Chapter 3: Dynamic Routing

CCNA Routing and Switching
Routing and Switching Essentials v6.0
3.1 Dynamic Routing Protocols
   • Explain the function of dynamic routing protocols.
   • Explain the purpose of dynamic routing protocols.
   • Explain the use of dynamic routing and static routing.

3.2 RIPv2
   • Implement RIPv2.
   • Configure the RIPv2 routing protocol.

3.3 The Routing Table
   • Determine the route source, administrative distance, and metric for a given route.
   • Explain the components of an IPv4 routing table entry for a given route.
   • Explain the parent/child relationship in a dynamically built routing table.
   • Determine which route will be used to forward a IPv4 packet.
   • Determine which route will be used to forward a IPv6 packet.
3.1 Dynamic Routing Protocols
RIP protocol was updated to RIPv2 to accommodate growth in the network environment

- RIPv2 does not scale to current larger network implementations

Routing Protocols developed to meet the need of larger networks include:

- Open Shortest Path First (OSPF)
- Enhanced IGRP (EIGRP)

Border Gateway Protocol (BGP) is used between Internet service providers (ISPs)
Dynamic Routing Protocol Overview

Dynamic Routing Protocol Components

- Purpose of dynamic routing protocols includes:
  - Discovery of remote networks
  - Maintaining up-to-date routing information
  - Choosing the best path to destination networks
  - Ability to find a new best path if the current path is no longer available

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

Static Routing Uses

- Networks often use both static and dynamic routing.
- Static Routing is used as follows:
  - For easy routing table maintenance in small networks.
  - Routing to and from a stub network.
  - Accessing a single default route.
## Dynamic versus Static Routing

### 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.</td>
</tr>
<tr>
<td>Very secure. No advertisements are sent as compared to dynamic routing protocols.</td>
<td>Configuration complexity increases dramatically as network grows.</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>
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</table>
Dynamic routing is the best choice for large networks.

Dynamic routing protocols help the network administrator manage the network:

- Providing redundant paths
- Automatically implementing the alternate path when a link goes down.
## Dynamic Routing Advantages and Disadvantages

<table>
<thead>
<tr>
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</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>
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</tbody>
</table>
3.2 RIPv2
Dynamic versus Static Routing

Router RIP Configuration Mode

- Use the **router rip** command to enable RIP v1

- Use the **no router rip** command to disable RIP
Configuring the RIP Protocol

Advertise Networks

- The **network network-address** router configuration mode command:
  - Enables RIP on all interfaces that belong to a specific network
  - Advertises the network in RIP routing updates sent to other routers every 30 seconds.

**Note**: RIPv1 is a classful routing protocol for IPv4.
Configuring the RIP Protocol

Verify RIP Routing

**show ip protocols**

```plaintext
*** 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
- Redistribution: 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)
```

**show ip route**

```plaintext
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 [10/1] via 192.168.2.2, 00:00:24, Serial0/0/0
T 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
R1#```

**show ip protocols** – displays IPv4 routing protocols configured on the router.

**show ip route** – displays RIP routes installed in the routing table.
Configuring the RIP Protocol
Enable and Verify RIPv2

- Use the **version 2** router configuration mode command to enable RIPv2.
- Use the **show ip protocols** command to verify that RIPv2 is configured.
- Use the **show ip route** command to verify the RIPv2 routes in the routing table.
Configuring the RIP Protocol

Disable Auto Summarization

- RIPv2 automatically summarizes networks at major network boundaries.

- Use the `no auto-summary` router configuration mode command to disable auto summarization.

- Use the `show ip protocols` command to verify that auto summarization is off.
RIP updates:

- Are forwarded out all RIP-enabled interfaces by default.
- Only need to be sent out interfaces that are connected to other RIP-enabled routers.

Sending RIP updates to LANs wastes bandwidth, wastes resources, and is a security risk.

Use the `passive-interface` router configuration command to stop routing updates out the interface. Still allows that network to be advertised to other routers.
Configuring the RIP Protocol

Propagate a Default Route

- In the diagram a default static route to the Internet is configured on R1.
- The `default-information originate` router configuration command instructs R1 to send the default static route information in the RIP updates.
3.3 The Routing Table
Parts of an IPv4 Route Entry

Routing Table Entries

Routing Table for 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 [20/2] via 209.165.200.226, 00:00:12, Serial0/0/0
R 172.16.1.0/24 [20/0] via 209.165.200.226, 00:00:12, Serial0/0/0
R 172.16.2.0/24 [20/0] via 209.165.200.226, 00:00:12, Serial0/0/0
C 172.16.3.0/24 is directly connected, GigabitEthernet0/0
L 172.16.4.0/28 [20/0] via 209.165.200.226, 00:00:12, Serial0/0/0
R 172.16.5.0/24 [20/0] via 209.165.200.226, 00:00:12, Serial0/0/0
R 172.16.6.0/16 [20/0] via 209.165.200.226, 00:00:12, Serial0/0/0
C 209.165.200.0/16 is directly connected, Serial0/0/0
L 209.165.200.224/30 is directly connected, Serial0/0/1
R 209.165.200.228/30 [120/2] 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
R1#
Parts of an IPv4 Route Entry

Directly Connected Entries

- Directly Connected Networks (C) are automatically added to the routing table when the interface is configured and activated.

- Entries contain the following information:
  - Route source - how the route was learned.
  - Destination network – remote network.
  - Outgoing Interface – exit interface used to forward packets to destination.

- Other route source entries include:
  - S – Static Route
  - D – EIGRP routing protocol
  - O – OSPF routing protocol
  - R - RIP routing protocol
Parts of an IPv4 Route Entry

Remote Network Entries

- Routes to remote networks contain the following information:
  - Route source – how route was learned
  - Destination network
  - Administrative distance (AD) - trustworthiness of the route.
  - Metric – value assigned to reach the remote network. Lower is better.
  - Next hop – IPv4 address of the next router that the packet should be forwarded to.
  - Route timestamp – time since the route was updated.
  - Outgoing interface - the exit interface to use to forward the packet
Dynamically Learned IPv4 Routes

Routing Table Terms

- The routing table is a hierarchical structure that is used to speed up the lookup process when locating routes and forwarding packets.

- The hierarchy includes:
  - Ultimate Routes
  - Level 1 routes
  - Level 1 parent routes
  - 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
C   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
    209.165.200.24/24 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#```
Dynamically Learned IPv4 Routes

Ultimate Route

- An ultimate route is a routing table entry that contains either a next-hop IPv4 address or an exit interface.
- Directly connected, dynamically learned, and local routes are ultimate routes.
Dynamically Learned IPv4 Routes

Level 1 Route

- A level 1 route can be a:
  - **Network route** - a network route that has a subnet mask equal to that of the classful mask.
  - **Supernet route** - a network address with a mask less than the classful mask, for example, a summary address.
  - **Default route** - a static route with the address 0.0.0.0/0
Dynamically Learned IPv4 Routes

Level 1 Parent Route

- A parent route is a level 1 network route that is subnetted.
- In the routing table, it basically provides a heading for the specific subnets it contains.
Dynamically Learned IPv4 Routes

Level 2 Child Route

- A level 2 child route is a route that is a subnet of a classful network address.
- Level 1 parent routes contain level 2 child routes.
- Level 2 child routes are also ultimate routes.
The IPv4 Route Lookup Process

Route Lookup Process

- **Router lookup process:**
  - If the best match is a level 1 ultimate route, then this route is used to forward the packet.
  - If the best match is a level 1 parent route, the router then examines child routes (the subnet routes).
  - If there is a match with a level 2 child route, that is used to forward the packet.
  - If there is no match with level 2 child routes, the router searches level 1 supernet or default routes. If there is a match, that route is used.
  - If there is no match found in the routing table the packet is dropped.

![Diagram of the IPv4 Route Lookup Process](image-url)
The IPv4 Route Lookup Process

Best Route = Longest Match

- The best match is the route in the routing table that has the most number of far left matching bits with the destination IPv4 address of the packet.

- The route with the greatest number of equivalent far left bits, or the longest match, is always the preferred route.
An IPv6 routing table includes directly connected, static and dynamically learned routes.

All IPv6 routes are level 1 ultimate routes.
Analyze an IPv6 Routing Table

Directly Connected Entries

- Use the `show ipv6 route` command to display the IPv6 routing table.

- The directly connected route entries include the following:
  - Route source – How the route was learned. Directly connected indicated with a C and L for local route.
  - Directly connected network address.
  - Administrative distance – Trustworthiness of the route (lower more trustworthy).
  - Metric – Value assigned to reach the network (lower is preferred route).
  - Outgoing interface – Exit interface used to forward packet.
The remote IPv6 route entries also include the following:

- **Route source** – How the route was learned. Common codes include O (OSPF), D (EIGRP), R (RIP), and S (Static route).

- **Next hop** - Identifies the IPv6 address of the next router to forward the packet to.

The IPv6 router lookup process:

- Examines level 1 network routes for the best match.
- Longest match is the best match.
3.4 Chapter Summary
Conclusion

Chapter 3: Dynamic Routing

- Explain the function of dynamic routing protocols.
- Implement RIPv2.
- Determine the route source, administrative distance, and metric for a given route.