

Implementation of Enhanced Interior Gateway Routing Protocol (EIGRP) in IPv6 Network

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Abstract— With the huge growth in internet users, there is a huge demand of IPv6 addressing scheme. However, the modern operating systems has option for this and with the development of IPv6 which removes the limitations imposed by IPv4 and provides the large number of address space. In this paper, we have considered the Enhanced Interior Gateway Routing Protocol and presented a scenario which is implemented in IPv6 networks. The scenario is implemented in Cisco packet tracer and obtain the results. In this scenario, we were find the shortest path between the sending and receiving device.

Keywords— EIGRP, IPv6, routing, local area network, wide area network.

I. INTRODUCTION

Recently, a lot of developments have been taken place in computer networks and now it is the necessity that the computer in one geographical location must communicate with another computer located at different geographical location. For doing so, though there are various available alternatives but almost all alternatives require use of Internet Protocol (IP) address to uniquely identify the machine over the network. If the two different computers are in the same location then they can communicate via Local Area Network (LAN), if not, then different available alternatives can be used for connectivity and communication over the networks and Wide Area Network (WAN) is one of them. To communicate over networks, numbers of devices are required and router is one of them and the routing protocol must be configured properly on each router. This routing protocol maintains the routing table which further maintains the shortest path of communication from source to destination. Commonly, this routing protocol is in IPv4 but nowadays IPv4 addresses are depleting so these protocols are now using IPv6 addresses. There are number of dynamic routing protocols (DRP) supported by IPv6 such as RIPng, EIGRP, OSPFv3, IS-IS, and Multiprotocol BGP etc.

In this paper, we have considered the Enhanced Interior Gateway Routing Protocol (EIGRP) for IPv6 as a routing protocol, which is a Cisco proprietary protocol and uses classless routing schemes based on diffusion update algorithm (DUAL) for calculating a shortest path from source to destination. It also supports unequal path load balancing that is the main reason of its fastest protocol. Its administrative distance is 90 that represent the trustworthiness of protocol. EIGRP selects fastest path based on delay, bandwidth, reliability, and load. For this, smaller size of packets is transmitted after every 5 seconds to see whether neighbour

router is up or not. These packets are sent for various different reasons like:

- For discovering neighbour,
- For building relation with neighbour,
- For maintaining relation with neighbour.

DUAL algorithm used, includes Successor(S), Feasible Successor (FS), Feasibility Condition (FC), Feasible Distance (FD), and reported distance (RD).

II. IPv6

The IPv6 protocol is an upgrade of the IPv4 protocol, belonging to the TCP/IP (Transmission Control Protocol / Internet Protocol) suites protocol stack, used to identify, by means of an IP address, each computer interface or device that connects to Internet or to an Intranet. Migrating from IPv4 to IPv6 in an instant is impossible because of the huge size of the Internet and of the great number of IPv4 users.

IPv6 is a 128 bits or 16 bytes addressing scheme, which is represented by a series of eight 16 bits field separated by colons. The format of IPv6 is x:x:x:x:x:x:x:x, where x is 16 bits hexadecimal numbers with leading zeros in each x field are optional. Successive x fields with 0 can be represented as: but only once, for example 2031:0000:0000:013f:0000:0000:0000:0001. Security in IPv6 is inherit, which provides authentication and encryption and has simple header format for higher processing.

Configuration of IPv6 on router

- To enable IPv6 Routing
Router (config) # ipv6 unicast-routing
- Configure IPv6 address
Router (config-if) # ipv6 address <IPv6 Address>/<prefix>

III. EIGRP IN IPv6

Designed by Cisco, the Enhanced Interior Gateway Routing Protocol for IPv6 (EIGRPv6) uses the Diffusing Update Algorithm (DUAL) which is also used by EIGRP in an IPv4 environment. The majority of EIGRP's features for IPv4 have been integrated into IPv6. These similarities include:

- The use of DUAL to compute EIGRP Successor and Feasible Successors.
- Using bandwidth and delay as the default metrics.
- The use of Reliable Transport Protocol (RTP).
- No periodic updates.
- EIGRPv6 implements the same authentication mechanism (MD5) as EIGRP.

However, despite the almost identical properties between EIGRP and EIGRPv6, a few changes have been

implemented to prepare the protocol for routing within an IPv6 environment. these changes include:

- The use of Link Local Addresses to establish neighbour adjacencies instead of using an IP subnet.
- EIGRP routers will use the IPv6 multicast address FF02::10 rather than the previous 224.0.0.10 multicast address.
- EIGRPv6 is also configured on a per interface basis rather than been globally enabled.
- The creation of a router ID is required to successfully start routing operations.

EIGRPv6 does not incorporate the use of IPsec to encrypt its routing updates, but instead uses the MD5 authentication method that was previously used in EIGRP for IPv4.

IV. IMPLEMENTATION OF EIGRP IN IPv6

Here, we have used simulation strategy by using packet tracer software. In this paper, we have proposed a network topology, which consists of three routers and each router is connected to personal computer through switch. In this topology as shown in figure 1, three different networks are used where one network consists of PC1, SWITCH (SW), ROUTER R1, second network consists of PC1, SWITCH (SW) and ROUTER R2.

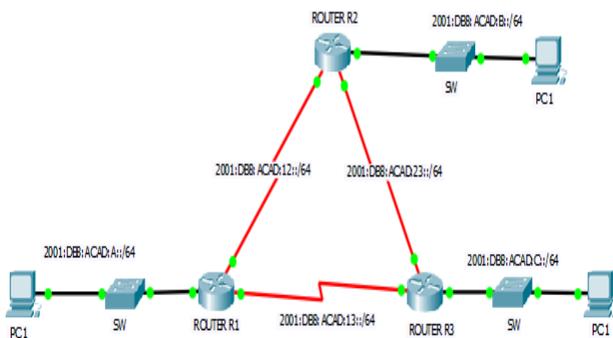


Fig. 1. Implemented topology in packet tracer.

And third network consists of PC1, SWITCH (SW) and ROUTER R3. PC1 of ROUTER R1 consist of IPV6 address 2001:DB8:ACAD:A::3/64, PC1 of ROUTER R2 consist of IPv6 address 2001:DB8:ACAD:B::3/64 and PC1 of ROUTER R3 consist of IPv6 address 2001:DB8:ACAD:C::3/64. if one end user wants to communicate with other end user then there is need of router as they both are the part of different networks. Two interfaces, Ethernet and serial port are required on the router to enable this communication. Let Router R1 consist of three interfaces known as Ethernet 0/0, Serial 0/0/0 and Serial 0/1/0. Ethernet 0/0 has IPv6 address 2001:DB8:ACAD:A::1/64, serial0/0/0 has IPv6 address 2001:DB8:ACAD:12::1/64 and serial0/1/0 has IPv6 address 2001:DB8:ACAD:13::1/64. Router R2 consist of three interfaces known as Ethernet 0/0, Serial 0/0/0 and Serial0/2/0. Ethernet0/0 has IPv6 address 2001:DB8:ACAD:B::1/64, serial0/0/0 has IPv6 address 2001:DB8:ACAD:12::2/64 and serial0/2/0 has IPv6 address

2001:DB8:ACAD:23::1/64. Router R3 consist of three interfaces known as Ethernet 0/0, Serial 0/0/0 and Serial0/0/1. Ethernet0/0 has IPv6 address 2001:DB8:ACAD:C::1/64, serial0/0/0 has IPv6 address 2001:DB8:ACAD:23::2/64 and serial0/0/1 has IPv6 address 2001:DB8:ACAD:13::2/64.

A. Main Configuration Command

These are the commands which are used to configure the IPv6 EIGRP protocol on the router R1, R2 and router R3, which can learn the shortest path and deliver the packet between different network through a corresponding shortest path. IPv6 unicast-routing command is used for enabling IPv6 forwarding, which will be the first command as after enabling IPv6 another command can be executed. IPv6 unicast-routing command is configured on the router in its configuration mode and no shut command is mandatory as to start the routing process. The various router configurations are shown as follows:

a) Router R1 configuration

```
hostname R1
!
ipv6 unicast-routing//IPv6 forwarding is enabled//
!
interface FastEthernet0/0
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:A::1/64
//configure IPv6 address for interface f0/0//
no shutdown
ipv6 eigrp 100// Enables the EIGRP for IPv6 process on the
fastethernet 0/0 interface//
!
interface Serial0/0/0
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:12::1/64
//configure IPv6 address for interface s0/0/0//
no shutdown
ipv6 eigrp 100// Enables the EIGRP for IPv6 process on the
serial0/0/0 interface//
clock rate 128000
!
interface Serial0/1/0
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:13::1/64
//configure IPv6 address for interface s0/1/0//
no shutdown
ipv6 eigrp 100// Enables the EIGRP for IPv6 process on the
serial0/0/0 interface//
clock rate 128000
!
ipv6 router eigrp 100
//eigrp ipv6 routing protocol is enabled//
eigrp router-id 1.1.1.1//Router Id is defined//
no shutdown// Enables no shut mode so the routing process
can start running//
!
end
```

b) Router R2 configuration

```
hostname R2
!
ipv6 unicast-routing//IPv6 forwarding is enabled //
!
interface FastEthernet0/0
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:B::1/64
//configure IPv6 address for interface f0/0//
no shutdown
ipv6 eigrp 100// Enables the EIGRP for IPv6 process on the
fastethernet 0/0 interface//
!
interface Serial0/0/0
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:12::2/64
//configure IPv6 address for interface s0/0/0//
no shutdown
ipv6 eigrp 100// Enables the EIGRP for IPv6 process on the
serial0/0/0 interface//
clock rate 2000000
!
interface Serial0/2/0
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:23::1/64
//configure IPv6 address for interface s0/2/0//
no shutdown
ipv6 eigrp 100// Enables the EIGRP for IPv6 process on the
serial0/2/0 interface//
clock rate 128000
!
ipv6 router eigrp 100
//eigrp ipv6 routing protocol is enabled//
eigrp router-id 2.2.2.2//Router Id is defined//
no shutdown// Enables no shut mode so the routing process
can start running//
!
end
```

c) Router R3 configuration

```
hostname R3
!
ipv6 unicast-routing//IPv6 forwarding is enabled //
!
interface FastEthernet0/0
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:C::1/64
//configure IPv6 address for interface f0/0//
no shutdown
ipv6 eigrp 100// Enables the EIGRP for IPv6 process on the
fastethernet 0/0 interface//
!
interface Serial0/0/0
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:23::2/64
//configure IPv6 address for interface s0/0/0//
no shutdown
ipv6 eigrp 100// Enables the EIGRP for IPv6 process on the
serial0/0/0 interface//
```

```
clock rate 2000000
!
interface Serial0/0/1
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:13::2/64
//configure IPv6 address for interface s0/0/1//
no shutdown
ipv6 eigrp 100// Enables the EIGRP for IPv6 process on the
serial0/0/1 interface//
clock rate 2000000
!
ipv6 router eigrp 100
//eigrp ipv6 routing protocol is enabled//
eigrp router-id 3.3.3.3//Router Id is defined//
no shutdown// Enables no shut mode so the routing process
can start running//
!
end
```

V. EXPERIMENTS RESULTS

This section represents the various obtained results for the router R1, R2 & R3 in the form of routing table, routing protocol information, IPv6 EIGRP neighbour information, and interface information.

A. Routing Table

Routing table of router R1, R2 & R3 as shown in figure 2, figure 3 and figure 4 maintains the shortest path to other routers. The letter C represents that the routing is directly connected to the router R1. The letter D represents that the routing is local and is done by using EIGRP. The following command shows IPv6-specific EIGRP routes:

Command: R1#show ipv6 route

```
IPv6 Routing Table - 10 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 2001:DB8:ACAD:A::/64 [0/0]
  via ::, FastEthernet0/0
L 2001:DB8:ACAD:A::1/128 [0/0]
  via ::, FastEthernet0/0
D 2001:DB8:ACAD:B::/64 [90/20514560]
  via FE80::2, Serial0/0/0
D 2001:DB8:ACAD:C::/64 [90/20514560]
  via FE80::3, Serial0/1/0
C 2001:DB8:ACAD:12::/64 [0/0]
  via ::, Serial0/0/0
L 2001:DB8:ACAD:12::1/128 [0/0]
  via ::, Serial0/0/0
C 2001:DB8:ACAD:13::/64 [0/0]
  via ::, Serial0/1/0
L 2001:DB8:ACAD:13::1/128 [0/0]
  via ::, Serial0/1/0
D 2001:DB8:ACAD:23::/64 [90/21024000]
  via FE80::2, Serial0/0/0
  via FE80::3, Serial0/1/0
L FF00::/8 [0/0]
  via ::, Null0
```

Fig. 2. Shows routing table of router R1.

Command: R2#show ipv6 route

```
R2#
R2#show ipv6 route
IPv6 Routing Table - 10 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
D 2001:DB8:ACAD:A::/64 [90/2684416]
  via FE80::3, Serial0/2/0
C 2001:DB8:ACAD:B::/64 [0/0]
  via ::, FastEthernet0/0
L 2001:DB8:ACAD:B::1/128 [0/0]
  via ::, FastEthernet0/0
D 2001:DB8:ACAD:C::/64 [90/2172416]
  via FE80::3, Serial0/2/0
C 2001:DB8:ACAD:12::/64 [0/0]
  via ::, Serial0/0/0
L 2001:DB8:ACAD:12::2/128 [0/0]
  via ::, Serial0/0/0
D 2001:DB8:ACAD:13::/64 [90/2681856]
  via FE80::3, Serial0/2/0
C 2001:DB8:ACAD:23::/64 [0/0]
  via ::, Serial0/2/0
L 2001:DB8:ACAD:23::1/128 [0/0]
  via ::, Serial0/2/0
L FF00::/8 [0/0]
  via ::, Null0
```

Fig. 3. Shows routing table of router R2.

Command: R3#show ipv6 route

```
R3#
R3#show ipv6 route
IPv6 Routing Table - 10 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
D 2001:DB8:ACAD:A::/64 [90/2172416]
  via FE80::1, Serial0/0/1
D 2001:DB8:ACAD:B::/64 [90/2172416]
  via FE80::2, Serial0/0/0
C 2001:DB8:ACAD:C::/64 [0/0]
  via ::, FastEthernet0/0
L 2001:DB8:ACAD:C::1/128 [0/0]
  via ::, FastEthernet0/0
D 2001:DB8:ACAD:12::/64 [90/21024000]
  via FE80::2, Serial0/0/0
  via FE80::1, Serial0/0/1
C 2001:DB8:ACAD:13::/64 [0/0]
  via ::, Serial0/0/1
L 2001:DB8:ACAD:13::2/128 [0/0]
  via ::, Serial0/0/1
C 2001:DB8:ACAD:23::/64 [0/0]
  via ::, Serial0/0/0
L 2001:DB8:ACAD:23::2/128 [0/0]
  via ::, Serial0/0/0
L FF00::/8 [0/0]
  via ::, Null0
R3#
```

Fig. 4. shows routing table of router R3.

B. Routing Protocol Information

The routing protocol information shows that EIGRP IPv6 routing protocol has been established and assigned process ID is 100. EIGRP is enabled on interfaces of R1, R2 & R3. Maximum hop count supported by EIGRP is 100.

Command: R1#show ipv6 protocol

```
R1#show ipv6 protocols
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "static"
IPv6 Routing Protocol is "eigrp 100"
EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
```

```
EIGRP maximum hopcount 100
EIGRP maximum metric variance 1
Interfaces:
FastEthernet0/0
Serial0/0/0
Serial0/1/0
Redistributing: eigrp 100
Maximum path: 16
Distance: internal 90 external 170
```

Command: R2#show ipv6 protocol

```
R2#show ipv6 protocols
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "static"
IPv6 Routing Protocol is "eigrp 100"
EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
EIGRP maximum hopcount 100
EIGRP maximum metric variance 1
Interfaces:
FastEthernet0/0
Serial0/0/0
Serial0/2/0
Redistributing: eigrp 100
Maximum path: 16
Distance: internal 90 external 170
```

Command: R3#show ipv6 protocol

```
R3#show ipv6 protocols
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "static"
IPv6 Routing Protocol is "eigrp 100"
EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
EIGRP maximum hopcount 100
EIGRP maximum metric variance 1
Interfaces:
FastEthernet0/0
Serial0/0/0
Serial0/0/1
Redistributing: eigrp 100
Maximum path: 16
Distance: internal 90 external 170
```

C. IPv6 EIGRP Neighbour Information

The obtained results also display the adjacency has been accomplished with their neighbouring routers. The link local address of a neighbour router is displayed in the table. These results are listed in table I, table II and table III.

Command: R1#show ipv6 eigrp neighbors

TABLE I. IPv6-EIGRP neighbours for Router R1.

H	0	1
Address	FE80::2	FE80::3
Interface (Sec)	Se0/0/0	Se0/1/0
Hold (ms)	12	14
Uptime Seq Cnt	00:21:14	00:24:17
SRTT Num	40	40
RTO	1000	1000
Q	0	0
Seq Num	11	14

Command: R2#show ipv6 eigrp neighbors

TABLE II. IPv6-EIGRP neighbours for Router R2.

H	0	1
Address	FE80::1	FE80::3
Interface (Sec)	Se0/0/0	Se0/2/0
Hold (ms)	14	11
Uptime Seq Cnt	00:21:14	00:24:17
SRTT Num	40	40
RTO	1000	1000
Q	0	0
Seq Num	9	13

Command: R3#show ipv6 eigrp neighbours

TABLE III. IPv6-EIGRP neighbours for Router R3.

H	0	1
Address	FE80::2	FE80::1
Interface (Sec)	Se0/0/0	Se0/0/1
Hold (ms)	10	10
Uptime Seq Cnt	00:21:14	00:24:17
SRTT Num	40	40
RTO	1000	1000
Q	0	0
Seq Num	12	10

- H indicates the order in which the neighbour discovered.
- Hold time in seconds is how long this router will wait for a hello packet to arrive from a specific neighbour.
- The uptime value indicates how long the neighbour relationship has been established.
- The SRTT field is the smooth round-trip timer and represents how long it takes to complete a round-trip from this router to its neighbour and back.
- The time between multicast attempts is specified by the Retransmission Time Out (RTO) field, which is based upon SRTT value.
- The Q values tells us if there are any outstanding messages in the queue.
- The seq field shows the sequence number of the last update from its neighbour.

D. EIGRP IPv6 Topology information

To display output of the EIGRP IPv6 topology table. The following EIGRP IPv6 topology command can be used to determine diffusion update algorithm (DUAL) states and to debug possible DUAL problems. Here, obtained results are displayed in figure 5, figure 6 and figure 7.

Command: R1#show ipv6 eigrp topology

```
R1#show ipv6 eigrp topology
IPv6-EIGRP Topology Table for AS 100/ID(1.1.1.1)

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

P 2001:DB8:ACAD:A::/64, 1 successors, FD is 28160
   via Connected, FastEthernet0/0
P 2001:DB8:ACAD:B::/64, 1 successors, FD is 20514560
   via FE80::2 (20514560/28160), Serial0/0/0
   via FE80::3 (21026560/2172416), Serial0/1/0
P 2001:DB8:ACAD:C::/64, 1 successors, FD is 20514560
   via FE80::3 (20514560/28160), Serial0/1/0
   via FE80::2 (21026560/2172416), Serial0/0/0
P 2001:DB8:ACAD:12::/64, 1 successors, FD is 20512000
   via Connected, Serial0/0/0
P 2001:DB8:ACAD:13::/64, 1 successors, FD is 20512000
   via Connected, Serial0/1/0
P 2001:DB8:ACAD:23::/64, 2 successors, FD is 21024000
   via FE80::2 (21024000/2169856), Serial0/0/0
   via FE80::3 (21024000/2169856), Serial0/1/0
```

Fig. 5. Shows topology table of router R1.

Command: R2#show ipv6 eigrp topology

```
R2#show ipv6 eigrp topology
IPv6-EIGRP Topology Table for AS 100/ID(2.2.2.2)

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

P 2001:DB8:ACAD:A::/64, 1 successors, FD is 2684416
   via FE80::3 (2684416/2172416), Serial0/2/0
   via FE80::1 (20514560/28160), Serial0/0/0
P 2001:DB8:ACAD:B::/64, 1 successors, FD is 28160
   via Connected, FastEthernet0/0
P 2001:DB8:ACAD:C::/64, 1 successors, FD is 2172416
   via FE80::3 (2172416/28160), Serial0/2/0
P 2001:DB8:ACAD:12::/64, 1 successors, FD is 20512000
   via Connected, Serial0/0/0
P 2001:DB8:ACAD:13::/64, 1 successors, FD is 2681856
   via FE80::3 (2681856/2169856), Serial0/2/0
P 2001:DB8:ACAD:23::/64, 1 successors, FD is 2169856
   via Connected, Serial0/2/0
```

Fig. 6. Shows topology table of router R2.

Command: R3#show ipv6 eigrp topology

```
R3#show ipv6 eigrp topology
IPv6-EIGRP Topology Table for AS 100/ID(3.3.3.3)

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

P 2001:DB8:ACAD:A::/64, 1 successors, FD is 2172416
   via FE80::1 (2172416/28160), Serial0/0/1
P 2001:DB8:ACAD:B::/64, 1 successors, FD is 2172416
   via FE80::2 (2172416/28160), Serial0/0/0
P 2001:DB8:ACAD:C::/64, 1 successors, FD is 28160
   via Connected, FastEthernet0/0
P 2001:DB8:ACAD:12::/64, 2 successors, FD is 21024000
   via FE80::2 (21024000/20512000), Serial0/0/0
   via FE80::1 (21024000/20512000), Serial0/0/1
P 2001:DB8:ACAD:13::/64, 1 successors, FD is 2169856
   via Connected, Serial0/0/1
P 2001:DB8:ACAD:23::/64, 1 successors, FD is 2169856
   via Connected, Serial0/0/0
```

Fig. 7. shows topology table of router R3.

VI. CONCLUSION

Routing is the process of moving packets from one network to the other network. Basically, the routing involves two activities: determining best path and forwarding packets through this path. These two activities of routing vary on the basis of selection of routing protocol. However, various routing protocols select different selection process for the best path. Routing protocols such as RIP, OSPF, IS-IS, and EIGRP are used, but we use the best routing protocol. So these routing protocols should use IPv6 address as the IPv4 addresses are depleted day-by-day. EIGRP protocol is the best protocol for routing because its convergence is very fast. EIGRP protocol has better routing capabilities hence EIGRP IPv6 will be mainly used in the future.

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