Routing Protocols and Concepts

Router components and their functions

- **Random access memory (RAM)**
  Contains the running copy of configuration file. Stores routing table.

- **Non-volatile RAM (NVRAM)**
  Stores startup configuration.

- **Flash memory**
  Contains the operating system (Cisco IOS)

Primary Function of the Router

- **Switching** - the process used to switch a packet from an incoming interface to an outgoing interface on the same router.
- **Path selection** – determines the best path to the destination network
- **Router de-encapsulates the frame**
- **Remaining packet passed up to layer 3**
  - Routing decision made at this layer by examining destination IP address
  - Packet is then re-encapsulated & sent out outbound interface

Cisco Discovery Protocol (CDP)

- **CDP is a Cisco proprietary tool used to gather information about other directly connected Cisco devices**
- It runs on all Cisco devices by default
- CDP advertisements sent periodically
- CDP operates at Layer 2 only
- A Cisco device will maintain a table of CDP information about its Cisco directly connected neighbors, which can be queried by the Administrator by entering `show cdp` commands

Default Administrative Distance

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Administrative Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connected</td>
<td>0</td>
</tr>
<tr>
<td>Static</td>
<td>1</td>
</tr>
<tr>
<td>EIGRP summary route</td>
<td>5</td>
</tr>
<tr>
<td>BGP (External)</td>
<td>20</td>
</tr>
<tr>
<td>EIGRP (Internal)</td>
<td>90</td>
</tr>
<tr>
<td>IGRP</td>
<td>100</td>
</tr>
<tr>
<td>OSPF</td>
<td>110</td>
</tr>
<tr>
<td>IS-IS</td>
<td>115</td>
</tr>
<tr>
<td>RIP</td>
<td>120</td>
</tr>
<tr>
<td>EIGRP (External)</td>
<td>170</td>
</tr>
<tr>
<td>BGP (Internal)</td>
<td>200</td>
</tr>
<tr>
<td>Route will not be installed</td>
<td>255</td>
</tr>
</tbody>
</table>
Installing a route into the routing table

- Choose route source with the lowest AD
- Choose route with the lowest metric
- If this results in more than one route, then they both go in the routing table and load balancing across the routes take place
- Otherwise just one route is installed in the routing table.

Similarities between RIPv1 & RIPv2

- Use of hold-down timers to prevent routing loops
- Use of split horizon or split horizon with poison reverse
- Use of periodic and triggered updates
- Hop count used as metric
- Maximum hop count of 15
- Both do automatic summarization of routes at the class boundary by default

RIPv2 Enhancements

- Supports VLSM – updates include subnet mask
- Automatic summarization can be disabled 
  `no auto-summary`
- Routing updates are multicast
- Authentication option available

Preventing loops with holdown timers

- `Holddown timers` allow a router to not accept any changes to a route for a specified period of time.
- `Point of using holddown timers`
  - Allows routing updates to propagate through network with the most current information.

Configuring Static Routes

```
ip route 172.16.1.0 255.255.255.0 172.16.2.1
```

```
ip route 172.16.1.0 255.255.255.0 s0/0
```

Route Summarization

- Find the summary route for
  192.168.49.0/24
  192.168.50.0/24
  192.168.51.0/24
  192.168.52.0/24
- These are summarized by the single route
  192.168.48.0/21

- `.49 = .00110001`
- `.52 = .00110100`
- `.00110000 = .48`
Routing Table Example

```
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
     S  10.1.0.0 is directly connected, Serial0/0
     C  192.168.1.0/24 is directly connected, Serial0/1
     C  192.168.100.0/24 is directly connected, Serial0/1
     S* 0.0.0.0/0 is directly connected, Serial0/1
R2#
```

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

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 subnet is used to forward the packet
- If no match, then determine routing behavior

<table>
<thead>
<tr>
<th>IP Packet Destination</th>
<th>Prefix Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>172.16.0.10</td>
<td>24</td>
</tr>
<tr>
<td>172.16.0.12</td>
<td>16</td>
</tr>
<tr>
<td>172.16.0.18</td>
<td>16</td>
</tr>
<tr>
<td>172.16.0.26</td>
<td>16</td>
</tr>
</tbody>
</table>

In the example above, 172.16.0.10 matches all three routes
Route 3 is the best match because it has a longer prefix
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
  ```
  ip classless is the default behavior

EIGRP - DUAL Concepts
- Successor
  The **best route** to a destination. Added to the routing table
- Feasible distance (FD)
  The **lowest calculated metric** along a path to a destination network
- Feasible Successor
  This a loop free backup route to same destination as the Successor route, i.e. a backup route

DUAL Concepts
- Reported distance (RD)
  The metric that a router reports to a neighbor about its own cost to that network
- Feasibility Condition
  Met when a neighbor’s RD is less than the local router’s FD to the same destination network

EIGRP Topology Table dissected

Features of Link-State Routing Protocols
- A link state protocol builds a complete map of the network – topology table
- Much faster convergence than distance vector protocols
- Requires more router resources – memory, CPU cycles
- Main link-state protocol is OSPF
Forming Neighbor Adjacencies

- Unlike EIGRP, two OSPF routers can form a neighbor adjacency only if they agree on three values:
  - Hello interval
  - Dead interval
  - Network type
- Each OSPF router maintains an Adjacency database
- Display neighbor adjacencies with the command: `show ip ospf neighbors`

Comparison of OSPF and EIGRP

- **OSPF**
  - Uses Dijkstra’s SPF algorithm
  - No automatic summarization.
  - Neighbors must have same hello and dead intervals
  - Metric is cost

- **EIGRP**
  - Uses DUAL algorithm
  - Default auto-summary
  - Adjacencies between routers with different hello and dead intervals
  - Metric based on bandwidth and delay