Performance comparison of dynamic routing Protocols EIGRP & OSPF on IPv6

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Abstract— *Interior Gateway Routing Protocol (IGRP) is a distance-vector routing protocol while Enhanced Interior Gateway Routing Protocol (EIGRP) is an advanced distance vector routing protocol. As the name implies, EIGRP is better than IGRP. So, we hypothesized network using EIGRP will have a better routing performance. This paper consist of comparisons of OSPF, IGRP with EIGRP, Implementation of dynamic routing protocol EIGRP in the IPv6 network, and gives how the routing tables are preparing using EIGRP routing technique. EIGRP protocol is performing the job of updating the routing tables using DUAL algorithm and metric calculations. Finally this paper gives different commands on the router on EIGRP routing techniques to get the require results for connection establishment of WAN interfaces and LAN networks.*

Keywords—EIGRP; OSPF; Routing; Packet; Protocol

I. INTRODUCTION

Due to the limitations of Routing Information Protocol (RIP), in the mid-1980s Cisco Systems Inc. created IGRP to overcome the problems. IGRP is an interior gateway protocol (IGP) which is a distance-vector routing protocol used within an autonomous system (AS). EIGRP is an advanced distance-vector routing protocol that relies on features commonly associated with link-state protocols. OSPF's best traits, such as partial updates and neighbor discovery, are similarly put to use by EIGRP.

As we mentioned before, IGRP is a distance vector Interior Gateway Protocol (IGP). Distance vector routing protocols mathematically compare routes using some measurement of distance. This measurement is known as the distance vector. Routers using a distance vector protocol must send all or a portion of their routing table in a routing update message at regular intervals to each of their neighboring routers. As routing information distributes through the network, routers can identify new destinations as they are added to the network, learn of failures in the network, and calculate distances to all known destinations. EIGRP is also a distance-vector

Interior Gateway Protocol, which evolved from IGRP. Which means that it saves the distance such as hop count and a vector such as next hop when determining the best path to a destination. Creation of EIGRP is to answer the increasing needs in networking and demands of diverse, large-scale internetworks. EIGRP transports the subnet mask information, which makes it a Classless routing protocol. EIGRP contains an important protocol called Diffusing update algorithm (DUAL) developed at SRI International by Dr. J.J. Garcia- Luna-Aceves.

DUAL enables EIGRP routers to determine whether a path advertised by a neighbor is looped or loop-free, and allows a router running EIGRP to find alternate paths without waiting on updates from other routers. Therefore, EIGRP minimizes both the routing instability triggered by topology changes and the use of bandwidth and processing power in the router. When a change in the network happens, the routers with EIGRP sends out just the changes to the routing table. Also the EIGRP is not limited to the number of Hops so it can reach out very far without slowing down.We can also note that IGRP does not support VLSM where EIGRP does. VLSM allows you to subdivide a classful network into subnets. Also be aware that EIGRP and IGRP are compatible with each other. An automatic-redistribution mechanism allows IGRP routes to be imported into EIGRP, and vice versa. Because the metrics for both protocols are directly translatable, they are easily comparable. IGRP and EIGRP path selection is based on Bandwidth/Delay metric. Using some EIGRP commands maximum bandwidth can be changed as required.

II. EIGRP FUNDAMENTALS

It is an enhanced distance vector protocol that relies on the Diffused Update Algorithm (DUAL) to calculate the shortest path to a destination within a network. EIGRP for IPv6 works in the same way as EIGRP IPv4 where they can be configured and managed separately.

Restrictions: Configuring EIGRP for IPv6 has some restrictions they are listed below:

The interfaces can be is in "no shut" mode to start running the protocol.

EIGRP supports for IPX: In this Time-driven protocols, IPX RIP and SAP, generate updates every 60 seconds by default. These updates can crowd low-speed WANlinks, especially in large internetworks.

An EIGRP router will receive routing and service updates and then updates other routers only when changes in the SAP or routing tables occur. Routing updates occur as they would in any EIGRP network - using partial updates, thus conserving bandwidth on the low-speed WAN links. Neighbor table listing adjacent routers, comparable to the OSPF adjacency database. Some terms are given below.

Topology table - Every EIGRP router maintains a topology table for each configured network protocol showing all learned routes to a destination.

Routing table - EIGRP chooses the best routes to a destination from the topologytable and places these routes in the routing table.

Successor - A successor is a route selected as the primary route to use to reach adestination. Multiple successors for a destination can be retained in the routing table.

Feasible successor - A feasible successor is a backup route. Multiple feasible successors for a destination can be retained in the topology table.

EIGRP has the following four basic components:

1. Neighbor discovery of neighbor recovery
2. Reliable transport protocol
3. DUAL finite state machine
4. Protocol-dependent modules

Neighbor discovery/recovery--- Used by routers to dynamically learn about other routers on theirdirectly attached networks. Routers must also discover when their neighbors becomeunreachable or inoperative. This process is achieved with low overhead by periodically sendingsmall hello packets. As long as a router receives hello packets from a neighboring router, itassumes that the neighbor is functioning, and they can exchange routing information.

Reliable Transport Protocol (RTP)-Responsible for guaranteed, ordered delivery of Enhanced IGRP packets to all neighbors. It supports inter mixed transmission of multicast or unicast packets. For efficiency, only certain Enhanced IGRP packets are transmitted reliably. For example, on a multi-access network that has multicast capabilities, such as Ethernet, it is not necessary to send hello packets reliably to all neighbors individually. For that reason, Enhanced IGRP sends a single multicast hello packet containing an indicator that informs the receivers that the packet need not be acknowledged. Other types of packets, such as updates, indicate in the packet that acknowledgment is required. RTP has a provision for sending multicast packets quickly when unacknowledged packets are pending, which helps ensure that convergence time remains low in the presence of varying speed links.

Neighbor discovery/recovery - Used by routers to dynamically learn about other routers on their directly attached networks. Routers must also discover when their neighbors become unreachable or in operative. This process is achieved with low overhead by periodically sending small hello packets. As long as a router receives hello packets from a neighboring router, itassumes that the neighbor is functioning, and they can exchange routing information.

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DUAL finite state machine-Embodies the decision process for all route computations. It tracks all routes advertised by all neighbors. DUAL uses distance information to select efficient, loopfree paths and selects routes for insertion in a routing table based on feasible successors. A feasible successor is a neighboring router used for packet forwarding that is a least-cost path to a destination that is guaranteed not to be part of a routing loop. When a neighbor changes a metricor when a topology change occurs, DUAL tests for feasible successors. If one is found, DUAL uses it to avoid recomputing the route unnecessarily. When there are no feasible successors but there are neighbors advertising the destination, a recomputation (also known as a diffusing computation) must occur to determine a new successor. Although recomputation is not processor intensive, it does affect convergence time, so it is advantageous to avoid unnecessary recomputations.

Protocol-dependent modules-Responsible for network-layer protocol-specific requirements. For example, the IP-Enhanced IGRP module is responsible for sending and receiving EnhancedIGRP packets that are encapsulated in IP. IP-Enhanced IGRP is also responsible for parsingEnhanced IGRP packets and informing DUAL of the new information that has been received.IP-Enhanced IGRP asks DUAL to make routing decisions, the results of which are stored in theIP routing table. IP-Enhanced IGRP is responsible for redistributing routes learned by other IP routing protocols.

III. EIGRP PACKET TYPES

The five EIGRP packet types are: Hello – used to discover, verify, andrediscover neighbor routers. EIGRP routers sendhellos at a fixed but configurable interval, called the hello interval. The default hello interval depends on the bandwidth of the interface, 60 seconds for 1.54 mbps or less and 5 seconds for more than 1.54 mbps. Hellos are sent multicast to IP address 224.0.0.10.Acknowledgment – sent as unicast toindicate receipt of any EIGRP packet during a"reliable" exchange.

Update - used when a routerdiscovers a new neighbor or when a routerdiscovers a topology change. Sent unicast and reliably.

Query - can be multicast or unicast, used when routers need specific information from one or all neighbors. Sent reliably. *Reply* -used to respond to a query.

Always sent as a unicast.

EIGRP Metrics

EIGRP can utilize 5 separate metrics to determine the best route to adestination:

Bandwidth (K1) – Slowest link in the route path, measured in kilobits

Load (K2) – Cumulative load of all outgoing interfaces in the path, given as a fraction of 255

Delay of the Line (K3) – Cumulative delay of all outgoing interfacesin the path in tens of microseconds

Reliability (K4) – Average reliability of all outgoing interfaces in thepath, given as a fraction of 255

MTU (K5) – The smallest Maximum Transmission Unit in the path.

The MTU value is actually never used to calculate the metric

By default, only Bandwidth and Delay of the Line are used. This isidentical to IGRP, except that EIGRP provides a more granular metric bymultiplying the bandwidth and delay by 256. Bandwidth and delay are determined by the interfaces that lead towards the destination network.

By default, the full formula for determining the EIGRP metric is:

[10000000/bandwidth + delay] * 256

The bandwidth value represents the link with the lowest bandwidth in thepath, in kilobits. The delay is the total delay of all outgoing interfaces in thepath.

As indicated above, each metric is symbolized with a "K" and then anumber. When configuring EIGRP metrics, we actually identify whichmetrics we want EIGRP to consider. Again, by default, only Bandwidth andDelay are considered. Thus, using on/off logic:

K1 = 1, K2 = 0, K3 = 1, K4 = 0, K5 = 0

If all metrics were set to "on," the full formula for determining the EIGRPmetric would be:

$$\left[\left(K_1 \cdot \text{Bandwidth}_E + \frac{K_2 \cdot \text{Bandwidth}_E}{256 - \text{Load}} + K_3 \cdot \text{Delay}_E\right) \cdot \frac{K_5}{K_4 + \text{Reliability}}\right] \cdot 256$$

Remember, the "K" value is either set to on ("1") or off ("0").

Configuring EIGRP Metrics

EIGRP allows us to identify which metrics the protocol should consider, using the following commands:

Router(config)# router eigrp 10.

Router(config-router)# metric weights 0 1 1 1 0 0.

The first command enables the EIGRP process for Autonomous System 10.

The second actually identifies which EIGRP metrics to use. The first number(0) is for Type of Service, and should always be zero. The next numbers, inorder, are K1 (1), K2 (1), K3 (1), K4 (0), and K5 (0). Thus, we are instructing EIGRP to use bandwidth, load, and delay to calculate the total metric, but not reliability or MTU.

Our formula would thus be:

$$\left[\left(K_1 \cdot \text{Bandwidth}_E + \frac{K_2 \cdot \text{Bandwidth}_E}{256 - \text{Load}} + K_3 \cdot \text{Delay}_E\right) \cdot \frac{K_5}{K_4 + \text{Reliability}}\right] \cdot 256$$

The actual values of our metrics (such as bandwidth or delay) must be configured indirectly. To adjust the bandwidth (in Kbps) of an interface:

IV. RESULTS

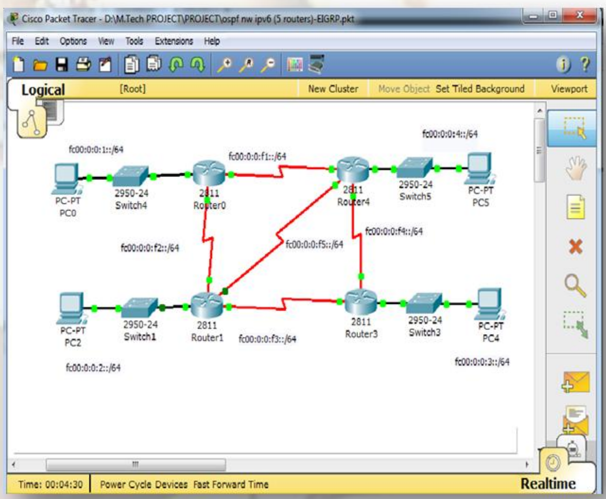

Fig. 1. Network Diagram

In the above network consists of four routers, they are connected with WAN interface and Ethernet LAN interface.

Configuration of Router R0:

interface FastEthernet0/0

noip address

duplex auto

speed auto

ipv6 address FC00:0:0:1::1/64

ipv6mtu 1500

ipv6eigrp 65000

ipv6 enable

ipv6 ospf 1 area 0!

interface Serial0/0/0

bandwidth 2048

noip address

ipv6 address FC00:0:0:F1::1/64

ipv6mtu 1500

ipv6eigrp 65000

ipv6 enable

ipv6 ospf 1 area 0!

interface Serial0/0/1

noip address

ipv6 address FC00:0:0:F2::1/64

ipv6mtu 1500

ipv6eigrp 65000

ipv6 enable

ipv6 ospf 1 area 0

clock rate 64000

Neighbor Database: Neighbors are discovered via the EIGRP hello sub-protocol. When an EIGRP router forms an adjacency with another EIGRP router, it stores this neighbor information in the neighbor database.

The show ipv6eigrp neighbors command can be used to display the information stored in this database. Sample output is show in the following figure:

Router#sh ipv6 eigrpneighbors

IPv6-EIGRP neighbors for process 65000

H Address Interface Hold Uptime SRT RTO

Seq (sec) (ms) CntNum

0 FE80::201:43FF:FE3E:E301Se0/0/1 12 00:08:57 40 1000 0 32

1 FE80::201:C7FF:FE4D:701Se0/0/0 12 00:08:57 40 1000 0 47

Topology Database: EIGRP routers store not only the best route to a destination, they store up to fivealternative routes as well. The next hop, along with other necessary information such as feasible distance and reported distance are stored in the topology database. The information that is stored inthe topology database can be viewed by issuing the show ipv6eigrp topology command.

Thefollowing figure details the output from this command:

Router#sh ipv6 eigrp topology

IPv6-EIGRP Topology Table for AS 65000/ID(10.10.10.10)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,

r - Reply status

P FC00:0:0:1::/64, 1 successors, FD is 28160

via Connected, FastEthernet0/0

P FC00:0:0:F2::/64, 1 successors, FD is 2169856

via Connected, Serial0/0/1

P FC00:0:0:F1::/64, 1 successors, FD is 1761792

via Connected, Serial0/0/0

P FC00:0:0:2::/64, 1 successors, FD is 2172416

via FE80::201:43FF:FE3E:E301 (2172416/28160), Serial0/0/1

P FC00:0:0:F5::/64, 2 successors, FD is 2681856

via FE80::201:43FF:FE3E:E301 (2681856/2169856), Serial0/0/1

via FE80::201:C7FF:FE4D:701 (2681856/2169856), Serial0/0/0

P FC00:0:0:4::/64, 1 successors, FD is 1764352

via FE80::201:C7FF:FE4D:701 (1764352/28160), Serial0/0/0

P FC00:0:0:F4::/64, 1 successors, FD is 2681856

via FE80::201:C7FF:FE4D:701 (2681856/2169856), Serial0/0/0

P FC00:0:0:F3::/64, 1 successors, FD is 2681856

via FE80::201:43FF:FE3E:E301 (2681856/2169856), Serial0/0/1

P FC00:0:0:3::/64, 2 successors, FD is 2684416

via FE80::201:43FF:FE3E:E301 (2684416/2172416), Serial0/0/1

via FE80::201:C7FF:FE4D:701 (2684416/2172416), Serial0/0/0

Routing table: Stores the actual routes to all destinations the routing table is populated from the topology table with every destination network that has its successor and optionally feasible successor identified (if unequal-cost load-balancing is enabled using the variance command). The successors and feasible successors serve as the next hop routers for these destinations.

Router#sh ipv6 route

IPv6 Routing Table - 13 entries

Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP

U - Per-user Static route, M - MIPv6

I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary

O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2

ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2 D - EIGRP, EX - EIGRP external

C FC00:0:0:1::/64 [0/0]

via ::, FastEthernet0/0

L FC00:0:0:1::1/128 [0/0]

via ::, FastEthernet0/0

D FC00:0:0:2::/64 [90/2172416]

via FE80::201:43FF:FE3E:E301, Serial0/0/1

D FC00:0:0:3::/64 [90/2684416]

via FE80::201:43FF:FE3E:E301, Serial0/0/1

via FE80::201:C7FF:FE4D:701, Serial0/0/0

D FC00:0:0:4::/64 [90/1764352]

via FE80::201:C7FF:FE4D:701, Serial0/0/0

C FC00:0:0:F1::/64 [0/0]

via ::, Serial0/0/0

L FC00:0:0:F1::1/128 [0/0]

via ::, Serial0/0/0

C FC00:0:0:F2::/64 [0/0]

via ::, Serial0/0/1

L FC00:0:0:F2::1/128 [0/0]

via ::, Serial0/0/1

D FC00:0:0:F3::/64 [90/2681856]

via FE80::201:43FF:FE3E:E301, Serial0/0/1

D FC00:0:0:F4::/64 [90/2681856]

via FE80::201:C7FF:FE4D:701, Serial0/0/0

D FC00:0:0:F5::/64 [90/2681856]

via FE80::201:43FF:FE3E:E301, Serial0/0/1

via FE80::201:C7FF:FE4D:701, Serial0/0/0

L FF00::/8 [0/0]

via ::, Null0

Issue	EIGRP	OSPF
Ease of Implementation	Easy, but remember “no auto-summary”	Complicated
Support of IPX and AppleTalk	Yes	No
Standards-based	Cisco Proprietary	IETF Open Standard
Hierarchical Design	No – summary statements on interfaces	Yes – hierarchy is part of the design
VLSM Support	Yes	Yes
Protocol Type	Enhanced Distance Vector	Link State
Routing Metrics	Combination of bandwidth, delay, reliability and load	Link 10^8/Interface-Bandwidth
CPU Requirements	Lower CPU and memory requirements	Higher CPU and memory requirements
Maturity	Since 1986	Since 1986
Stability	Excellent	Excellent

CONCLUSION

Enhanced Interior Gateway Protocol is a proprietary routing protocol developed by Cisco and used exclusively in their routing products. Although it is often lumped in with OSPF as a link state protocol, it is actually a hybrid containing the best elements of both link state and distance vector protocols. EIGRP has greater control on timing issues, such as hold times and hello intervals, than does OSPF.

Optimizing the routing table calculation improves the responsiveness and the scalability of the routing engine by reducing the convergence time and by reducing the need for more CPU power as the network grows. Finally, this paper has helped to learn different commands on the router on EIGRP routing techniques to get the require results for connection establishment of WAN interfaces and LAN networks.

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