The Routing Table: A Closer Look

Routing Protocols and Concepts – Chapter 8

Routing Table Example 1

```
R2#show ip route
Gateway of last resort is 0.0.0.0 to network 0.0.0.0
172.16.0.0/24 is subnetted, 4 subnets
R   172.16.1.0 [120/1] via 172.16.2.1, 00:00:27, S0/0
C   172.16.2.0 is directly connected, Serial0/0
C   172.16.3.0 is directly connected, FastEthernet0/0
S   172.16.4.0 [1/0] via 192.168.1.2
10.0.0.0/16 is subnetted, 1 subnets
C   10.1.0.0 is directly connected, Serial0/0
C   192.168.1.0/24 is directly connected, Serial0/1
S* 0.0.0.0/0 is directly connected, Serial0/1
R2#
```

Routing Table Example 2

```
Routing Table Example 2

Gateway of last resort not set
172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
C   172.16.0.0/30 is directly connected, Serial0/1
C   192.168.0.0/24 is directly connected, Loopback0
12.0.0.0/24 is subnetted, 1 subnets
B   12.0.1.0/24 [20/0] via 10.0.0.1, 00:08:17
C   192.168.1.0/24 is directly connected, Loopback1
S* 0.0.0.0/0 [220/0] via 172.16.0.1
SanJose#
```

Routing Table Example 3

```
Routing Table Example 3

Gateway of last resort is 10.0.0.1 to network 210.210.210.0
C   172.16.0.0/30 is directly connected, Serial0/1
B  172.16.0.0/24 [20/0] via 172.16.0.1, 00:23:23
10.0.0.0/30 is subnetted, 1 subnets
C   10.0.0.0 is directly connected, Serial0/0
C   192.168.0.0/24 is directly connected, Loopback0
12.0.0.0/24 is subnetted, 1 subnets
B   12.0.1.0/24 [20/0] via 10.0.0.1, 00:08:17
C   192.168.1.0/24 is directly connected, Loopback1
S* 0.0.0.0/0 [220/0] via 172.16.0.1
SanJose#
```

Ultimate routes

- A route in the routing table may contain
  - A next-hop address
  - Or an exit interface
  - Or both
- A route with an exit interface is an ultimate route
- When a packet arrives at the router, the routing table is searched recursively to find an ultimate route that matches the packet’s destination IP address.

Searching the Routing Table

- A recursive search means
  - If the matching route only has a next-hop address, then repeat the search to find a match for the next-hop address
  - Repeat until an ultimate route is found
- The packet is sent out the exit interface specified in the ultimate route
- If an ultimate route is not found, the packet is dropped.
Routing Table Structure

- Cisco IP routing table is a hierarchical structure (The reason for this is to speed up lookup process)
- Level 1 Routes
  - Have a subnet mask equal to or less than the classful mask of the network address.
  - Level 1 route can function as
    - Default route 0.0.0.0/0
    - Supernet route 192.168.16.0/20
    - Network route 172.30.0.0/16

Level 1 and Level 2 routes

- A level 2 route has a subnet mask greater than the classful network
- A Level 2 route is a subnet

Examples

- 172.16.1.0/24
- 10.0.0.0/30

Parent and Child Routes

- A parent route is a Level 1 route that does not contain any next-hop IP address or exit interface information
- A parent route is followed by one or more child routes
- A child route is a Level 2 route
- Child routes are subnets of a classful parent route

The table above has 4 child networks belonging to the parent route 172.16.0.0 / 16
- Both child routes have the same subnet mask
- This means the parent route maintains the /24 mask

Parent and Child Routes in a Classless Environment VLSM routes

- In classless networks, child routes do not have to share the same subnet mask

Gateway of last resort not set

172.16.0.0/24 is variably subnetted, 3 subnets
  C 172.16.1.4/30 is directly connected, Serial0/1
  C 172.16.3.0/24 is directly connected, FastEthernet0/0
  C 172.16.3.0/24 is directly connected, FastEthernet0/0
  R 172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
    C 172.16.1.4/30 is directly connected, Serial0/1
    C 172.16.1.8/30 is directly connected, Serial0/1
    R 172.16.3.0/24 is directly connected, FastEthernet0/0
RouterX#
Parent and Child Routes in a Classless Environment

Matching a destination IP address with a route
- Each route includes a network number and associated mask (or prefix)
- The mask specifies the minimum number of bits in both the route and the destination IP address that must match
- If the minimum number of bits differ, then the route is not a match for the IP address
- If more than one route matches then the best match is the one with the most matching bits (i.e. largest prefix)
- If two routes have the same bits, the one with the largest prefix is said to be a more specific route

The Route Lookup Process
- Examine level 1 routes
- If best match is a level 1 ultimate route, this route is used to forward the packet
- If best match is a parent route, examine its child routes
- If there is a match with a level 2 child route then that route is used to forward the packet
- If there is a match with more than one level 2 child route then forward the packet using the more specific route (i.e. largest prefix)
- If no match, then determine routing behavior

Routing Behavior
- Classless Routing Behavior
  - Configuration file includes the command:
    ```
    R# ip classless
    ```
  - Required for Discontiguous Networks and CIDR Supernets
- Classful Routing Behavior
  - Include the command:
    ```
    R# no ip classless
    ```
  - Beginning with IOS 11.3, ip classless is the default behavior

The Route Lookup Process
- Router determines classful or classless routing behavior
- If classful then packet is dropped
- If classless
  - Router searches level one supernet and default routes
  - If there exists a level 1 supernet or default route match then packet is forwarded.
  - If not packet is dropped

In the example above, 172.16.0.10 matches all three routes
Route 3 is the best match because it has a longer prefix
**Classful Routing Behavior – Search Process**

- The reason why the router will not search beyond the child routes.
  
  Originally networks were all classful.
  
  This meant an organization could subnet a major network address and "enlighten" all the organization’s routers about the subnetting.
  
  Therefore, if the subnet was not in the routing table, the subnet did not exist and packet was dropped.

**Classless Routing Behavior – Search Process**

- If no match is found in child routes then Router continues to search the routing table for a match that may have fewer bits in the match.

**Routing Behavior**

- **Classful vs. Classless Routing Behavior**
  
  - It is recommended to use classless routing behavior.
  
  - Reason: so supernet and default routes can be used whenever needed.

**Routing Behavior Summary**

- This refers to how a routing table is searched.

  - **Classful routing behavior**
    - Indicated by the use of the `no ip classless` command.
    - Router will not look beyond child routes for a lesser match.

  - **Classless routing behavior**
    - Indicated by the use of the `ip classless` command.
    - Router will look beyond child routes for a lesser match.
    - Required for Discontiguous Networks and CIDR Supernets.