Chapter 6: EIGRP

Scaling Networks

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Chapter 6 - Sections & Objectives

- 6.1 EIGRP Characteristics
  - Explain the features and characteristics of EIGRP
- 6.2 Implement EIGRP for IPv4
  - Implement EIGRP for IPv4 in a small to medium-sized business network
- 6.3 EIGRP Operation
  - Explain how EIGRP operates in a small to medium-sized business network
- 6.4 Implement EIGRP for IPv6
  - Implement EIGRP for IPv6 in a small to medium-sized business network

6.1 EIGRP Characteristics

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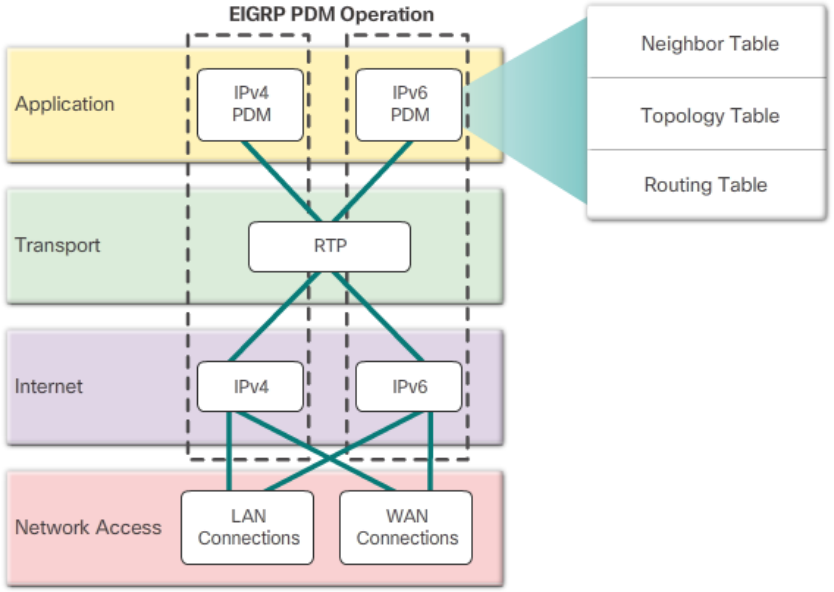
EIGRP Basic Features

- Features of EIGRP
  - Uses the **Diffusing Update Algorithm** (**DUAL**) to calculate paths and back-up paths.
  - Establishes **Neighbor Adjacencies**.
  - Uses the **Reliable Transport Protocol** (**RTP**), instead of TCP or UDP, to provide delivery of EIGRP packets to neighbors.
  - **Partial and Bounded Updates**. **Sends updates only when there is a change and only to the routers that need the information**.
  - Supports **Equal and Unequal Cost Load Balancing**.
- Protocol Dependent Modules – responsible for network layer protocol-specific tasks
  - Sends and receives EIGRP packets that are encapsulated in IPv4
  - Parses EIGRP packets and informs DUAL of the new information and DUAL makes routing decisions. The results are stored in the IPv4 routing table.

EIGRP Basic Features (Cont.)

- Reliable Transport Protocol
  - Used for the delivery and reception of EIGRP packets
  - Can send EIGRP packets as **unicast** or **multicast**.
    - Reserved IPv4 multicast address 224.0.0.10.
    - Reserved IPv6 multicast address FF02::A.
- Authentication
  - Only accepts routing information from other routers with the same authentication information
  - **Does not encrypt the routing updates**



EIGRP Packet Types

- EIGRP Hello Packets
  - Are sent as **multicasts** and uses RTP for **unreliable delivery**
  - Used to **form and maintain EIGRP neighbor adjacencies**

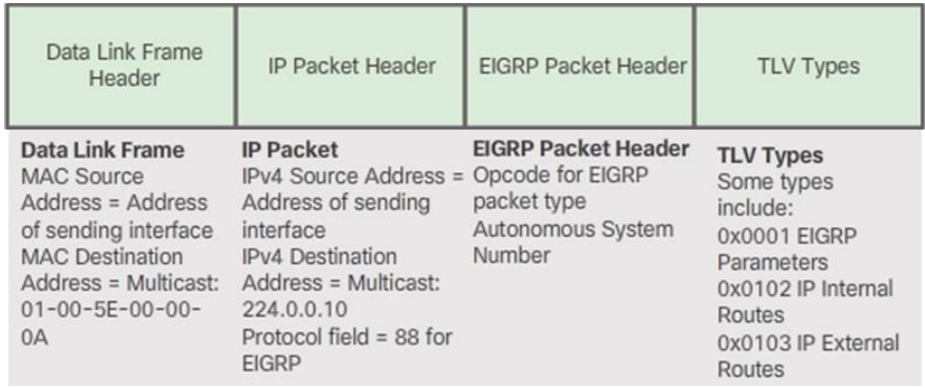
Bandwidth	Example Link	Default Hello Interval	Default Hold Time
1.544 Mb/s	Multipoint Frame Relay	60 seconds	180 seconds
Greater than 1.544 Mb/s	T1, Ethernet	5 seconds	15 seconds

- EIGRP Update and Acknowledgment Packets
  - Update packets **propagate updated routing information <u>when necessary</u> to the <u>routers that require the information</u>** using RTP **reliable delivery**
  - Acknowledgment packets are send to acknowledge the update was received.
- EIGRP Query and Reply Packets
  - **Searches for networks**
  - Uses RTP **reliable delivery**
  - **Queries** are **multicast** or **unicast**. **Replies** are **always unicast**.

Practice with activity 6.1.2.5

EIGRP Messages

- Encapsulating EIGRP Messages
  - The EIGRP packet headers and TLV (type, length, value) are encapsulated in an IP packet.



- EIGRP Packet Header and TLV
  - EIGRP Packet Header
    - **EIGRP Packet Type**: **Update**, **Query**, **Reply**, and **Hello**
    - **Autonomous System Number** is the ID for the **EIGRP routing process**
  - EIGRP Parameters TLV
    - **K values**: **K1** (**bandwidth**) and **K3** (**delay**) are set to **1**. Other K values are set to 0
    - **Hold Time**: Maximum time the router should wait for the next hello
  - Internal TLV
    - The IP internal message is used to advertise EIGRP routes **within an autonomous system**.
    - Important metric fields: **delay**, **bandwidth**, prefix length, and destination
  - EIGRP TLV: External Routes
    - The IP external message is used when **external routes** are imported into the EIGRP routing process.

6.2 Implement EIGRP for IPv4

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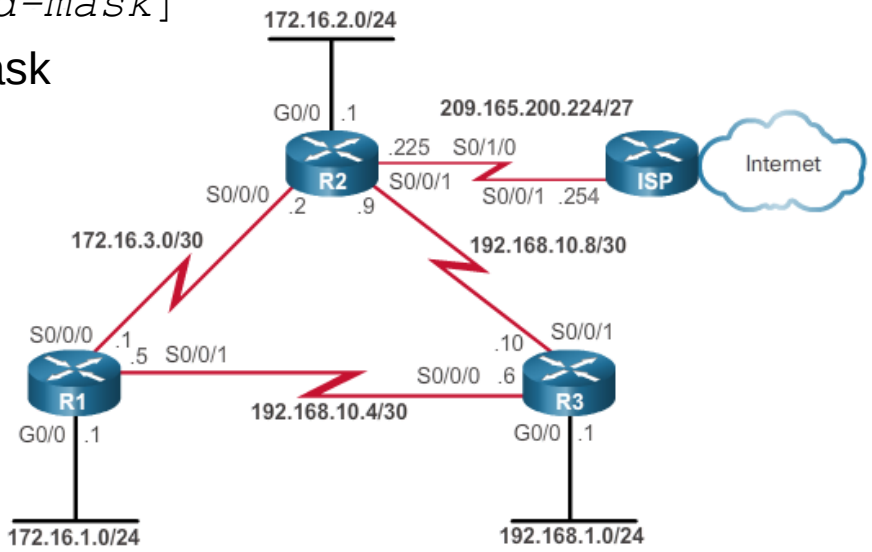
Configure EIGRP with IPv4

- Autonomous System Numbers
  - **IANA globally assigned autonomous numbers**
    - **Used by ISP and other large institutions**
    - Used in exterior routing protocol, such as BGP, to propagate routing information
  - **`router eigrp`** *`autonomous-system`* command
    - Starts the EIGRP process in the router
    - Autonomous system number is **only significant to local EIGRP local domain**
    - Autonomous system number functions as a **process ID** and allows multiple running instances of EIGRP
    - All routers within the same domain must have the same autonomous system number
- EIGRP Router ID – uniquely identifies each router in the EIGRP routing domain
  - Determined in 3 ways using the following order:
    1. The **`router router-id`** *`ipv4-address`* command
    2. The highest active IPv4 address of any of the **loopback** address
    3. The highest active IPv4 address of any of the **physical** interface

Configure EIGRP with IPv4 (Cont.)

- The **network** *ipv4-network-address* command
  - Enables any interface on the router that matches the network address in the **network** command to send and receive EIGRP updates
  - By default, *ipv4-network-address* is the classful network address for each directly connected network
- The **network** command and Wildcard Mask
  - **network** *network-address* [*wildcard-mask*]
  - Wildcard mask is the inverse of a subnet mask
  - To calculate the wildcard mask:

```
  255.255.255.255
- 255.255.255.252   Subnet mask
-----------------
    0.   0.   0.   3   Wildcard mask
```



- Passive Interface - prevent the neighbor adjacencies
  - Suppress unnecessary update traffic
  - Increase security controls
  - **passive-interface** *interface-type interface-number*

Verify EIGRP with IPv4

- The show commands are useful in verifying EIGRP operations and for debugging and troubleshooting purposes.
- **`show ip eigrp neighbors`** command
  - View the neighbor table
  - Verify neighbor adjacencies have been established
- **`show ip protocols`** Command
  - Identify the parameters and other information about the current state of any active IPv4 routing protocol processes configured on the router
  - What information can you get from this show command?
- **`show ip route`**
  - Verify the routes are installed in the IPv4 routing table as expected
  - Check for convergence
- **See 6.2.2.1 – 6.2.2.3**

6.3 EIGRP Operation

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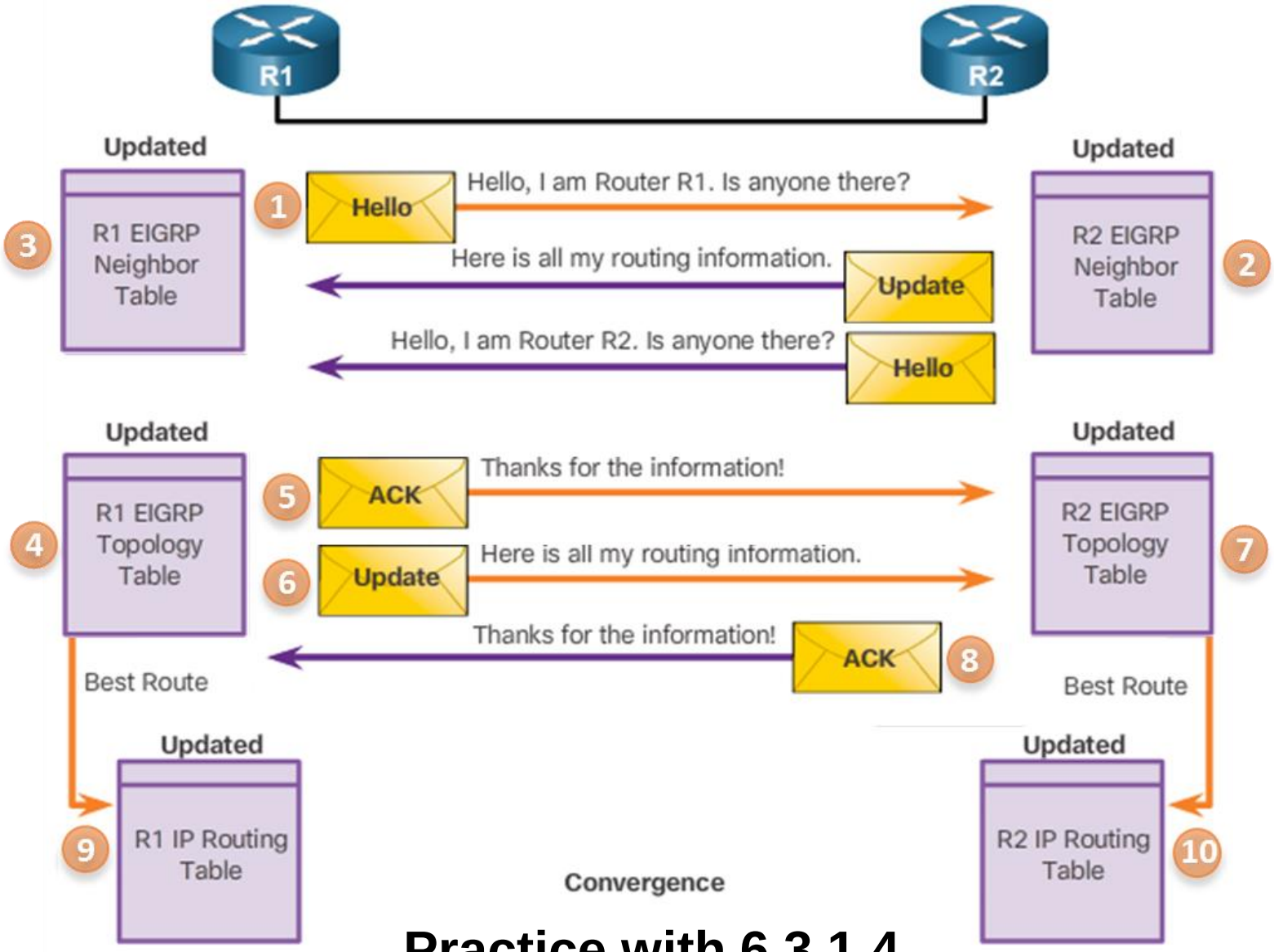
EIGRP Initial Route Discovery



Practice with 6.3.1.4

EIGRP Metrics

- Composite Metric
  - EIGRP uses **bandwidth and delay** values in the composite metric to calculate the preferred path to a network.
  - The k values and EIGRP AS number must match to form an adjacency.

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

Routing Protocol is "eigrp 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP-IPv4 Protocol for AS(1)
    Metric weight k1=1, k2=0, k3=1, k4=0, k5=0
    NSF-aware route hold timer is 240
    Router-ID: 1.1.1.1
```

  - The **`show ip protocols`** command can be used to verify k values.
- Bandwidth Metric (BW)
  - The **`bandwidth`** *`kilobits-bandwidth-value`* command is used to modify the bandwidth metric.
  - Use the **`show interfaces`** command to verify the bandwidth changes

```
R1# show interfaces serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Hardware is WIC MBRD Serial
  Internet address is 172.16.3.1/30
  MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
```

- Delay Metric (DLY)
  - Delay is the measure of the time it takes for a packet to traverse a route.
  - Use the **`show interfaces`** command to view the delay values.

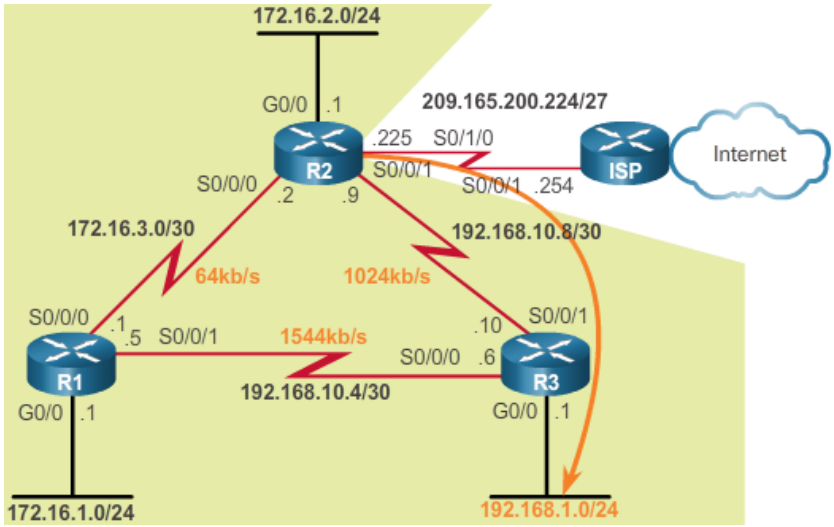
EIGRP Metrics (Cont.)

- Complete Composite Metric Formula
  - $(K1 * bandwidth + \frac{K2 * bandwidth}{256 - load} + K3 * delay) * \frac{K5}{reliability + K4} * 256$
- Using the default metric weight, the formula becomes
  - Metric = $(K1 * bandwidth + K3 * delay) * 256$

where K1 and K3 equal to 1, K2, K4, and K5 equal to 0 when not in use, and If K5 = 0, $\frac{K5}{reliability+K4}$ becomes 1.

- Calculate the EIGRP metric between R2 and R3
  - Metric = $256 * (\frac{10^7}{bandwidth} + \frac{\text{sum of delay}}{10})$
  - What is **bandwidth of the slowest link**?
  - What is the **sum of all delays**?

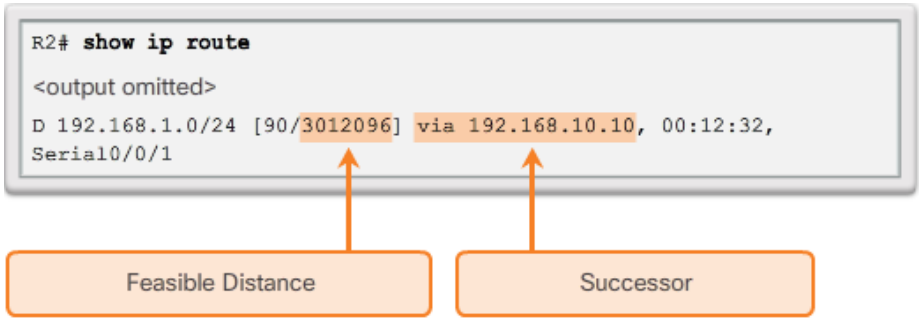
Media	Delay
Ethernet	1,000
Fast Ethernet	100
Gig Ethernet	10
Serial WAN	20,000



Practice with 6.3.2.7

DUAL and the Topology Table

- Diffusing Update Algorithm (DUAL) provides
  - Loop-free paths
  - Loop-free backup paths that can be used immediately
  - Fast convergence
- Successor and Feasible Distance
  - A **successor is a neighboring router that is used for packet forwarding and is the least-cost route to the destination network**.
  - **Feasible Distance** is the metric listed in the routing table entry



- Feasible Successors, Feasibility Condition, and Reported Distance
  - The **reported distance is an EIGRP neighbor's feasible distance to the destination network**.
  - The **feasibility condition** (FC) is met when a **neighbor's reported distance (RD) to a network is less than the local router's feasible distance to the same destination network**.
  - A **feasible successor** is a neighbor that has a loop-free backup path to the same network as the successor, and it satisfies the Feasibility Condition

DUAL and the Topology Table (Cont.)

- The **show ip eigrp topology** command
  - Displays the Topology Table
- Topology Table
  - Lists all successors and FSs to destination networks
  - Only successors are installed in the routing tables
- Can you name all the highlighted parts in the topology table below?
  - Which is the successor? Which is not a feasible successor?

```
R1# show ip eigrp topology all-links

P 192.168.1.0/24, 1 successors, FD is 2170112, serno 9
        via 192.168.10.6 (2170112 /2816), Serial0/0/1
        via 172.16.3.2 (41024256/3012096), Serial0/0/0
```

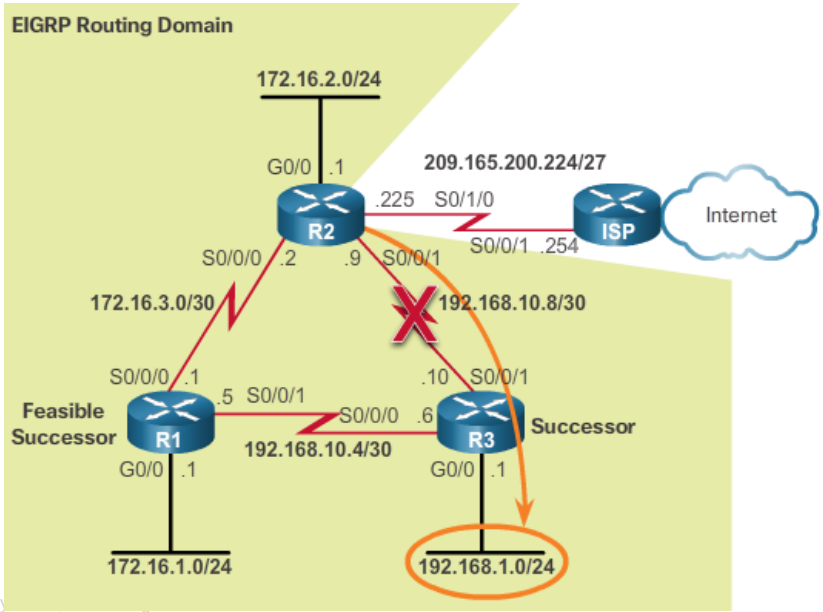
See 6.3.3.6-7 and practice with 6.3.3.8

DUAL and Convergence

- DUAL Finite State Machine (FSM)
  - **Contains all of the logic** used to calculate and compare routes in an EIGRP network
- DUAL: Feasible Successor

  When a path to the successor goes down with FS in the topology table:
  1. Router informs all EIGRP neighbors of the lost link.
  2. Router updates its own routing and topology table.
- DUAL: No Feasible Successor

  When a path to the successor goes down with no FS in the topology table:
  1. DUAL puts the route into an **active state**.
  2. DUAL sends EIGRP queries asking other routers for a path to the network.
  3. Other routers return EIGRP replies, letting the sender of the EIGRP query know that they have a path to the requested network. If there is no reply, the sender of the query does not have a route to this network.
  4. If the sender receives EIGRP replies with a path to the requested network, the preferred path is added as the new successor and also added to the routing table.



6.4 Implement EIGRP for IPv6

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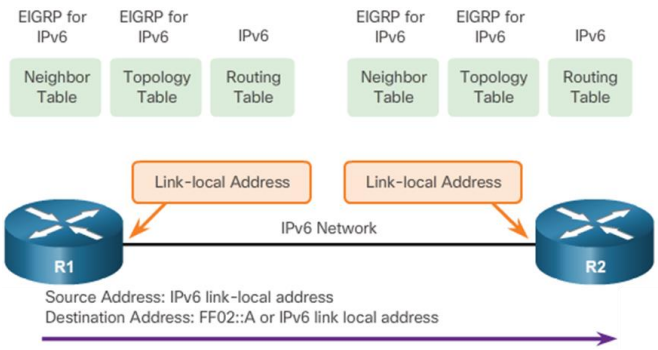
EIGRP for IPv6

- EIGRP for IPv6
  - Similar functionality as EIGRP for IPv4
  - Uses IPv6 for communication with EIGRP for IPv6 peers and advertising IPv6 routes
  - Uses DUAL
  - EIGRP for IPv6 is a separate process from EIGRP for IPv4

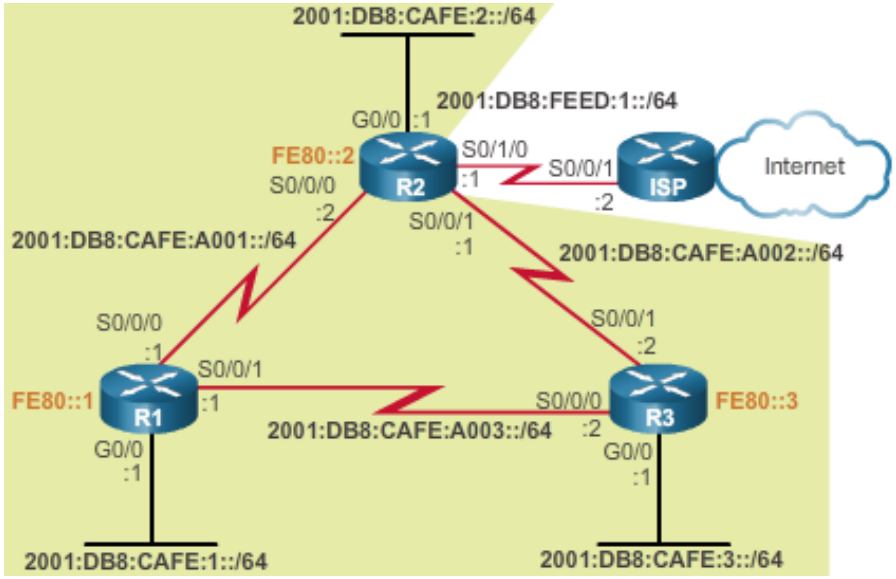
	EIGRP for IPv4	EIGRP for IPv6
Advertised Routes	IPv4 networks	IPv6 prefixes
Distance Vector	Yes	Yes
Convergence Technology	DUAL	DUAL
Metric	Bandwidth and delay by default, reliability and load are optional	Bandwidth and delay by default, reliability and load are optional
Transport Protocol	RTP	RTP
Update Messages	Incremental, partial, and bounded updates	Incremental, partial, and bounded updates
Neighbor Discovery	Hello packets	Hello packets
Source and Destination Addresses	IPv4 source address and 224.0.0.10 IPv4 multicast destination address	IPv6 link-local source address and FF02::A IPv6 multicast destination address
Authentication	MD5, SHA256	MD5, SHA256
Router ID	32-bit router ID	32-bit router ID

- IPv6 Link-local Address
  - Packets with a source or destination link-local address cannot be routed beyond the link from where the packet originated.
  - IPv6 link-local addresses are in the FE80::/10 range.



Configure EIGRP for IPv6

- Configuring IPv6 Link-local Addresses
  - Link-local address can be automatically created or manually configured
    - When created automatically, the router creates the link-local address using FE80::/10 prefix and the EUI-64 process. Use the **ipv6 address** *link-local-address* **link-local** command to manually configure the link-local address using the FE80::10 prefix
  - Link-local addresses must be unique on the same local link.



Configure EIGRP for IPv6 (Cont.)

- Configuring the EIGRP for IPv6 Routing Process
  - The **ipv6 unicast-routing** command enable IPv6 routing
  - The **ipv6 route eigrp** *autonomous-system* command is used to enter the router configuration mode. The process needs to be activated with the **no shutdown** command.
  - To configure the Router ID, use the **eigrp router-id** command.
  - Both the **no shutdown** command and a router ID are required for the router to form neighbor adjacencies.
- The **ipv6 eigrp interface** command
  - EIGRP for IPv6 is configured directly on the interface.
    - **ipv6 eigrp** *autonomous-system*
  - Configure passive interface in the router configuration mode
    - **passive-interface** *interface*

```
R2(config)# ipv6 unicast-routing
R2(config)# ipv6 router eigrp 2
R2(config-rtr)# eigrp router-id 2.0.0.0
R2(config-rtr)# no shutdown
```

```
R2(config)# ipv6 router eigrp 2
R2(config-rtr)# passive-interface gigabitethernet 0/0
R2(config-rtr)# end
```

```
R2(config)# interface g 0/0
R2(config-if)# ipv6 eigrp 2
R2(config-if)# exit
R2(config)# interface s 0/0/0
R2(config-if)# ipv6 eigrp 2
R2(config-if)# exit
%DUAL-5-NBRCHANGE: EIGRP-IPv6 2: Neighbor FE80::1
(Serial0/0/0) is up: new adjacency
```

Verify EIGRP for IPv6

- IPv6 Neighbor Table
  - The **`show ipv6 eigrp neighbors`** command is used to display neighbor adjacencies
- The **`show ip protocols`** command
  - Displays the parameters and other information about the state of any active IPv6 routing protocol processes currently configured on the router.
  - Displays different types of output specific to each IPv6 routing protocol.
- The EIGRP for IPv6 Routing Table
  - The **`show ipv6 route`** command is used to view the IPv6 routing table

```
R1# show ipv6 eigrp neighbors
EIGRP-IPv6 Neighbors for AS(2)
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
1   Link-local address:     Se0/0/1          13  00:37:17  45    270  0  8
    FE80::3
0   Link-local address:     Se0/0/0          14  00:53:16  32    2370 0  8
    FE80::2
R1#
```

Neighbor's IPv6 Link-local Address.

Local Interface receiving EIGRP for IPv6 Hello packets.

Amount of time since this neighbor was added to the neighbor table.

Seconds remaining before declaring neighbor down.

The current hold time and is reset to the maximum hold time whenever a Hello packet is received.

```
R1# show ipv6 protocols
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "eigrp 2"
EIGRP-IPv6 Protocol for AS(2)
  Metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  NSF-aware route hold timer is 240
  Router-ID: 1.0.0.0
  Topology : 0 (base)
    Active Timer: 3 min
    Distance: internal 90 external 170
    Maximum path: 16
    Maximum hopcount 100
    Maximum metric variance 1

  Interfaces:
    GigabitEthernet0/0
    Serial0/0/0
    Serial0/0/1
  Redistribution:
    None
R1#
```

1 Routing protocol and Process ID (AS Number)

2 K values used in composite metric

3 EIGRP Router ID

4 EIGRP Administrative Distances

5 Interfaces enabled for EIGRP for IPv6

```
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#
```

6.5 Chapter Summary

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Chapter Summary

Summary

- **EIGRP** (Enhanced Interior Gateway Routing Protocol) is a **classless**, **distance vector routing protocol**.
- EIGRP uses the source code of "**D**" for **DUAL** in the routing table. EIGRP has a **default administrative distance of 90 for internal routes and 170 for routes imported from an external source, such as default routes**. These features include: Diffusing Update Algorithm (DUAL), establishing neighbor adjacencies, Reliable Transport Protocol (RTP), partial and bounded updates, and equal and unequal cost load balancing.
- EIGRP uses **PDMs** (Protocol Dependent Modules) giving it the **capability to support different Layer 3 protocols** including IPv4 and IPv6. EIGRP uses **reliable delivery for EIGRP updates, queries and replies**; and uses **unreliable delivery for EIGRP Hellos and acknowledgments**. Reliable RTP means an EIGRP acknowledgment must be returned.
- Before any EIGRP updates are sent, a router must first **discover its neighbors** using EIGRP **Hello packets**. The Hello and hold-down values do not need to match for two routers to become neighbors. The **show ip eigrp neighbors** command is used to view the neighbor table and verify that EIGRP has established an **adjacency** with its neighbors.
- EIGRP sends **partial or bounded updates, which include only route changes**. Updates are sent **only to those routers that are affected by the change**. EIGRP composite metric uses **bandwidth**, **delay**, reliability, and load to determine the best path. By default only bandwidth and delay are used.

Summary (Cont.)

- At the center of EIGRP is DUAL (Diffusing Update Algorithm). The DUAL Finite State Machine is used to determine best path and potential backup paths to every destination network. The **successor** is a neighboring router that is used to forward the packet using the least-cost route to the destination network. **Feasible distance** (FD) is the lowest calculated metric to reach the destination network through the successor. A **feasible successor** (FS) is a neighbor who has a loop-free backup path to the same network as the successor, and also meets the feasibility condition. The **feasibility condition** (FC) is met when a neighbor's **reported distance** (RD) to a network is less than the local router's feasible distance to the same destination network. The reported distance is simply an EIGRP neighbor's feasible distance to the destination network.
- EIGRP is configured with the **`router eigrp`** *`autonomous-system`* command. The autonomous-system value is actually a **process-id** and **must be the same on all routers in the EIGRP routing domain**. The **`network`** command is similar to that used with RIP. The network is the classful network address of the directly connected interfaces on the router. A **wildcard mask** is an optional parameter that can be used to include only specific interfaces.
- EIGRP for IPv6 shares many similarities with EIGRP for IPv4. However, unlike the IPv4 network command, IPv6 is enabled on the interface using the **`ipv6 eigrp`** *`autonomous-system`* interface configuration command.