EIGRP

EIGRP Classic Mode

In This Section

- Configuring Classic EIGRP
- Verifying EIGRP Adjacencies
- Verifying EIGRP Topology

Classic EIGRP Overview

- EIGRP prior to EIGRP Named Mode
  - I.e. EIGRP prior to IOS 15.x
- AKA EIGRP Autonomous System Configuration
  - Process name is the AS number

Enabling Classic EIGRP

- Enable the global process
  - router eigrp [AS]
  - AS number must match to be adjacent
- Enable the interface process
  - network [address] [wildcard]
  - Similar to OSPF network statement

Verifying EIGRP

- Verify EIGRP is enabled
  - **show ip eigrp interfaces [detail]**
  - **show ip protocols**
- Verify EIGRP transport
  - **debug eigrp packet [hello | ack | update | query | reply…]**

Verifying EIGRP

- Verify neighbor adjacencies
  - **show ip eigrp neighbors [detail]**
  - Queue count should be 0 if converged
- Verify EIGRP topology
  - **show ip eigrp topology [all-links]**
  - **show ip eigrp topology [prefix/len]**

EIGRP

EIGRP Named Mode

In This Section

+ Configuring EIGRP Named Mode

EIGRP Named Mode (Multi-AF Mode)

- New EIGRP configuration as of IOS 15.x
  - Old configuration is EIGRP Classic Mode
- Better config hierarchy
  - All config now goes under global process
- Better IPv4 & IPv6 feature parity
  - Syntax is unified for IPv4 and IPv6 under one process
  - Uses address-families to distinguish v4 and v6
- Newer features aren’t supported in Classic Mode
  - E.g. Wide Metrics, IPv6 VRF Lite, etc.

Configuring EIGRP Named Mode

- Enable the global process
  - **router eigrp [name]**
  - Name is not the AS number
- Enable the address-family
  - E.g. **address-family ipv4 unicast autonomous-system 1**
- Enable the interface process
  - **network [address] [wildcard]**
  - Similar to OSPF network statement
- Customize the interfaces
  - **af-interface [default | int]**

Converting EIGRP Classic to Named Mode

+ Conversion is automated as of IOS 15.4S
  + **Router(config-router)# eigrp upgrade-cli**
+ Conversion is hitless
  + Performs graceful restart automatically
+ Supports both IPv4 and IPv6 EIGRP
  + Can be in different ASes

EIGRP

EIGRP Classic Metric Calculation

In This Section

- EIGRP Classic Metric Calculation

EIGRP Classic Path Selection

- EIGRP uses lowest composite metric based on…
  - Bandwidth
    - Inverse lowest bandwidth along path in Kbps scaled by 10^7 * 256
  - Delay
    - Cumulative delay along path in tens of microseconds (µs) scaled by 256
  - Load
    - Highest load along path
  - Reliability
    - Lowest reliability along path

EIGRP Classic Metric Calculation

- Composite metric is computed as…
  - metric = [k1 * BW + (k2 * BW)/(256 - load) + k3 * delay]
  - If k5 != 0, metric = metric * [k5/(reliability + k4)]
- “K” values allow for manual weighting
  - Defaults are K1 = 1, K2 = 0, K3 = 1, K4 = 0, K5 = 0
  - Implies default composite is bandwidth + delay
- Can be modified with **metric weights** command
  - Must match for adjacency to occur

EIGRP

EIGRP Wide Metric Calculation

In This Section

- EIGRP Wide Metric Calculation

EIGRP Classic Bandwidth Metric Problem

- Classic EIGRP Metric uses bandwidth as…
  - CLASSIC_EIGRP_BW = 10^7 * 256 / INT_BW
- As bandwidths increase, visibility is lost
  - 1 GigE = 2560
  - 10 GigE = 256
  - 20 GigE = 256
  - 40 GigE = 256
  - 100 GigE = 256

EIGRP Classic Delay Metric Problem

- Minimum configurable delay in IOS is 10µs
- As bandwidths increase, delay visibility is lost
  - 1 GigE = 10µs
  - 10 GigE = 10µs
  - 20 GigE = 10µs
  - 40 GigE = 10µs
  - 100 GigE = 10µs

EIGRP Wide Metrics

+ Wide Metric is now 64 bits
+ BW problem fixed by scaling higher
  + WIDE_EIGRP_BW = 10^7 * 65536 / INT_BW
+ DLY problem fixed by moving to picoseconds
  + WIDE_EIGRP_DLY = DLY_PICO * 65536 / 10^6

EIGRP Wide Metric Formula

- BW is now Throughput
  - Throughput = K1 * (EIGRP_BANDWIDTH * EIGRP_WIDE_SCALE) / Interface Bandwidth (kbps)
- DLY is now Latency
  - Latency = K3 * (Delay * EIGRP_WIDE_SCALE) / EIGRP_DELAY_PICO
- Default metric is still the same formula
  - metric = (K1 * min(Throughput)) + (K3 * sum(Latency))

EIGRP Wide Metric Configuration

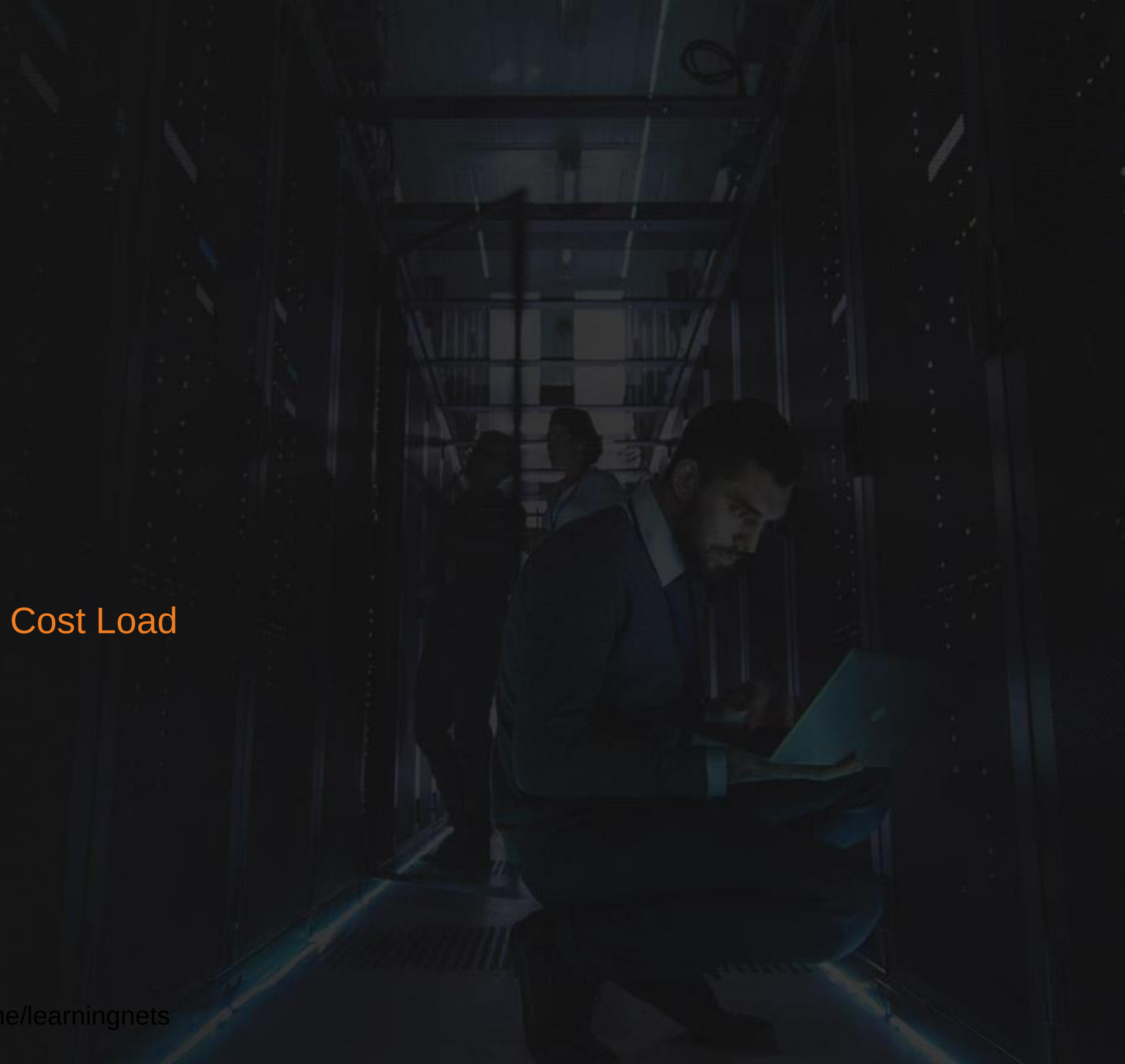
+ Enable EIGRP named mode
+ Wide Metrics automatically enabled
+ Still backwards compatible with Classic

Wide Metric & RIB Scaling

- IOS RIB only supports 32-bit metrics
- After EIGRP DUAL, metric is scaled down to fit in the RIB
  - Default is to scale * 1/128
  - Can be modified with **metric rib-scale**

EIGRP

EIGRP Traffic Engineering & Unequal Cost Load Balancing



In This Section

- EIGRP Feasibility Condition
- Modifying EIGRP Path Selection
- EIGRP Unequal Cost Load Balancing

EIGRP Feasibility Condition

- Feasibility Condition (FC) is used to select loop-free backup paths
  - Paths meeting the FC are pre-computed during DUAL
- Pre-computed backup paths have multiple advantages
  - Sub-second reconvergence when primary path fails
  - Fault isolation
  - Unequal cost load distribution

Feasibility Condition High Level Overview

- First, find the best path
  - Take the metric of the best path as X
- Next, find alternate backup paths
  - Anyone with a metric less than X is closer to the destination than me
  - Exclude anyone with a metric greater than or equal to X

Feasibility Condition Terminology

- Successor
  - Best path to a destination
- Feasible Distance (FD)
  - Composite metric of best path (successor)
- Reported Distance (RD)
  - Composite metric learned from neighbors
- Feasible Successor (FS)
  - Backup paths that meet the Feasibility Condition

Feasibility Condition in Detail

- Once best path is chosen, additional paths are examined for backup routes
- FC finds loop-free backup routes via logic…
  - If RD < FD, path is loop-free and viable backup
  - e.g. if your metric is lower than mine, you are closer to the destination and loop-free
- Paths that meet FC are Feasible Successors (FS)
  - Only Feasible Successors can be used for unequal cost load balancing

EIGRP Reconvergence

- Reconvergence differs for paths with or without a FS
- Paths without a Feasible Successor
  - Loss of Successor sends route into Active state
  - Send QUERY to all neighbors
  - Reconverged when REPLY heard from all neighbors
- Paths with a Feasible Successor
  - Loss of Successor does not make route Active
  - Feasible Successor promoted to Successor
  - QUERY not generated
  - Result is sub-second convergence

EIGRP Traffic Engineering

- Default EIGRP composite metric is Bandwidth + Delay
  - Based on default K1 and K3 metric weights
- Bandwidth is lowest bandwidth along the path on a per prefix basis
  - Essentially the bandwidth bottleneck
  - Hard to predict what a modification will affect
- Delay is cumulative on a hop-by-hop basis
  - Easier to influence path selection with
  - Modified with **delay** interface command

EIGRP Unequal Cost Load Balancing

- EIGRP allows load distribution among unequal paths
  - Only Feasible Successors are candidate for load balancing
- Controlled by **variance** command
  - If Feasible Distance * variance > feasible successor, load balancing occurs
- Traffic share is automatically calculated
  - Links used in ratio proportional to their composite metrics
  - Actual load balancing still controlled by switching path
    - E.g. CEF per-flow

EIGRP

EIGRP Authentication

In This Section

+ EIGRP Authentication
+ Classic vs. Named Mode Authentication

EIGRP Authentication

- Supports two types of authentication
  - MD5
  - HMAC-SHA-256
- MD5 Authentication
  - Both Classical and Named EIGRP
  - Uses key chains
  - Supports automatic key rotation
- SHA Authentication
  - Only Named EIGRP
  - No key chains, no rotation

Classic EIGRP Authentication

- Supports MD5 only
- Define key chain globally
  - Whitespace counts as a character
  - Key number must match
  - Supports automatic key rotation
- Applied at interface level
  - **ip authentication mode eigrp [AS] md5**
  - **ip authentication key-chain eigrp [AS] [key-chain]**

Automatic Key Rotation

- Key chain supports multiple key numbers
  - Router always sends lowest valid key
- Key number's validity is based on time
  - **accept-lifetime**
    - When is key valid to be received
  - **send-lifetime**
    - When is key valid to be sent
- Automatic rotation by defining different validity times
  - Implies time must be agreed upon
  - accept-lifetime should overlap in case of mismatch of time

Named EIGRP Authentication

- Supports MD5 and SHA
  - MD5 uses same global key chains as Classic
  - SHA uses static key
- Defined under af-interface
  - Can use **af-interface default**
  - Specific interface overrides default

EIGRP

EIGRP Summarization

In This Section

+ EIGRP Query Scoping
+ EIGRP Summarization

EIGRP Scalability

- Sub-second convergence with Feasible Successors
  - Pre-calculated backup routes which pass Feasibility Condition
- What if I can’t engineer Feasible Successors?
  - If no backup routes, QUERY message is sent
  - Convergence now a function of QUERY domain size
- QUERY domain can be bounded by…
  - Summarization
  - Stub router advertisement

EIGRP Query Scoping

- QUERY is generated when a route becomes Active
  - E.g. link loss, neighbor loss, metric change
- QUERY is sent for exact match of lost route
  - E.g. do you have a route to 1.2.3.0/24?
- REPLY is immediately sent if no match
  - E.g. 1.2.3.0/24 doesn't match my 1.0.0.0/8
  - This is how summaries limit the QUERY domain

EIGRP Summarization

- EIGRP supports two types of summaries
  - Auto-summary
  - Manual summary
- EIGRP hierarchy is arbitrary
  - Summaries can be enforced anywhere
  - Big design advantage over OSPF and IS-IS

EIGRP Auto-Summary

- EIGRP still supports legacy auto-summary
  - Advertisements between major network boundaries are summarized to classful boundary
  - VLSM is supported within the same major network
- Auto-summary is disabled in newer IOS
  - Can be enabled with **auto-summary**
  - Process level in Classic EIGRP
  - Base topology in Named EIGRP

EIGRP Manual Summarization

- Manual summarization
  - Supports any bit boundary including 0.0.0.0/0
  - Automatically suppresses subnet advertisements
  - Can advertise subnets through **leak-map** argument
- Classic EIGRP configuration
  - **ip summary-address eigrp** at the link level
- Named EIGRP configuration
  - **summary-address** at **af-interface**

EIGRP Summary Metrics

- EIGRP summary route inherits metrics from its subnets
  - Subnet with the best metric is used
- Churning subnets means churning summary
  - Change of best subnet metric means summary must be re-advertised
- **summary-metric** can mitigate this
  - Metric is statically defined per-summary in **topology base**

EIGRP

EIGRP Traffic Engineering with Summarization

In This Section

- EIGRP Traffic Engineering with Summarization
- EIGRP Leak Maps

Traffic Engineering with Summarization

+ EIGRP automatically suppresses subnet advertisements of summaries
+ Since EIGRP hierarchy is arbitrary, selective summaries can be used for traffic engineering
  + Longest match route is always preferred
  + Implies router performing the summary is less-preferred

EIGRP Leak Maps

+ Leak Map allows selective advertisement of subnet(s) in a summary
+ Can be used for longest match traffic engineering
+ Applied through a **route-map**
  + i.e. **match ip address prefix-list**…

EIGRP

EIGRP over DMVPN

In This Section

- EIGRP over DMVPN
  - Split Horizon
  - Next Hop Processing

EIGRP Split-Horizon

- EIGRP is Distance Vector
  - Still relies on split horizon rule
- Split Horizon rule
  - Don’t advertise routes out the interface you received them on
- Why would you not want Split Horizon?
  - Partial mesh NBMA
  - E.g. DMVPN

EIGRP Next Hop Processing

- EIGRP updates includes “Next Hop Forwarding Address”
  - I.e. the next-hop for the route
- If zero, use IP address from the received IP header
  - I.e. next-hop is who you learned the route from
- Why would you not want this?
  - Third party next hop
  - E.g. DMVPN Phase 2

EIGRP

EIGRP Stub Routing

In This Section

+ EIGRP Stub Routing

EIGRP Scalability

- Sub-second convergence with Feasible Successors
  - Pre-calculated backup routes which pass Feasibility Condition
- What if I can’t engineer Feasible Successors?
  - If no backup routes, QUERY message is sent
  - Convergence now a function of QUERY domain size
- QUERY domain can be bounded by…
  - Summarization
  - Stub router advertisement

EIGRP Stub Router Advertisement

- Stub routers don’t receive QUERY messages
- Stub routers aren’t used for transit
  - Normally
- Good design option for DMVPN spokes

EIGRP

EIGRP Route Filtering

In This Section

- EIGRP Filtering Overview
- EIGRP Filtering Methods
- EIGRP Filtering Examples

EIGRP Filtering Overview

- Like RIP, EIGRP is a Distance Vector IGP
  - Routers only know what directly connected neighbors tell them
  - Routers do not need to agree on the topology details like Link State
  - Implies that filtering can be applied anywhere

EIGRP Route Filtering Methods

- EIGRP filtering methods similar to RIPv2 include…
  - Distribute-Lists
  - Offset-Lists
  - Administrative Distance
  - Passive Interface
- EIGRP specific filtering methods include…
  - Distribute-List with Route-Maps
  - Route Tag Enhancements
  - Per Neighbor Prefix Limits

EIGRP

EIGRP IPv6 Routing

In This Section

+ IPv6 EIGRP Overview
+ IPv6 EIGRP Configuration
    + Classic Mode
    + Named Mode

IPv6 EIGRP Overview

+ Separate control plane from IPv4 EIGRP
  + Forms separate adjacencies
  + Maintains separate topology
  + Performs separate DUAL
+ Cannot advertise IPv4 prefixes
  + Unlike OSPFv3, IS-IS, BGP

IPv6 EIGRP Transport

- Uses IPv6 protocol 88
- Uses both multicast and unicast
  - Multicast to FF02::A
  - Unicast to link-local
- Multicast can be disabled
  - **neighbor** to link-local address

IPv6 EIGRP Prerequisites

- Enable IPv6 routing
  - **ipv6 unicast-routing**
- Ensure valid router-id
  - Uses IPv4 address format
  - If no up/up IPv4 interface you must manually specify eigrp router-id

Configuring Classic Mode IPv6 EIGRP

- Create global process
  - **ipv6 router eigrp [AS]**
- Enable global process
  - **no shutdown**
  - Default in some versions
- Enable IPv6 EIGRP on the link
  - **ipv6 eigrp [AS]**

Verifying Classic IPv6 EIGRP

- Nearly identical to IPv4 EIGRP
  - **show ipv6 eigrp interface**
  - **show ipv6 eigrp neighbor**
  - **show ipv6 eigrp topology [all-links]**

Configuring Named Mode IPv6 EIGRP

- Create named process
  - **router eigrp [name]**
- Enable IPv6 AFI
  - **address-family ipv6 unicast autonomous-system [as]**
  - Does not need to match IPv4 AS
- Process starts on all interfaces automatically
  - Can be disabled with **shutdown** under **af-interface**

Verifying Named Mode IPv6 EIGRP

- Nearly identical to Named IPv4 EIGRP
  - **show eigrp address-family ipv6 interface**
  - **show eigrp address-family ipv6 neighbor**
  - **show eigrp address-family ipv6 topology [all-links]**
- Classic EIGRP show commands still supported
  - **show ipv6 eigrp…**