>
</tr>
<tr>
<td>0.0.0.0/0</td>
<td>0</td>
<td>00000000.00000000.00000000.00000000</td>
<td>00000000.00000000.00000000.00000000</td>
</tr>
</tbody>
</table>

Do Activity on 7.5.3.3
Both buttons
Analyze an IPv6 Routing Table

Directly Connected Entries

IPv6 Routing Table of R1

```
R1#show ipv6 route
*C  2001:DB8:CAFE:1::/64 [0/0]
   via GigabitEthernet0/0, directly connected
L  2001:DB8:CAFE:1::1/128 [0/0]
   via GigabitEthernet0/0, receive
D  2001:DB8:CAFE:2::/64  [90/3524096]
   via FE80::3, Serial0/0/1
D  2001:DB8:CAFE:3::/64  [90/2170112]
   via FE80::3, Serial0/0/1
C  2001:DB8:CAFE:A001::/64  [0/0]
   via Serial0/0/0, directly connected
L  2001:DB8:CAFE:A001::1/128 [0/0]
   via Serial0/0/0, receive
D  2001:DB8:CAFE:A002::/64  [90/3523840]
   via FE80::3, Serial0/0/1
C  2001:DB8:CAFE:A003::/64  [0/0]
   via Serial0/0/1, directly connected
L  2001:DB8:CAFE:A003::1/128 [0/0]
   via Serial0/0/1, receive
L  FF00::/8  [0/0]
   via Null0, receive
R1#
```
Analyze an IPv6 Routing Table
Remote IPv6 Network Entries

Remote Network Entries on R1

```
R1#show ipv6 route
<Output omitted>

C  2001:DB8:CAFE:1::/64  [0/0]
    via GigabitEthernet0/0, directly connected
L  2001:DB8:CAFE:1::1/128  [0/0]
    via GigabitEthernet0/0, receive
D  2001:DB8:CAFE:2::/64  [90/3524096]
    via FE80::3, Serial0/0/1
D  2001:DB8:CAFE:3::/64  [90/2170112]
    via FE80::3, Serial0/0/1
C  2001:DB8:CAFE:A001::/64  [0/0]
    via Serial0/0/0, directly connected
L  2001:DB8:CAFE:A001:1/128  [0/0]
    via Serial0/0/0, receive
D  2001:DB8:CAFE:A002::/64  [90/3523840]
    via FE80::3, Serial0/0/1
C  2001:DB8:CAFE:A003::/64  [0/0]
    via Serial0/0/1, directly connected
L  2001:DB8:CAFE:A003:1/128  [0/0]
    via Serial0/0/1, receive
L  FF00::/8  [0/0]
    via Null0, receive
R1#
```
Analyze an IPv6 Routing Table
7.5.4.4 Activity - Identify Parts of an IPv6 Routing Table Entry

**Activity – Part 1: Identify Parts of an IPv6 Routing Table Entry**

Analyze the IPv6 routing table to determine the route source, administrative distance, and outgoing interface for the specified network. Drag each value to its corresponding field in the table. Click Button 2 to continue this activity.

Specified Network: 2001:DB8:CAFE:A001::/64

```
R1# show ipv6 route
<output omitted>
C  2001:DB8:CAFE:1::/64 [0/0]
   via GigabitEthernet0/0, directly connected
L  2001:DB8:CAFE:1::1/128 [0/0]
   via GigabitEthernet0/0, receive
D  2001:DB8:CAFE:2::/64 [90/3524096]
   via FE80::3, Serial0/0/1
   via FE80::3, Serial0/1/0
D  2001:DB8:CAFE:3::/64 [90/2170112]
   via FE80::3, Serial0/1/0
D  2001:DB8:CAFE:A001::/64 [0/0]
   via Serial0/0/0, directly connected
L  2001:DB8:CAFE:A001::1/128 [0/0]
   via Serial0/0/0, receive
D  2001:DB8:CAFE:A002::/64 [90/3523840]
   via FE80::3, Serial0/0/1
R1#
```
Chapter 7: Summary

Dynamic routing protocols:

- Used by routers to automatically learn about remote networks from other routers
- Purpose includes: discovery of remote networks, maintaining up-to-date routing information, choosing the best path to destination networks, and ability to find a new best path if the current path is no longer available
- Best choice for large networks but static routing is better for stub networks.
- Function to inform other routers about changes
- Can be classified as either classful or classless, distance-vector or link-state, and an interior or an exterior gateway protocol
Chapter 7: Summary

Dynamic routing protocols (continued):

- A link-state routing protocol can create a complete view or topology of the network by gathering information from all of the other routers.

- Metrics are used to determine the best path or shortest path to reach a destination network.

- Different routing protocols may use different metrics (hops, bandwidth, delay, reliability, and load).

- Show ip protocols command displays the IPv4 routing protocol settings currently configured on the router; for IPv6, use show ipv6 protocols.
Chapter 7: Summary

Dynamic routing protocols (continued):

- Cisco routers use the administrative distance value to determine which routing source to use
- Each dynamic routing protocol has a unique administrative value, along with static routes and directly connected networks, lower is preferred the route
- Directly connected networks are preferred source, followed by static routes and then various dynamic routing protocols
- An OSPF link is an interface on a router, information about the state of the links is known as link-states
- Link-state routing protocols apply Dijkstra’s algorithm to calculate the best path route which uses accumulated costs along each path, from source to destination, to determine the total cost of a route