Post 7

Thursday, January 24, 2019 11:20 PM

EIGRP P1

EIGRP: Enhanced Interior Gateway Routing Protocol: Distance vector: Cisco: Features found in link-state protocols

- Lots of diff topologies
- Scalable
- Quick convergence times

Features: Released 1992: Proprietary Cisco: 2013 Open standard to IETF (other vendors can use)

- Things like EIGRP stub: Needed for DMVPN (Dynamic Multipoint VPN) wasn't released to other vendors
- Has both link-state/distance vector features
- Info about rest of network learned from directly connected neighbors
- Advanced distance vector

DUAL: Diffusing Update Algorithm: Center of protocol: Guarantees loop-free/backup paths through routing domain

- DUAL stores all avail backup routes for dest: Can quickly adapt alt routes when necessary

Neighbor Adjacencies: Establishes adjacencies w/directly connected routers: Used to track neighbor status

RTP: Reliable Transport Protocol: Unique/provides delivery of EIGRP packets to neighbors: Tracks neighbor adj. for DUAL

Partial/Bounded Updates:

- Partial/bounded: Updates
- Unlike RIP: Doesn't send period updates/route entries don't age out

Partial: Update only includes info about route changes (Example: new link avail/unavail)

Bound: Propagation of partial updates: Sent only to routers changes affect: Min's BW required to send EIGRP updates

Equal/Unequal Cost Load Balancing: Allows admins to distribute better traffic flow: EIGRP NOT hybrid bet dist vector/link-state

Protocol Dependent Modules: EIGRP can route 7 diff protocols like IPv4/IPv6 using PDMs (protocol-dependent modules):

- Obsolete now but EIGRP PDMs: Route Novell's IPX/Apple AppleTalk network layer protocols

PDMs: Responsible for network layer protocol-specific tasks

Example: Module responsible for sending/receiving EIGRP packets encapsulated in IPv4

- Also responsible for parsing EIGRP packets/informing DUAL of new info received
- EIGRP asks DUAL to make routing decisions: Results stored in IPv4 table

Specific tasks for each network layer protocol:

- Maintaining neighbor/topology tables of EIGRP routers that belong to protocol suite
- Building/translating protocol-specific packets for DUAL
- Interfacing DUAL to protocol-specific table
- Computing metric/passing info to DUAL
- Implementing filtering/access lists
- Performing redistribution functions to/from other protocols
- Redistributing routes learned by other protocols

When router discovers new neighbor: Records neighbor's address/ints as entry in table

- 1 neighbor table exists for each PDM (like IPv4)
- Maintains a topology table: Contains all destinations advertised by neighbors
- Separate topology table for each PDM

Reliable Transport Protocol: EIGRP uses RTP for delivery/reception of EIGRP packets

- EIGRP designed as network layer independent protocol
- **Can't use TCP/UDP:** Used for protocols other than TCP/IP suite (like IPX/AppleTalk)
- RTP includes both reliable/unreliable delivery of EIGRP packets (like TCP/UDP)

- RTP can send EIGRP packets as unicast/multicast

Reliable RTP: Ack returned by receiver/sender
Unreliable RTP: Packet doesn't require an ack
Example: EIGRP update packet sent reliably over RTP: Requires ack
EIGRP Hello packet also sent over RTP unreliably doesn't need ack
Authentication: Can be config for authentication

- RIPv2/EIGRP/OSPF/IS-IS/BGP can each be config to auth routing info
- Ensures routers only accept info from other routers that have been config w/same pass/auth info
- EIGRP routing updates aren't encrypted

EIGRP Packet Types: AKA: EIGRP Packet Formats: AKA: EIGRP Messages

Packet Type	Description
Hello	Discover other EIGRP routers in network
Acknowledgement	Receipt of EIGRP packet
Update	Convey routing info to known destinations
Query	Request specific info from neighbor
Reply	Respond to query

- Uses 5 diff packet types: Some in pairs
- Packets sent using RTP (reliable/unreliable)
- Sent as unicast/multicast/both
- Hello packets: Neighbor discovery/maintain adjacencies
    - Unreliable delivery
    - Multicast
- Update packets: Propagates routing info to EIGRP neighbors
    - Reliable delivery
    - Unicast/Multicast
- Acknowledgment packets: Receipt of EIGRP msg sent using reliable delivery
    - Unreliable delivery
    - Unicast
- Query packets: Query routes from neighbors
    - Reliable delivery
    - Unicast/multicast
- Reply packets: Response to EIGRP query
    - Reliable delivery
    - Unicast

EIGRP msgs typically encapsulated in IPv4/IPv6 packets:
IPv4 msg: As network layer protocol: Protocol field uses 88 to indicate data portion of packet is EIGRP
IPv6 msg: Encapsulated using header field of 88: Next header field indicates type of data carried
Hello Packets: Discover other EIGRP-enabled routers on directly connected links

- Used by routers to form EIGRP neighbor adjacencies
- Sent as IPv4/IPv6 multicasts: RTP unreliable delivery (Receiver doesn't reply w/ack packet)

Reserved multicast IPv4: 224.0.0.10
Reserved multicast IPv6: FF02::A

- Discover neighbors/establish adjacencies w/neighbor routers
- Multicast every 5 sec

Multipoint/NBMA Nonbroadcast multiple access (X.25/Frame Relay/ATM: Async Transfer Mode): Ints w/access links T1/slower:

- Unicast every 60 sec

Hello packets maintain established adjacencies: EIGRP router assumes as long as receives Hello's from neighbor: Viable
Hold Timers: Determines max time router should wait to receive next Hello before declaring neighbor unreachable

- **Default:** Hold time is 3x Hello interval
    - 15 sec most networks
    - 180 sec on low-speed NBMA networks

If hold time expires: EIGRP declares route down: DUAL searches for new path by sending out queries
Update Packets: Sends Update packets to propagate routing info: Sent only when necessary

- Updates contain only routing info needed
- Only sent to routers that require it

Unlike RIP: EIGRP doesn't send periodic updates/route entries don't age out

- EIGRP sends incremental updates only when state of destination changes
- May include new network becomes avail/existing network becomes unavail/change occurs in metric for existing network
- Min BW required to send EIGRP updates
- Reliable delivery as a multicast when required by multiple routers/unicast when required by single router

Acknowledgment Packets: ACK packets when reliable delivery used

- Ack is Hello packet w/out any data
- RTP uses reliable delivery for EIGRP update/query/reply packets
- Ack packets always sent as unreliable unicast

Query Packets: DUAL uses query/reply packets when searching for networks/other tasks

- Queries/replies: Reliable delivery
- Multicast/unicast: Replies always unicast

Reply Packets: Neighbors must send reply: Whether/not they have route to downed network

Encapsulating EIGRP Messages: Data portion of EIGRP msg encapsulated in packet: **TLV: Time/Length Value**

- EIGRP header included w/every packet: Regardless of type
- EIGRP header/TLV encapsulated in an IPv4 packet
- **Protocol field set to 88:** Indicates EIGRP/IPv4 destination address set to **multicast 224.0.0.10**
- **Packet encapsulated in eth0 frame?** Dest MAC also **multicast 01-00-5E-00-00-0A**

Data Link Frame Header	IP Packet Header	EIGRP Packet Header	TLV Types
MAC source = Addr of sending int **MAC dest** = Multicast 01-00-5E-00-00-0A	Source addr = Addr of sending int Dest addr = Multicast 224.0.0.10 Protocol = 88: EIGRP	Opcode for EIGRP packet type Autonomous Sys #	0x0001 EIGRP Params 0x0102 Internal routes 0x0102 External routes

EIGRP: IPv6: Similar encapsulation:

- Destination addr multicast FF02::A
- Header field also 88

Opcode field/Autonomous System Number: Opcode specifies EIGRP packet type as follows:

1. Update
2. Query
3. Reply
4. Hello

Autonomous system number: Specifies EIGRP routing process:

- Multiple instances of EIGRP can run on network (unlike RIP)
- The ASN is used to track each running EIGRP process

EIGRP Packet Header

EIGRP's TLV params: Includes metric weights

Default: BW/Delay: **Both weighted equally:** K1/K3 both set to 1 | **Other K:** 0

Hold Time: Amt of time EIGRP neighbor receiving msg should wait before considering router down

IP Internal Routes TLV: IP internal msg used to advertise EIGRP routes w/in autonomous sys

Impt fields:

- Metric fields (delay/BW)
- Subnet mask field (prefix length)
- Dest field

Delay: Sum of delays from source to destination in units of 10 microseconds

Bandwidth: Lowest config BW of any int along route

Subnet Mask: Prefix length/# of network bits in mask: Example: 255.255.255.0 /24: 24 # of network bits

Destination field: Stores address of dest. network

- Based on value of network portion of 32-bit address

Example: 10.1.0.0/16 is 10.1: Destination field stores 1st 16 bits

- Min length of field 24 bits: Remainder padded w/0's
- Longer than 24 bits? Dest field extended another 32 bits (total 56 bits)/unused bits padded w/0's

IP External Routes TLV: Used when external routes imported into EIGRP process

- All fields used by Internal TLV

MTU: Max transmission Unit: Not metric used by EIGRP: Included in updates/not to determine metric

Autonomous System Numbers: Config not associated w/IANA globally assigned ASN's used by external protocols

Diff bet IANA globally assigned ASN/EIGRP ASN?

IANA: Collection of networks under admin control of single entity that presents common routing policy to Internet

- **RIR: Regional Internet Registry (RIR):** Responsible for assigning ASN to entity from block of assigned ASN's

ISPs: Backbone providers/large institutions connecting to other entities require ASN

- **Exterior Gateway Routing Protocol:** BGP: Border Gateway Protocol: To propagate r-info
- BGP: Only protocol that uses an actual ASN in config

Companies w/IP networks don't need ASN: Controlled by larger entity (ISP)

- **Interior Gateway Protocols**: RIP/EIGRP/OSPF/IS-IS: To route packets w/in their networks

ASN used for EIGRP only significant to EIGRP routing domain:

- Functions as PID to help routers keep track of many instances of EIGRP
- Possible to have more than 1 instance of EIGRP on network
- Each instance can be config to support/exchange updates for diff networks

Router EIGRP:

R1(config)# router [*global config*] Used to begin config of any dynamic routing protocol

R1(config)# router ? [*global config*] Lists all avail routing protocols supported by that ver of IOS

R1(config)# router eigrp autonomous-system [*global config*] Enter router config mode for EIGRP/Start process

- ***autonomous-system*** Can be assigned any 16-bit value bet 1-65,535: All routers w/in EIGRP domain must use same ASN

R1(config)# router eigrp 1 [*global config*] 1 ID's particular EIGRP process

R1(config-router)#

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R2(config)# router eigrp 1

R3(config)# router eigrp 1

- **To establish adjacencies:** All routers in same domain use same ASN

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R1(config)# no router eigrp autonomous-system [*global config*] Remove EIGRP routing process from device

EIGRP Router ID: Determining RID: Used to ID each router in EIGRP domain: Used in both EIGRP/OSPF

IPv4: Uses 32-bit r-ID to ID originating router for redistribution of external routes: More relevant for IPv6

Cisco: RID on 3 criteria in order:

1. IPv4 addr config **eigrp router-id** [*router config*]
2. **RID not config**: Router chooses highest IPv4 addr of loopback ints
3. **No loopback ints config:** Router chooses highest active IPv4 addr of physical ints

R1(router-config)# eigrp router-id [*router config*] Config router ID

Some ver of IOS:

R1(router-config)# router-id

- Can be config w/any IPv4 address w/2 exceptions: 0.0.0.0 **|** 255.255.255.255

Loopback Used as RID: Another option to specify r-ID is to use an IPv4 loopback

Advantage: It can't fail/no actual cables/devices the int depends on to be in an up state

Enable/config loopback int:

Router(config)# int <*loopback number*>

Router(config-if)# ip address <*address mask*>

Verify EIGRP:

show ip protocols Displays params/current state of any active routing protocol process EIGRP/OSPF

- Diff types of output specific to each r-protocol

Network Command/Wildcard Mask:

network *[router config*] Enable EIGRP on int: Classful address for each directly connected network: Same function in IGP r-protocols

- Enables any int on router that matches network address to send/receive updates
- Network of ints included in routing updates

R1(config-router)# network <*ipv4-address*>

R1(config-router)# eigrp log-neighbor-changes [*router config*] Display any changes in EIGRP neighbor adjacencies

- Help verify neighbor adjacencies during config

- Advise admin when adjacencies removed

R1(config-router)# network network-address [wildcard-mask] | Config EIGRP to advertise specific subnets only

- Wildcard mask: Inverse of subnet mask: Inverse of mask 255.255.255.252 is 0.0.0.3
- **Calc:** Subtract subnet mask from 255

Passive Interface: As soon as a new int enabled w/in EIGRP: It attempts to form adjacency w/neighbors to send/receive updates

May need to include a directly connected network to EIGRP update: But not allow adjacencies off of int to form

- **Passive-interface** can be used to prevent neighbor adjacencies

2 reasons for enabling passive-int:

1. suppress unnecessary update traffic
2. Prevents the exchange of routes on int

R1(config-router)# passive-int [router config] Disables transmission/receipt of Hello packets on these ints

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R2(config)# router eigrp as-number

R2(config-router)# passive-interface int-type int-number

R2(config-router)# passive-interface [*router config*] Config all ints as passive

Verify EIGRP: Examine Neighbors

show ip eigrp neighbors View neighbor table/verify EIGRP established adjacency w/neighbors

- For each router: Should see address of adjacent router/int it uses to reach neighbor

Output:

H column	Lists neighbors in order learned
Address	Address of neighbor
Int	Local int Hello packet received on
Hold	Hello received: Value reset to max hold for int: Then counts down to 0: If 0 neighbor considered down
Uptime	Amt of time since neighbor was added to table
SRTT/RTO	**Smooth Round Trip Timer/Retransmission Timeout:** Used by RTP to manage reliable EIGRP packets
Queue Count	Should always be 0: If more: EIGRP packets wait to be sent
Sequence Number	Track updates/queries/reply packets

show ip protocols Displays params/other info about current state of any active IPv4 routing protocol processes config

- Displays diff output for each protocol

EIGRP parameters, including:

1. autonomous system number
2. EIGRP router ID
3. administrative distances: internal: 90 **|** external: 170 (default)
4. does not auto summarize networks. Subnets included in updates
5. neighbor adjacencies with other routers used to receive updates

show ip route Verifies routes received by EIGRP neighbors installed in table

R1(config-router)# no auto-summary

Neighbor Adjacency: Before any update packets exchanged: Must discover neighbors/routers on directly connected networks

- Hello packets establish/maintain neighbor adjacencies
- For two EIGRP routers to become neighbors: 7 params bet them must match
- Each EIGRP router maintains neighbor table: Contains list of routers on shared links that have an adjacency w/
- Used to track status of neighbors

Topology Table: Updates contain networks reachable from router sending them:

- As updates exchange bet neighbors: Receiving router adds these entries to its topology table
- Table includes route entries for every destination router learns from directly connected neighbors

Composite Metric: Default: EIGRP uses the following in its composite metric to calc preferred path:

BW	Slowest BW among all outgoing ints along path from source to dest

Delay	Sum of all int delays along path

The following can be used: Not recommended: Frequent recalcs

Reliability	Worse reliability bet source/dest.: Based on keepalives
Load	Worse load on a link bet source/dest.: Computed based on packet rate/config BW of int

Formula consists of values K1-K5: EIGRP metric weights

- K1/K3: BW/delay
- K2: Load
- K4/K5: Reliability
- Default: K1/K3 are set to 1
- K2/K4/K5 set to 0
- Only the BW/delay values are used in default composite metric computation
- K values/EIGRP ASN must match: If not: No adjacency

K values can be changed:

R1(config-router)# metric weights tos k1 k2 k3 k4 k5

Verify k Values: show ip protocols | show interfaces

Examining Metric Values

BW	BW of int: Kb/s
DLY	Delay of int: Microseconds
Reliability	Int as fraction of 255 (255/255 is 100% reliability): Calc as exponential avg over 5 min
Txload/Rxload	Transmit/Receive load on int as a fraction of 255 (255/255 completely saturated): • Calc as exponential avg over 5 min

BW Metric: A static value used by some protocols (EIGRP/OSPF) to calc routing metric

- Displayed in Kb/s
- Most serial ints use default BW value: 1544 kb/s **|** 1,544,000 b/s (1.544 Mb/s) (T1)

Most serial links: BW metric defaults to 1544 kb/s **| show int** to check BW metrics

- B/C EIGRP/OSPF use BW in default metric calc, correct value for BW super impt

Mod BW metric:

R1(config-if)# bandwidth kilobits-bandwidth-value

no bandwidth Restore default value

Delay Metric: The measure of time it takes for a packet to traverse a route

- Static value based on type of link int is connected to
- Expressed in microseconds
- Not measured dynamically: Router doesn’t actually track how long packets take to get to dest
- Delay value: Is a default value that can be changed
- Sum of all int delays along path measured in tens of microseconds

Calc EIGRP Metric

1. Determine link w/slowest BW: Use that value to calc BW (10,000,000)
2. Determine delay value for each outgoing int on way to dest
3. Add delay values/divide by 10 (sum of delay/10)
4. Composite metric produces 24-bit value: EIGRP uses 32-bit value. Multiply 24-bit value w/256 extends into 32 bits
    1. Add computed values for BW/delay/multiply sum by 256 to obtain EIGRP metric