Chapter 9

Enhanced Interior Gateway Routing Protocol (EIGRP)

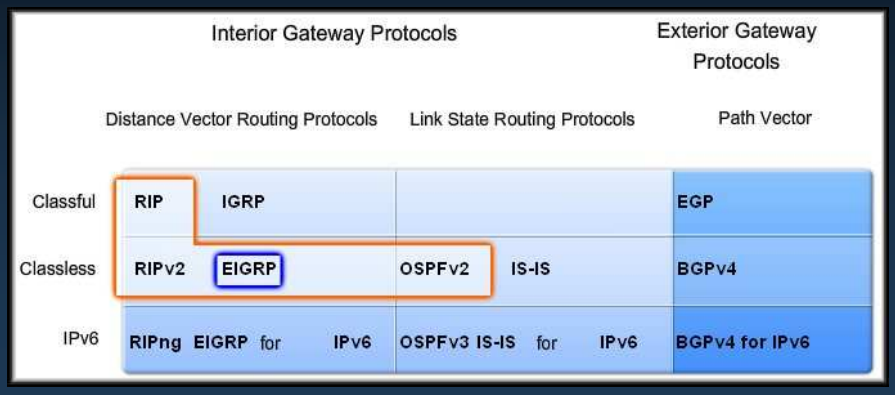
Part I

Note for Instructors

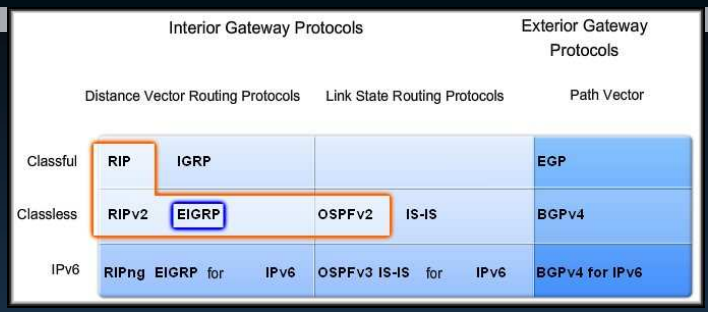
- These presentations are the result of a collaboration among the instructors at St. Clair College in Windsor, Ontario.
- Thanks must go out to Rick Graziani of Cabrillo College. His material and additional information was used as a reference in their creation.
- If anyone finds any errors or omissions, please let me know at:
  - tdame@stclaircollege.ca.

EIGRP

Introduction to EIGRP

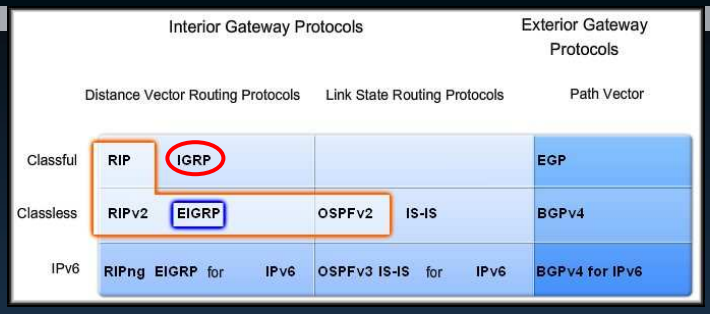


Roots of EIGRP



- Enhanced Interior Gateway Routing Protocol (EIGRP) is a Distance Vector, Classless routing protocol.
  - Released in 1992 with Cisco IOS Software Release 9.21.
  - Enhancement of Cisco's Interior Gateway Routing Protocol (IGRP).
  - Both are Cisco proprietary protocols and operate only on Cisco routers.

Roots of EIGRP

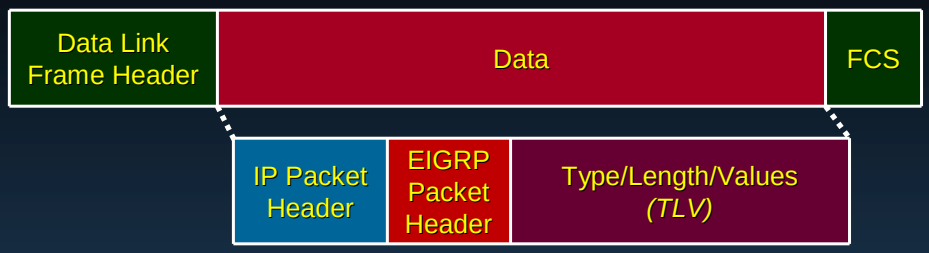


- *Cisco's Interior Gateway Routing Protocol (IGRP) has been **discontinued** and is no longer supported by Cisco.*

Roots of EIGRP

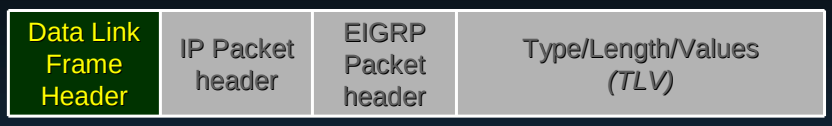
Traditional Distance Vector Routing Protocols	Enhanced Distance Vector Routing Protocol: EIGRP
Uses the Bellman-Ford or Ford-Fulkerson algorithm.	Uses DUAL.
Ages out routing entries and uses periodic updates.	Does not age out routing entries or use periodic updates.
Keeps track of only the best routes; the best path to a destination network.	Maintains a topology table separate from the routing table, which includes the best path and any loop-free backup paths.
When a route becomes unavailable, the router must wait for a new routing update.	When a route becomes unavailable, DUAL uses a backup path if one exists in the topology table.
Slower convergence due to hold-down timers.	Faster convergence because of the absence of hold-down timers and a system of coordinated route calculations.

EIGRP Message Format



- The EIGRP frame is encapsulated just like any other frame on an Ethernet network.
  - Like any other protocol, the content of the fields themselves is important to the proper functioning of EIGRP.

EIGRP Message Format



- **Data Link Frame Header:**
  - **Source MAC Address:**
    - The MAC address of the sending interface.
  - **Destination MAC Address:**
    - The multicast address **10-00-05-00-00-0A**.
- Unlike a RIP broadcast, EIGRP **multicasts** its frames using a specific multicast address. Only those hosts on the network (other routers) listening on that address will accept the frame.

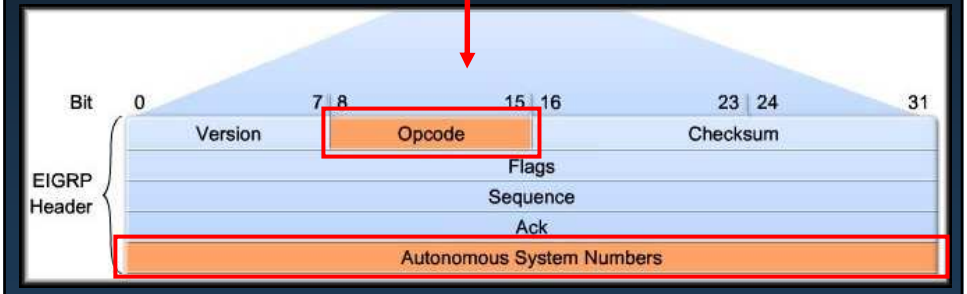
EIGRP Message Format

Data Link Frame Header	IP Packet header	EIGRP Packet header	Type/Length/Values *(TLV)*

- IP Packet Header:
  - Source IP Address:
    - The IP Address of the sending interface.
  - Destination IP Address:
    - The multicast address 224.0.0.10.
  - Protocol Field:
    - 88 for EIGRP.

EIGRP Message Format

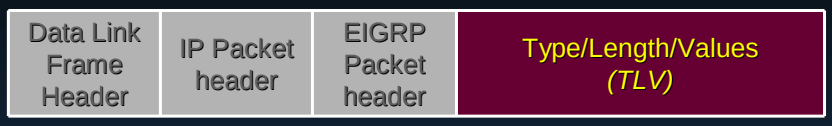
Data Link Frame Header	IP Packet header	EIGRP Packet header	Type/Length/Values *(TLV)*



EIGRP Message Format

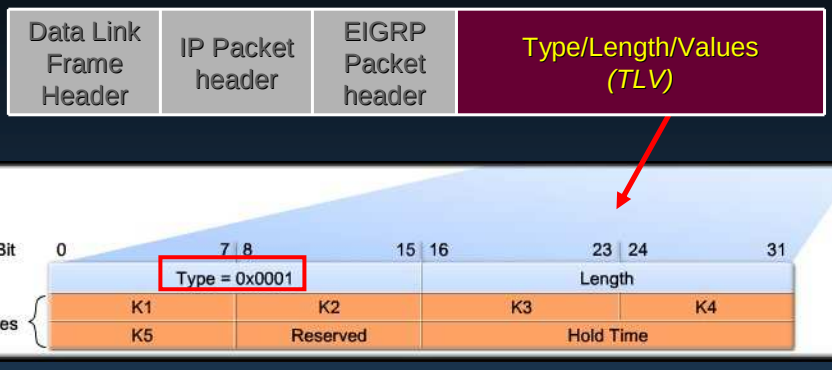
- EIGRP Packet Header:
  - Opcode:
    - Specifies the type of EIGRP packet.
      - Update, Query, Reply, Hello
  - Autonomous System Number:
    - Specifies the EIGRP routing process. Unlike RIP, routers using EIGRP can have multiple instances of EIGRP running concurrently.

EIGRP Message Format



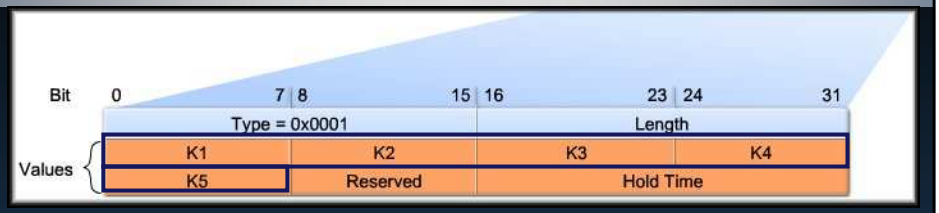
- The Type/Length/Values (TLV) field is used to convey different EIGRP information and/or parameters.
- Each is distinguished by a specific 4 byte hexadecimal type code.
- We will be discussing:
  - Type 0x0001 – EIGRP Parameters
  - Type 0x0002 – IP Internal Routes
  - Type 0x0003 – IP External Routes

EIGRP Message Format



- Type 0x0001 – EIGRP Parameters:
  - Contains information regarding the metric and the hold time for the route to the receiving neighbour.

EIGRP Message Format

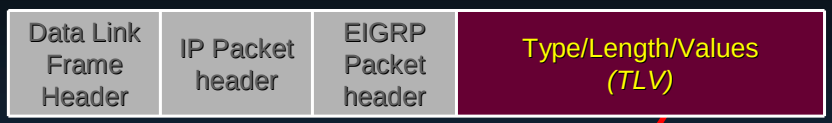


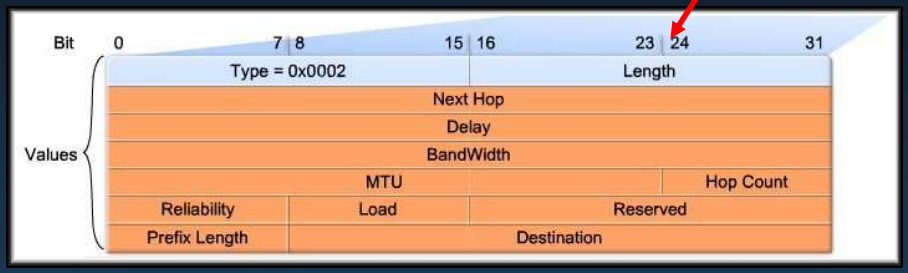
- RIP uses hop count to provide the metric used to determine the best path to a destination.
- EIGRP weighs bandwidth, delay, reliability and load to produce a composite metric value.
- These weights are included in the "K" value fields.
  - K1 (Bandwidth) and K3 (Delay) default to 1.
  - Others default to 0.

EIGRP Message Format

- **Hold Time:**
  - The amount of time that the EIGRP router receiving this message should wait in between messages.
  - If this timer expires before another EIGRP message is received, the receiving router will consider the sending router to be down.

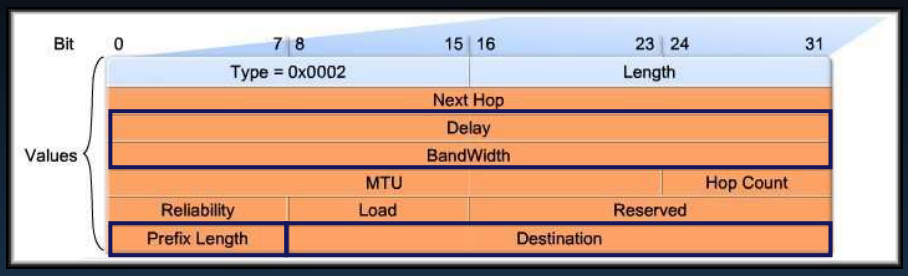
EIGRP Message Format





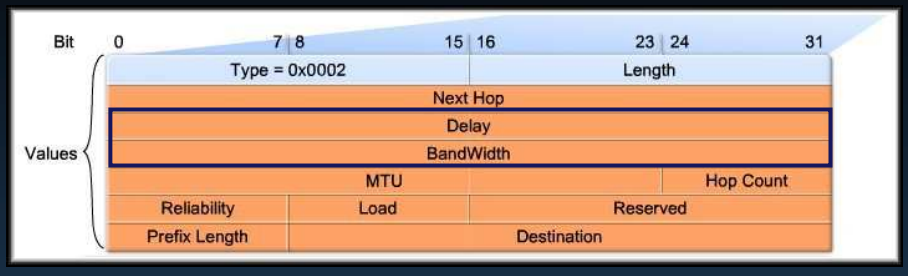
- **Type 0x0002 – IP Internal Routes:**
  - This message is used to advertise EIGRP routes **within an Autonomous System**.

EIGRP Message Format



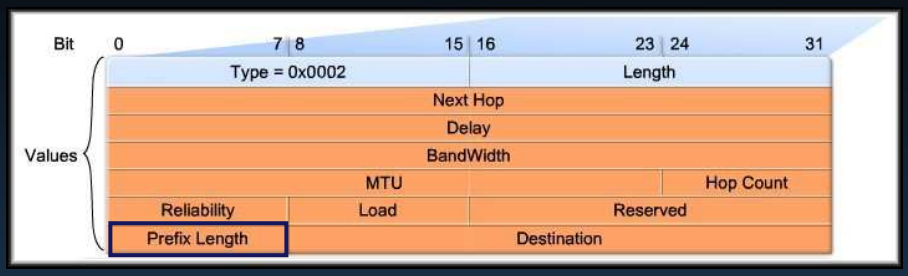
- We will be concerned with:
  - The metric fields Delay and Bandwidth.
  - Prefix Length.
  - Destination.

EIGRP Message Format



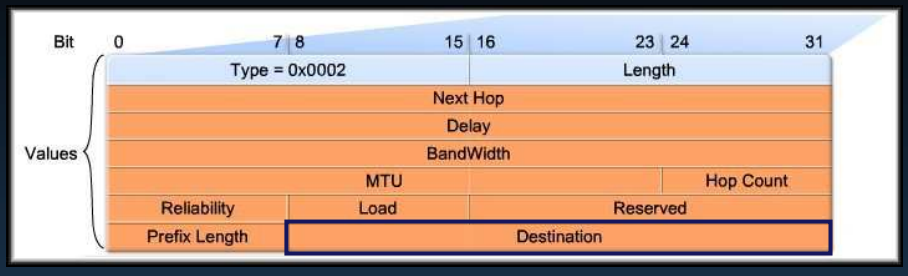
- Delay and Bandwidth:
  - Delay is calculated as the sum of delays from source to destination in units of 10 microseconds.
  - Bandwidth is the lowest configured bandwidth of any interface along the route.

EIGRP Message Format



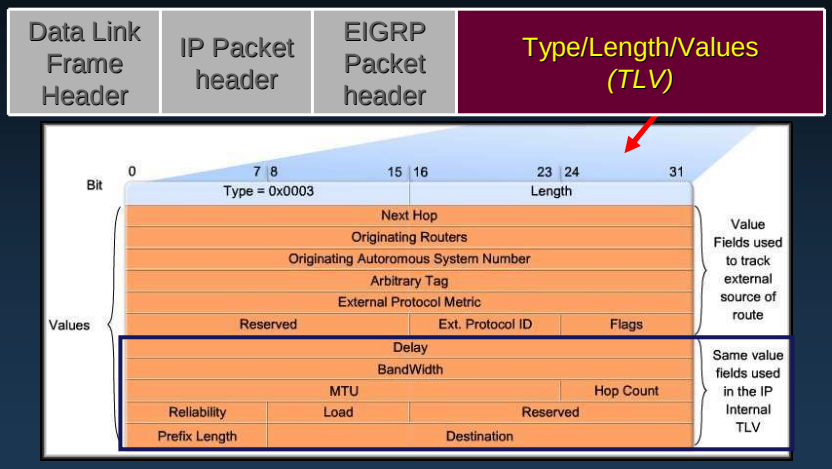
- **Prefix Length:**
  - Essentially, the subnet mask.
  - Subnet mask of 255.255.255.0 has a prefix length of 24.

EIGRP Message Format



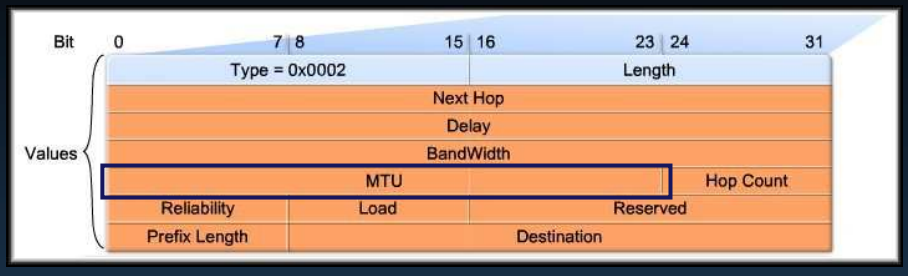
- **Destination:**
  - The destination network.
  - Because the minimum length of this field is 24 bits, the remainder of the field is padded with 0s.
  - If a network address is longer than 24 bits (192.168.1.32/27), the field is extended for another 32 bits and the unused bits are padded with 0s.

EIGRP Message Format



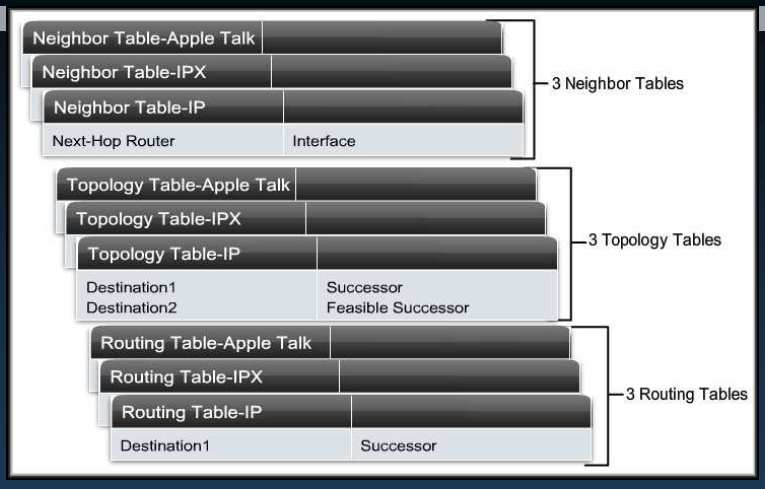
- Type 0x0003 – IP External Routes
  - Routes received from outside the AS.

EIGRP Message Format



- Note on MTU:
  - Some EIGRP literature might incorrectly state that the maximum transmission unit (MTU) is one of the metrics used by EIGRP.
  - While it is included in the routing update, the MTU is not part of the metric used by EIGRP.

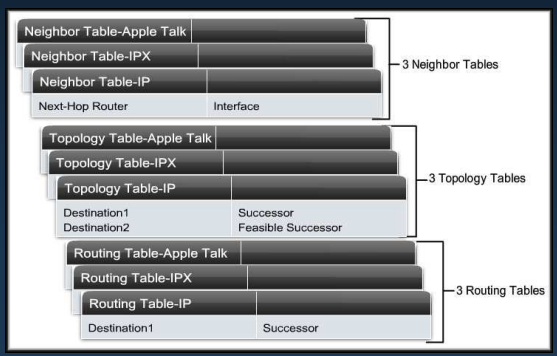
Protocol-Dependant Modules



- **Protocol-Dependant Modules** are responsible for the specific routing tasks for each network layer protocol.

Protocol-Dependant Modules

- Each PDM keeps route and topology information readily available in RAM so it can react quickly to changes.
  - It saves this information in three tables.
    - Neighbour Table
    - Topology Table
    - Routing Table



Protocol-Dependant Modules

- Neighbor Table:
  - Lists all adjacent or neighbour routers.
- Topology Table:
  - Includes route entries for all destinations that the router has learned.
- Routing Table:
  - EIGRP chooses the best routes to a destination from the topology table and places these routes in the routing table.

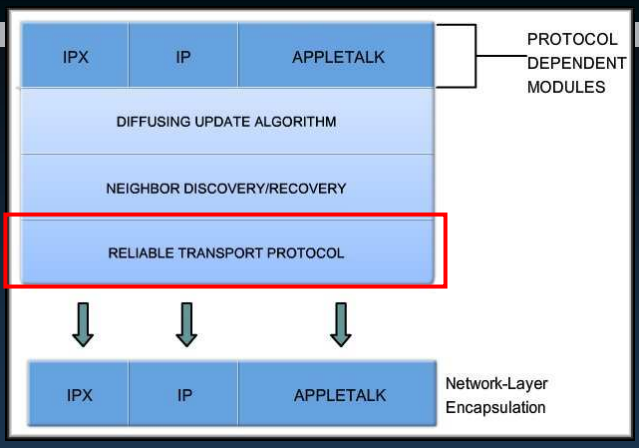
Protocol-Dependant Modules

- Neighbor Table:
  - When newly discovered neighbours are learned, the address and interface of the neighbour is recorded.
  - When a neighbour sends a hello packet, it advertises a hold time.
  - When the hold time expires, the link is considered unavailable and the new topology must be recalculated.

Protocol-Dependant Modules

- **Topology Table:**
  - The topology table is made up of all the EIGRP routing tables in the autonomous system.
  - DUAL uses the information in the neighbour and topology tables to calculate the lowest cost routes to each destination.
  - All learned routes to a destination are maintained in the topology table.

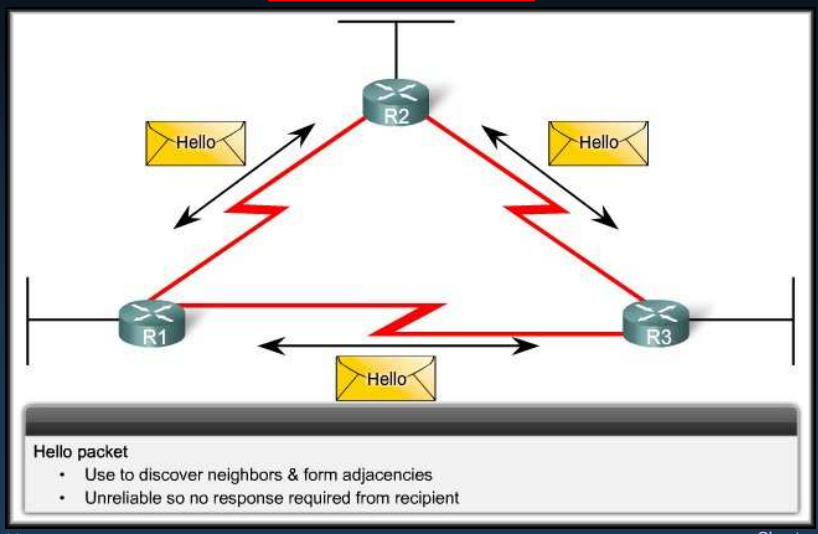
RTP and EIGRP Packet Types



- **Reliable Transport Protocol (RTP)** is the protocol used by EIGRP for the delivery and reception of EIGRP packets.
- RTP includes **both reliable delivery and unreliable** delivery of EIGRP packets, similar to TCP and UDP.

RTP and EIGRP Packet Types

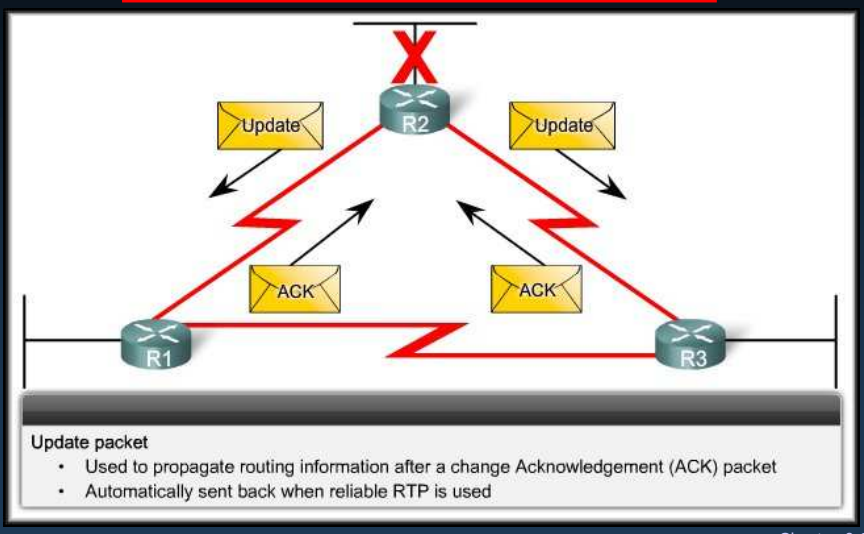
Hello Packet



Hello packet
- Use to discover neighbors & form adjacencies
- Unreliable so no response required from recipient

RTP and EIGRP Packet Types

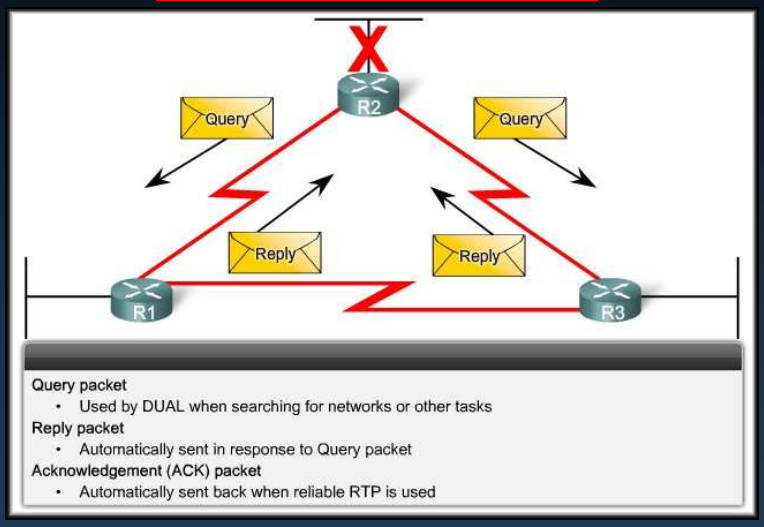
Update and Acknowledgment Packets



Update packet
- Used to propagate routing information after a change Acknowledgement (ACK) packet
- Automatically sent back when reliable RTP is used

RTP and EIGRP Packet Types

Query and Reply Packets



Query packet
- Used by DUAL when searching for networks or other tasks

Reply packet
- Automatically sent in response to Query packet

Acknowledgement (ACK) packet
- Automatically sent back when reliable RTP is used

Hello Protocol

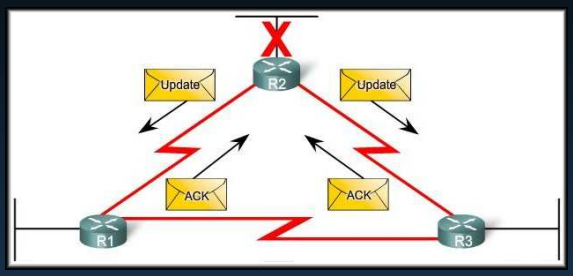
Most Networks

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

- Before any EIGRP packets can be exchanged between routers, EIGRP must first discover its neighbors.
- EIGRP routers **discover neighbors and establish adjacencies** with neighbor routers using the hello packet.
- **Hold Time:**
  - An EIGRP router assumes that as long as it is receiving hello packets from a neighbor, the neighbor and its routes remain viable.

EIGRP Bounded Updates

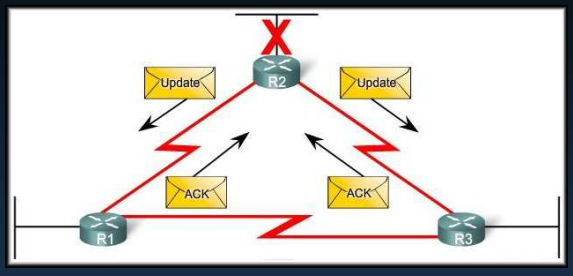
- EIGRP uses the terms **partial** and **bounded** when referring to its update packets.



- EIGRP sends its updates **only when the metric for a route changes**.
- **Partial:**
  - The update **only includes information about the route changes** instead of sending the entire contents of the routing table.

EIGRP Bounded Updates

- EIGRP uses the terms **partial** and **bounded** when referring to its update packets.



- EIGRP sends its updates **only when the metric for a route changes**.
- **Bounded:**
  - Refers to the propagation of partial updates sent **only to those routers that are affected** by the change.

DUAL: An Introduction

- **Diffusing Update Algorithm (DUAL)** is the convergence algorithm used by EIGRP.
  - Routing loops can be extremely detrimental to network performance.
  - Distance vector routing protocols such as RIP prevent routing loops with hold-down timers and split horizon.
  - Although EIGRP uses both of these techniques, it uses them somewhat differently.
  - **The primary way that EIGRP prevents routing loops is with the DUAL algorithm.**

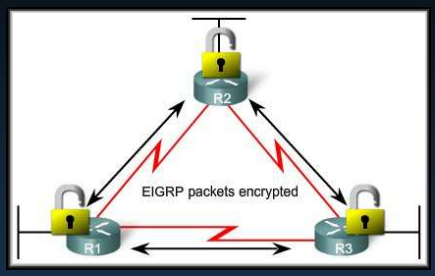
Administrative Distance

Route Source	Administrative Distance
Connected	0
Static	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
RIP	120
External EIGRP	170
Internal BGP	200

- When compared to other interior gateway protocols, EIGRP is the most preferred by the Cisco IOS software because it has the lowest AD.

Authentication

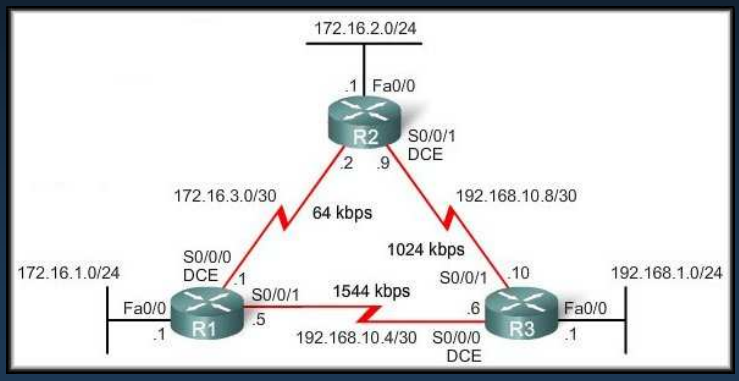
- Like other routing protocols, EIGRP can be configured for authentication.
- Authentication ensures that routers will only accept routing information from other routers that have been configured with the same password or authentication information.



- The router authenticates the source of each routing update packet that it receives.
- Authentication itself does not encrypt the router's routing table.

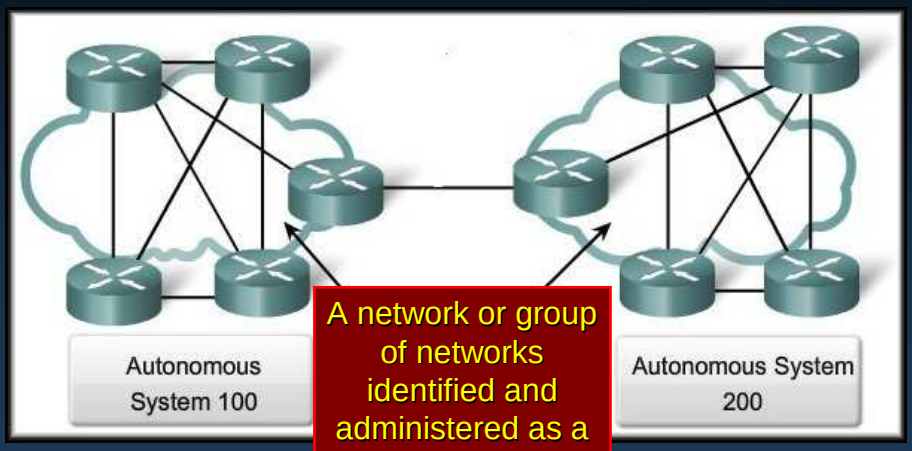
EIGRP

Basic EIGRP Configuration



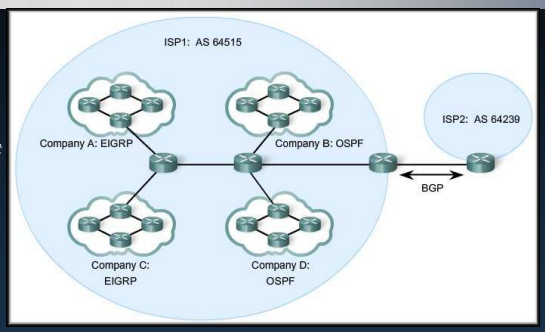
Autonomous System

- Concept of Autonomous Systems (AS):



Autonomous System

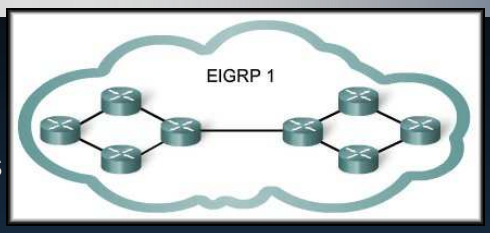
- *An **autonomous system** is a collection of networks under the administrative control of a single entity that presents a common routing policy to the Internet.*



- Autonomous system numbers are assigned by the Internet Assigned Numbers Authority (IANA).
- Who needs an Autonomous System number?
  - Internet Service Providers (ISPs), Internet Backbone Providers, and large institutions connecting to other entities that also have an autonomous system number.

Process ID

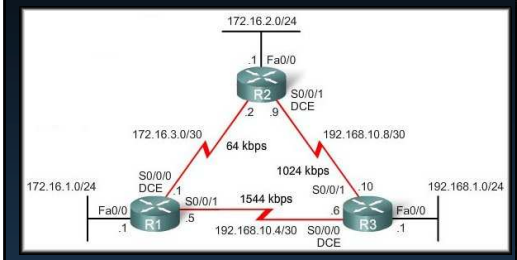
- Although EIGRP refers to the parameter as an "autonomous-system" number, it actually functions as a Process ID.




```
Router(config)# router eigrp ?
   <1-65535>  Autonomous System Number
```

- The autonomous system parameter is a number chosen by the network administrator between 1 and 65,535.

The `router eigrp` Command




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

R2(config)# router eigrp 1
R2(config-router)#

R3(config)# router eigrp 1
R3(config-router)#
```

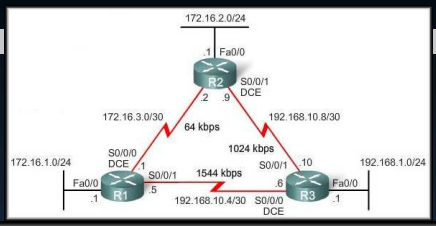
- The Global configuration mode **`router eigrp`** command enables EIGRP.
- All routers in an EIGRP routing domain must use the same process ID number (autonomous system number).

The network Command

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

- The **network** command in EIGRP has the same function as in other IGP routing protocols:
  - Any interface on this router that matches the network address in the **network** command will be enabled to send and receive EIGRP updates.
  - This network (or subnet) will be included in EIGRP routing updates.

The network Command



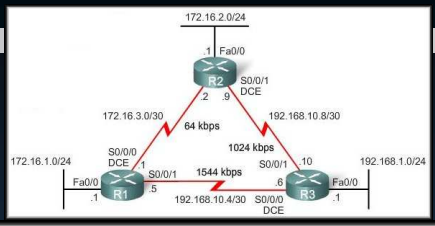

```
R1(config-router)# network 172.16.0.0

R2(config-router)# network 172.16.0.0

%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 172.16.3.1
                   (Serial0/0) is up: new adjacency
```

- The *network-address* is the classful network address for this interface.
- A single classful network statement is used on R1 to include both 172.16.1.0/24 and 172.16.3.0/30 subnets.

The network Command

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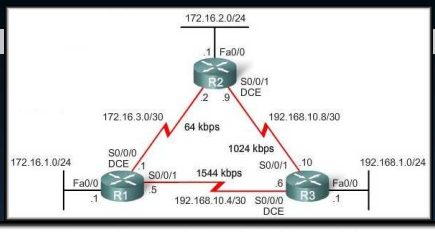
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 172.16.3.1
                   (Serial0/0) is up: new adjacency
```

- If you enter the individual network numbers for the interfaces, the Cisco IOS software will automatically convert them to a single, summarized network.

The network Command

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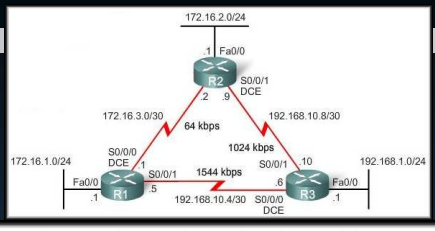
                   (Serial0/0) is up: new adjacency
```

- When EIGRP is configured on R2, DUAL sends a notification message to the console stating that a neighbor relationship with another EIGRP router has been established.

The network Command

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%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 172.16.3.1
                   (Serial0/0) is up: new adjacency
```

- This new adjacency happens automatically because both R1 and R2 are using the same EIGRP 1 routing process and both routers are now sending updates on the 172.16.0.0 network.

The network Command with a Wildcard Mask

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

- By default, when the network command and a classful network address such as 172.16.0.0 are used, all interfaces on the router that belong to that classful network address will be enabled for EIGRP.
- There may be times when the network administrator does not want to include all interfaces within a network when enabling EIGRP.
- To configure EIGRP to advertise specific subnets only, use the wildcard-mask option.

The network Command with a Wildcard Mask

```
  255.255.255.255
- 255.255.255.252   Subtract the subnet mask
  ---------------
    0.  0.  0.  3   Wildcard mask
```

- Think of a wildcard mask as the inverse of a subnet mask.
- To calculate the inverse of the subnet mask, subtract the subnet mask from 255.255.255.255.

The network Command with a Wildcard Mask

```
R2(config-router)# network 192.168.10.8 0.0.0.3

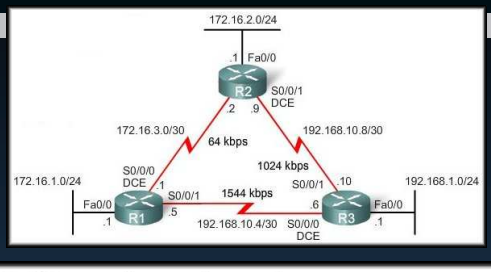
         -----   OR   -----

R2(config-router)# network 192.168.10.8 255.255.255.252

R2# show running-config
<some output omitted>
!
router eigrp 1
 network 172.16.0.0
 network 192.168.10.8 0.0.0.3
 auto-summary
```

- Some Cisco IOS software versions also let you enter the subnet mask.
- However, Cisco IOS software then converts the command to the wildcard mask format.

Network EIGRP Configuration




```
R1(config)# router eigrp 1
R1(config-router)# network 172.16.0.0
R1(config-router)# network 192.168.10.4

R2(config)# router eigrp 1
R2(config-router)# network 172.16.0.0
R2(config-router)# network 192.168.10.8 0.0.0.3

R3(config)#router eigrp 1
R3(config-router)# network 192.168.1.0
R3(config-router)# network 192.168.10.0
```


Verifying EIGRP

```
R2#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq Type
                                            (sec)         (ms)       Cnt Num
1   192.168.10.10           Se0/0/1          10 00:01:41   20   200  0  7
0   172.16.3.1              Se0/0/0          10 00:09:49   25   200  0  28
```

Address of neighbors

Interface connected to neighbor

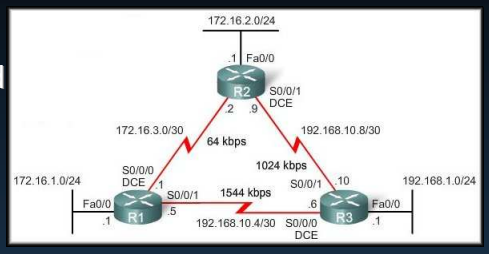
Amount of time left before neighbor is considered "down"

Amount of time since adjacency was established

- Verify adjacencies using **`show ip eigrp neighbors`**.

Verifying EIGRP

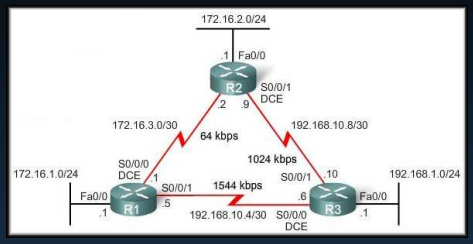
- **Troubleshooting:**
  - If a neighbor is not listed after adjacencies have been established with a router's neighbors, check that the local interface is activated using the **`show ip interface brief`** command.



  - If the interface is active, ping the IP address of the neighbor.
    - If the ping fails, it means that the neighbor interface is down and needs to be activated.

Verifying EIGRP

- **Troubleshooting:**
  - If the ping is successful and EIGRP still does not see the router as a neighbor, examine the following configurations:



    - Are both routers configured with the same EIGRP process ID?
    - Is the directly connected network included in the EIGRP **`network`** statements?
    - Is the **`passive-interface`** command inappropriately configured, thus preventing EIGRP hello packets on the interface?

Verifying EIGRP

```
R1# show ip protocols
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 metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 1
  Automatic network summarization is in effect
  Automatic address summarization:
    192.168.10.0/24 for FastEthernet0/0, Serial0/0/0
      Summarizing with metric 2169856
    172.16.0.0/16 for Serial0/0/1
      Summarizing with metric 28160
  Maximum path: 4
  Routing for Networks:
    172.16.0.0
    192.168.10.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    (this router)   90            00:03:29
    192.168.10.6    90            00:02:09
```


Examining The Routing Table: R1

```
R1# show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile,
       D - EIGRP, EX - EIGRP external, O - OSPF,
<Output omitted>

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:03:50, Null0
C       192.168.10.4/30 is directly connected, Serial0/0/1
D       192.168.10.8/30 [90/2681856] via 192.168.10.6,00:02:43, S0/0/1
     172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D       172.16.0.0/16 is a summary, 00:10:52, Null0
C       172.16.1.0/24 is directly connected, FastEthernet0/0
D       172.16.2.0/24 [90/2172416] via 172.16.3.2, 00:10:47, S0/0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
D    192.168.1.0/24 [90/2172416] via 192.168.10.6, 00:02:31, S0/0/1
```

- Notice that EIGRP routes are denoted in the routing table with a D, which stands for DUAL.

Examining The Routing Table: R2

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

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:04:13, Null0
D       192.168.10.4/30 [90/2681856] via 192.168.10.10,00:03:05,S0/0/1
C       192.168.10.8/30 is directly connected, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D       172.16.0.0/16 is a summary, 00:04:07, Null0
D       172.16.1.0/24 [90/2172416] via 172.16.3.1, 00:11:11, S0/0/0
C       172.16.2.0/24 is directly connected, FastEthernet0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
D    192.168.1.0/24 [90/2172416] via 192.168.10.10, 00:02:54, S0/0/1
```

- EIGRP is a classless routing protocol (includes the subnet mask in the routing update).
- EIGRP supports variable-length subnet masks (VLSM) and classless inter-domain routing (CIDR).

Examining The Routing Table: R3

```
R3# show ip route
<Output omitted>

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:03:11, Null0
C       192.168.10.4/30 is directly connected, Serial0/0/0
C       192.168.10.8/30 is directly connected, Serial0/0/1
D    172.16.0.0/16 [90/2172416] via 192.168.10.5, 00:03:23, S0/0/0
                   [90/2172416] via 192.168.10.9, 00:03:23, S0/0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/0
```

- By default, EIGRP automatically summarizes routes at the major network boundary.
- You can disable the automatic summarization with the **`no auto-summary`** command, just as you did for RIPv2.

Introducing the Null0 Summary Route

```
R2# show ip route
<Output omitted>
     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:04:13, Null0
D       192.168.10.4/30 [90/2681856] via 192.168.10.10,00:03:05,S0/0/1
C       192.168.10.8/30 is directly connected, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D       172.16.0.0/16 is a summary, 00:04:07, Null0
D       172.16.1.0/24 [90/2172416] via 172.16.3.1, 00:11:11, S0/0/0
C       172.16.2.0/24 is directly connected, FastEthernet0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
D    192.168.1.0/24 [90/2172416] via 192.168.10.10, 00:02:54, S0/0/1
```

- The 192.168.10.0/24 and 172.16.0.0/16 routes do not actually represent a path to reach the parent networks.
- If the packet matches the level 1 parent, but none of the child route subnets, the packet is discarded (sent to the **Null0** interface).

Introducing the Null0 Summary Route

```
R2# show ip route
<Output omitted>
     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:04:13, Null0
D       192.168.10.4/30 [90/2681856] via 192.168.10.10,00:03:05,S0/0/1
C       192.168.10.8/30 is directly connected, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D       172.16.0.0/16 is a summary, 00:04:07, Null0
D       172.16.1.0/24 [90/2172416] via 172.16.3.1, 00:11:11, S0/0/0
C       172.16.2.0/24 is directly connected, FastEthernet0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
D    192.168.1.0/24 [90/2172416] via 192.168.10.10, 00:02:54, S0/0/1
```

- EIGRP automatically includes a **Null0** summary route as a child route whenever both of the following conditions exist:
  - There is at least one subnet that was learned via EIGRP.
  - Automatic summarization is enabled.

R3 Routing Table

```
R3# show ip route
<Output omitted>

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:03:11, Null0
C       192.168.10.4/30 is directly connected, Serial0/0/0
C       192.168.10.8/30 is directly connected, Serial0/0/1
D    172.16.0.0/16 [90/2172416] via 192.168.10.5, 00:03:23, S0/0/0
                   [90/2172416] via 192.168.10.9, 00:03:23, S0/0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/0
```

- Because R3 is getting equal cost routes for 172.16.0.0/16 from R1 and R2, both are included in the routing table.
- Both R1 and R2 are automatically summarizing the 172.16.0.0/16 network and sending it as a single routing update.

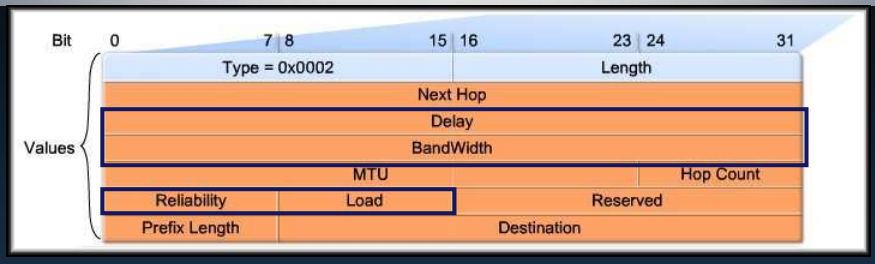
EIGRP

EIGRP Metric Calculation

Default Composite Formula:
metric = [K1*bandwidth + K3*delay]

Complete Composite Formula:
metric = [K1*bandwidth + (K2*bandwidth)/(256 - load) + K3*delay] * [K5/(reliability + K4)
(Not used if "K" values are 0)

EIGRP Composite Metric and the K Values



- EIGRP uses the following values in its composite metric to calculate the preferred path to a network:
  - Bandwidth
  - Delay
  - Reliability
  - Load

The Composite Metric

Default Composite Formula:
metric = [K1*bandwidth + K3*delay]

Only bandwidth and delay are used for the default composite metric.

Complete Composite Formula:
metric = [K1*bandwidth + (K2*bandwidth)/(256 - load) + K3*delay] * [K5/(reliability + K4)]
(Not used if "K" values are 0)

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

- By default, K1 and K3 are set to 1, and K2, K4, and K5 are set to 0.

Verifying the Composite Metric

```
R1# show ip protocols
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 metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  <output omitted>
```

- The K values on R1 are set to the default.
- Changing these values to other than the default is not recommended unless the network administrator has a very good reason to do so.

Examining the Metric Values

```
R1# show interface serial 0/0/0
  <output omitted>

  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255

  <output omitted>
```

- **The `show interface` command**, lets you can examine the actual values used for bandwidth, delay, reliability, and load in the computation of the routing metric.

Examining the Metric Values

```
R1# show interface serial 0/0/0
  <output omitted>

  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255

  <output omitted>
```

- Bandwidth:
  - The bandwidth metric (1544 Kbps) is a static value used by protocols such as EIGRP and OSPF.
  - Displayed in kilobits per second (Kbps).
  - The value displayed might or might not reflect the actual physical bandwidth of the interface.

Examining the Metric Values

```
R1# show interface serial 0/0/0
  <output omitted>

  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255

  <output omitted>
```

- Bandwidth:
  - Modifying the bandwidth value does not change the actual bandwidth of the link.
  - If the actual bandwidth of the link differs from the default bandwidth value, you should modify the bandwidth value to ensure an accurate composite metric.

Examining the Metric Values

```
R1# show interface serial 0/0/0
  <output omitted>

  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255

  <output omitted>
```

- **Delay:**
  - Delay is a measure of the time it takes for a packet to traverse a route.
  - The delay (DLY) metric is a static value based on the type of link and is expressed in microseconds.
  - The router does not actually track how long packets are taking to reach the destination.

Examining the Metric Values

```
R1# show interface serial 0/0/0
  <output omitted>

  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255

  <output omitted>
```

- **Reliability:**
  - Reliability is a measure of the probability that the link will fail or how often the link has experienced errors.
  - Unlike delay, reliability is measured dynamically with a value between 0 and 255, with **1 being a minimally reliable** link and **255 being 100 percent reliable**.

Examining the Metric Values

```
R1# show interface serial 0/0/0
  <output omitted>

  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255

  <output omitted>
```

- Reliability:
  - Reliability is a measure of the probability that the link will fail or how often the link has experienced errors.
  - Reliability is expressed as a fraction of 255; the higher the value, the more reliable the link.
  - 255/255 would be 100 percent reliable, whereas a link of 234/255 would be 91.8 percent reliable.

Examining the Metric Values

```
R1# show interface serial 0/0/0
  <output omitted>

  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255

  <output omitted>
```

- Load:
  - Load reflects the amount of traffic using the link.
  - Load is expressed as a fraction of 255. A lower load value is more desirable.
    - 1/255 would be a minimally loaded link.
    - 40/255 is a link at 16 percent capacity.
    - 255/255 is a link that is 100 percent saturated.

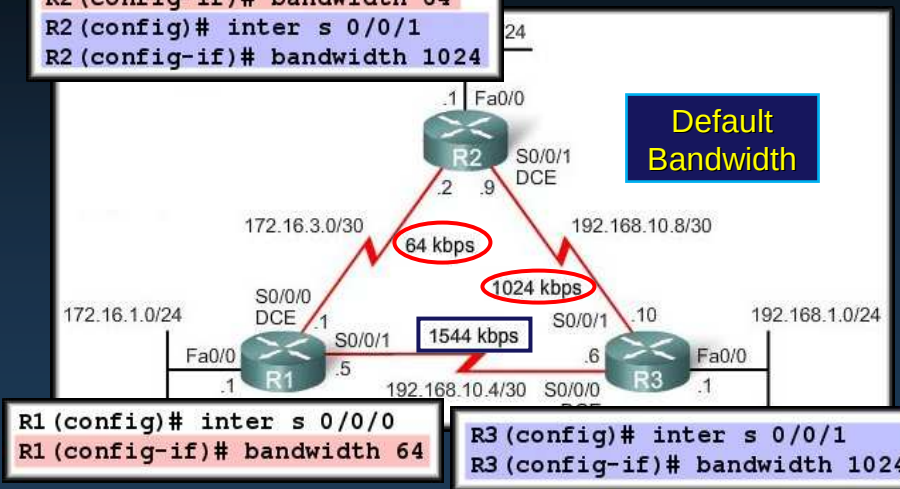
Using the **bandwidth** Command

```
Router(config-if)# bandwidth [kilobits]
```

- On most serial links, the bandwidth metric defaults to 1544 Kbps.
  - Because both EIGRP and OSPF use bandwidth in default metric calculations, a correct value for bandwidth is very important to the accuracy of routing information
  - Use the interface command **bandwidth** to modify the bandwidth metric.
  - Use the interface command **no bandwidth** to restore the default value.

Using the **bandwidth** Command

```
R2(config)# inter s 0/0/0
R2(config-if)# bandwidth 64
R2(config)# inter s 0/0/1
R2(config-if)# bandwidth 1024
```




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

```
R3(config)# inter s 0/0/1
R3(config-if)# bandwidth 1024
```

Using the **bandwidth** Command

```
R2# show interface serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 172.16.3.2/30
  MTU 1500 bytes, BW 64 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  <some output omitted>

R2# show interface serial 0/0/1
Serial0/0/1 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 192.168.10.9/30
  MTU 1500 bytes, BW 1024 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  <some output omitted>
```

- Verify the change using the **show interface** command.

Calculating the EIGRP Metric

If you like using a calculator, this slide is for you!

delay = sum of the delays of each link in route to the destination

Just know that the composite metric appears here in the routing table entry.

= EIGRP metric

```
R2#show ip route
***output omitted***
D    192.168.1.0/24 [90/3014400] via 192.168.10.10, 00:02:14, Serial0/0/1
```