# Instructor Materials
# Chapter 6: EIGRP

**CCNA Routing and Switching**

**Scaling Networks**

# Chapter 6: EIGRP

**Scaling Networks**

# 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

# 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 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 PDM Operation
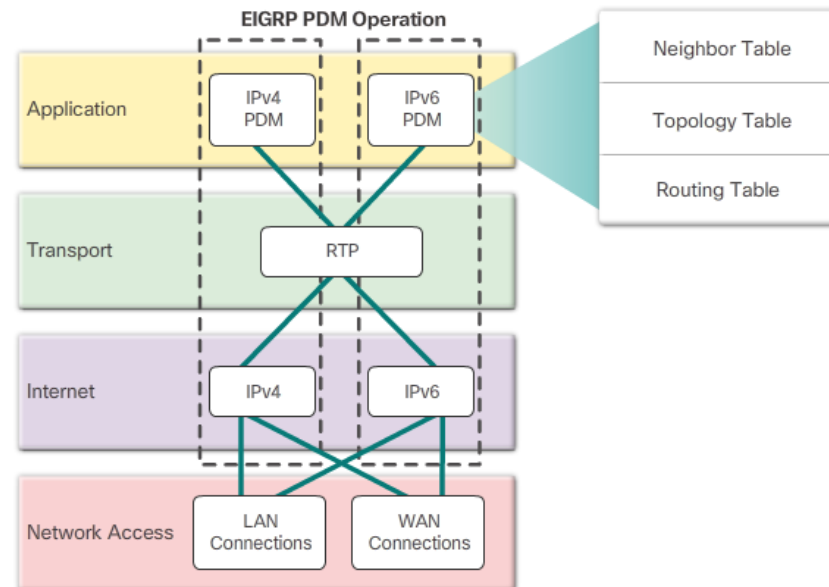
# EIGRP Packet Types

- ## 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 when necessary to the routers that require the information using RTP
  - Acknowledgment packets are send to acknowledge the update was received.

- ## EIGRP Query and Reply Packets
  - Searches for networks
  - Uses reliable delivery
  - Queries are multicast or unicast. Replies are always unicast.

# EIGRP Messages

- Encapsulating EIGRP Messages
  - The EIGRP packet headers and TLV 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 and K3 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

# 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
    - Autonomous system number is only significant to local EIGRP local domain
    - Autonomous system number functions as a process ID
    - All routers within the same domain must have the same autonomous system number
    - The command is used to begin the EIGRP routing protocol

- 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* router configuration mode 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*
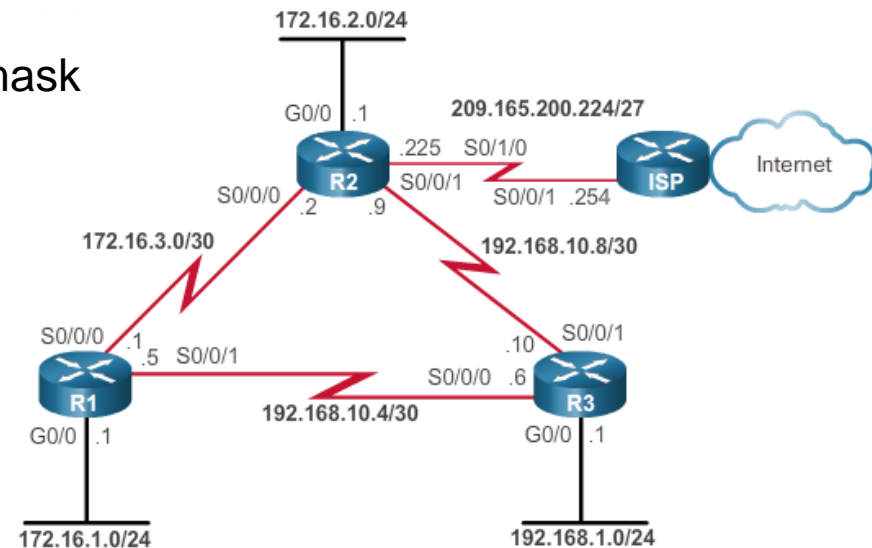
# Verify EIGRP with IPv4

- 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
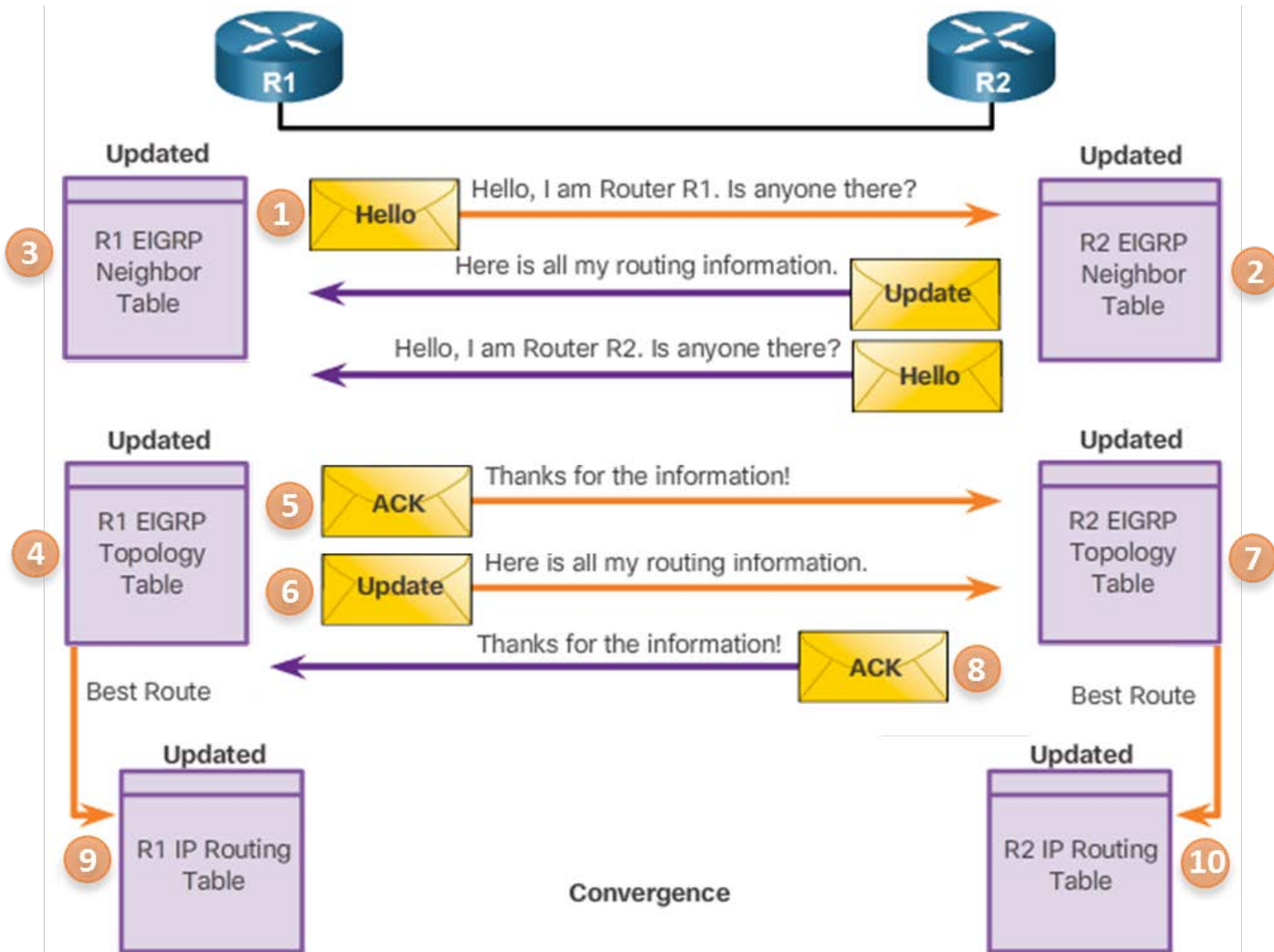
  - Check for convergence

6.3 EIGRP Operation

# EIGRP Initial Route Discovery

- Can you describe the initial route discovery process?

# 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.
  - The **show ip protocols** command can be used to verify k values.

```
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
```

- ## 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?
  - What command is used to verify the metric?

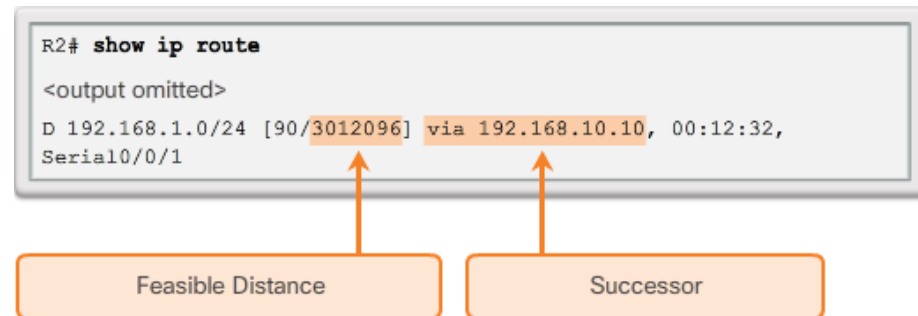| Media | Delay |
|---|---|
| Ethernet | 1,000 |
| Fast Ethernet | 100 |
| Gig Ethernet | 10 |
| Serial WAN | 20,000 |
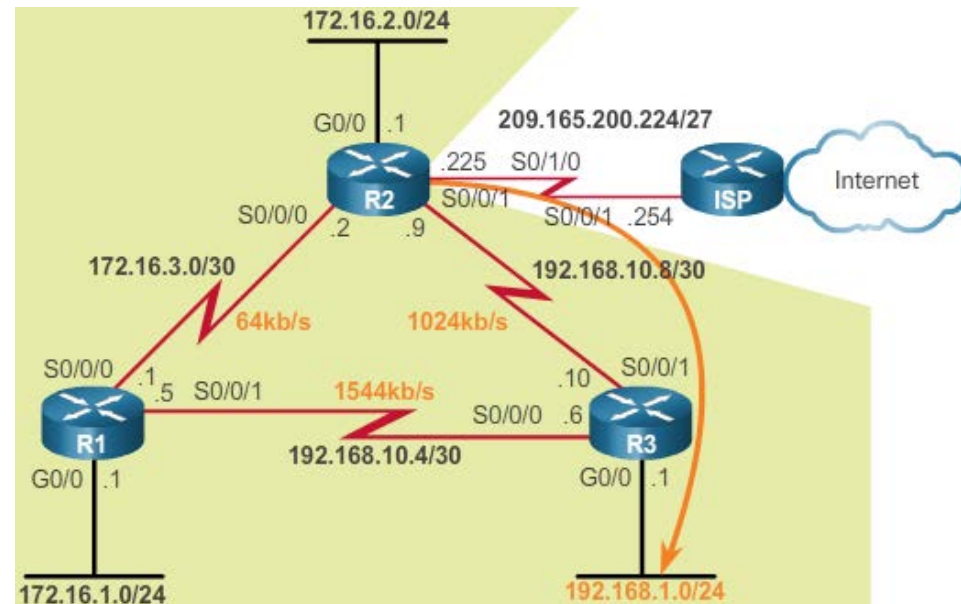
# DUAL and the Topology Table

- 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



```
R2# show ip route
<output omitted>
D 192.168.1.0/24 [90/3012096] via 192.168.10.10, 00:12:32,
Serial0/0/1
```

Feasible Distance          Successor

- 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
```

# 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.
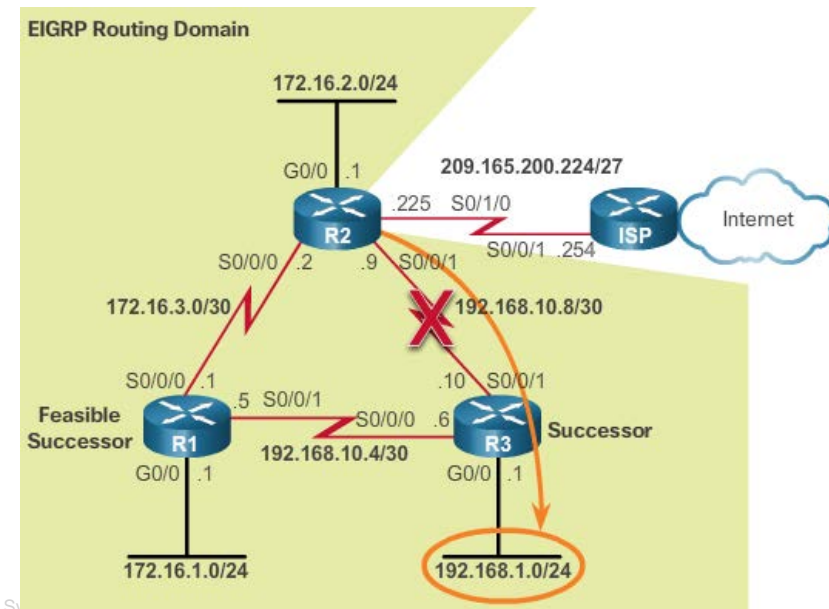
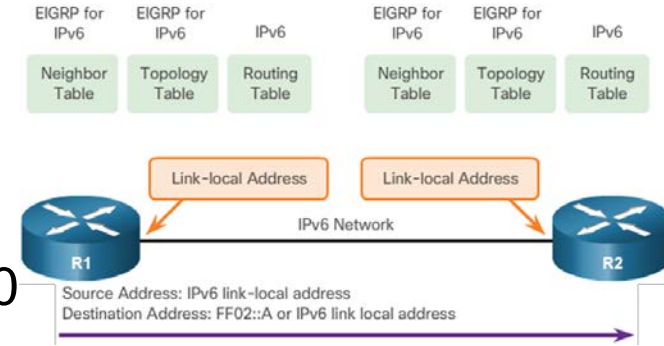6.4 Implement EIGRP for IPv6

# 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.
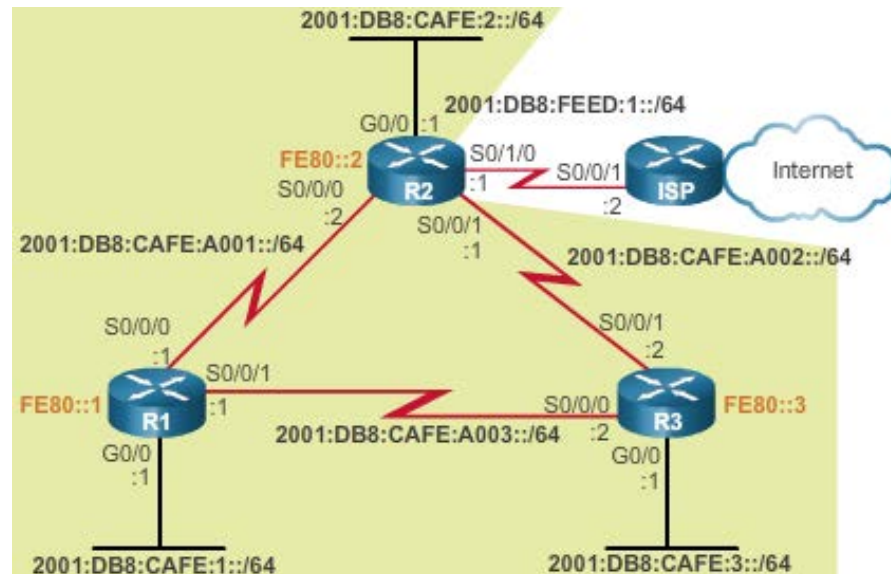
# Configure EIGRP for IPv6 (Cont.)

- 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

# 6.5 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.

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