Enhanced Interior Gateway Protocol (EIGRP)

EIGRP Routing

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Enhanced Interior Gateway Protocol (EIGRP)

Characteristics of EIGRP

Configuring EIGRP for IPv4

Operation of EIGRP

Configuration of EIGRP for IPv6

EIGRP Advanced Configurations

EIGRP Authentication

Characteristics of EIGRP

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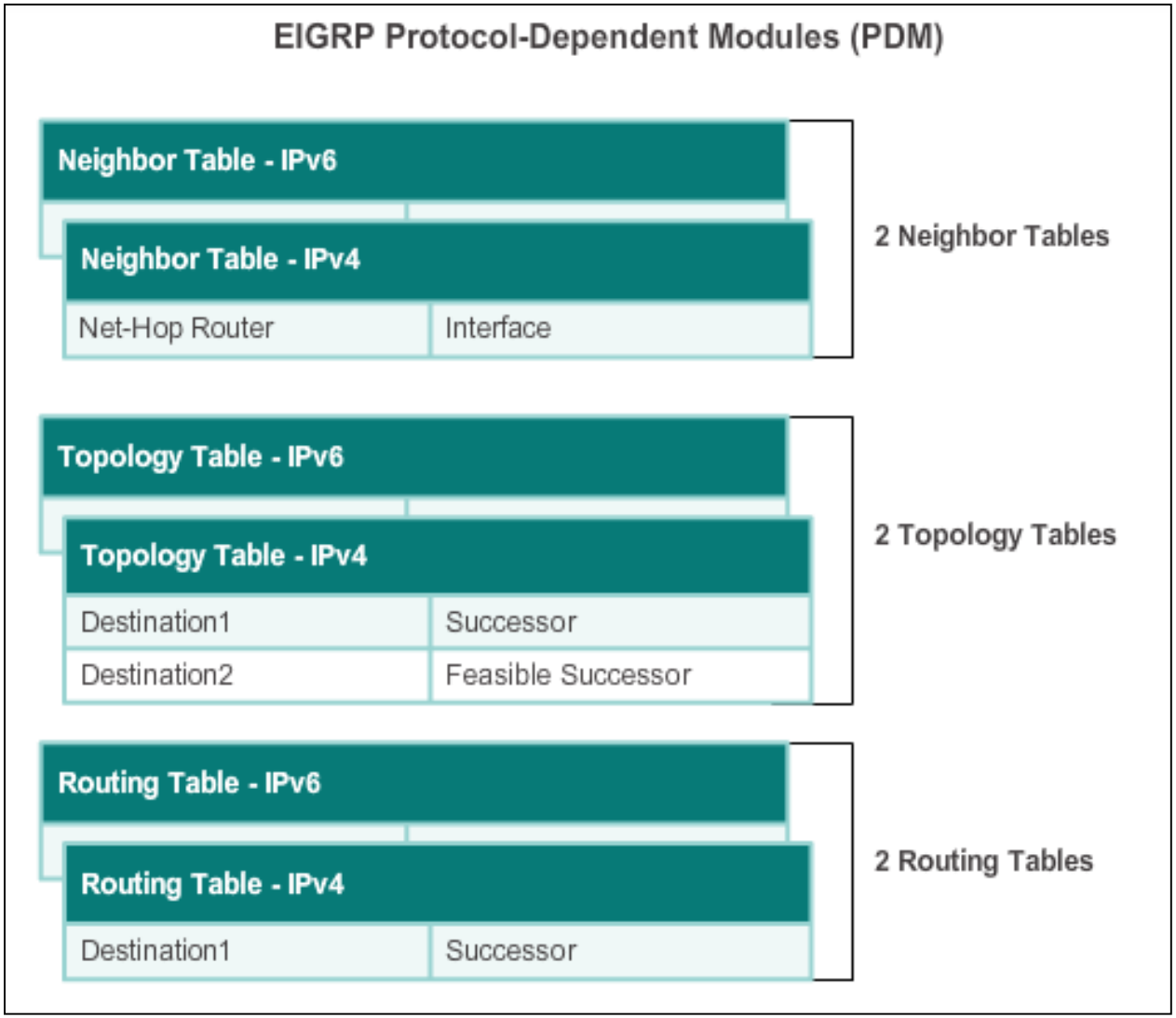
Features of EIGRP

- Released in 1992 as a Cisco proprietary protocol.
- 2013 basic functionality of EIGRP released as an open standard.
- Advanced Distance Vector routing protocol.
- 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. Send updates only when there is a change and only to the routers that need the information.
- Supports Equal and Unequal Cost Load Balancing.

Basic Features of EIGRP

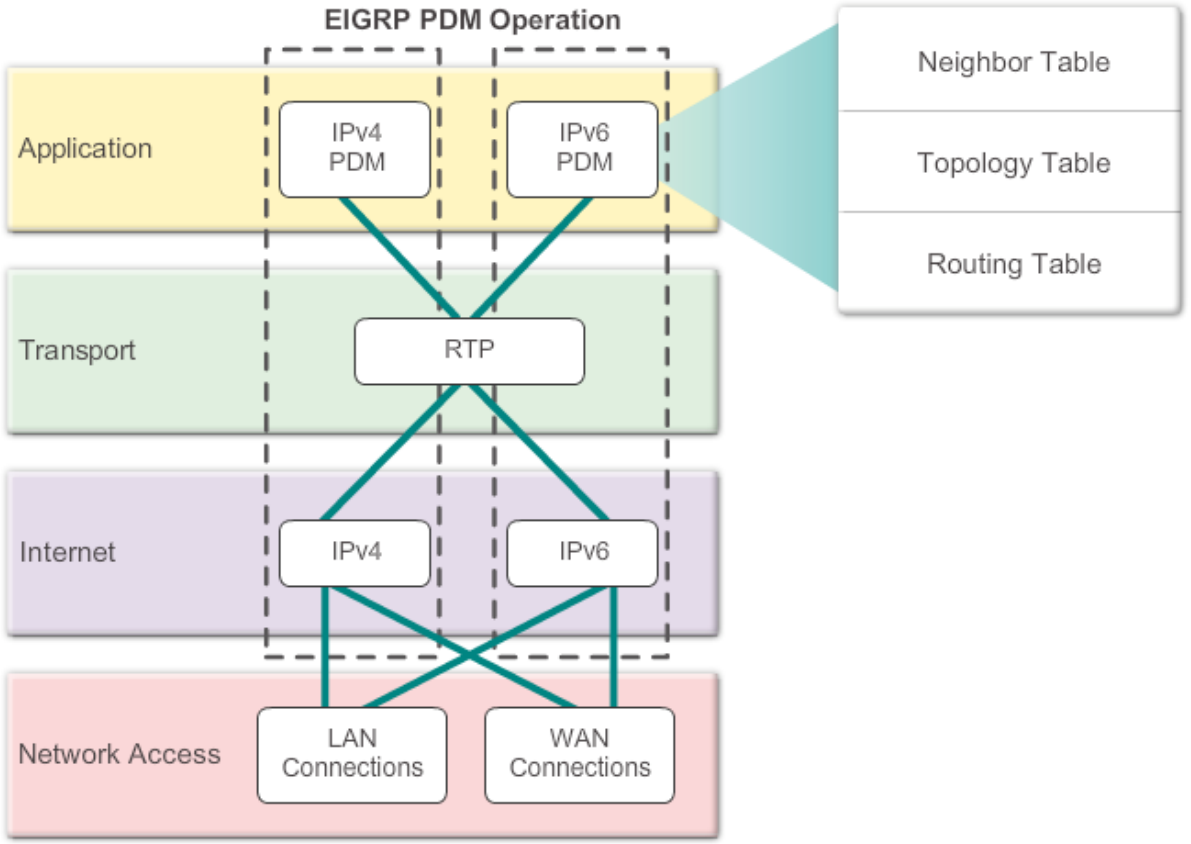
Protocol Dependent Modules



Basic Features of EIGRP

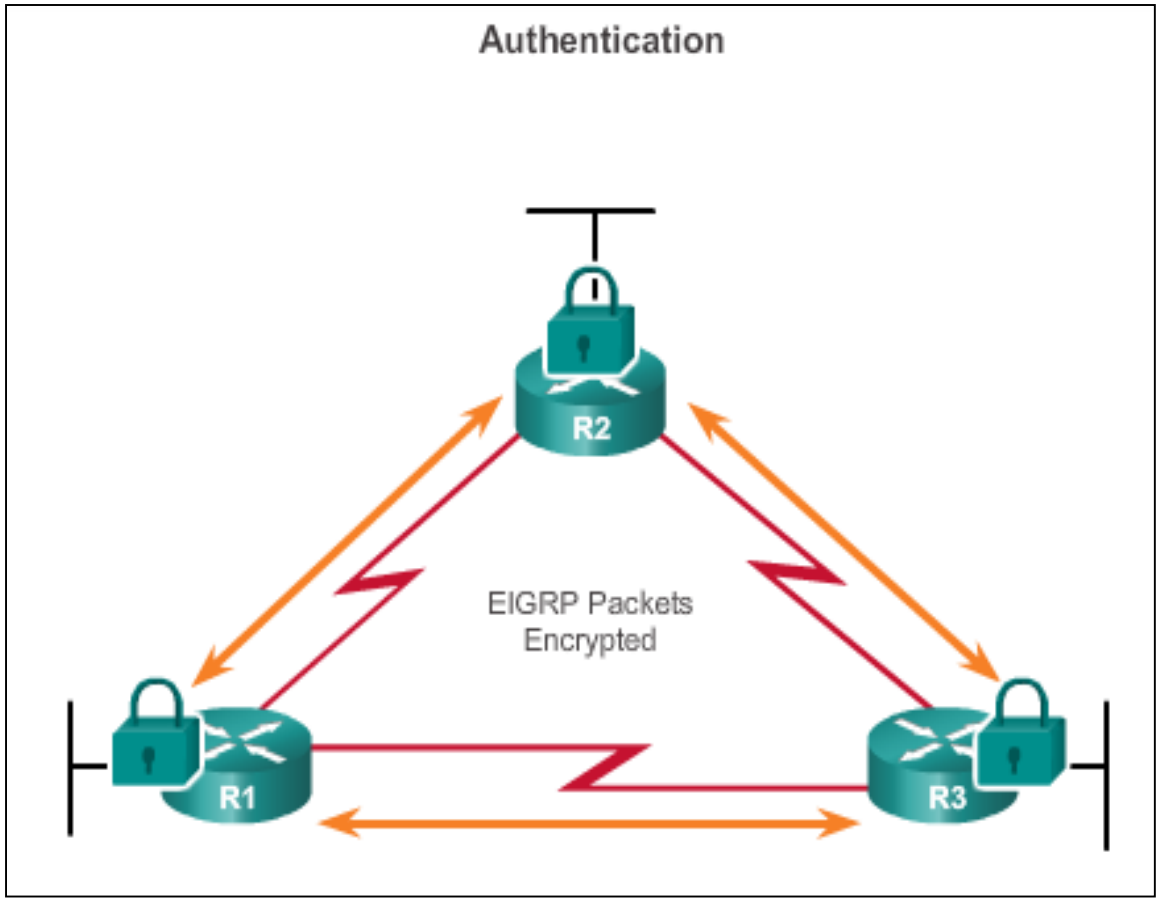
Reliable Transport Protocol

EIGRP Replaces TCP with RTP



Authentication

- EIGRP can be configured to authenticate routing information.
- Ensures routers only accept updates from routers that have been configured with the correct authentication information.



Types of EIGRP Packets

EIGRP Packet Types

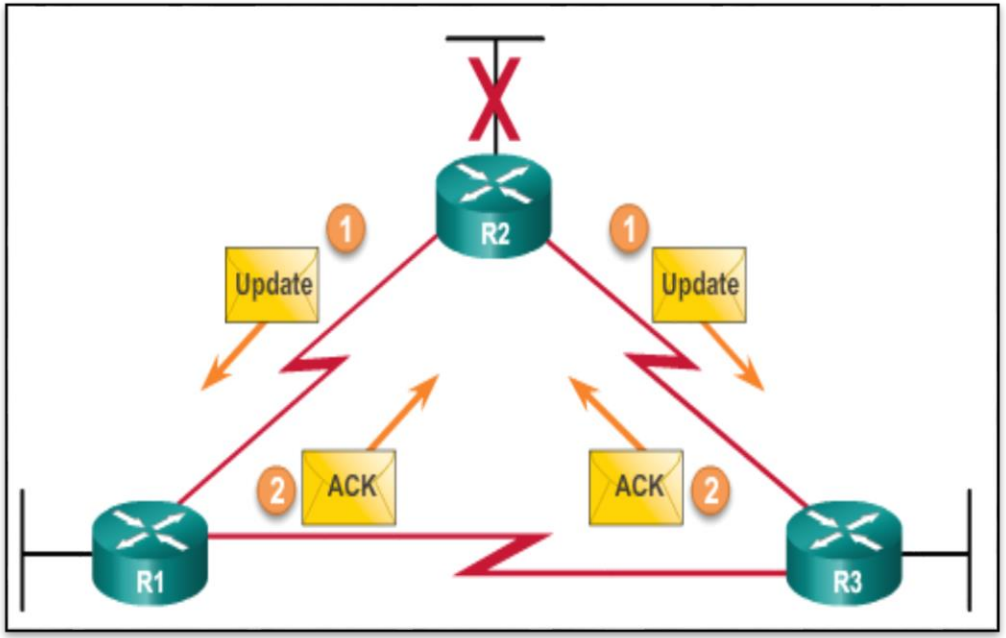
Packet Type	Description
Hello	Used to discover other EIGRP routers in the network.
Acknowledgement	Used to acknowledge the receipt of any EIGRP packet.
Update	Convey routing information to known destinations.
Query	Used to request specific information from a neighbor router.
Reply	Used to respond to a query.

EIGRP Hello Packets

- Used to discover EIGRP neighbors.
- Used to form and maintain EIGRP neighbor adjacencies.
- Sent as IPv4 or IPv6 multicasts.
- IPv4 multicast address 224.0.0.10.
- IPv6 multicast address FF02::A.
- Unreliable delivery.
- Sent every 5 seconds (every 60 seconds on low-speed NBMA networks).
- EIGRP uses a default Hold timer of three times the Hello interval before declaring neighbor unreachable.

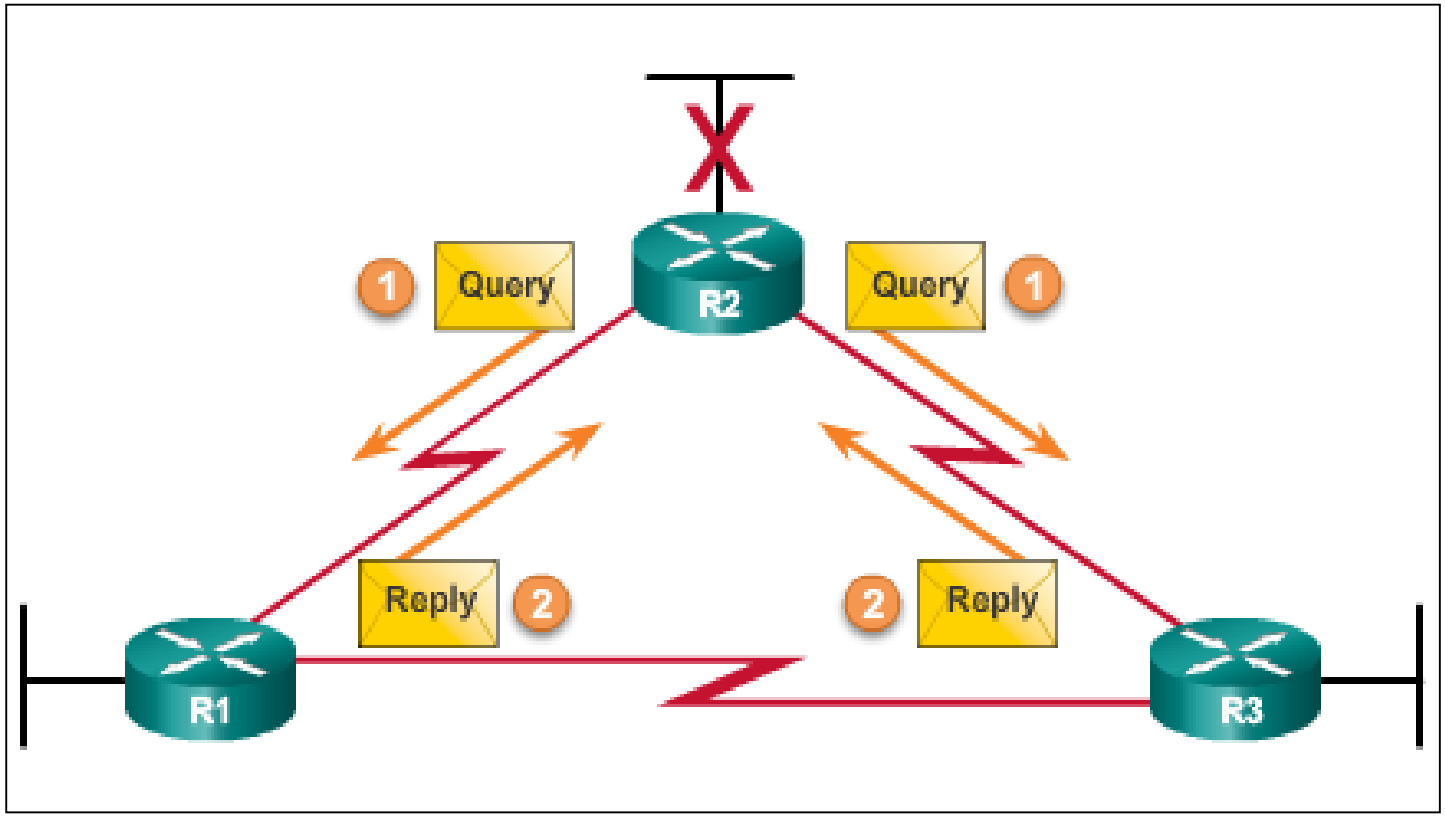
EIGRP Update & Acknowledgement Packets

- Update packets are sent to propagate routing information, only when necessary.
- Sends **Partial** updates – only contains information about route changes.
- Sends **Bounded** updates- sent only to routers affected by the change.
- Updates use reliable delivery, therefore, require an **acknowledgement**.

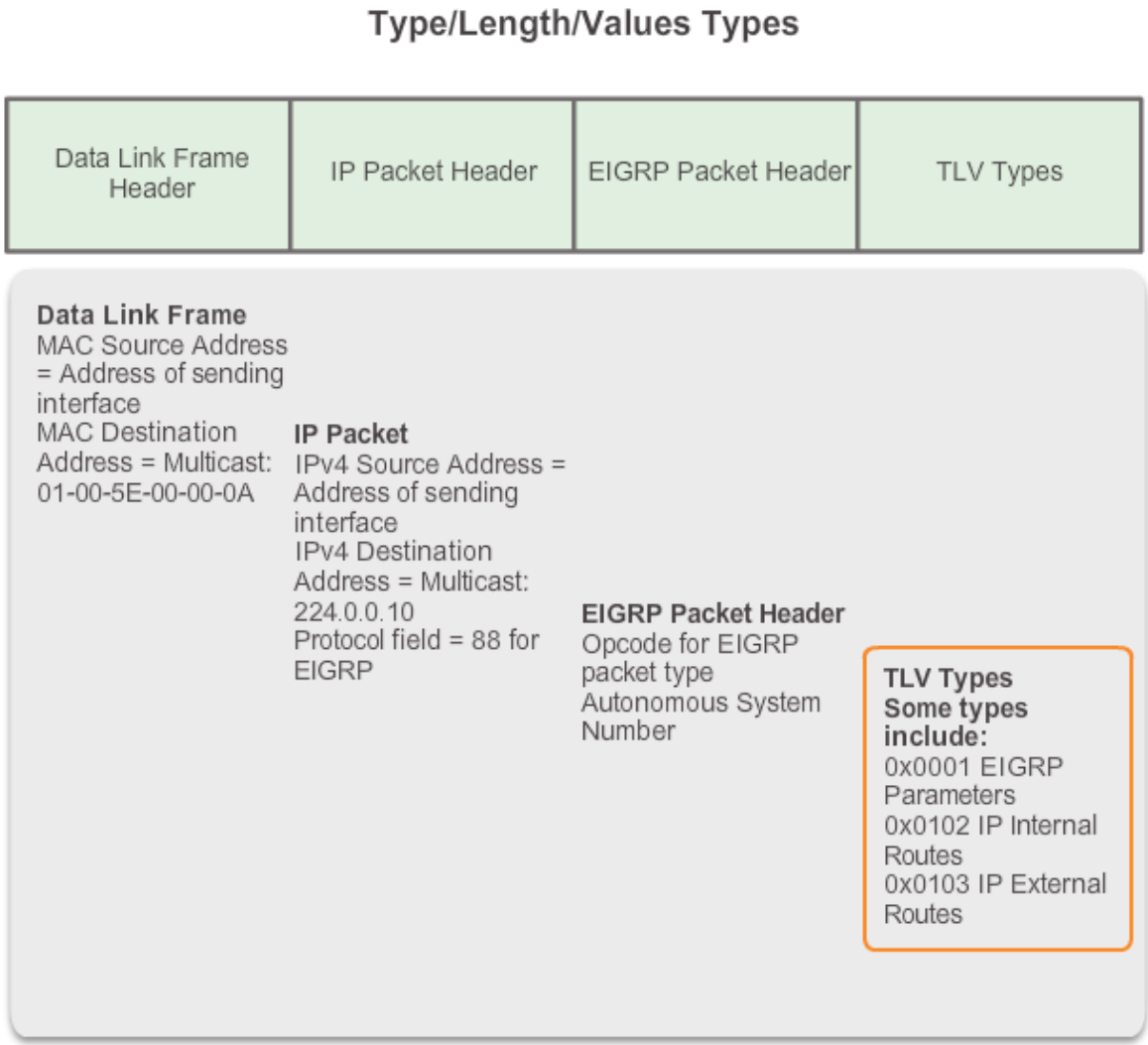


EIGRP Query and Reply Packets

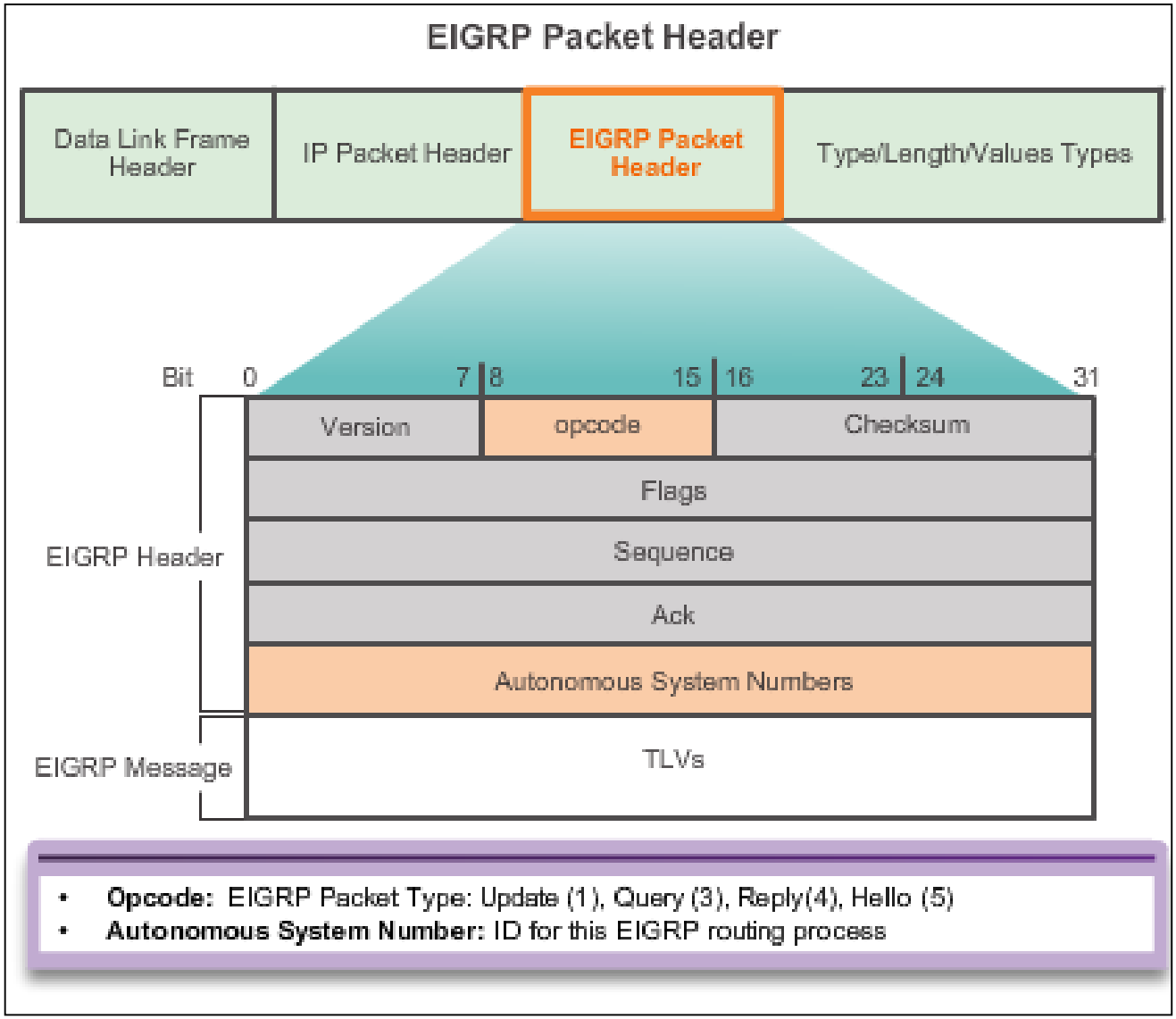
- Used when searching for networks.
- Queries use reliable delivery, which can be multicast or unicast.
- Replies use reliable delivery.



Encapsulating EIGRP Messages



EIGRP Packet Header and TLV



Configuring EIGRP for IPv4

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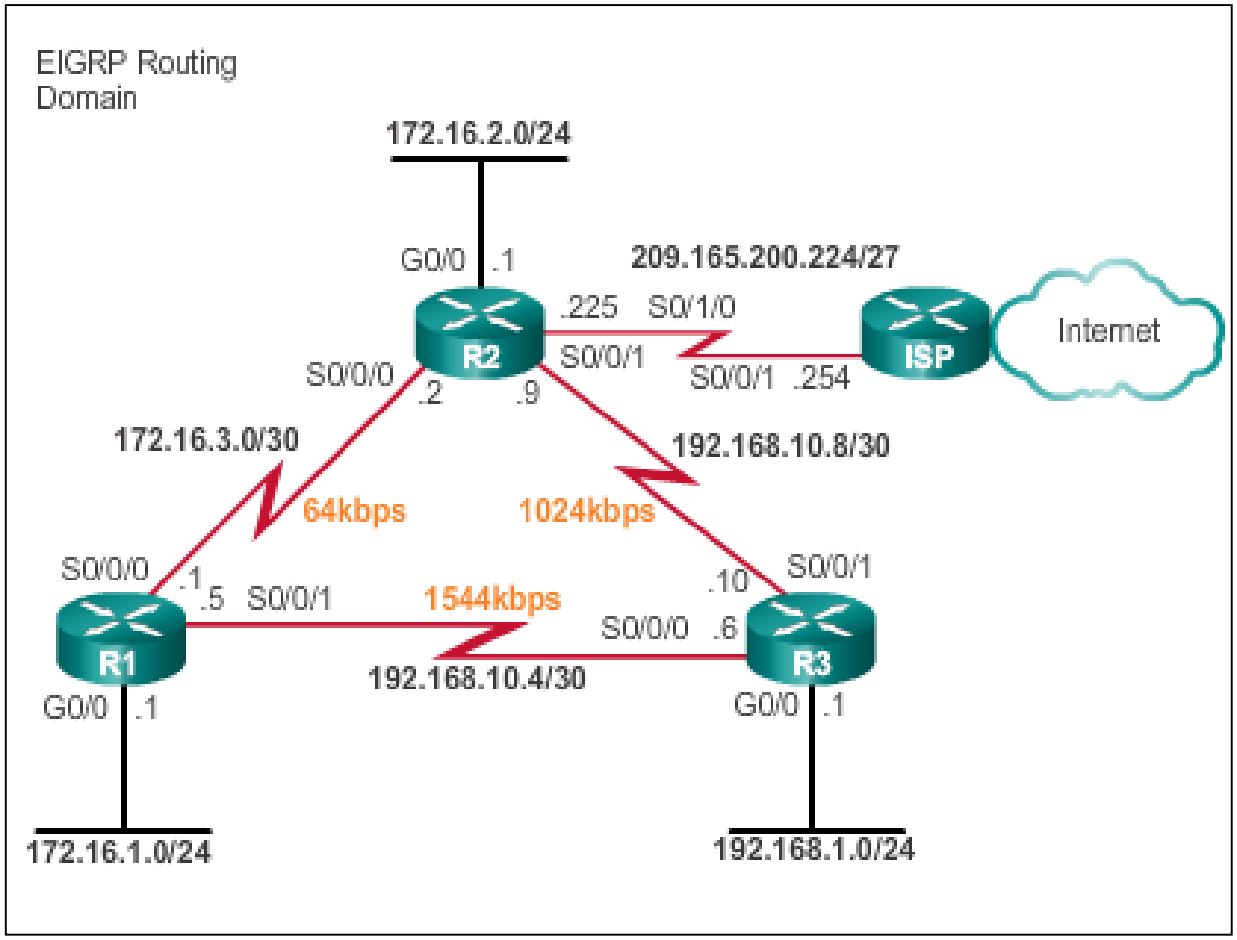
EIGRP Network Topology

This course uses the topology that configures EIGRP with IPv4.



Autonomous System Numbers

- The **`router eigrp`** *`autonomous-system`* command enables the EIGRP process.
- The autonomous system number is only significant to the EIGRP routing domain.
- The EIGRP autonomous system number is not associated with the Internet Assigned Numbers Authority (IANA) globally assigned autonomous system numbers used by external routing protocols.
- Internet Service Providers (ISPs) require an autonomous system number from IANA.
- ISPs often use the Border Gateway Protocol (BGP), which does use the IANA autonomous system number in its configuration.

Autonomous System Numbers

- Find the definition of AS Numbers and the RFC its described in.

Router EIGRP Command

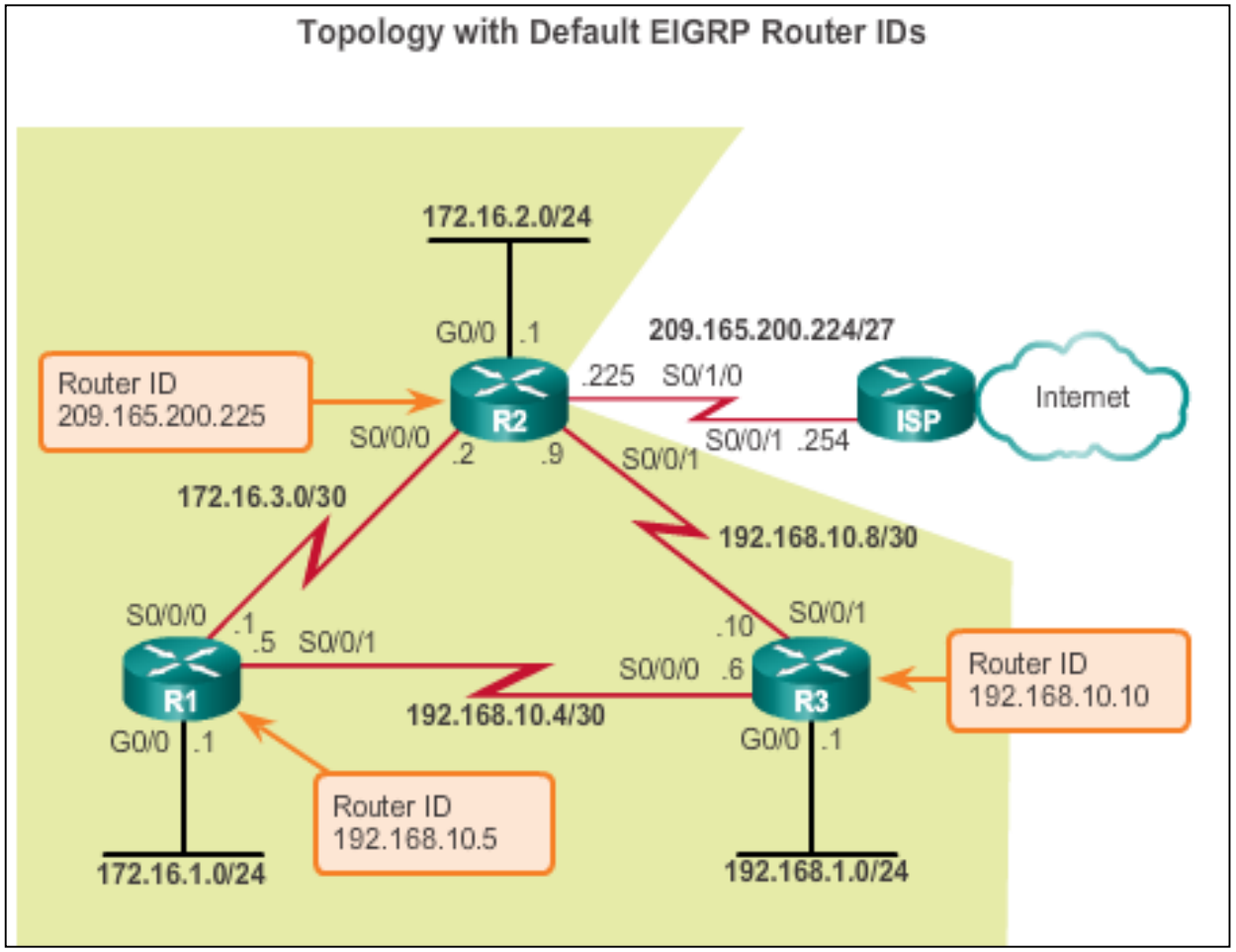
```
Router(config)# router eigrp autonomous-system
```

```
R1(config)#router eigrp 1
R1(config-router)#
```

To completely remove the EIGRP routing process from a device, use the **no router eigrp** *autonomous-system* command.

EIGRP Router ID

Used in both EIGRP and OSPF routing protocols, the router ID's role is more significant in OSPF.



Configuring the EIGRP Router ID

- Configuring the EIGRP router ID

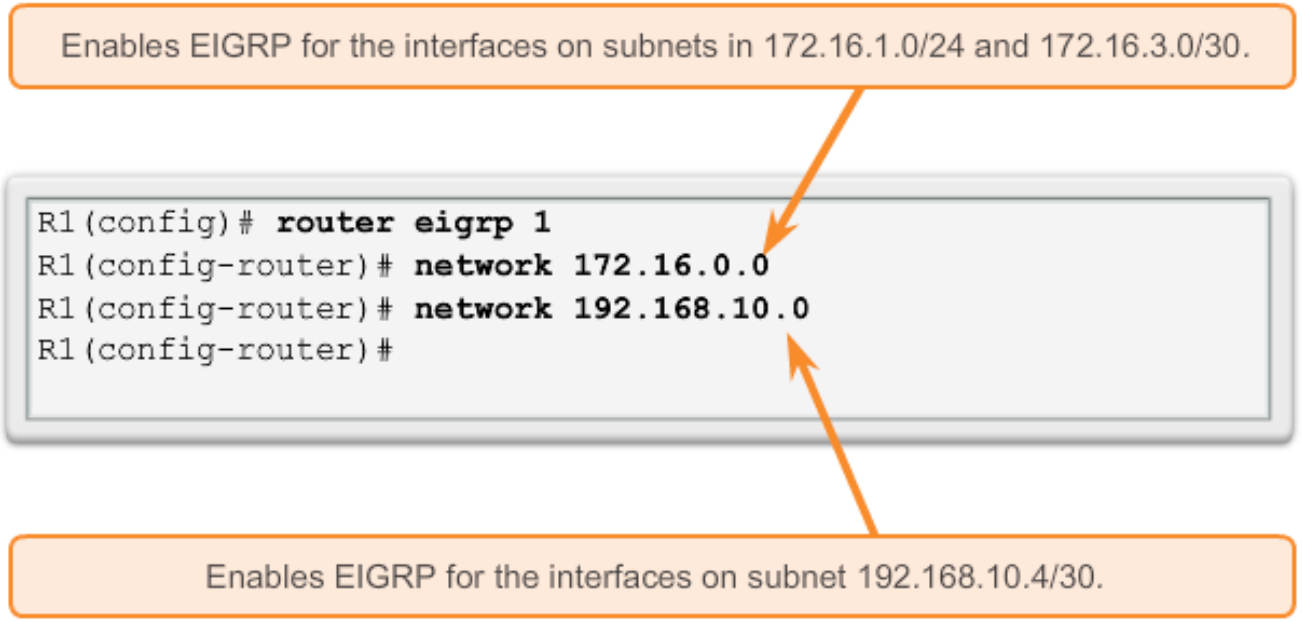
```
Router(config)# router eigrp autonomous-system
Router(config-router)# eigrp router-id ipv4-address
```

- The IPv4 loopback address can be used as the router ID.
- If the **eigrp** *router-id* value is not configured, the highest loopback address is selected as the router ID.
- Configuring a loopback interface

```
Router(config)# interface loopback number
Router(config-if)# ip addressipv4-address subnet-mask
```

Network Command

- Enables any interface on this router that matches the network address in the **network** router configuration mode command to send and receive EIGRP updates.
- These networks are included in EIGRP routing updates.



Network Command

The **`eigrp log-neighbor-changes`** router configuration mode

- On by default
- Displays changes in neighbor adjacencies
- Verifies neighbor adjacencies during configuration
- Indicates when any adjacencies have been removed

The Network Command and Wildcard Mask

- To configure EIGRP to advertise specific subnets only, use the *wildcard-mask* option with the **network** command.

```
Router(config-router)# network network
address [wildcard-mask]
```

- The wildcard mask is the inverse of the subnet mask.
- To calculate the wildcard mask, subtract the subnet mask from 255.255.255.255:

```
  255.255.255.255
- 255.255.255.252
-----------------
    0.   0.   0.   3   wildcard mask
```

- **Note**: Some IOS versions also let you enter the subnet mask instead of a wildcard mask.

Passive Interface

- Use the **passive-interface** command to:
  - Prevent neighbor adjacencies
  - Suppress unnecessary update traffic
  - Increase security controls, such as preventing unknown rogue routing devices from receiving EIGRP updates
- To configure:

```
Router(config)# router eigrp as-number
Router(config-router)# passive-interface interface-type interface-number
```

- To verify:

```
Router# show ip protocols
```

Verifying EIGRP: Examining Neighbors

show ip eigrp neighbors Command

```
R1#show ip eigrp neighbors
EIGRP-IPv4 Neighbors for AS(1)
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
1   192.168.10.6            Se0/0/1          11 04:57:14   27   162  0   8
0   172.16.3.2              Se0/0/0          13 07:53:46   20   120  0   10
R1#
```

- Neighbor's IPv4 Address
- Local Interface receiving EIGRP Hello packets
- Seconds remaining before declaring neighbor down. The current hold time and is reset to the maximum hold time whenever a Hello packet is received.
- Amount of time since this neighbor was added to the neighbor table.

Verifying EIGRP: `show ip protocols` Command

`show ip protocols` Command

```
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
    Topology : 0 (base)
      Active Timer: 3 min
      Distance: internal 90 external 170
      Maximum path: 4
      Maximum hopcount 100
      Maximum metric variance 1

  Automatic Summarization: disabled
  Maximum path: 4
  Routing for Networks:
    172.16.0.0
    192.168.10.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.10.6         90       00:40:20
    172.16.3.2           90       00:40:20
  Distance: internal 90 external 170

R1#
```

1. Routing protocol and Process ID (AS Number)
2. EIGRP Router ID
3. EIGRP Administrative Distances
4. EIGRP Automatic Summarization is disabled.
5. EIGRP Routing Information Sources lists all the EIGRP routing sources the IOS uses to build its IPv4 routing table.

Verifying EIGRP: Examine the IPv4 Routing Table

R1's IPv4 Routing Table

```
      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
D        172.16.2.0/24 [90/2170112] via 172.16.3.2,
00:14:35, Serial0/0/0
C        172.16.3.0/30 is directly connected, Serial0/0/0
L        172.16.3.1/32 is directly connected, Serial0/0/0
D     192.168.1.0/24 [90/2170112] via 192.168.10.6,
00:13:57, Serial0/0/1
      192.168.10.0/24 is variably subnetted, 3 subnets, 2
masks
C        192.168.10.4/30 is directly connected,
Serial0/0/1
L        192.168.10.5/32 is directly connected,
Serial0/0/1
D        192.168.10.8/30 [90/2681856] via 192.168.10.6,
00:50:42, Serial0/0/1
                         [90/2681856] via 172.16.3.2,
00:50:42, Serial0/0/0
R1#
```

Operation of EIGRP

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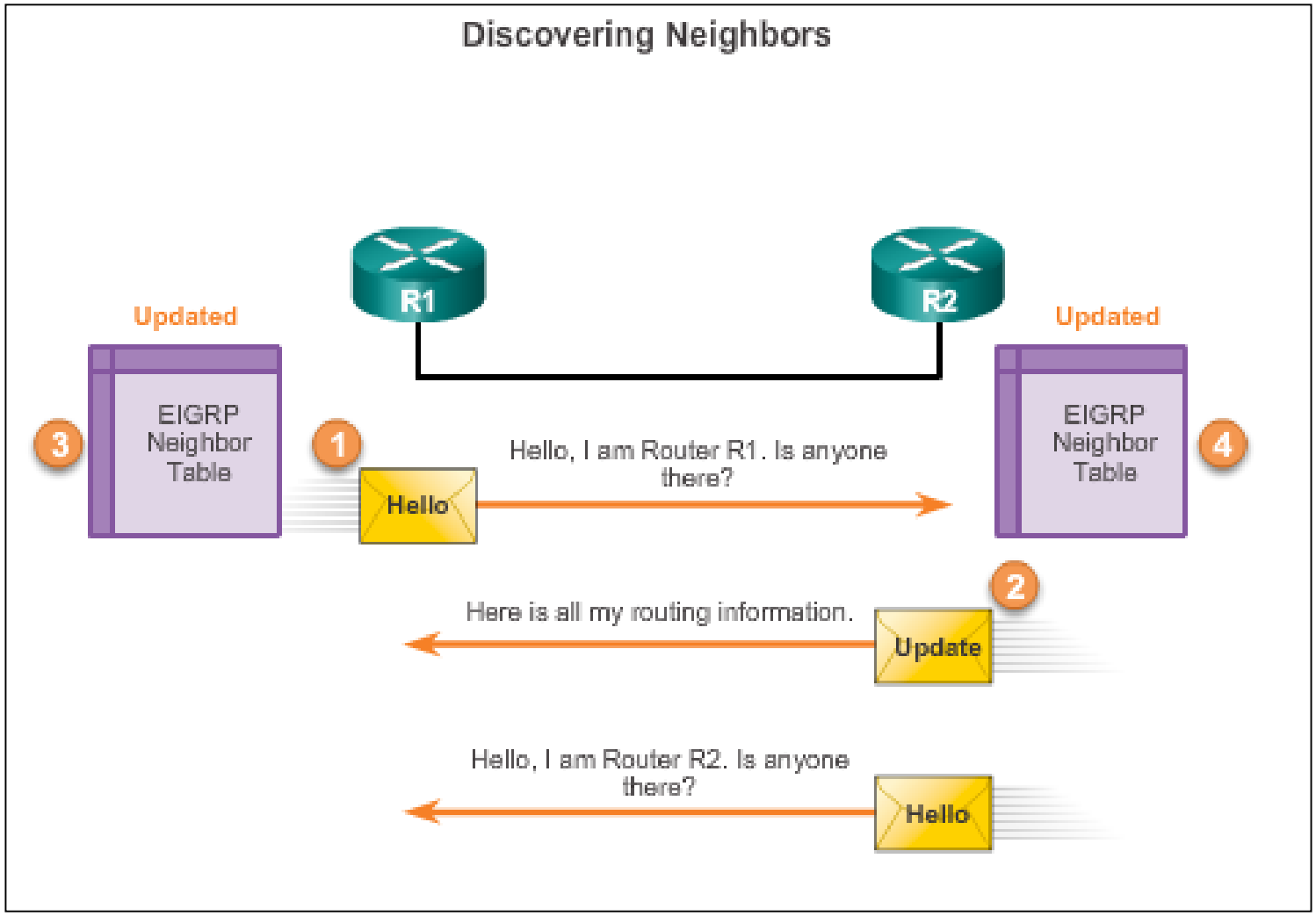
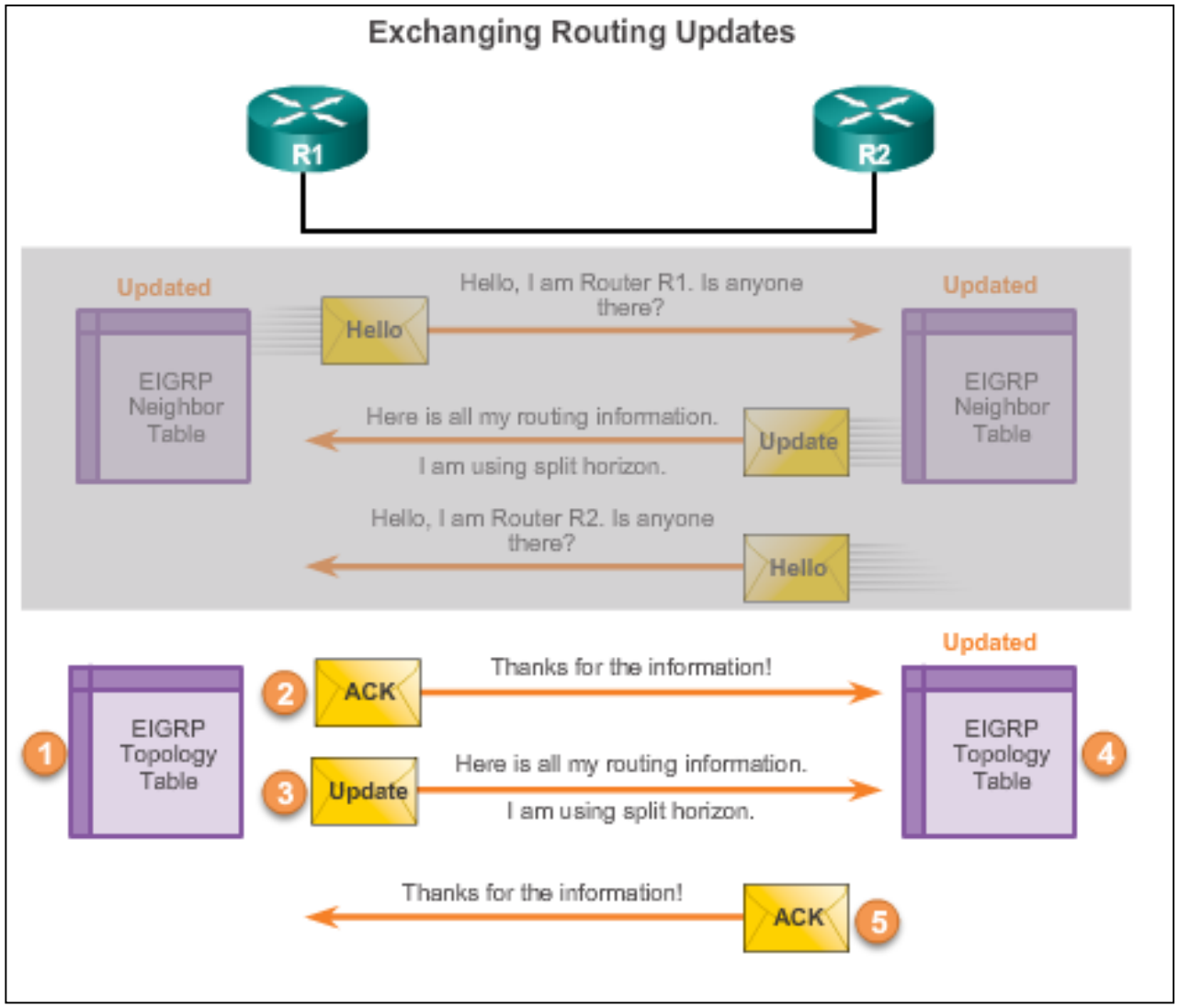
EIGRP Initial Route Discovery

EIGRP Neighbor Adjacency



EIGRP Initial Route Discovery

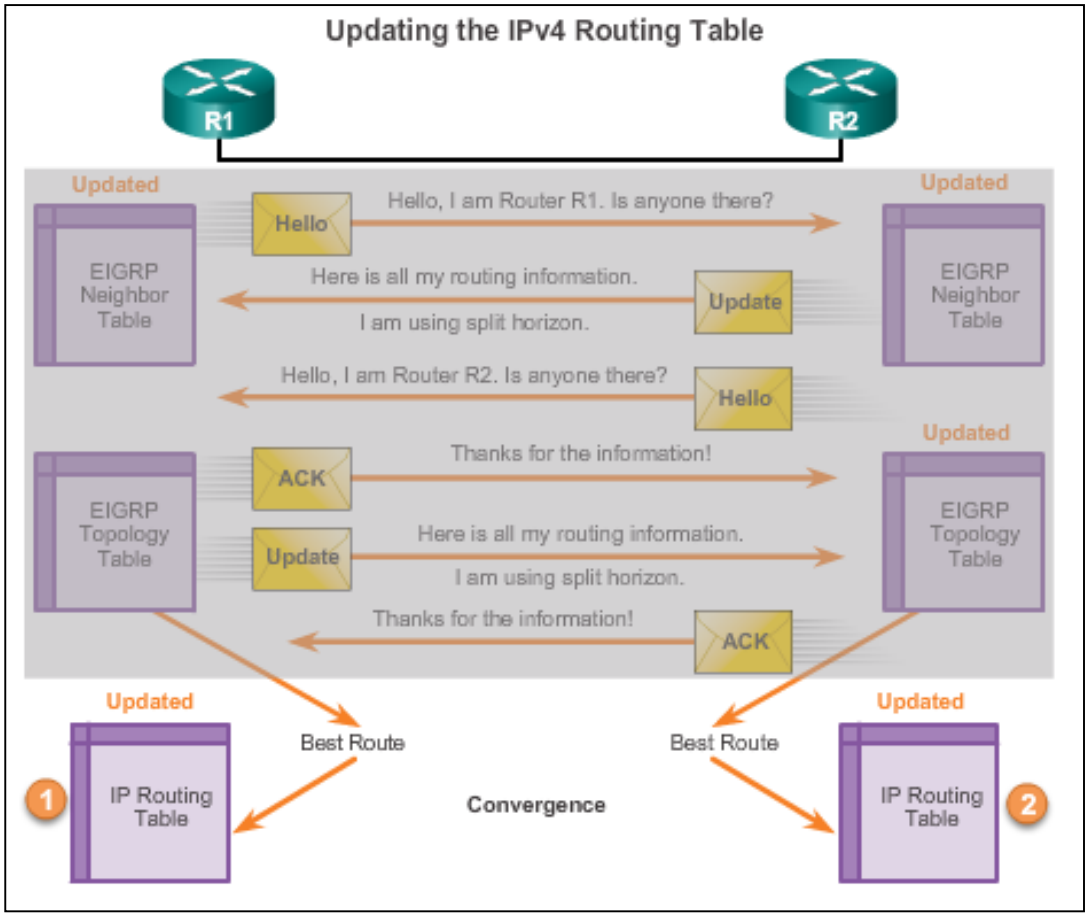
EIGRP Topology Table



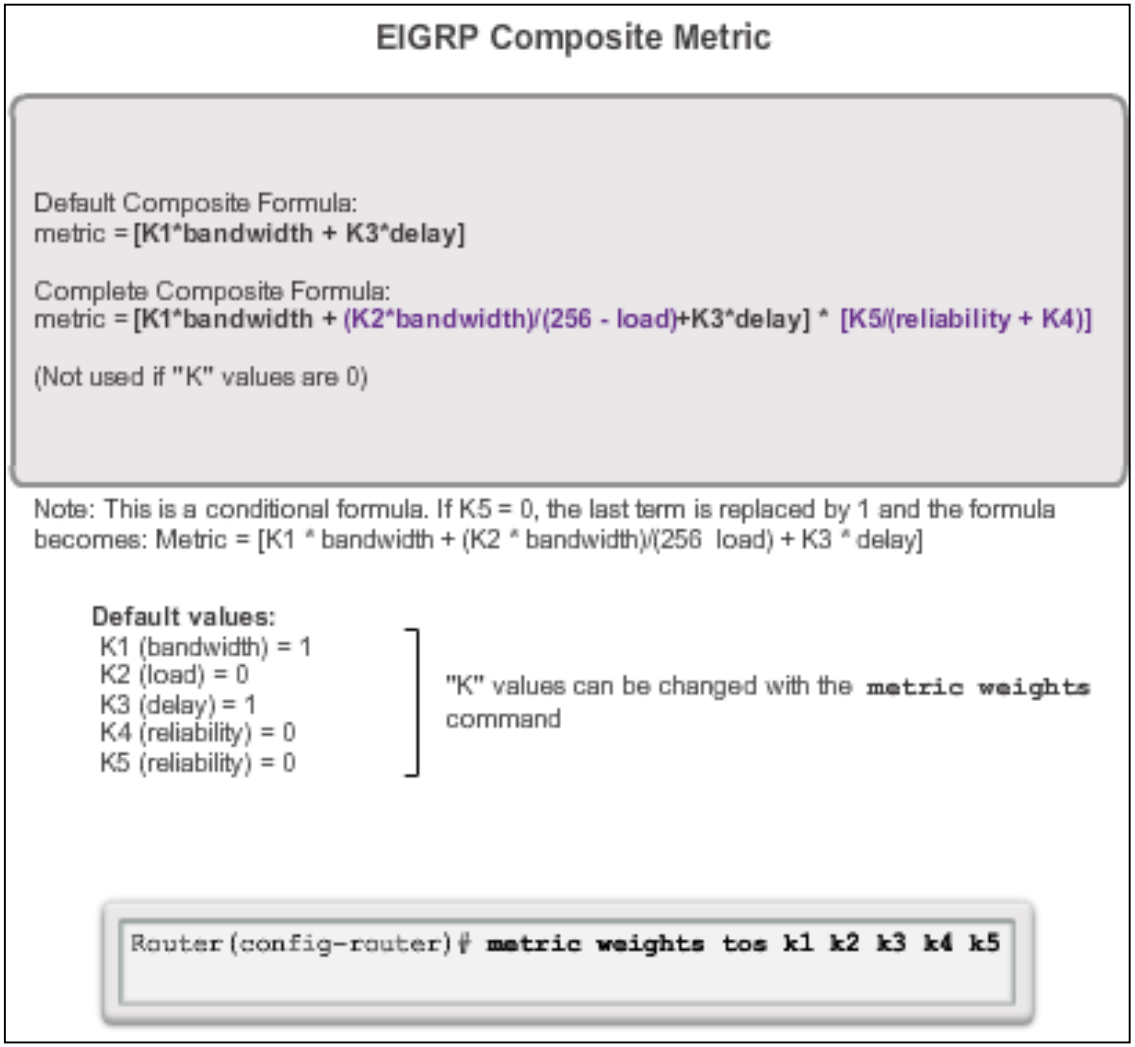
EIGRP Initial Route Discovery

EIGRP Convergence

Convergence – All routers have the correct, most up-to-date information about the network.



EIGRP Composite Metric



Examining Interface Values

- BW – Bandwidth of the interface (in Kilobits per second).
- DLY – Delay of the interface (microseconds).
- Reliability – Reliability of interface; by default, the value is not included in the computing metric.
- Txload, Rxload – By default, the value is not included in the computing metric.

```
R1#show interface 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
<Output omitted>
R1#

R1#show interface gigabitethernet 0/0
GigabitEthernet0/0 is up, line protocol is up
  Hardware is CN Gigabit Ethernet, address is fc99.4775.c3e0 (bia
fc99.4775.c3e0)
  Internet address is 172.16.1.1/24
  MTU 1500 bytes, BW 100000 Kbit/sec, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
<Output omitted>
R1#
```

Bandwidth Metric

- Use the **`show interfaces`** command to verify bandwidth.
- Most serial bandwidths are set to 1,544 kb/s (default).
- A correct value for bandwidth is very important in order to calculate the correct metric (both sides of link must have same bandwidth).

```
R1(config)# interface s 0/0/0
R1(config-if)# bandwidth 64
```

```
R1# show interface s 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 64 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
<Output omitted>
```

Metrics

Delay Metric

Interface Delay Values

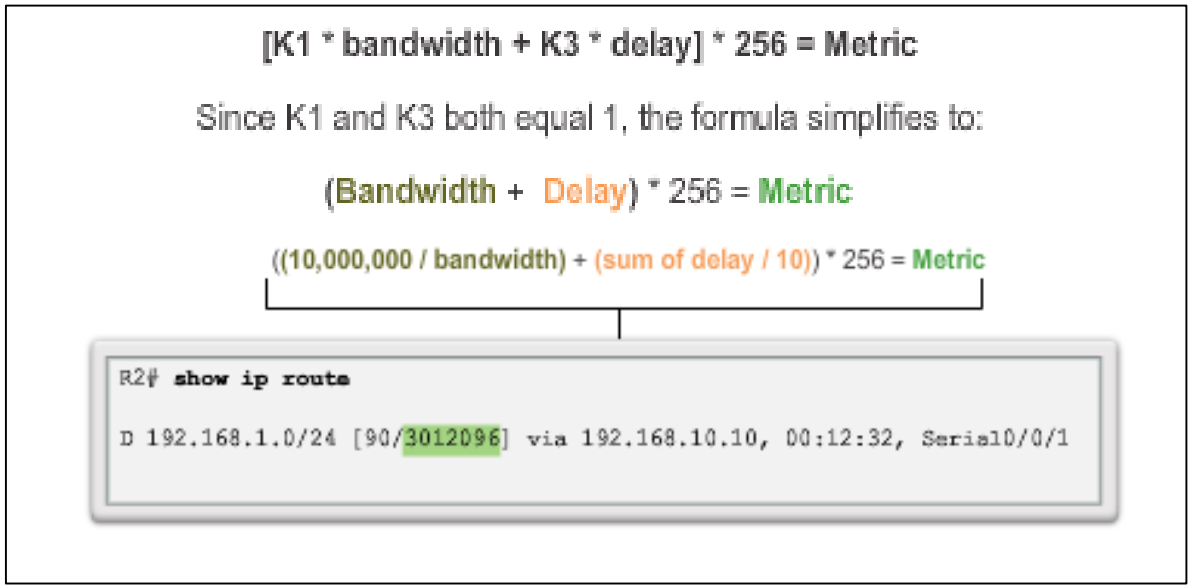
Media	Delay
Ethernet	1,000
Fast Ethernet	100
Gigabit Ethernet	10
16M Token Ring	630
FDDI	100
T1 (Serial Default)	20,000
DS0 (64 Kbps)	20,000
1024 Kbps	20,000
56 Kbps	20,000

Calculating the EIGRP Metric

Step 1. Determine the link with the slowest bandwidth. Use that value to calculate bandwidth (10,000,000/bandwidth).

Step 2. Determine the delay value for each outgoing interface on the way to the destination. Add the delay values and divide by 10 (sum of delay/10).

Step 3. Add the computed values for bandwidth and delay, and multiply the sum by 256 to obtain the EIGRP metric.

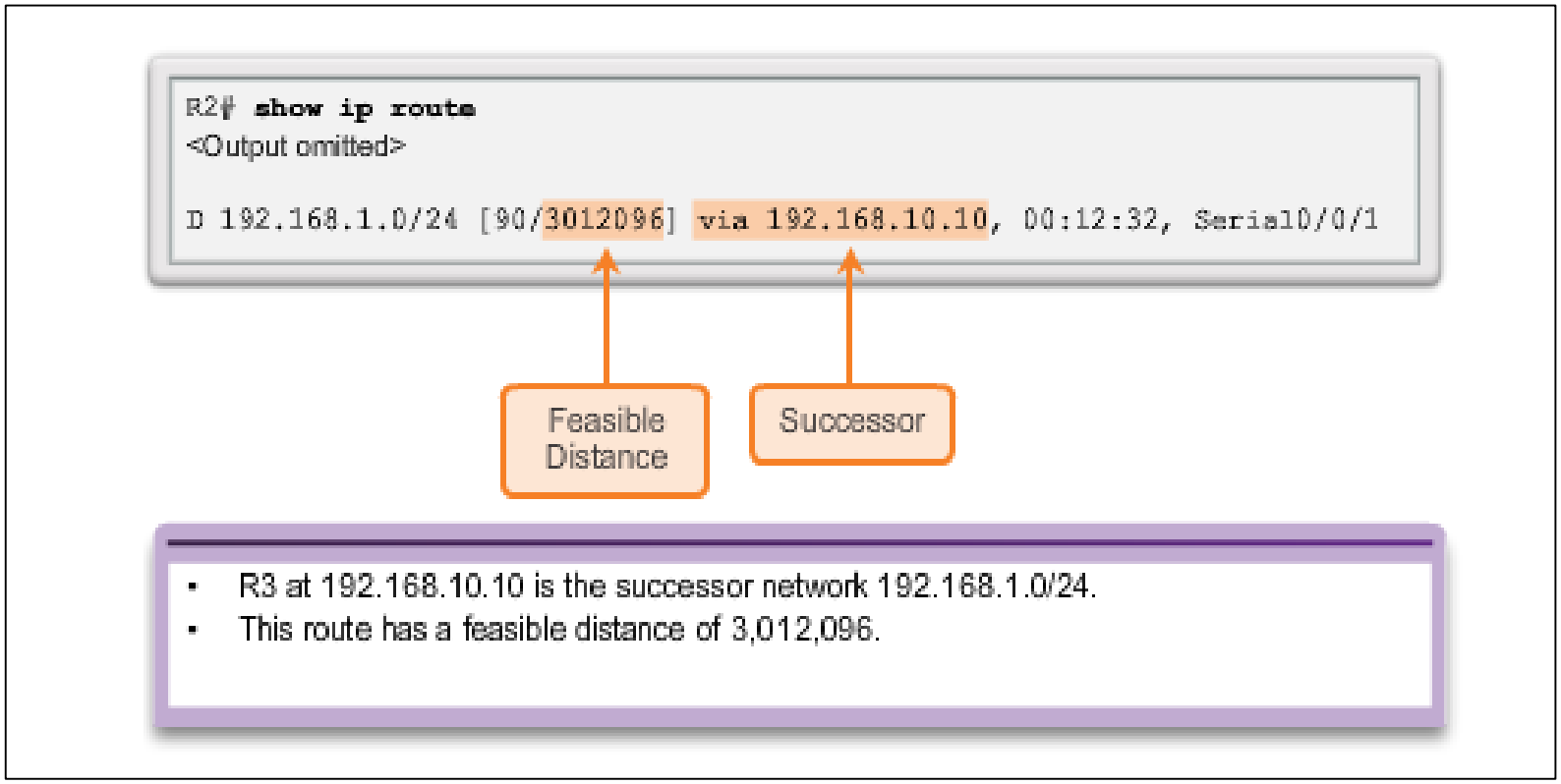


DUAL Concepts

- **Diffusing Update ALgorithm (DUAL)** provides the following:
  - Loop-free paths and loop-free backup paths
  - Fast convergence
  - Minimum bandwidth usage with bounded updates
- The decision process for all route computations is done by the **DUAL Finite State Machine (FSM)**
  - DUAL FSM tracks all routes.
  - Uses EIGRP metrics to select efficient, loop-free paths.
  - Identifies the routes with the least-cost path to be inserted into the routing table.
- EIGRP maintains a list of backup routes that DUAL has already determined that can be used immediately if the primary path fails.

Successor and Feasible Distance

- The **Successor** is the least-cost route to the destination network.
- The **Feasible Distance** (FD) is the lowest calculated metric to reach the destination network.



Feasible Successors, Feasibility Condition, and Reported Distance

- **Feasible Successor** (FS) is a neighbor that has a loop-free backup path to the same network as the successor, and it satisfies the Feasibility Condition (FC).
- **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.
- **Reported Distance** (RD) is an EIGRP neighbor's feasible distance to the same destination network.

Topology Table: `show ip eigrp` Command

```
R2#show ip eigrp topology
EIGRP-IPv4 Topology Table for AS(1)/ID(2.2.2.2)
Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 172.16.2.0/24, 1 successors, FD is 2816
        via Connected, GigabitEthernet0/0
P 192.168.10.4/30, 1 successors, FD is 3523840
        via 192.168.10.10 (3523840/2169856), Serial0/0/1
        via 172.16.3.1 (41024000/2169856), Serial0/0/0
P 192.168.1.0/24, 1 successors, FD is 3012096
        via 192.168.10.10 (3012096/2816), Serial0/0/1
        via 172.16.3.1 (41024256/2170112), Serial0/0/0
```

```
R2#show ip eigrp topology
<Output omitted>

P 192.168.1.0/24, 1 successors, FD is 3012096
        via 192.168.10.10 (3012096/2816), Serial0/0/1
        via 172.16.3.1 (41024256/2170112), Serial0/0/0
```

Feasible distance

Successor's (R3) Reported Distance

Next hop address of the successor

Outbound interface to reach this network

```
R2#show ip eigrp topology
<Output omitted>

P 192.168.1.0/24, 1 successors, FD is 3012096
        via 192.168.10.10 (3012096/2816), Serial0/0/1
        via 172.16.3.1 (41024256/2170112), Serial0/0/0
```

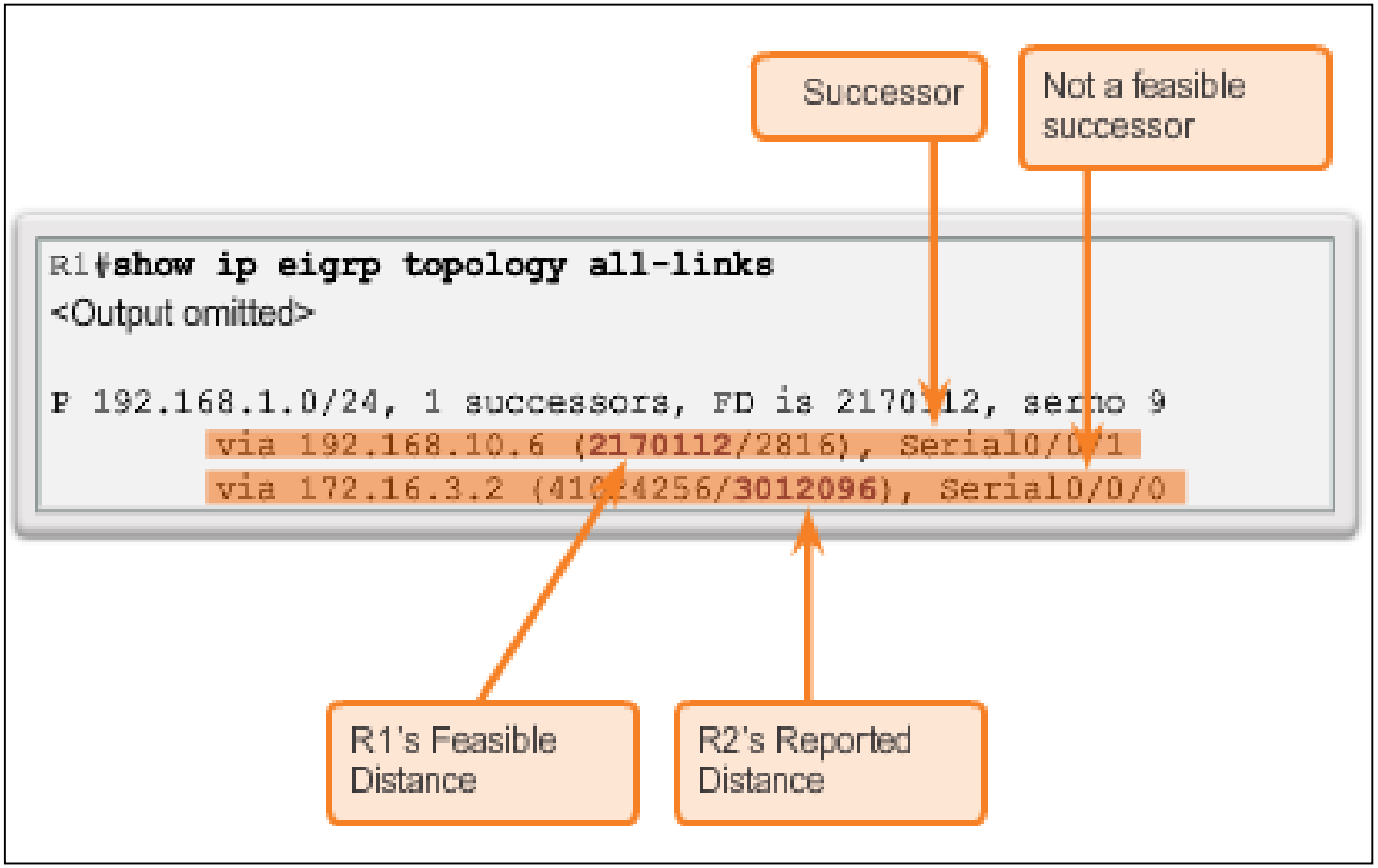
Feasible distance if the feasible successor (R1) was the successor

Outbound interface to reach this network

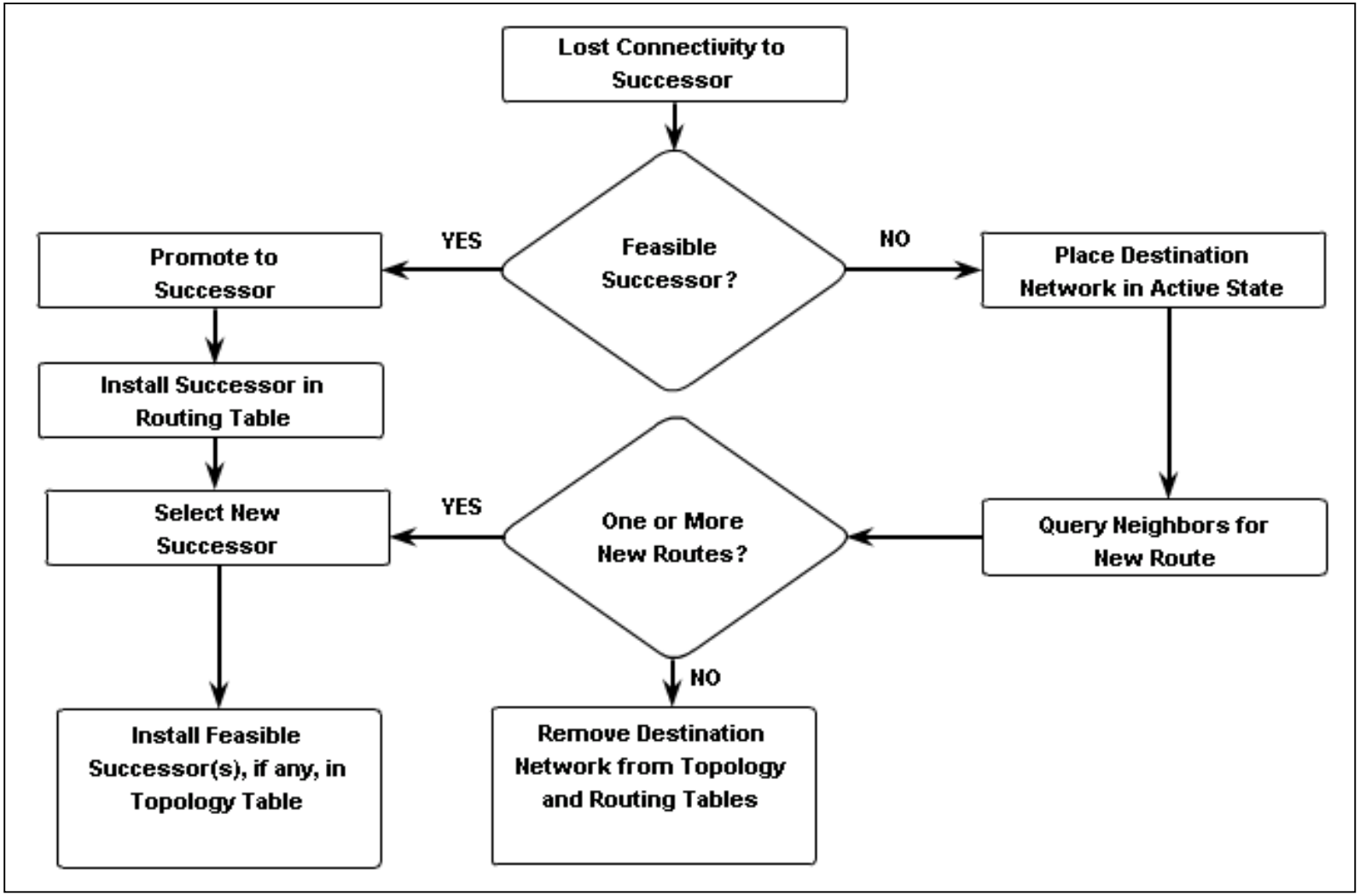
Next hop address of the feasible successor (R1)

Feasible Successor's (R1) Reported Distance

Topology Table: No Feasible Successor



DUAL Finite State Machine (FSM)



DUAL: Feasible Successor

```
R2#debug eigrp fsm
EIGRP Finite State Machine debugging is on
R2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#interface s 0/0/1
R2(config-if)#shutdown
<Output omitted>
EIGRP-IPv4(1):Find FS for dest 192.168.1.0/24. FD is 3012096,
RD is 3012096 on tid 0
DUAL: AS(1) Removing dest 172.16.1.0/24, nexthop 192.168.10.10
DUAL: AS(1) RT installed 172.16.1.0/24 via 172.16.3.1
<Output omitted>
R2(config-if)#end
R2#undebug all
```

```
R2#show ip route
<Output omitted>

D 192.168.1.0/24 [90/41024256] via 172.16.3.1, 00:15:51,
Serial0/0/0
```

New Successor (R1)

DUAL: No Feasible Successor

```
R1#show ip eigrp topology
<Output omitted>

P 192.168.1.0/24, 1 successors, FD is 2170112
        via 192.168.10.6 (2170112/2816), Serial0/0/1
```

Successor (R3)

No feasible successor

```
R1#debug eigrp fsm
EIGRP Finite State Machine debugging is on
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface s 0/0/1
R1(config-if)#shutdown
<Output omitted>
EIGRP-IPv4(1): Find FS for dest 192.168.1.0/24. FD is 2170112,
RD is 2170112
DUAL: AS(1) Dest 192.168.1.0/24 entering active state for tid
0.
EIGRP-IPv4(1): dest(192.168.1.0/24) active
EIGRP-IPv4(1): rcvreply: 192.168.1.0/24 via 172.16.3.2 metric
41024256/3012096 EIGRP-IPv4(1): reply count is 1
EIGRP-IPv4(1): Find FS for dest 192.168.1.0/24. FD is
72057594037927935, RD is 72057594037927935
DUAL: AS(1) Removing dest 192.168.1.0/24, nexthop 192.168.10.6
DUAL: AS(1) RT installed 192.168.1.0/24 via 172.16.3.2
<Output omitted>
R1(config-if)#end
R1#undebug all
```

DUAL: No Feasible Successor

- **Who invented DUAL?**

Configuration of EIGRP for IPv6

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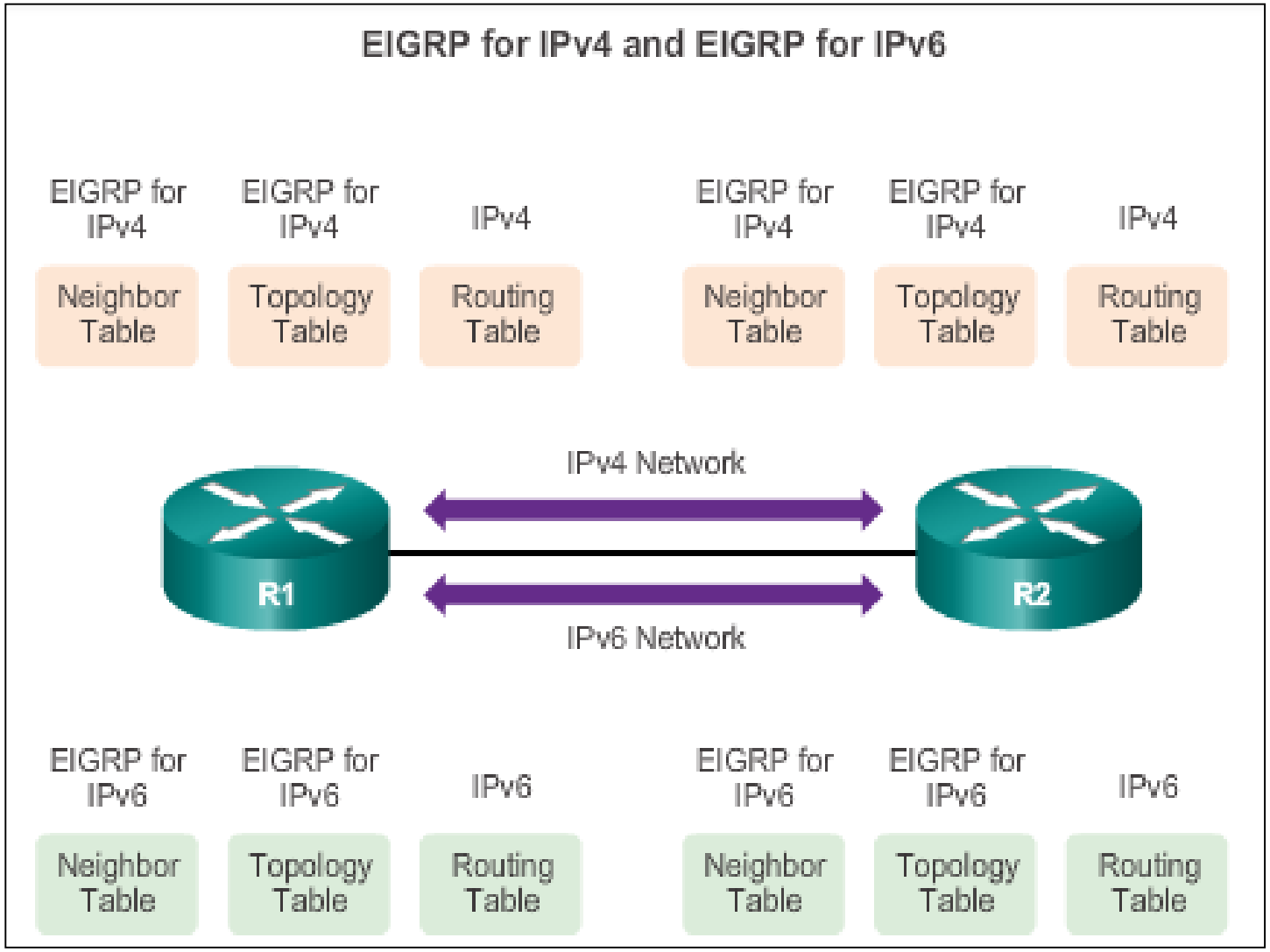
EIGRP for IPv6



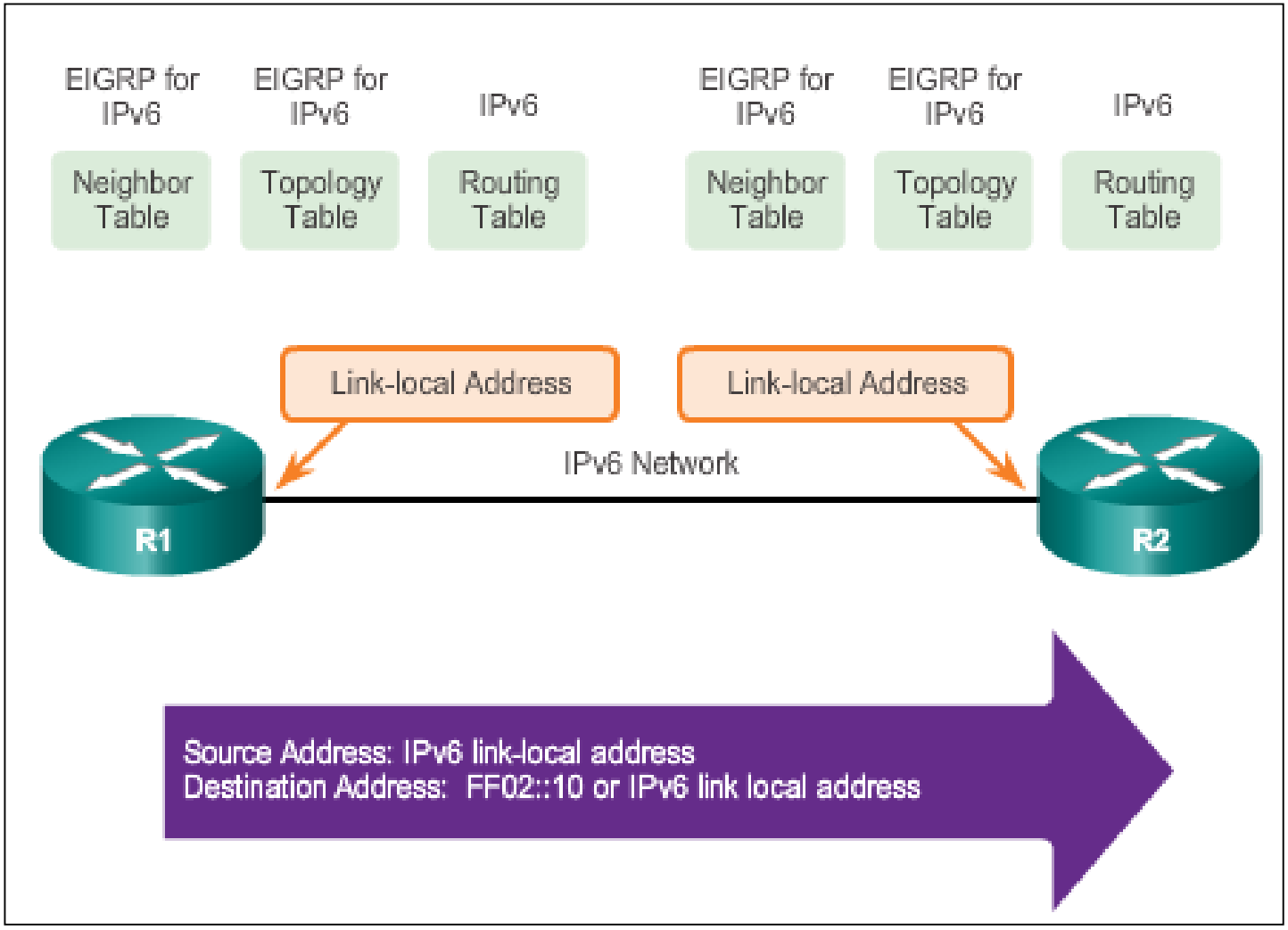
EIGRP for IPv4 vs. IPv6

Comparing EIGRP for IPv4 and IPv6

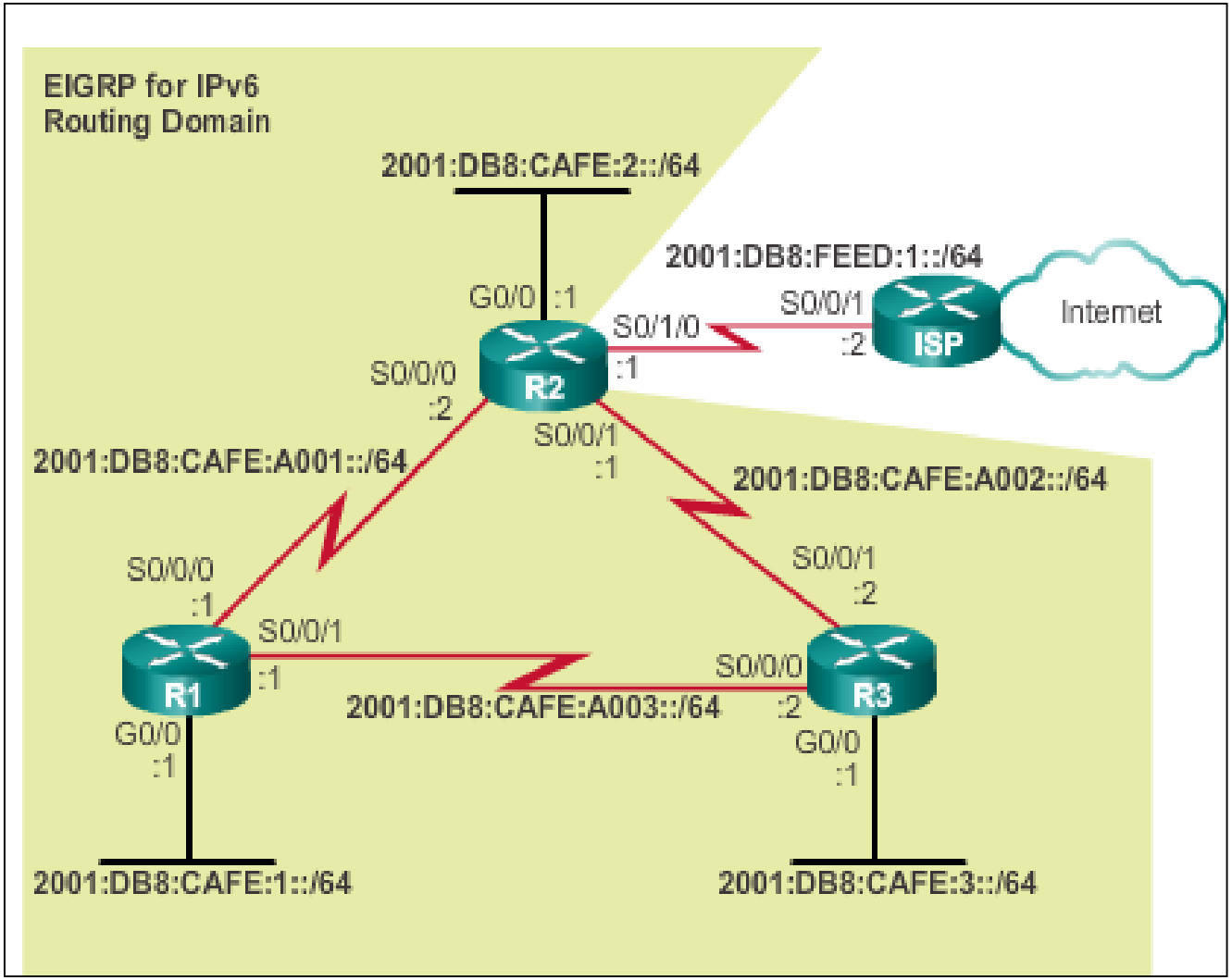
	EIGRP for IPv4	EIGRP for IPv6
Advertised routes	IPv4 networks	IPv6 prefixes
Distance vector	Yes	Yes
Convergence technology	DUAL	DUAL
Metric	Bandwidth and delay by default, reliability and load are optional	Bandwidth and delay by default, reliability and load are optional
Transport protocol	RTP	RTP
Update 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::10 IPv6 multicast destination address
Authentication	Plain text and MD5	MD5
Router ID	32-bit router ID	32-bit router ID

EIGRP for IPv4 vs. IPv6

IPv6 Link-local Addresses



EIGRP for IPv6 Network Topology



Configuring IPv6 Link-Local Addresses

Manually configuring link-local addresses

```
R1(config)#interface s 0/0/0
R1(config-if)#ipv6 address fe80::1 ?
  link-local  Use link-local address

R1(config-if)#ipv6 address fe80::1 link-local
R1(config-if)#exit
R1(config)#interface s 0/0/1
R1(config-if)#ipv6 address fe80::1 link-local
R1(config-if)#exit
R1(config)#interface g 0/0
R1(config-if)#ipv6 address fe80::1 link-local
R1(config-if)#
```

Verifying link-local addresses

```
R1#show ipv6 interface brief
GigabitEthernet0/0      [up/up]
    FE80::1
    2001:DB8:CAFE:1::1
Serial0/0/0             [up/up]
    FE80::1
    2001:DB8:CAFE:A001::1
Serial0/0/1             [up/up]
    FE80::1
    2001:DB8:CAFE:A003::1
R1#
```

Same IPv6 link-local address is configured on all interfaces.

Configuring EIGRP for the IPv6 Routing Process

- The **ipv6 unicast-routing** global configuration mode command is required to enable any IPv6 routing protocol.
- Configuring EIGRP for IPv6

```
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-rtr)#
```

- The **no shutdown** command and a router ID are required for the router to form neighbor adjacencies.

ipv6 eigrp interface Command

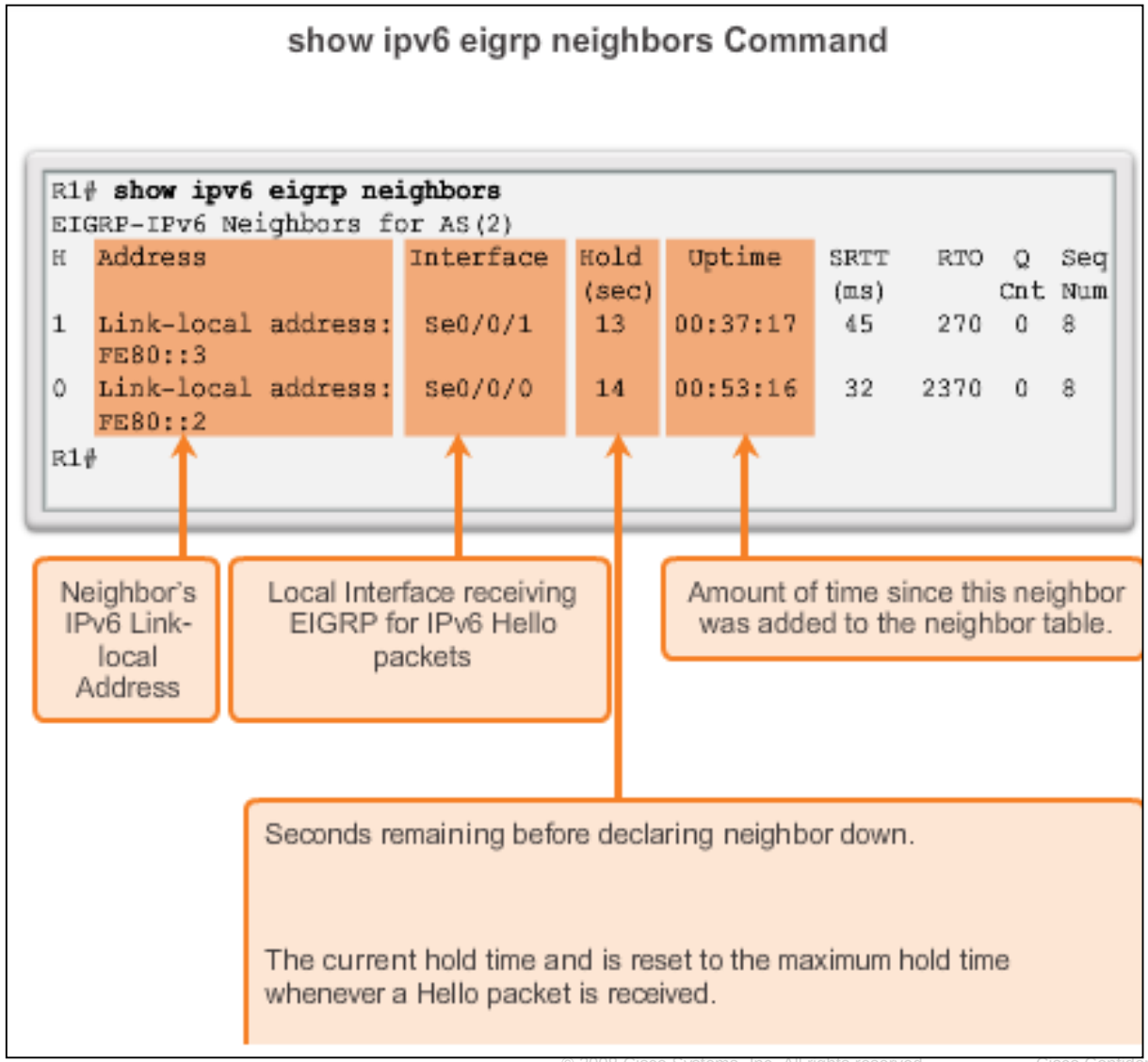
Enabling EIGRP of IPv6 on an Interface

```
R1(config)#interface g0/0
R1(config-if)#ipv6 eigrp 2
R1(config-if)#exit
R1(config)#interface s 0/0/0
R1(config-if)#ipv6 eigrp 2
R1(config-if)#exit
R1(config)#interface s 0/0/1
R1(config-if)#ipv6 eigrp 2
R1(config-if)#
```

```
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
R2(config)#interface s 0/0/1
R2(config-if)#ipv6 eigrp 2
R2(config-if)#
```

Verifying EIGRP for IPv6

Verifying EIGRP for IPv6: Examining Neighbors



Verifying EIGRP for IPv6: `show ip protocols` Command

```
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)                    1  Routing protocol and Process ID (AS Number)

  Metric weight K1=1, K2=0, K3=1, K4=0, K5=0     2  K values used in composite metric

  NSF-aware route hold timer is 240
  Router-ID: 1.0.0.0                             3  EIGRP Router ID
  Topology : 0 (base)
    Active Timer: 3 min
    Distance: internal 90 external 170           4  EIGRP Administrative Distances
    Maximum path: 16
    Maximum hopcount 100
    Maximum metric variance 1

  Interfaces:                                    5  Interfaces enabled for this EIGRP for IPv6.
    GigabitEthernet0/0
    Serial0/0/0
    Serial0/0/1
  Redistribution:
    None
R1#
```

Verifying EIGRP for IPv6: Examine the Routing Table

Use the **`show ipv6 route`** command to examine the IPv6 routing table.

```
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#
```

EIGRP Advanced Configurations

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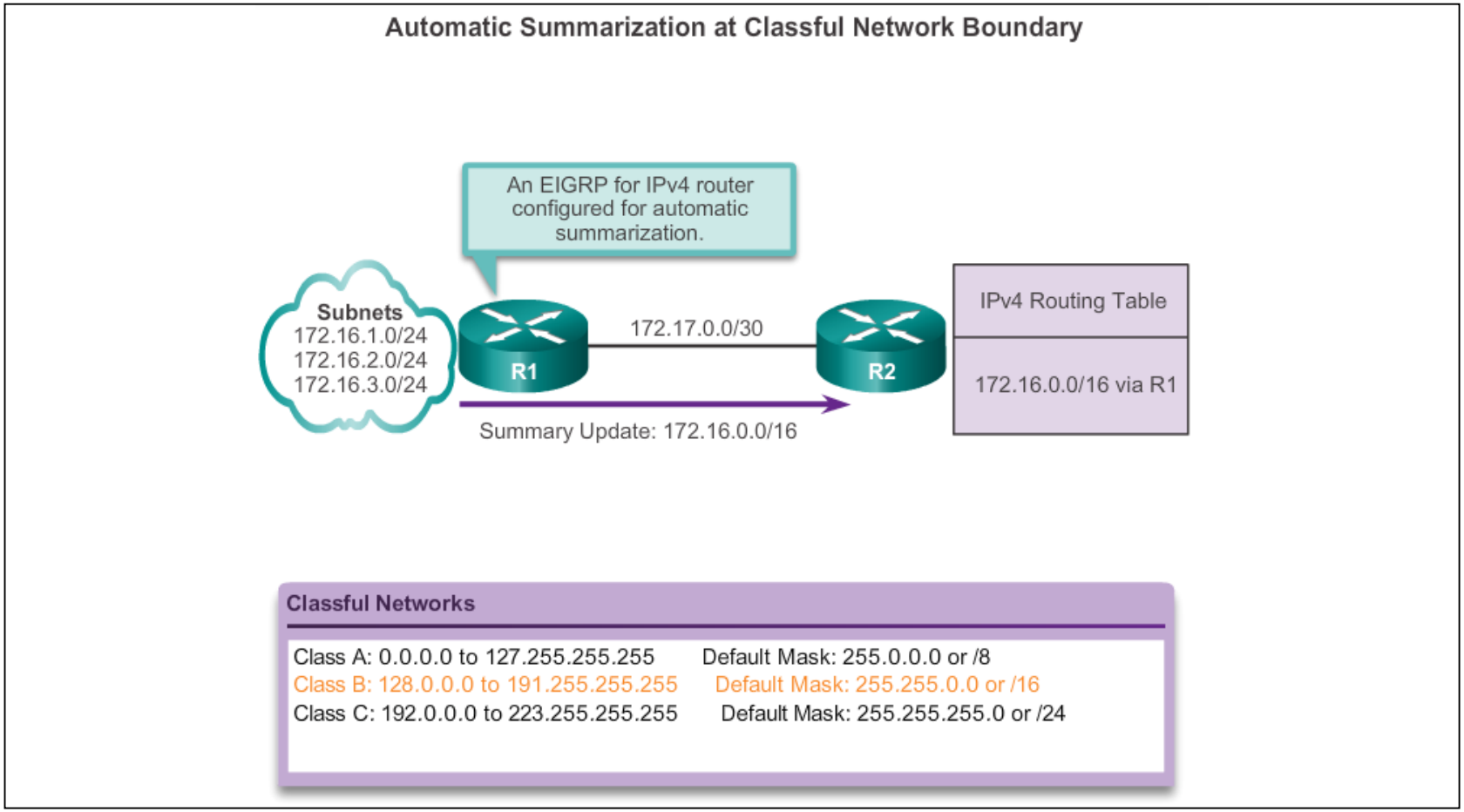
Automatic Summarization

EIGRP Automatic Summarization



Configuring EIGRP Automatic Summarization

- EIGRP for IPv4 automatic summarization is disabled, by default, beginning with Cisco IOS Release 15.0(1)M and 12.2(33). Prior to this, automatic summarization was enabled, by default.
- To enable automatic summarization for EIGRP, use the **auto-summary** command in router configuration mode.

```
R1(config)# router eigrp autonomous-system
R1(config-router)# auto-summary
```

- Use the **no** form of this command to disable autosummarization.

```
R1(config)# router eigrp autonomous-system
R1(config-router)# no auto-summary
```

Verifying Autosummarization: show ip protocols

Verifying Automatic Summarization is Enabled

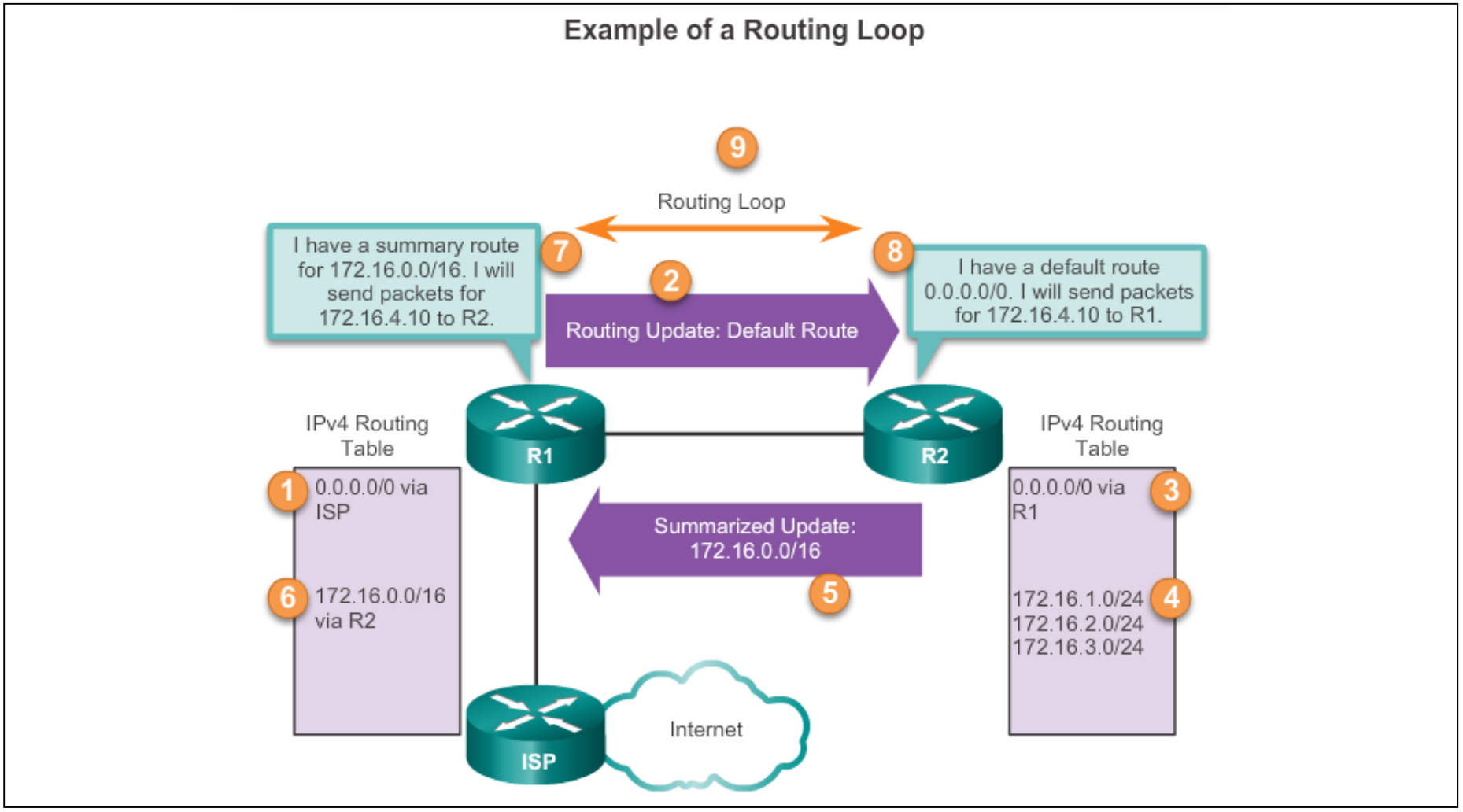
```
R1# show ip protocols
*** IP Routing is NSF aware ***

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
<Output omitted>

Automatic Summarization: enabled
    192.168.10.0/24 for Gi0/0, Se0/0/0
      Summarizing 2 components with metric 2169856
    172.16.0.0/16 for Se0/0/1
      Summarizing 3 components with metric 2816
<Output omitted>
```

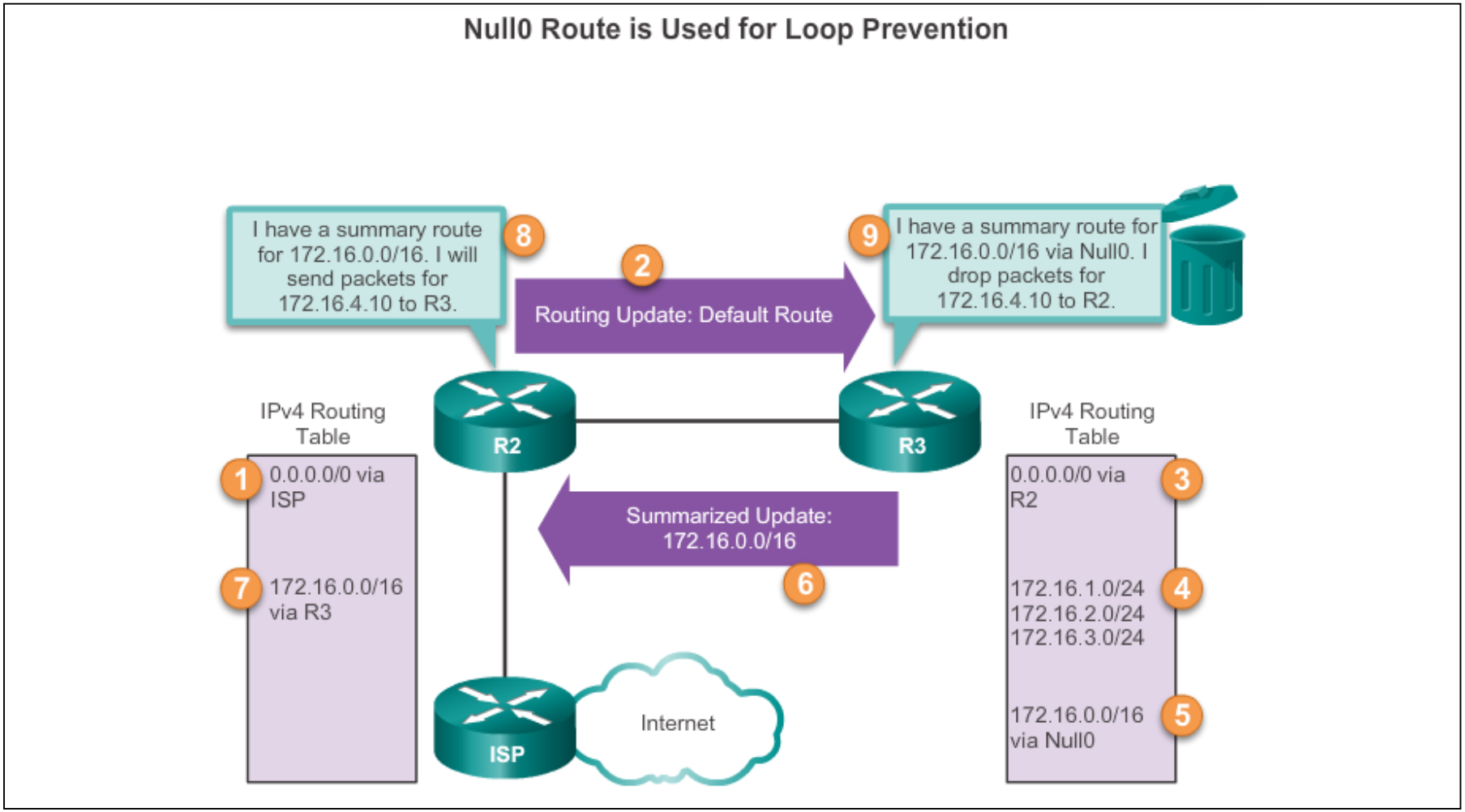
Autosummarization

Summary Route



Autosummarization

Summary Route (cont.)



Manual Summary Routes

- EIGRP can be configured to summarize routes, whether or not autosummarization is enabled.
- Because EIGRP is a classless routing protocol and includes the subnet mask in the routing updates, manual summarization can include supernet routes.
- A supernet is an aggregation of multiple major classful network addresses.

Manual Summarization

Configuring EIGRP Manual Summary Routes

Calculating a Summary Route

```
192.168.1.0: 11000000 . 10101000 . 000000001 . 00000000
192.168.2.0: 11000000 . 10101000 . 000000010 . 00000000
192.168.3.0: 11000000 . 10101000 . 000000011 . 00000000
```

22 matching bits

22 matching bits = a/22 subnet mask or 255.255.252.0

```
R3(config)# interface serial 0/0/0
R3(config-if)# ip summary-address eigrp 1 192.168.0.0
255.255.252.0
R3(config-if)#
```

Configure the summary route on all interfaces that send EIGRP packets.

Manual Summarization

Verifying Manual Summary Routes

Verifying Summary Route Received on R1 and R2

```
R1# show ip route
<Output omitted>

D 192.168.0.0/22 [90/2170112] via 192.168.10.6, 01:53:19, Serial0/0/1
R1#
```

```
R2# show ip route
<Output omitted>

D 192.168.0.0/22 [90/3012096] via 192.168.10.10, 01:53:33, Serial0/0/1
R2#
```

Manual Summarization

EIGRP for IPv6: Manual Summary Routes

IPv6 Manually Summary Configuration on R3

```
R3(config)# interface serial 0/0/0
R3(config-if)# ipv6 summary-address eigrp 2 2001:db8:acad::/48
R3(config-if)# exit
R3(config)# interface serial 0/0/1
R3(config-if)# ipv6 summary-address eigrp 2 2001:db8:acad::/48
R3(config-if)# end

R3# show ipv6 route

D   2001:DB8:ACAD::/48 [5/128256]
     via Null0, directly connected

<Output omitted>
```

Propagating a Default Static Route

- Using a static route to 0.0.0.0/0 as a default route is not routing protocol-dependent.
- The quad zero static default route can be used with any currently supported routing protocols.
- The static default route is usually configured on the router that has a connection to a network outside the EIGRP routing domain, for example, to an ISP.

```
R2(config)# ip route 0.0.0.0 0.0.0.0 serial 0/1/0
R2(config)# router eigrp 1
R2(config-router)# redistribute static
```

Verifying the Propagated Default Route

The entry for the EIGRP-learned default route is identified by the following:

- **D** – This route was learned from an EIGRP routing update.
- ***** – The route is a candidate for a default route.
- **EX** – The route is an external EIGRP route; in this case, a static route outside of the EIGRP routing domain.
- **170** – This is the administrative distance of an external EIGRP route.

```
R1# show ip route | include 0.0.0.0
Gateway of last resort is 192.168.10.6 to network 0.0.0.0
D*EX  0.0.0.0/0 [170/3651840] via 192.168.10.6, 00:25:23,
Serial0/0/1
R1#
```

EIGRP for IPv6- Default Route

```
R2(config)# ipv6 route ::/0 serial 0/1/0
R2(config)# ipv6 router eigrp 2
R2(config-router)# redistribute static
```

Note: Some IOSs may require that the **redistribute static** command include the EIGRP metric parameters and maximum transmission unit (MTU) before the static route can be redistributed. These parameters may vary, but an example for this scenario would be:

```
R2(config)# ipv6 router eigrp 2
R2(config-router)# redistribute static metric 64 2000
255 1 1500
```

EIGRP Bandwidth Utilization

EIGRP Bandwidth for IPv4

- By default, EIGRP uses only up to 50% of an interface's bandwidth for EIGRP information, which prevents the EIGRP process from overutilizing a link and not allowing enough bandwidth for the routing of normal traffic.
- The **ip bandwidth-percent eigrp** command can be used to configure the percentage of bandwidth that may be used by EIGRP on an interface.

```
Router(config-if)# ip bandwidth-percent eigrp as-number
percent
```

EIGRP Bandwidth Utilization (cont.)

EIGRP Bandwidth for IPv6

To configure the percentage of bandwidth that may be used by EIGRP for IPv6 on an interface, use the **ipv6 bandwidth-percent eigrp** command in interface configuration mode. To restore the default value, use the **no** form of this command.

```
Router(config-if)# ipv6 bandwidth-percent eigrp as-number percent
```

Fine-tuning EIGRP Interfaces

Hello and Hold Timers

Configuring EIGRP for IPv4 Hello and Hold Timers

```
R1(config)# interface serial 0/0/0
R1(config-if)# ip hello-interval eigrp 1 60
R1(config-if)# ip hold-time eigrp 1 180
```

Default Hello Intervals and Hold Times for EIGRP

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

Load Balancing IPv4

- Equal-cost load balancing is the ability of a router to distribute outbound traffic using all interfaces that have the same metric from the destination address.
- The Cisco IOS will, by default, allow load balancing using up to four equal-cost paths; however, this can be modified. Using the **maximum-paths** router configuration mode command, up to 32 equal-cost routes can be kept in the routing table.

```
Router(config-router)# maximum-paths value
```

- If the value is set to 1, load balancing is disabled.

Fine-tuning EIGRP Interfaces

Load Balancing IPv6

R3's IPv6 Routing Table

```
R3# show ipv6 route eigrp
<Output omitted>

EX   ::/0 [170/3011840]
      via FE80::2, Serial0/0/1
D    2001:DB8:ACAD::/48 [5/128256]
      via Null0, directly connected
D    2001:DB8:CAFE:1::/64 [90/2170112]
      via FE80::1, Serial0/0/0
D    2001:DB8:CAFE:2::/64 [90/3012096]
      via FE80::2, Serial0/0/1
D    2001:DB8:CAFE:A001::/64 [90/41024000]
      via FE80::2, Serial0/0/1
      via FE80::1, Serial0/0/0
R3#
```

Proprietary protocols

- When did Cisco release a IETF draft for EIGRP?

EIGRP Authentication

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Routing Protocol Authentication Overview

- Network administrators must be aware that routers are at risk from attack just as much as end-user devices. Anyone with a packet sniffer, such as Wireshark, can read information propagating between routers.
- A method to protect routing information on the network is to authenticate routing protocol packets using the Message Digest 5 (MD5) algorithm.
- Routing protocols, such as RIPv2, EIGRP, OSPF, IS-IS, and BGP all support various forms of MD5 authentication.

Secure EIGRP

Configuring EIGRP with MD5 Authentication

EIGRP Authentication with MD5

Step 1: Create a Keychain

```
Router(config)# key chain name-of-chain
Router(config-keychain)# key key-id
Router(config-keychain-key)# key-string key-string-text
```

Step 2: Configure EIGRP Authentication Using Keychain and Key

```
Router(config)# interface type number
Router(config-if)# ip authentication mode eigrp as-number md5
Router(config-if)# ip authentication key-chain eigrp as-number
name-of-chain
```

Secure EIGRP

EIGRP Authentication Example

Configuring EIGRP MD5 Authentication on R1

```
R1(config)# key chain EIGRP_KEY
R1(config-keychain)# key 1
R1(config-keychain-key)# key-string cisco123
R1(config-keychain-key)# exit
R1(config-keychain)# exit
R1(config)# interface serial 0/0/0
R1(config-if)# ip authentication mode eigrp 1 md5
R1(config-if)# ip authentication key-chain eigrp 1 EIGRP_KEY
R1(config-if)# exit
R1(config)# interface serial 0/0/1
R1(config-if)# ip authentication mode eigrp 1 md5
R1(config-if)# ip authentication key-chain eigrp 1 EIGRP_KEY
R1(config-if)# end
R1#
```

EIGRP Authentication Example (cont.)

Configuring EIGRP for IPv6 MD5 Authentication on R1

```
R1(config)# key chain EIGRP_IPV6_KEY
R1(config-keychain)# key 1
R1(config-keychain-key)# key-string cisco123
R1(config-keychain-key)# exit
R1(config-keychain)# exit
R1(config)# interface serial 0/0/0
R1(config-if)# ipv6 authentication mode eigrp 2 md5
R1(config-if)# ipv6 authentication key-chain eigrp 2
               EIGRP_IPV6_KEY
R1(config-if)# exit
R1(config)# interface serial 0/0/1
R1(config-if)# ipv6 authentication mode eigrp 2 md5
R1(config-if)# ipv6 authentication key-chain eigrp 2
               EIGRP_IPV6_KEY
R1(config-if)#
```

Secure EIGRP

Verifying Authentication

- Adjacencies are only formed when both connecting devices have authentication configured.
- To verify that the correct EIGRP adjacencies were formed after being configured for authentication, use the **show ip eigrp neighbors** command on each router.
- To verify the neighbor adjacencies EIGRP for IPv6, use the **show ipv6 eigrp neighbors** command.