Chapter 4/Module 3
EIGRP

CCNA 3 version 3.0
EIGRP

• “Enhanced” Interior Gateway Routing Protocol
• Based on IGRP and developed to allow easy transition from IGRP to EIGRP. (“Like IGRP+”)
• Cisco proprietary, released in 1994
• EIGRP is an advanced distance-vector routing protocol that relies on features commonly associated with link-state protocols. (sometimes called a hybrid routing protocol).
• Note: The Hybrid term sometimes misleads people into thinking EIGRP has the topology benefits of a link state routing protocol. It does not. EIGRP is a distance vector routing protocol and suffers from all of the same disadvantages of any other distance vector routing protocol, i.e. routing loops.
• Note: “Often described as a hybrid routing protocol offering the best of distance-vector and link-state algorithms.” - I would say “features of distance-vector and link-state” not necessarily “the best.”
# IGRP and EIGRP: A migration path

<table>
<thead>
<tr>
<th>IGRP</th>
<th>EIGRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classful Routing Protocol</td>
<td>Classless Routing Protocol</td>
</tr>
<tr>
<td></td>
<td>• VLSM, CIDR</td>
</tr>
<tr>
<td>bandwidth = (10,000,000/bandwidth kbps) spaces: 24 bit metric</td>
<td>bandwidth = (10,000,000/bandwidth kbps) * 256 spaces: 32 bit metric</td>
</tr>
<tr>
<td>delay = delay/10</td>
<td>delay = (delay/10) * 256</td>
</tr>
<tr>
<td>24 bit metric for bandwidth and delay</td>
<td>32 bit metric for bandwidth and delay</td>
</tr>
<tr>
<td>Maximum Hop Count = 255</td>
<td>Maximum Hop Count = 224</td>
</tr>
<tr>
<td>No differentiation between internal and external routes.</td>
<td>Outside routes (redistributed) are tagged as external routes.</td>
</tr>
<tr>
<td>Automatic redistribution between IGRP and EIGRP as long as “AS”</td>
<td></td>
</tr>
<tr>
<td>numbers are the same.</td>
<td></td>
</tr>
</tbody>
</table>
Both EIGRP and IGRP use the following metric calculation:

\[
\text{metric} = [K1 \times \text{bandwidth} + (K2 \times \text{bandwidth})/(256 - \text{load}) + (K3 \times \text{delay})] \times [K5/(\text{reliability} + K4)]
\]

The following are the default constant values:

\[K1 = 1, K2 = 0, K3 = 1, K4 = 0, K5 = 0\]

When K4 and K5 are 0, the \([K5/\text{reliability} + K4]\) portion of the equation is not factored in to the metric. Therefore, with the default constant values, the metric equation is as follows:

\[
\text{metric} = \text{bandwidth} + \text{delay}
\]

IGRP and EIGRP, which scales the value of 256, use the following equations to determined the values used in the metric calculation:

- bandwidth for IGRP = \((10000000/\text{bandwidth})\)
- bandwidth for EIGRP = \((10000000/\text{bandwidth}) \times 256\)
- delay for IGRP = delay/10
- delay for EIGRP = delay/10 \times 256

---

- k1 for bandwidth
- k2 for load
- k3 for delay
- k4 and k5 for Reliability

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

**bandwidth is in kbps**
Displaying Interface Values

Router> show interface s0/0
Serial0/0 is up, line protocol is up
    Hardware is QUICC Serial
    Description: Out to VERIO
    Internet address is 207.21.113.186/30
    MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
    rely 255/255, load 246/255
    Encapsulation PPP, loopback not set
    Keepalive set (10 sec)

shows reliability as a fraction of 255, for example (higher is better):
    rely 190/255 (or 74% reliability)
    rely 234/255 (or 92% reliability)
    rely 255/255 (or 100% reliability)

shows load as a fraction of 255, for example (lower is better):
    load 10/255 (or 3% loaded link)
    load 40/255 (or 16% loaded link)
    load 255/255 (or 100% loaded link)
Displaying Interface Values

Router> show interface s0/0
Serial0/0 is up, line protocol is up
   Hardware is QUICC Serial
   Description: Out to VERIO
   Internet address is 207.21.113.186/30
   MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
       rely 255/255, load 246/255
   Encapsulation PPP, loopback not set
   Keepalive set (10 sec)
<output omitted>

Routing Table Metric

- Default: Slowest of bandwidth plus the sum of the delays of all outgoing interfaces from “this router” to the destination network.
## EIGRP Metrics

Values displayed in show interface commands and sent in routing updates.

<table>
<thead>
<tr>
<th>Media</th>
<th>Bandwidth K= kilobits</th>
<th>BW&lt;sub&gt;EIGRP&lt;/sub&gt; 10,000,000/Bandwidth *256</th>
<th>Delay</th>
<th>DLY&lt;sub&gt;EIGRP&lt;/sub&gt; Delay/10 *256</th>
</tr>
</thead>
<tbody>
<tr>
<td>100M ATM</td>
<td>100,000K</td>
<td>25,600</td>
<td>100 μS</td>
<td>2,560</td>
</tr>
<tr>
<td>Fast Ethernet</td>
<td>100,000K</td>
<td>25,600</td>
<td>100 μS</td>
<td>2,560</td>
</tr>
<tr>
<td>FDDI</td>
<td>100,000K</td>
<td>25,600</td>
<td>100 μS</td>
<td>2,560</td>
</tr>
<tr>
<td>HSSI</td>
<td>45,045K</td>
<td>56,832</td>
<td>20,000 μS</td>
<td>512,000</td>
</tr>
<tr>
<td>16M Token Ring</td>
<td>16,000K</td>
<td>160,000</td>
<td>630 μS</td>
<td>16,128</td>
</tr>
<tr>
<td>Ethernet</td>
<td>10,000K</td>
<td>256,000</td>
<td>1,000 μS</td>
<td>25,600</td>
</tr>
<tr>
<td>T1 (Serial Default)</td>
<td>1,544K</td>
<td>1,657,856</td>
<td>20,000 μS</td>
<td>512,000</td>
</tr>
<tr>
<td>512K</td>
<td>512K</td>
<td>4,999,936</td>
<td>20,000 μS</td>
<td>512,000</td>
</tr>
<tr>
<td>DS0</td>
<td>64K</td>
<td>40,000,000</td>
<td>20,000 μS</td>
<td>512,000</td>
</tr>
<tr>
<td>56K</td>
<td>56K</td>
<td>45,714,176</td>
<td>20,000 μS</td>
<td>512,000</td>
</tr>
</tbody>
</table>

BW<sub>EIGRP</sub> and DLY<sub>EIGRP</sub> display values as sent in EIGRP updates and used in calculating the EIGRP metric.

Calculated values (cumulative) displayed in routing table (show ip route).
A Closer Look at the Routing Table Metrics
How does SanJose2 calculate the cost for this route?

SanJose2#show ip route

D  192.168.72.0/24  [90/2172416]
   via 192.168.64.6, 00:28:26, Serial0
Displaying Interface Values

Westasman> show interface fa0/0
Ethernet0 is up, line protocol is up
   Hardware is Lance, address is 0010.7b3a.cf84 (bia 0010.7b3a.cf84)
   MTU 1500 bytes, **BW 100000 Kbit, DLY 100 usec,**
   rely 255/255, load 1/255
<output omitted>

SanJose2> show interface s0/0
Serial0/0 is up, line protocol is up
   Hardware is QUICC Serial
   Description: Out to Westasman
   Internet address is 192.168.64.5/30
   MTU 1500 bytes, **BW 1544 Kbit,** **DLY 20000 usec,**
   rely 255/255, load 246/255
<output omitted>
Determining the costs

Bandwidth \(= (10,000,000/\text{bandwidth kbps}) \times 256\)

FastEthernet

\[= (10,000,000/100,000) \times 256\]

\[= 25,600\]

T1

\[= (10,000,000/1544) \times 256\]

\[= 1,657,856\]
Determining the costs

\[
\text{Delay} = \left(\frac{\text{delay}}{10}\right) \times 256
\]

**FastEthernet**

\[
= \left(\frac{100}{10}\right) \times 256
= 2,560
\]

**T1**

\[
= \left(\frac{20,000}{10}\right) \times 256
= 512,000
\]

**Bandwidth**

\[
\text{Bandwidth} = 1,657,856
\]

**Delay**

\[
\text{Delay} = 2,560
\]

**Bandwidth**

\[
\text{Bandwidth} = 25,600
\]

**Delay**

\[
\text{Delay} = 512,000
\]

**Bandwidth**

\[
\text{Bandwidth} = 1,657,856
\]
Determining the costs

What is the cost (metric) for 192.168.72.0/24 from SanJose2?

Cost: Slowest bandwidth

+ sum of delays

\[
\begin{align*}
&1,657,856 \\
&512,000 \\
&2,560 \\
\end{align*}
\]

\[\text{-------------}\]

\[2,172,416\]

The cost!

\[\text{bandwidth} = \left(\frac{10,000,000}{\text{bandwidth kbps}}\right) \times 256\]

\[\text{delay} = \left(\frac{\text{delay}}{10}\right) \times 256\]

EIGRP

AS 100
SanJose2#show ip route

D  192.168.72.0/24 [90/2172416]
   via 192.168.64.6, 00:28:26, Serial0

The Routing Table

Cost: Slowest bandwidth
+ sum of delays
1,657,856
512,000
2,560
--------------------
2,172,416

Delay = 2,560
Bandwidth = 25,600

Delay = 512,000
Bandwidth = 1,657,856

The cost!

SanJose1
Fa0/0 192.168.1.1/24
S0/0 192.168.64.1/30

Westasman
Fa0/0 192.168.72.1/24
S0/0 192.168.64.2/30

SanJose2
Fa0/0 192.168.1.2/24
S0/0 192.168.64.5/30

EIGRP
AS 100

Slowest!
EIGRP and IGRP compatibility

- Automatic redistribution occurs when the same AS number is used for EIGRP and IGRP.
- EIGRP scales the IGRP metric by a factor of 256.
- IGRP reduces the metric by a factor of 256.
EIGRP and IGRP compatibility

- EIGRP will tag routes learned from IGRP, or any outside source, as external because they did not originate from EIGRP routers.
- IGRP cannot differentiate between internal and external routes.

10,476 = 6,476 (BW) + 2,000 (DLY) + 2,000 (DLY)
IGRP Metrics! (Does not multiply by 256.)
Features of EIGRP

- **Classless** Routing Protocol (VLSM, CIDR)
- **Faster convergence** times and improved scalability
- **Multiprotocol** support: TCP/IP, IPX/SPX, Appletalk
  - There is no IPX/SPX or Appletalk in CCNA or CCNP
- **Rapid Convergence and Better handling of routing loops** – (DUAL) (coming)
- **Efficient Use of Bandwidth**
  - Partial, bounded updates: Incremental updates only to the routers that need them.
  - Minimal bandwidth consumption: Uses Hello packets and EIGRP packets by default use no more that 50% of link’s bandwidth EIGRP packets.
- **PDM (Protocol Dependent Module)**
  - Keeps EIGRP is modular
  - Different PDMs can be added to EIGRP as new routed protocols are enhanced or developed: IPv4, IPv6, IPX, and AppleTalk
- **Unequal-cost load balancing** same as IGRP (unlike OSPF)
EIGRP Terminology

- **Neighbor table** – Each EIGRP router maintains a neighbor table that lists adjacent routers. This table is comparable to the adjacency database used by OSPF. There is a neighbor table for each protocol that EIGRP supports.

- **Topology table** – Every EIGRP router maintains a topology table for each configured network protocol. This table includes route entries for all destinations that the router has learned. All learned routes to a destination are maintained in the topology table.

- **Routing table** – EIGRP chooses the best routes to a destination from the topology table and places these routes in the routing table. Each EIGRP router maintains a routing table for each network protocol.

- **Successor** – A successor is a route selected as the primary route to use to reach a destination. Successors are the entries kept in the routing table. Multiple successors for a destination can be retained in the routing table.

- **Feasible successor** – A feasible successor is a backup route. These routes are selected at the same time the successors are identified, but are kept in the topology table. Multiple feasible successors for a destination can be retained in the topology table.
 Neighbor Table

- Each EIGRP router maintains a neighbor table that lists adjacent routers.
- This table is comparable to the adjacency database used by OSPF.
- There is a neighbor table for each protocol that EIGRP supports.
- Whenever a new neighbor is discovered, the address of that neighbor and the interface used to reach it are recorded in a new neighbor table entry.

```
RouterC#show ip eigrp neighbors
IP-EIGRP neighbors for process 44
H   Address       Interface   Hold Uptime   SRTT   RTO  Q  Seq
   (sec)         (ms)       Cnt Num
0   192.168.0.1   Se0           11 00:03:09 1138  5000  0  6
1   192.168.1.2   Et0           12 00:34:46    4   200  0  4
```
Neighbor Table

RouterC#show ip eigrp neighbors
IP-EIGRP neighbors for process 44

<table>
<thead>
<tr>
<th>H</th>
<th>Address</th>
<th>Interface</th>
<th>Hold Uptime</th>
<th>SRTT</th>
<th>RTO</th>
<th>Q</th>
<th>Seq</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>192.168.0.1</td>
<td>Se0</td>
<td>11 00:03:09</td>
<td>1138</td>
<td>5000</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>1</td>
<td>192.168.1.2</td>
<td>Et0</td>
<td>12 00:34:46</td>
<td>4</td>
<td>200</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

- **Neighbor address** The network-layer address of the neighbor router(s).
- **Queue count** The number of packets waiting in queue to be sent. If this value is constantly higher than zero, then there may be a congestion problem at the router. A zero means that there are no EIGRP packets in the queue.
Neighbor Table

RouterC#show ip eigrp neighbors
IP-EIGRP neighbors for process 44

<table>
<thead>
<tr>
<th>H</th>
<th>Address</th>
<th>Interface</th>
<th>Hold</th>
<th>Uptime</th>
<th>SRTT</th>
<th>RTO</th>
<th>Q</th>
<th>Seq</th>
<th>Cnt</th>
<th>Num</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>192.168.0.1</td>
<td>Se0</td>
<td>11</td>
<td>00:03:09</td>
<td>1138</td>
<td>5000</td>
<td>0</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>192.168.1.2</td>
<td>Et0</td>
<td>12</td>
<td>00:34:46</td>
<td>4</td>
<td>200</td>
<td>0</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Smooth Round Trip Timer (SRTT)** The average time it takes to send and receive packets from a neighbor.
  - This timer is used to determine the retransmit interval (RTO)

- **Hold Time** The interval to wait without receiving anything from a neighbor before considering the link unavailable.
  - Originally, the expected packet was a hello packet, but in current Cisco IOS software releases, any EIGRP packets received after the first hello will reset the timer.
Topology Table

- **Topology table**
  - Each EIGRP router maintains a topology table for each configured network protocol.
  - This table includes route entries for all destinations that the router has learned.
  - All learned routes to a destination are maintained in the topology table.
- EIGRP uses its **topology table** to store all the information it needs to calculate a set of distances and vectors to all reachable destinations.

More about this table later!

RouterB#show ip eigrp topology
IP-EIGRP Topology Table for process 44
Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply, r - Reply status
P 206.202.17.0/24, 1 successors, FD is 2195456
    via 206.202.16.1 (2195456/2169856), Ethernet0
P 206.202.18.0/24, 2 successors, FD is 2198016
    via 192.168.0.2 (2198016/284160), Serial0
    via 206.202.16.1 (2198016/2172416), Ethernet0
RTX#sh ip eigrp top 204.100.50.0

IP-EIGRP topology entry for 204.100.50.0/24
State is Passive, Query origin flag is 1, 1 Successor(s), FD is 2297856
Routing Descriptor Blocks: FD/RD
10.1.0.1 (Serial0), from 10.1.0.1, Send flag is 0x0
Composite metric is (2297856/128256), Route is External

Vector metric:
Minimum bandwidth is 1544 Kbit
Total delay is 25000 microseconds
Reliability is 255/255
Load is 1/255
Minimum MTU is 1500
Hop count is 1

External data:
Originating router is 192.168.1.1
AS number of route is 0
External protocol is Connected, external metric is 0
Administrator tag is 0 (0x00000000)
**Question:** Since EIGRP has a topology table, does this make it a link-state routing protocol?

**Answer:**
- No, the information in the topology table is **not** in the form of LSAs describing the complete network topology.
- The EIGRP topology table contains information about paths through the router’s adjacent neighbors.
- Also, EIGRP does not perform shortest-path calculation by calculating the shortest-path tree, but instead uses the DUAL algorithm.

*Alex Zinin, Cisco IP Routing*
IP Routing Table

- EIGRP chooses the best routes (that is, successor) to a destination from the topology table and places these routes in the routing table.
- Each EIGRP router maintains a topology table for each network protocol.
- EIGRP displays both internal EIGRP routes and external EIGRP routes.

RouterB#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
        D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
        E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
        i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default U - per-user static route
Gateway of last resort is not set
C    10.1.1.0 is directly connected, Serial0
D    172.16.0.0 [90/2681856] via 10.1.1.0, Serial0
D EX 192.168.1.0 [170/2681856] via 10.1.1.1, 00:00:04, Serial0
The routing table contains the routes installed by DUAL as the best loop-free paths to a given destination.

EIGRP will maintain **up to four routes** per destination.

These routes can be of **equal, or unequal cost** (if using the **variance** command). (later)

```
RouterB#show ip route
Codes:  C - connected,  S - static,  I - IGRP,  R - RIP,  M - mobile,  B - BGP
       D - EIGRP,  EX - EIGRP external,  O - OSPF,  IA - OSPF inter area
       E1 - OSPF external type 1,  E2 - OSPF external type 2,  E - EGP
       i - IS-IS,  L1 - IS-IS level-1,  L2 - IS-IS level-2,  * - candidate
       default U - per-user static route
Gateway of last resort is not set
C   10.1.1.0 is directly connected, Serial0
D   172.16.0.0 [90/2681856] via 10.1.1.0, Serial0
D EX 192.168.1.0 [170/2681856] via 10.1.1.1, 00:00:04, Serial0
```
EIGRP Technologies

Four key technologies set EIGRP apart from IGRP

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Neighbor discovery and recovery</td>
<td></td>
</tr>
<tr>
<td>• Reliable Transport Protocol</td>
<td></td>
</tr>
<tr>
<td>• DUAL finite-state machine</td>
<td></td>
</tr>
<tr>
<td>• Protocol-specific modules</td>
<td></td>
</tr>
</tbody>
</table>
Establishing Adjacencies with Neighbors

Extra

- **EIGRP routers** establish **adjacencies** with neighbor routers by using small **hello packets**.
- **Hellos** are sent every **5 seconds** by default.
- **K values** must be the **same between neighbors**.
- An EIGRP router assumes that, as long as it is receiving hello packets from known neighbors, those neighbors (and their routes) remain viable.
- **Hold time** tells the router how long it should consider the neighbor alive if it has not received any EIGRP packets (Hello, EIGRP updates, etc.)
- **Hold time** is normally **three times** the configured **Hello interval**.
- Both the Hello and Hold time intervals are **configurable on a per interface basis**, and do not have to match **neighbor**.
- **EIGRP routers** exchange routing information the same way as other **distance vector routing protocols**, but do not send **periodic updates**.
- **EIGRP updates** are only sent when a network is added or removed from the **topology database**, when the successor for a given network changes, or when the locally used metric is updated. (later)
- **EIGRP**, like any other distance-vector routing protocol uses **split-horizon**.
Hello Intervals and Default Hold Times

- **Hello Time**  The interval of Hello Packets
- **Hold Time**  The interval to wait without receiving anything from a neighbor before considering the link unavailable.
The centerpiece of EIGRP is DUAL, the EIGRP route-calculation engine.
- The full name of this technology is DUAL finite state machine (FSM).
- This engine contains all the logic used to calculate and compare routes in an EIGRP network.

DUAL FSM

What is FSM?
- An FSM is an abstract machine, not a mechanical device with moving parts.
- FSMs define a set of possible states something can go through, what events causes those states, and what events result from those states.
- Designers use FSMs to describe how a device, computer program, or routing algorithm will react to a set of input events.
States such as Passive and Active trigger Certain Events.
DUAL FSM – Explained in a moment…

- DUAL selects alternate routes quickly by using the information in the EIGRP tables.
- If a link goes down, DUAL looks for a feasible successor in its neighbor and topology tables.
- A **successor** is a neighboring router that is currently being used for packet forwarding, provides the least-cost route to the destination, and is not part of a routing loop.
- **Feasible successors** provide the next lowest-cost path without introducing routing loops.
  - Feasible successor routes can be used in case the existing route fails; packets to the destination network are immediately forwarded to the feasible successor, which at that point, is promoted to the status of successor.
- Selects a best loop-free path to a destination, the next hop being known as the **successor**.
- All other routers to the same destination, that also meet the **feasible condition**, meaning they are also loop-free (later), become **feasible successors**, or back-up routes.
- `debug eigrp fsm`
Successors and Feasible Successors

Here is a route to Network Z, with a metric of 5.

RTB is successor to Network Z.

A successor is a neighbor router that is the next hop in a least-cost, loop-free path to any given destination.
Successors and Feasible Successors

This is also a route to Network Z, with a metric of 5.

Here is a route to Network Z, with a metric of 5.

RTB is successor to Network Z.
RTC is successor to Network Z.

RTA can install multiple successors, if these neighbors advertise routes with the same metric.
Successors and Feasible Successors

This is also a route to Network Z, with a metric of 5.

Here is a route to Network Z, with a metric of 5.

RTB is successor to Network Z
RTC is successor to Network Z
RTX is feasible successor to Network Z.

This is a route to Network Z with a metric of 6.

By identifying feasible successors, EIGRP routers can immediately install alternate routes if a successor fails.
**Successors and Feasible Successors**

**Feasible distance (FD)** is the minimum distance (metric) along a path to a destination network.

**Reported distance (RD)** is the distance (metric) towards a destination as advertised by an upstream neighbor. Reported distance is the distance reported in the queries, the replies and the updates.

A neighbor meets the **feasible condition (FC)** if the reported distance by the neighbor is smaller than or equal to the current feasible distance (FD) of this router. "If a neighbors metric is less than mine, then I know the neighbor doesn't have a loop going through me."

A **feasible successor** is a neighbor whose reported distance (RD) is less than the current feasible distance (FD). Feasible successor is one who meets the feasible condition (FC).

Your route (metric) to the network (RD to me) must be LESS than my current route (my total metric) to that same network. If your route (metric) to the network (RD to me) is LESS than my current route (my total metric), I will include you as a **FEASIBLE SUCCESSOR**.

If your route (metric) to the network (RD to me) is MORE than my current route (my total metric), I will **NOT** include you as a **FEASIBLE SUCCESSOR**.
Successors and Feasible Successors

RTA can reach network 24 via three different routers, but RTY is used as the successor because it provides the lowest cost path.
Successors and Feasible Successors

Feasible Successor, FC: RD30 < FD31

FD to 172.30.1.0 is 31 via Router Y

Current Successor = 31
RD of RTY= 21

RTZ is NOT Feasible Successor, FC: RD220 not< FD31

<table>
<thead>
<tr>
<th>Destination</th>
<th>Feasible Dist.</th>
<th>Reported. Dist.</th>
<th>Neighbor</th>
</tr>
</thead>
<tbody>
<tr>
<td>172.30.1.0</td>
<td>40</td>
<td>30</td>
<td>X In Topology Table</td>
</tr>
<tr>
<td>172.30.1.0</td>
<td><strong>31</strong></td>
<td>21</td>
<td>Y In Routing Table</td>
</tr>
<tr>
<td>172.30.1.0</td>
<td>230</td>
<td>220</td>
<td>Z Not in Topology Table</td>
</tr>
</tbody>
</table>
Successors and Feasible Successors

- RTY is successor with a computed cost of 31.
- “31” is the Feasible Distance (FD).
- RTX is a feasible successor because its RD is less than or equal to the FD.
  - RTX’s RD (30) is less than the FD (31).
- RTZ is **not** a feasible successor because its RD (220) is not less than the FD (31).

**Feasible Successor, FC: RD30 < FD31**

FD to 172.30.1.0 is 31 via Router Y

Current Successor = 31
RD of RTY= 21

RTY is successor with a computed cost of 31.
"31" is the Feasible Distance (FD).
RTX is a feasible successor because its RD is less than or equal to the FD.
- RTX’s RD (30) is less than the FD (31).
RTZ FD = 220
RTZ to RTA is 189
RTA to 172.30.1.0 is 31

RTZ has a Reported Distance to RTA of 220. Since its Reported Distance is greater than RTA’s own Feasible Distance of 31, RTA can’t trust that the route RTZ takes is somehow back through itself.
What if the successor fails?

Feasible Successor exists:

• If current successor route fails, feasible successor becomes the current successor, i.e. the current route.
• Routing of packets continue with little delay.

No Feasible Successor exists:

• This may be because the Reported Distance is greater than the Feasible Distance.
• Before this route can be installed, it must be placed in the active state and recomputed. (later)
• Routing of packets continue but with more of a delay.
Successors and Feasible Successors

- Since RTX is the feasible successor, and becomes the successor.
- RTX is immediately installed from the topology table into the routing table (no recomputation of DUAL).
- RTA's new FD via RTX is 40.
- RTZ is not a feasible successor, because it’s RD (220) is still greater than the new FD (40) for 172.30.1.0/24.
Successors and Feasible Successors

- RTZ is not a feasible successor.
- It’s RD (220) is greater than the previous FD (40) for 172.30.1.0/24.
- Before this route can be installed, the route to net 24 must be placed in the active state and recomputed.
- Coming soon!
Successors and Feasible Successors

Current Successor = 230
RD of RTZ = 220

FD to 172.30.1.0 is 230 via Router Z

RTZ is NOT Feasible Successor, FC: RD220 not< FD40

- After a series of EIGRP Queries and Replies (coming), and a recomputation of DUAL, RTZ becomes the successor.
- There is nothing better to prohibit it from being the successor.
One last reminder....

**Topology table**

- Each EIGRP router maintains a topology table for each configured network protocol.
- This table includes route entries for all destinations that the router has learned. All learned routes to a destination are maintained in the topology table.

**show ip eigrp topology**

- (Feasible Distance/Reported Distance)
- 1 successor (route) if FDs are different
  - smaller FD metric, that route is the only successor
  - larger FD metric, those routes are possible feasible successor
- 2 or more successors (routes) if FDs are the same
  - Load balancing happens automatically
Questions

**Question**: What if there is only one entry in the Topology Table?

**Answer**: There is only a successor and no feasible successors.

- There are either no other neighbors with a route to this network or the reported distance of that neighbor is greater than the current feasible distance. (You will see this in the lab.)

**Question**: Why does EIGRP use DUAL? I.e. Why doesn’t EIGRP install routes with an RD greater than its current FD?

**Answer**: EIGRP is a distance vector routing protocol. It only knows about distances/routes from what its’ neighbors tell it. The only way EIGRP can trust that another router’s route is not back through itself, is to make sure the other router’s distance is equal to or less than its own distance to that network.
No feasible successor in the topology table. EIGRP domain still finds another route.

SanJose2#debug eigrp fsm
EIGRP FSM Events/Actions debugging is on
SanJose2(config)#inter s 0
SanJose2(config-if)#shut

03:11:44: DUAL: Destination 192.168.72.0/24
03:11:44: DUAL: Find FS for dest 192.168.72.0/24. FD is 2172416, RD is 2172416
03:11:44: DUAL: 192.168.64.6 metric 4294967295/4294967295 not found Dmin is 4294967295
03:11:44: DUAL: Dest 192.168.72.0/24 entering active state.

Feasible successor is in the topology table. Backup route takes over right away.

Westasman#debug eigrp fsm
02:21:42: DUAL: Find FS for dest 192.168.64.4/30. FD is 2169856, RD is 2169856
02:21:42: DUAL: 0.0.0.0 metric 2169856/0
02:21:42: DUAL: 192.168.64.1 metric 4294967295/4294967295 found Dmin is 216985
Configuring EIGRP
Configuring EIGRP for IP networks

Router(config)#**router eigrp** autonomous-system-number
• This value must match all routers within the internetwork.

Router(config-router)#**network** network-number
• The **network** command configures only connected networks.

Router(config-router)#**eigrp log-neighbor-changes**
• This command enables the logging of neighbor adjacency changes to monitor the stability of the routing system and to help detect problems.

Router(config-if)#**bandwidth** kilobits
• When configuring serial links using EIGRP it is important to configure the bandwidth setting on the interface. If the bandwidth setting is not changed for these interfaces EIGRP assumes the default bandwidth on the link instead of the true bandwidth.
EIGRP automatically summarizes routes at the classful boundary, the boundary where the network address ends as defined by class-based addressing.
Summarizing EIGRP Routes: no auto-summary

- In the presence of discontiguous subnetworks, automatic summarization must be disabled for routing to work properly.
- To turn off auto-summarization, use the following command:
  ```
  Router(config-router)#no auto-summary
  ```
Summarizing EIGRP Routes: Interface Summarization

EIGRP summary addresses can be manually configured on a per-interface basis.

Router(config-if)#ip summary-address eigrp autonomous-system-number ip-address mask administrative-distance

RTC(config)#router eigrp 2446
RTC(config-router)#no auto-summary
RTC(config-router)#exit

RTC(config)#interface serial0/0
RTC(config-if)#ip summary-address eigrp 2446 2.1.0.0 255.255.0.0
Summarizing EIGRP Routes: Interface Summarization

RTC(config)#interface serial0/0
RTC(config-if)#ip summary-address eigrp 2446 2.1.0.0 255.255.0.0

RTC’s Routing Table:
D 2.1.0.0/16 is a summary, 00:00:22, Null0

- Notice that the summary route is sourced from Null0, and not an actual interface.
- That is because this route is used for advertisement purposes and does not represent a path that RTC can take to reach that network.
- On RTC, this route has an administrative distance of 5.
- RTD is oblivious to the summarization but accepts the route. It assigns the route the administrative distance of a "normal" EIGRP route, which is 90, by default.
# EIGRP show commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>show ip eigrp neighbors [type number] [details]</code></td>
<td>Displays EIGRP neighbor table. Use the type and number options to specify an interface. The details keyword expands the output.</td>
</tr>
<tr>
<td><code>show ip eigrp interfaces [type number] [as-number] [details]</code></td>
<td>Shows EIGRP information for each interface. The optional keywords limit the output to a specific interface or AS. The details keyword expands the output.</td>
</tr>
<tr>
<td>`show ip eigrp topology [as-number</td>
<td>[[ip-address] mask]]`</td>
</tr>
<tr>
<td>`show ip eigrp topology [active</td>
<td>pending</td>
</tr>
<tr>
<td><code>show ip eigrp topology all-links</code></td>
<td>Displays all routes, not just feasible successors, in the EIGRP topology.</td>
</tr>
<tr>
<td><code>show ip eigrp traffic [as-number]</code></td>
<td>Displays the number of EIGRP packets sent and received. Command output can be filtered by including an optional AS number.</td>
</tr>
</tbody>
</table>
# EIGRP debug commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>debug eigrp fsm</td>
<td>This command helps in observing EIGRP feasible successor activity and to determine whether route updates are being installed and deleted by the routing process.</td>
</tr>
<tr>
<td>debug eigrp packet</td>
<td>The output of the command shows transmission and receipt of EIGRP packets. These packet types may be hello, update, request, query, or reply packets. The sequence and acknowledgment numbers by the EIGRP reliable transport algorithm are shown in the output.</td>
</tr>
</tbody>
</table>
Few last items not in the curriculum...
IGRP and EIGRP also support **unequal** cost path load balancing, which is known as variance.

The **variance** command instructs the router to include routes with a metric less than or equal to $n$ times the minimum metric route for that destination, where $n$ is the number specified by the variance command.

**Note:** If a path isn't a feasible successor, then it isn't used in load balancing.
Let's look at an example, there are three ways to get to Network X, from Router E: (Note: metrics incorrectly not including outgoing interface to Net X.)

- E-B-A with a metric of 30
- E-C-A with a metric of 20  <<<-- Minimum Metric
- E-D-A with a metric of 45
EIGRP variance command

```
router eigrp 1
network x.x.x.x
variance 2
```

**variance 2**

- This increases the minimum metric to 40 (2 * 20 = 40).
- EIGRP includes all the routes that have a metric less than or equal to 40, and are feasible successors.
- In the above configuration, EIGRP now uses two paths to get to Network X, E-C-A and E-B-A, because both paths have a metric under 40.
EIGRP doesn't use path E-D-A because it has a metric of 45, and it's not a feasible successor. Can have up to 6 unequal cost paths.
EIGRP Traffic Share

- To control how traffic is distributed among routes when there are multiple routes for the same destination network that have different costs, use the `traffic-share` router configuration command.
- To disable this function, use the `no` form of the command.

```
traffic-share {balanced | min}
no traffic share {balanced | min}
```

- **balanced**
  - Distributes traffic proportionately to the ratios of the metrics.

- **min**
  - Uses routes that have minimum costs

- For more information:
Redistribution b/t EIGRP & IGRP

Same AS numbers

Router Two
router eigrp 2000
    network 172.16.1.0
!
router igrp 2000
    network 10.0.0.0

(automatic redistribution)

Different AS numbers

Router Two
router eigrp 2000
    redistribute igrp 1000
    network 172.16.1.0
!
router igrp 1000
    redistribute eigrp 2000
    network 10.0.0.0

So what is the difference? We’ll see later when discussing Redistribution.
EIGRP and Default Routes (Review)

There are three ways to inject a default route into EIGRP:

• Redistribute a static route
• IP default-network
• Summarize to 0.0.0.0/0
Redistribute a static route

- Use the first method when you want to draw all traffic to unknown destinations to a default route at the core of the network.
- This method is effective for advertising connections to the Internet, but will redistribute all static routes into EIGRP.
- For example:

**Gateway Router**

```
ip route 0.0.0.0 0.0.0.0 x.x.x.x (next hop)
```

```
router eigrp 100
  redistribute static
```

EIGRP and Default Routes (Review)

**Ip default-network**
- Propagates a default route to other routers, but needs to have a route or default route out once the packets arrive.

**Gateway Router**

```
router igrp 24
  <text omitted>
  network 207.21.20.0

ip route 0.0.0.0 0.0.0.0 207.21.20.1
ip default-network 207.21.20.0
```
EIGRP and Default Routes (Review)

Extra: Summarize to 0.0.0.0/0

- Summarizing to a default route is effective only when you want to provide remote sites with a default route.
- Since summaries are configured per interface, you don't need to worry about using distribute-lists or other mechanisms to prevent the default route from being propagated toward the core of your network.

```
router eigrp 100
  network 10.0.0.0

interface serial 0
  ip address 10.1.1.1
  ip summary-address eigrp 100 0.0.0.0 0.0.0.0
```
# OSPF versus EIGRP

<table>
<thead>
<tr>
<th>OSPF</th>
<th>EIGRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supports CIDR and VLSM, rapid convergence, partial updates, neighbor discovery</td>
<td>Supports CIDR and VLSM, rapid convergence, partial updates, neighbor discovery</td>
</tr>
<tr>
<td>Administrator can define route summarization</td>
<td>Automatic route-summarization and user-defined route summaries</td>
</tr>
<tr>
<td>Open standard; multivendor support</td>
<td>Proprietary; Cisco routers only</td>
</tr>
<tr>
<td>Scalable; administratively defined “areas” provide manageable hierarchy</td>
<td>Scalable, but no hierarchical design</td>
</tr>
<tr>
<td>Difficult to implement</td>
<td>Easy to implement</td>
</tr>
</tbody>
</table>

Equal-cost load balancing | Unequal-cost load balancing