Document Name: EIGRP

Enhanced Interior Gateway Routing Protocol or EIGRP is an open standard routing protocol developed by Cisco here is their documentation. It was not an open standard until Cisco released RFC 7868 in 2016. Here are some questions that Cisco answered about why they are releasing it.

How EIGRP Works

EIGRP is technically a distance vector routing protocol but is also sometimes referred to as a hybrid routing protocol. EIGRP is classes and supports VLSM, it also supports equal cost load balancing as well as unequal cost load balancing. EIGRP packets use IP number 88. EIGRP uses the **Diffusing Update Algorithm or DUAL** for path selection. EIGRP is known for fast convergence and low overhead.

Inter-Router Communication

When EIGRP discovers a neighbor that information about the neighbor is retained. The full routing table is shared when first forming an adjacency. Afterwards only updates are sent as the EIGRP topology changes. Hello packets are sent via multicast with the address 224.0.0.10. Hello packets are sent every five seconds, and the hold timer is 3x the hello timer (15 seconds by default). After that 15 second period the neighbor is removed.

Reliable Transport Protocol or RTP is used to send EIGRP packets. It ensures that routing updates are delivered reliably using sequence numbers to account for all packets and ensure delivery order. Updates are sent via multicast 224.0.0.10 or the MAC address 01:00:5e:00:00:0a and updates are acknowledged with unicast hello packets containing no data.

A sequence number of 0 indicates that a response is not needed. All update, query, and reply packets are deemed reliable. Hello and ACK packets are not considered reliable and do not require acknowledgement. All unicast packets require acknowledgement. EIGRP retries up to 16 times for each packet after which the neighbor relationship is terminated.

After the first multicast Hello packet(s) all communication is unicast until the neighbor is fully synchronized. Additionally, EIGRP requires that the neighbor relationship is formed before routes are added to the RIB

See all the packet types that EIGRP uses below:

Packet Type	Packet Name	Function
1	Hello	Used for neighbor discovery and as a keep alive for neighbors.
2	Request	Used to obtain specific information from a neighbor.
3	Update	Used to transmit routes with other neighbors.
4	Query	Sent by a routing searching for a path to a destination.
5	Reply	Sent in response to a query packet.

Path Selection

DUAL is used for path selection and ensuring a loop free topology. This is a mathematical equation which has been proven to prevents loops. DUAL does not require regular routing table updates or route hold-down timers that would otherwise slow convergence down.

DUAL selects a best path and a second-best path to reach a given destination. The first path is referred to as the *Successor* and the second-best patch is referred to as the *Feasible Successor*. The Feasible Successor satisfies the feasibility condition and is maintained as a backup router.

Term	**Definition**
Successor Route	The route with the lowest path metric to reach a destination
Successor	The first next-hop router for the successor route
Feasible Distance (FD)	The metric value for the lowest-metric path to reach a destination. This is the full metric of the route to the destination network.
Reported Distance (RD)	The distance reported by a router to reach a prefix. The reported distance value is the feasible distance for the advertising router. This is the metric from the next-hop router to the destination network.
Feasibility Condition	A condition under which, for a route to be considered a backup route, the reported distance received for that route must be less that the feasible distance calculated locally. This logic guarantees a loop-free path.
Feasible Successor	A route that satisfies the feasibility condition and is maintained as a backup route. The feasibility condition ensures that the backup route is loop-free.

Routers will send query packets to other neighbor routers in an attempt to find a feasible successor route. A neighbor can respond that indicates may have a feasible successor or send another query packet. If it's another query packet that will indicate that the neighbor does not have feasible successor and will participate in the re-computation.

If a router does not receive all the replies before the "active-time" timer expires the route is marked as stuck in active (SIA). The default active-time timer is three minutes.

Essentially a route in the active state is being re-computed and a passive route is a stable route.

A route can maintain one of three states.

Route State	**Definition**
Active	The successor route and feasible successor route no longer meet the feasibility condition. The DUAL algorithm will be run to calculate new successor and feasible successor routes.
Passive	A successor is in place and does not require and re-computation.
Stuck-in-active	The router that issues a query gives up and is not responsive, it is them removed as a neighbor

Metrics

The composite metric is based on bandwidth, delay, load, and reliability. MTU is not calculated as part of the metric but can cause issues if the MTU is not consistent across the whole path. By default, only bandwidth and delay are used as metrics.

- **Bandwidth** – Is the lowest interface bandwidth along the whole path.
- **Delay** – is the sum of the all the outbound interface delays along the whole path (in tens of milliseconds)
- **Load** – Is calculated dynamically using a value from 1 to 255. A value of 255/255 indicates a completely saturated link. 127/255 is 50%.
- **Reliability** – Is calculated dynamically using a value from 1 to 255 where 255/255 is a 100% reliable link.

EIGRP is good for more than 16 hops, with a default value of 100 but is configurable for up to 225. EIGRPv6 increases this to 255.

This is the EIGRP metric formula:

EIGRP metric = {k1 x BW + [(k2 x BW)/(256 – load) + k3 x delay} x {k5/(reliability + k4)}

By default, k1 = k3 = 1 and k2 = k4 = k5 = 0. Bandwidth is measured in kbps and delay is measured in microseconds. Below is a chart of the EIGRP default metric values.

Media	Delay	Bandwidth	Metric
10 Gigabit Ethernet	10 μ	10,000 Mbps	512
1 Gigabit Ethernet	10 μ	1,000 Mbps	2,816
Fast Ethernet	100 μ	100 Mbps	28,160
Ethernet	1,000 μ	10 Mbps	281,600
T1	20,000 μ	1.544 Mbps	2,170,031
64 kbps	512,000 μ	0.64 Mbps	53,107,200

The metrics can be modified as below:

This example configuration will enable all metrics.

Classic Configuration Mode

```
Router(config)# router eigrp 1
Router(router-config)# metric weights 0 1 1 1 1 1
```

Named Configuration Mode

```
Router(conifg)# router eigrp MAIN
Router(router-config)# address-family ipv4 unicast autonomous system 1
Router(router-config-af)# metric weights 0 1 1 1 1 1
```

Note: There is an option on some platforms for a k6 value. This has been reserved for EIGRP wide metrics for future use and currently has no use.

Timers

Updates are only sent when needed and only to neighboring routers, thus there is no update timer. Hello packets are used to discover and maintain neighbor relationships. On high-speed networks the Hello packet interval is 5 seconds with a hold timer of 15 seconds. On interfaces rated at T1 speeds and lower those timers are increased to 60 seconds with a hold timer of 180 seconds. All Hello packets are sent via multicast.

Stub Routers

Stub routers are used for remote branches in a hub and spoke configuration. Stub routing conserves hardware resources and assists in network quality.

When the stub routing feature is enabled on the spoke router only specific routes are advertised to the hub router. The stub router does not advertise routes received from other neighbors to the hub. This means that a stub router cannot be used as a redundant path in the network.

There are a few configuration options for stub routers.

- **Receive-only** – Can not advertise any networks.
- **Connected** – Can advertise directly connected networks.
- **Static** – Can advertise static routes.
- **Summary** – Can advertise summary routes.
- **Redistribution** – Can advertise redistributed routes.

Variance

The variance command allows for unequal cost load balancing. This is what the ENSLD 300-420 book says.
“
EIGRP allows unequal-cost routing with the use of the **variance #** command. If you have an active route with a metric of 10 and have feasible successors of 15, 25, and 55, you can adjust the variance number to make those routes active. If you use **variance 2**, then the active metric of 10 gets multiplied by 2, which equals 20. Any feasible successor less than 20 gets added as an active route. The route with a metric of 15 is added, so you have two active routes.

If you use **variance 3**, the routes with metrics of 10, 15, and 25 become active (3 × 10 = 30). Note that for this example, using a variance of 4 or 5 does not add the route with a metric of 55. You need to use a variance of 6 to add the route with a metric of 55 (6 × 10 = 60).
“

Configuration Modes

EIGRP has two configuration modes, Classic and Named mode. Most of the configuration for Classic mode is done in the EIGRP process but there are some exceptions. This creates some complexities as far as configuration goes.

Named mode was developed to solve these issues and adds more features such as:

- All configuration is done in one place
- Multi address family support
- VRF support

Below you will see the difference between Classic and Named mode.

Classic Configuration Mode

```
Router(config)# router eigrp [autonomous system]
Router(router-config)# network 10.0.0.0 0.0.0.0
```

Named Configuration Mode

```
Router(config)# router eigrp [instance name]
Router(router-config)# address-family [ipv4 I ipv6] unicast autonomous-system [autonomous system]
Router(router-config-af)# network 10.0.0.0 0.0.0.0
```

The configuration section later in this document will focus primarily on Named Mode.

Configuration (Classic Mode)

Classis mode only really supports IPv4. Named Configuration mode is highly recommended.

Enables EIGRP and configures the EIGRP ASN.
Router(config)# router eigrp [Autonomous System Number]

The wildcard mask is used to prevent auto summarization of the network. It is also used determine what interfaces to enable EIGRP on on the local router.
Router(config-router)# network A.B.C.D [wildcard mask]

Makes the route more or less preferable.
Router(config-router)# variance [multiplier]

Bandwidth in kilo-bits.
Router(config-if)# bandwidth [1-10000000]

Throughput delay in tens of microseconds.
Router(config-if)# delay [1-16777215]

This is how you would summarize routes. You must do it per interface in classic mode where A.B.C.D/XX is your summarized prefix.
Router(config-if)# ip summary-address eigrp A.B.C.D/XX

Configuration (Named Mode)

There is a way that you can upgrade to Named mode. It is hitless and does a graceful restart of your neighbors but does not have to relearn routes and repopulate the routing table. If you have multiple instances of EIGRP you must do each of them separately.

```
Router(config-router) eigrp upgrade-cli
```

This is how you configure EIGRP in named more.

```
Router(config)# router eigrp [instance name]
Router(config-router)# address-family [ipv4 I ipv6] unicast autonomous-system [sutonomous system]
```

This is how you would summarize a prefix. It is also done per interface BUT you configure it in the EIGRP process.

```
Router(config)# router eigrp [instance name]
Router(config-router)# address-family ipv4 unicast autonomous-system 100
Router(config-router-af)# af-interface [interface name]
Router(config-router-af-interface)# summary-address A.B.C.D/XX
```

This is how you configure stubs/stub sites.

```
Router(config-router-af)# eigrp stub [Then select what type of routes you do want to advertise]
```

This is how you configure a stub site.

```
Router(config-router-af)# eigrp stub-site 100:100
Router(config-router-af)# af-interface GigabitEthernet 0/0
Router(config-router-af-interface)# stub-site wan-interface
```

If running a DMVPN solution and you need to disable split-horizon this is how.

```
Router(config-router-af-interface)# no split-horizon
```

This is how you modify your timers.

```
Router(router-config-af)# af-interface GigabitEthernet 0/0
Router(router-config-af-interface)# hello-interval [1-65535 seconds]
Router(router-config-af-interface)# hold-time [1-65535 seconds]
```

This is how you configure authentication with a key-chain.

```
Router(config)# key chain [key chain name]
Router(config-keychain)# key [key number]
Router(config-keychain-key)# key-string [string]
Router(config-keychain-key)# cryptographic-algorithm hmac-sha-256

Router(config)# router eigrp [instance name]
Router(router-config)# address-family ipv4 unicast autonomous-system 100
Router(router-config-af)# af-interface GigabitEthernet 0/0
Router(router-config-af-interface)# authentication mode hmac-sha-256 0 [string]
Router(router-config-af-interface)# authentication key-chain LAB
```

Show and Debug commands

Router# show ip eigrp
Router# show ip eigrp neighbor
Router# show ip eigrp topology
Router# show ip eigrp topology all-links
Router# show ip eigrp packet
Router# show ip eigrp event
Router# debug ip eigrp
Router# debug eigrp packet