Chapter 7: Enhanced Interior Gateway Protocol (EIGRP)

Scaling Networks

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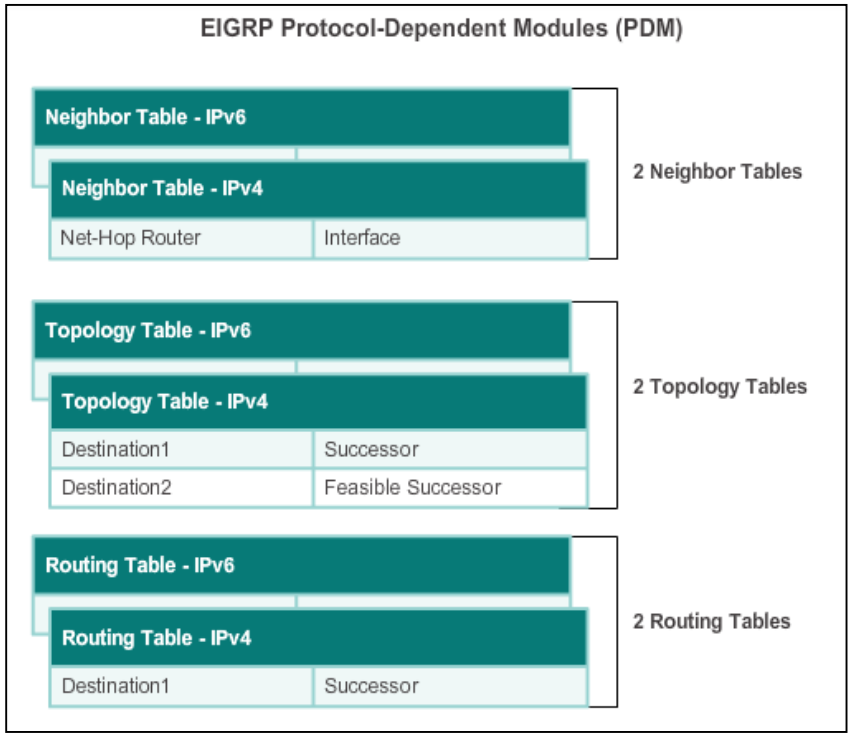
Features of EIGRP

- 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.

Protocol Dependent Modules

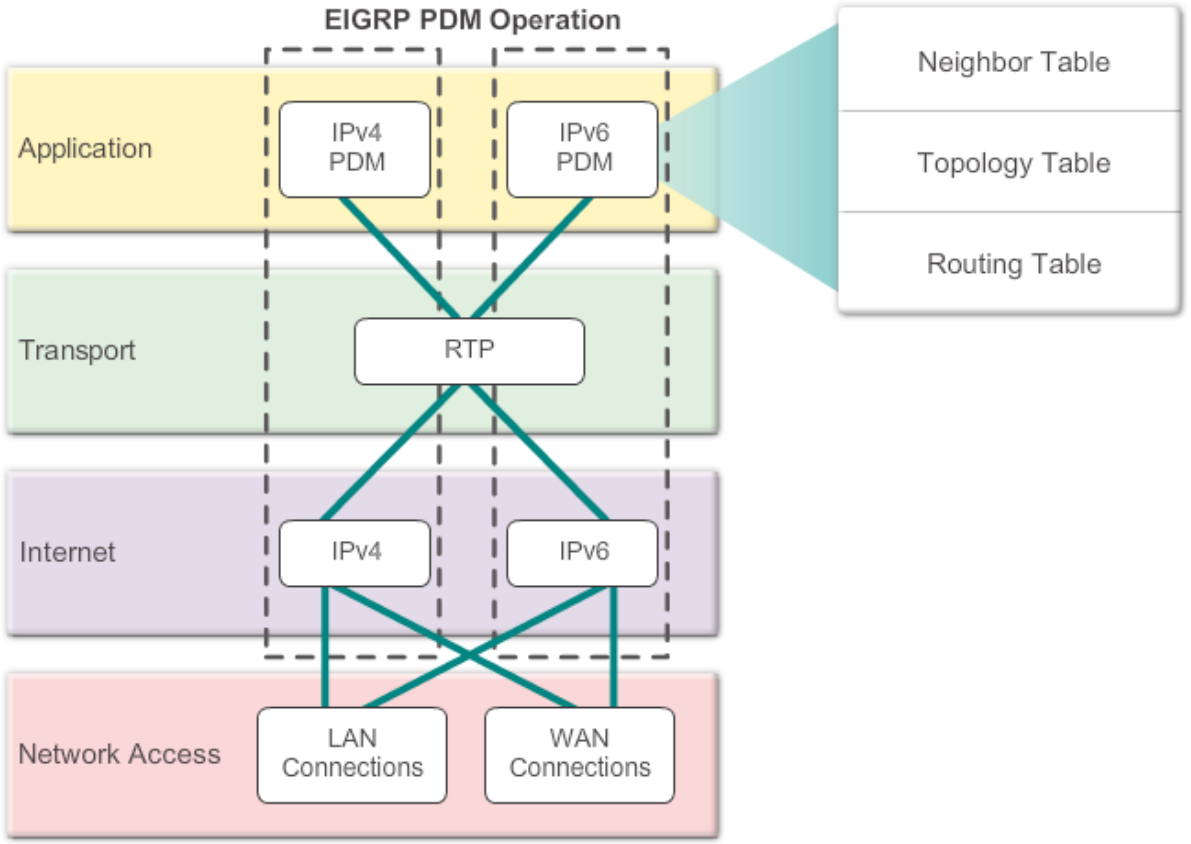
EIGRP:ssä tallennetaan kolme eri reititystaulua

- **Naapuri-informaatio / Neighbor table**
  - mm. naapurien osoitteet ja ”local interface”
  - *show ip eigrp neighbors*
- **Naapureilta opittu topologiainformaatio / Topology table**
  - Kaikki omat ja naapurien verkot
    - metric-arvot ja liitynnät kohdeverkkoihin
  - *Show ip eigrp topology*
- **Varsinainen reititystaulu / Routing table**
  - *Show ip route*



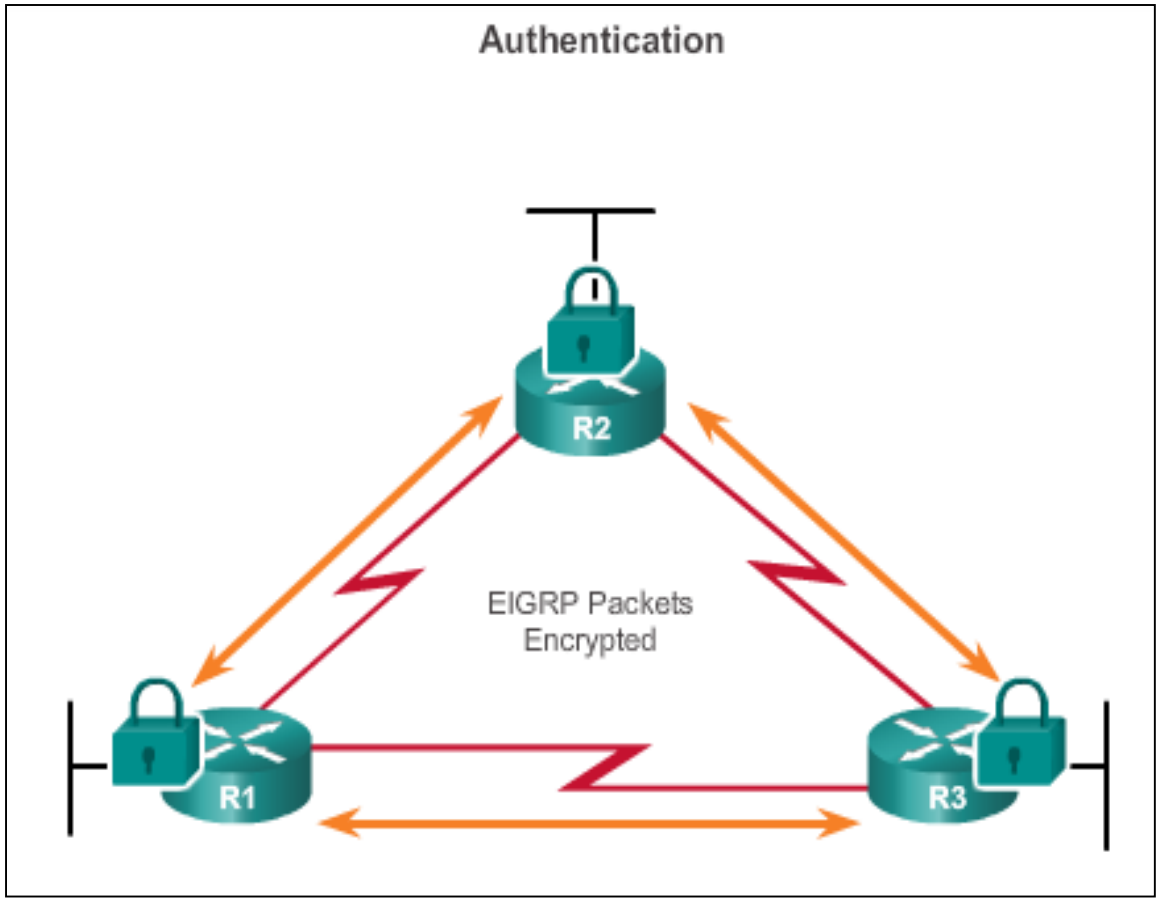
Reliable Transport Protocol

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

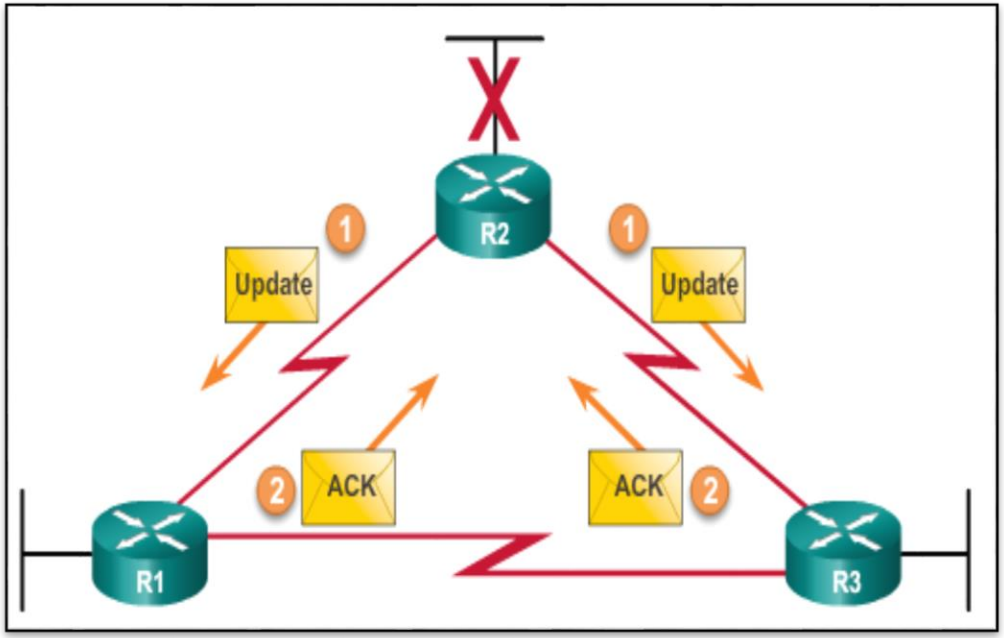
Packet Type	Description
Hello	Used to discover other EIGRP routers in the network.
Acknowledgement	Used to acknowledge the receipt of any EIGRP packet.
Update	Convey routing information to known destinations.
Query	Used to request specific information from a neighbor router.
Reply	Used to respond to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

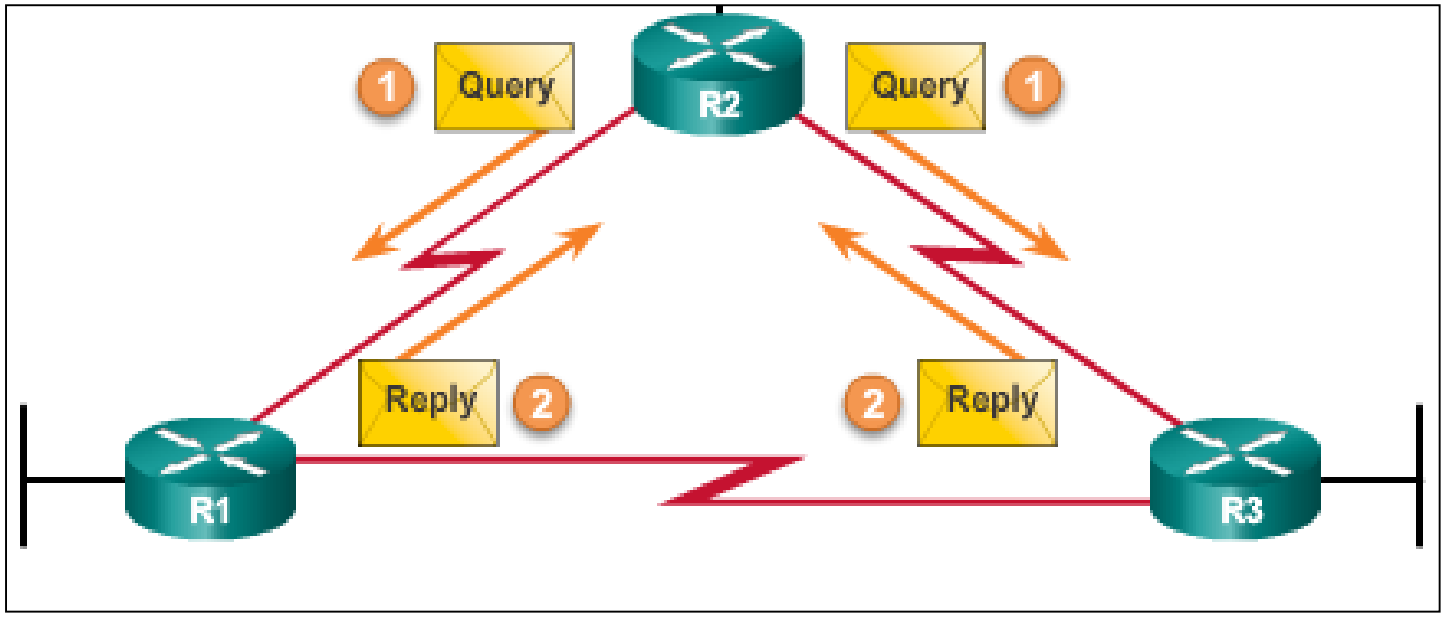
EIGRP Update & Acknowledgement Packets

- 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

- Query used to query routes from neighbors.
- Replay sent in response to an EIGRP query
- Both packets use reliable delivery.



7.2 Configuring EIGRP for IPv4

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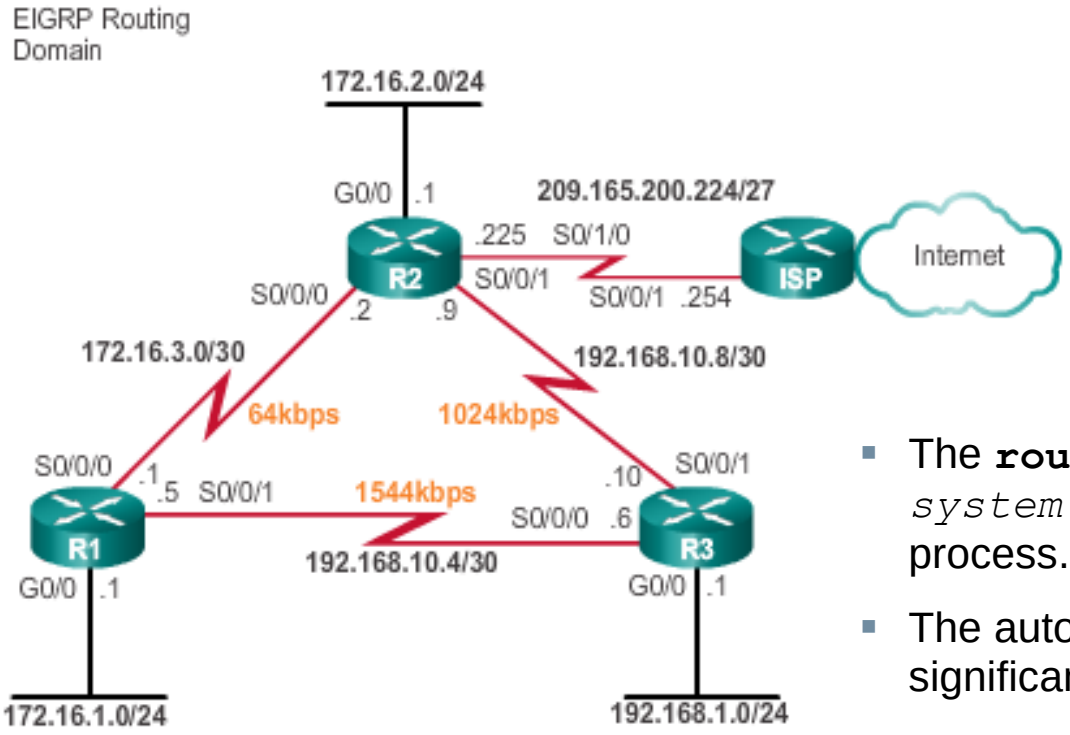
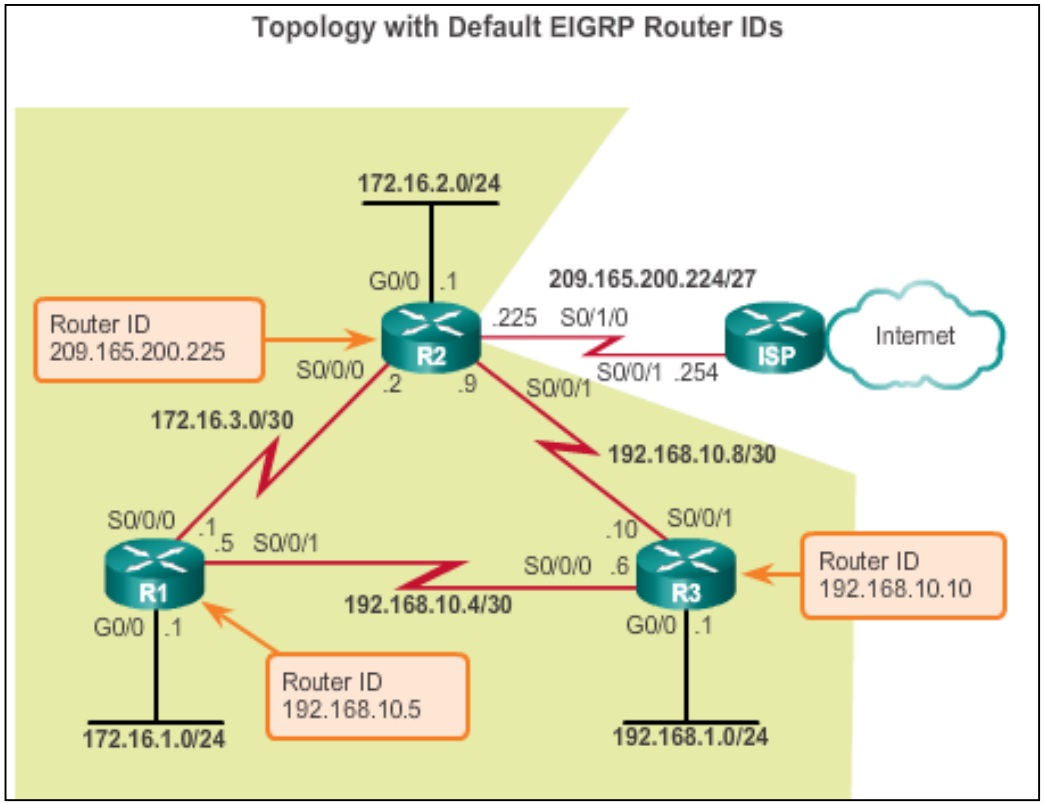
EIGRP Network Topology



- The **`router eigrp`** *`autonomous-system`* command enables the EIGRP process.
- The autonomous system number is only significant to the EIGRP routing domain.

EIGRP Router ID



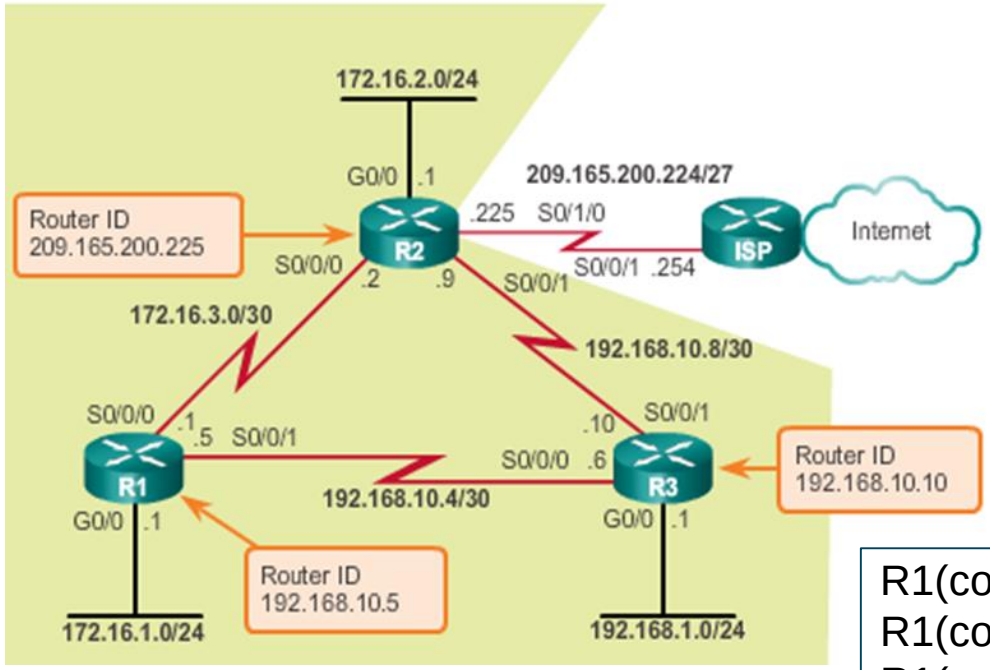
- Configuring the EIGRP router ID

  ```
  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.
- The IPV4 interface address can be used as the router ID

Network Command




```
R1(config)#router eigrp 1
R1(config-router)#network 172.16.0.0
R1(config-router)#network 192.168.10.0
R1(config-router)#
```

tai …

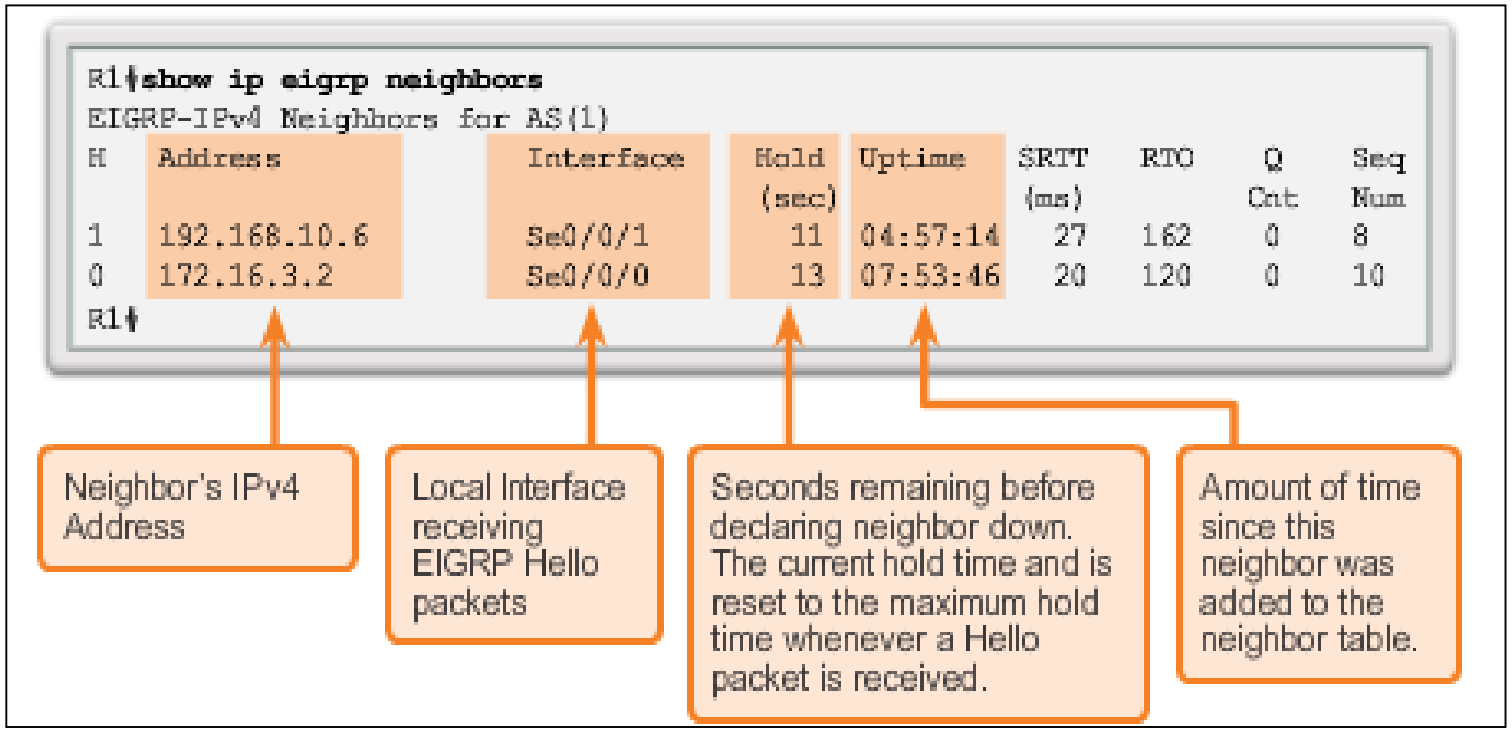
```
R1(config)#router eigrp 1
R1(config-router)#network 172.16.1.0 0.0.0.255
R1(config-router)#network 172.16.3.0 0.0.0.255
R1(config-router)#network 192.168.10.4 0.0.0.3
R1(config-router)#
```

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

- 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

Verifying EIGRP: Examining Neighbors



Q Count: Number of EIGRP packets (update, query, and reply) that the software is waiting to send.

Seq Num: Sequence number of the last update, query, or reply packet that was received from this neighbor.

SRTT: Smooth round-trip time. This is the number of milliseconds required for an EIGRP packet to be sent to this neighbor and for the local router to receive an acknowledgment of that packet.

RTO: Retransmission timeout (in milliseconds). This is the amount of time the software waits before resending a packet from the retransmission queue to a neighbor.

Configuring EIGRP with IPv4

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#
```

7.3 Operation of EIGRP

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EIGRP Composite Metric

Default Composite Formula:

metric = [K1*bandwidth + K3*delay] * 256

Complete Composite Formula:

metric = [K1*bandwidth + (K2*bandwidth) / (256 - load) + K3*delay] * [K5 / (reliability + K4)]

(Not used if "K" values are 0)

Note: This is a conditional formula. If K5 = 0, the last term is replaced by 1 and the formula becomes: Metric = [K1*bandwidth + (K2*bandwidth) / (256-load) + K3*delay] * 256

Default Values:
K1 (bandwidth) = 1
K2 (load) = 0
K3 (delay) = 1
K4 (reliability) = 0
K5 (reliability) = 0

"K" values can be changed with the command shown below.

```
Router(config-router)# metric weights tos k1 k2 k3 k4 k5
```

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>
```

Delay Metric

Interface Delay Values

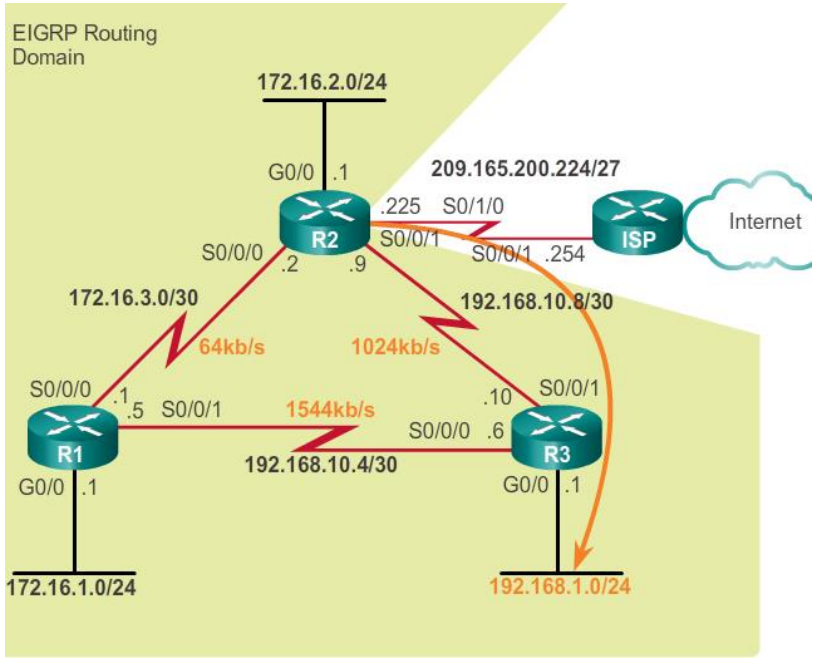
Media	Delay
Ethernet	1,000
Fast Ethernet	100
Gigabit Ethernet	10
16M Token Ring	630
FDDI	100
T1 (Serial Default)	20,000
DS0 (64 kb/s)	20,000
1024 kb/s	20,000
56 kb/s	20,000

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.



[K1 * bandwidth + K3 * delay] * 256 = Metric

Since K1 and K3 both equal 1, the formula simplifies to:

(Bandwidth + Delay) * 256 = Metric

((10,000,000 / bandwidth) + (sum of delay / 10)) * 256 = Metric

```
R2# show ip route

D 192.168.1.0/24 [90/3012096] via 192.168.10.10, 00:12:32, Serial0/0/1
```

B=10000000/1024

D=(20000+10)/10

(Bandwidth + Delay) * 256 = Metric

(9765 + 2001) * 256 = 3,012,096

DUAL Concepts

- EIGRP uses the Diffusing Update Algorithm (DUAL) to provide the best loop-free path and loop-free backup paths.
- **DUAL** provides the following:
  - Loop-free paths and loop-free backup paths
  - Fast convergence
  - Minimum bandwidth usage with bounded updates
  - EIGRP maintains a list of backup routes that DUAL has already determined that can be used immediately if the primary path fails.
- DUAL uses several terms

  Successor

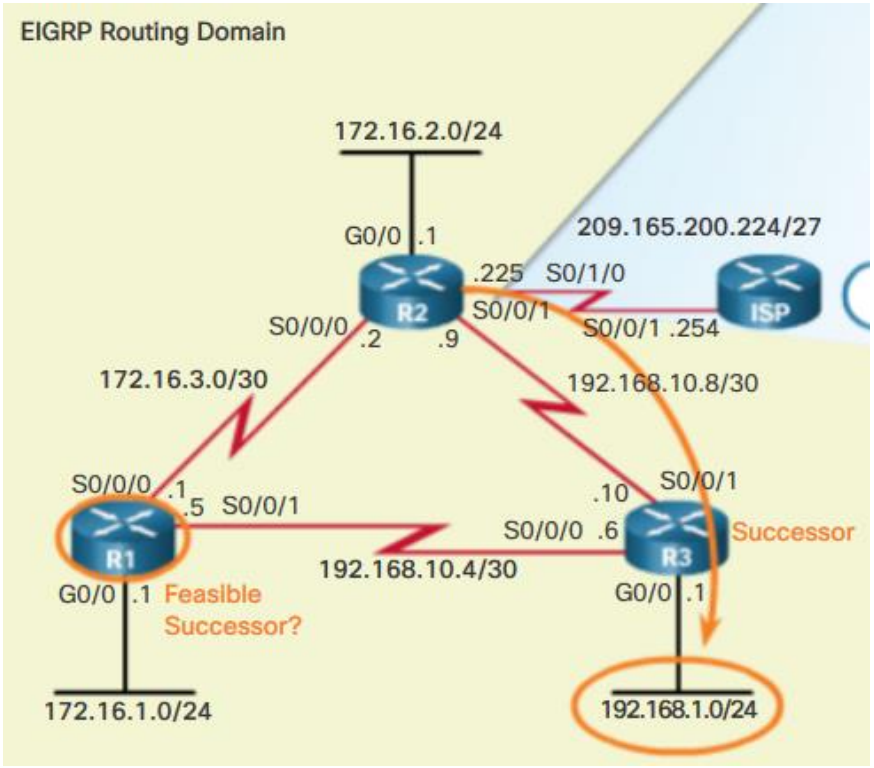
  Feasible Distance (FD)

  Feasible Successor (FS)

  Reported Distance (RD) or Advertised Distance (AD)

  Feasible Condition or Feasibility Condition (FC)

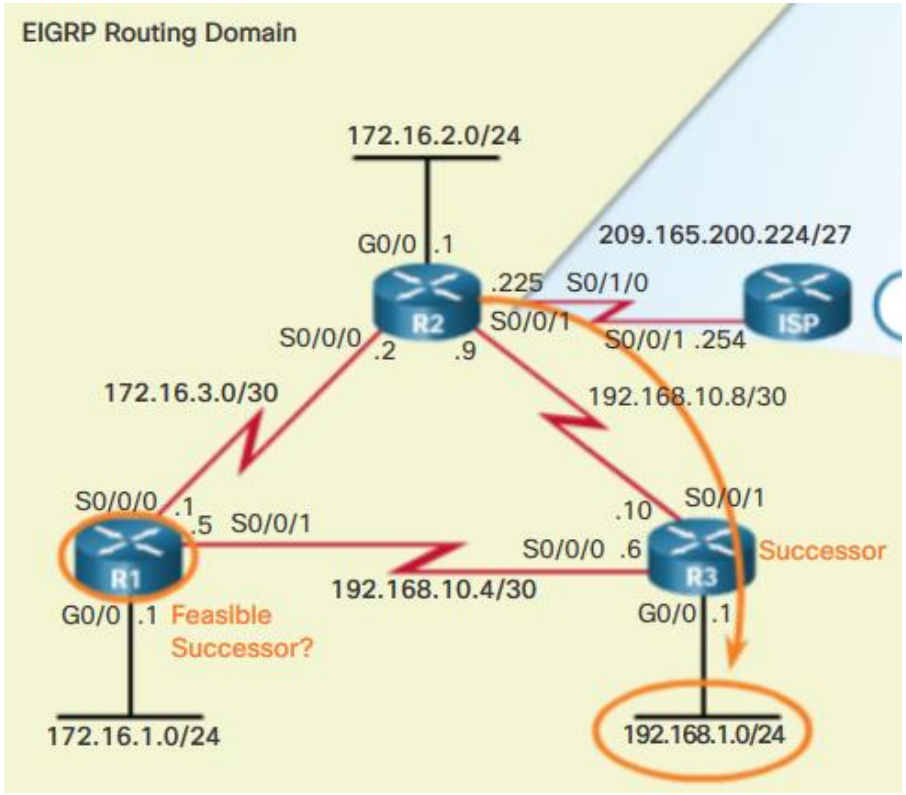
Successor and Feasible Distance

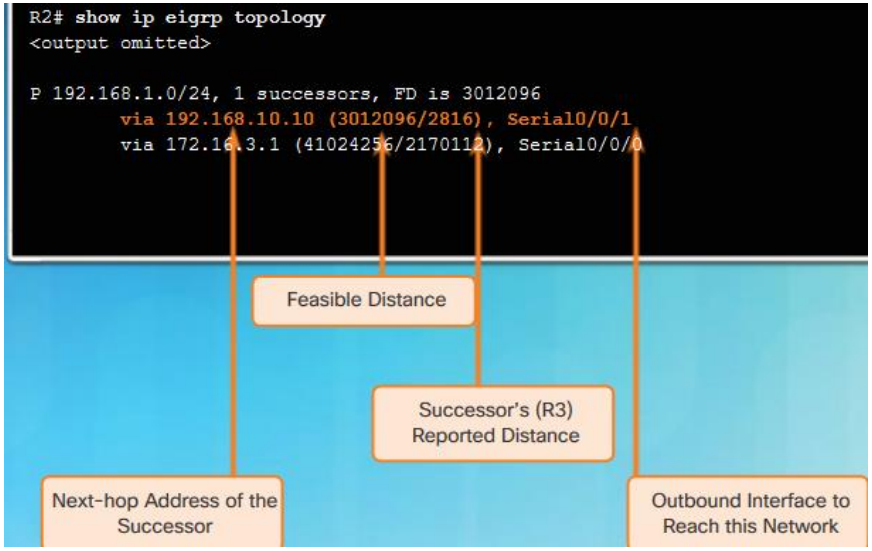


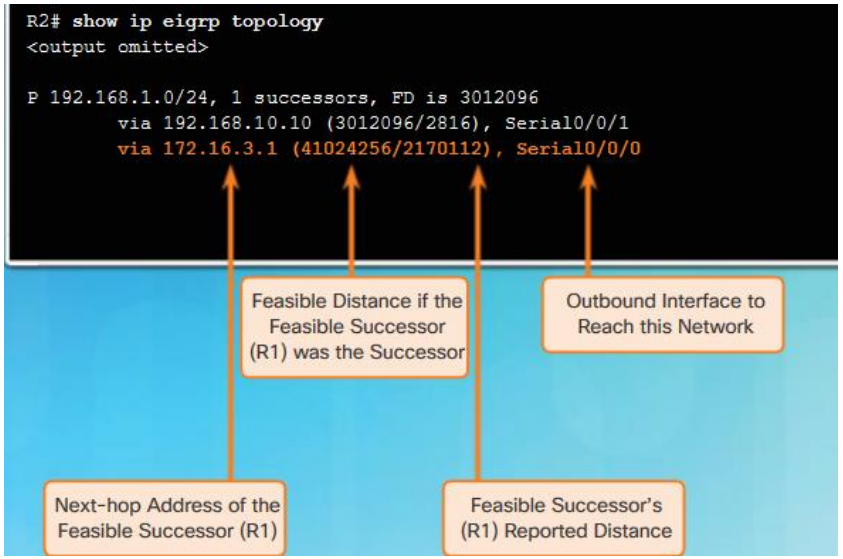
Feasible Successors, Feasibility Condition, and Reported Distance

- **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).
- **Reported Distance** (RD) is an EIGRP neighbor's feasible distance to the same destination network.
- **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.

Feasible Successors, Feasibility Condition, and Reported Distance







No Feasible Successor