Advanced EIGRP Routing Project

Project Overview

This project demonstrates the design and implementation of an advanced EIGRP-based routing topology in a multi-router network environment. The lab simulates a scalable enterprise WAN scenario where routing efficiency, security, and traffic optimization are critical requirements.

The topology consists of multiple interconnected routers with loopback networks used to emulate internal LAN segments. The network is intentionally structured to allow multiple routing paths, enabling the implementation of advanced EIGRP features such as manual route summarization, MD5-based authentication, and unequal load balancing.

Manual summarization is implemented to reduce routing table size and improve scalability. EIGRP authentication is configured between selected routers to secure routing adjacencies and prevent unauthorized route injection. Additionally, metric manipulation using delay and the variance command is applied to demonstrate unequal load balancing and traffic engineering.

The project emphasizes deep understanding of EIGRP's DUAL algorithm, Feasible Distance (FD), Successor and Feasible Successor concepts, and metric calculation. Verification is performed using routing tables, neighbor tables, and topology tables to analyze routing behavior before and after configuration changes.

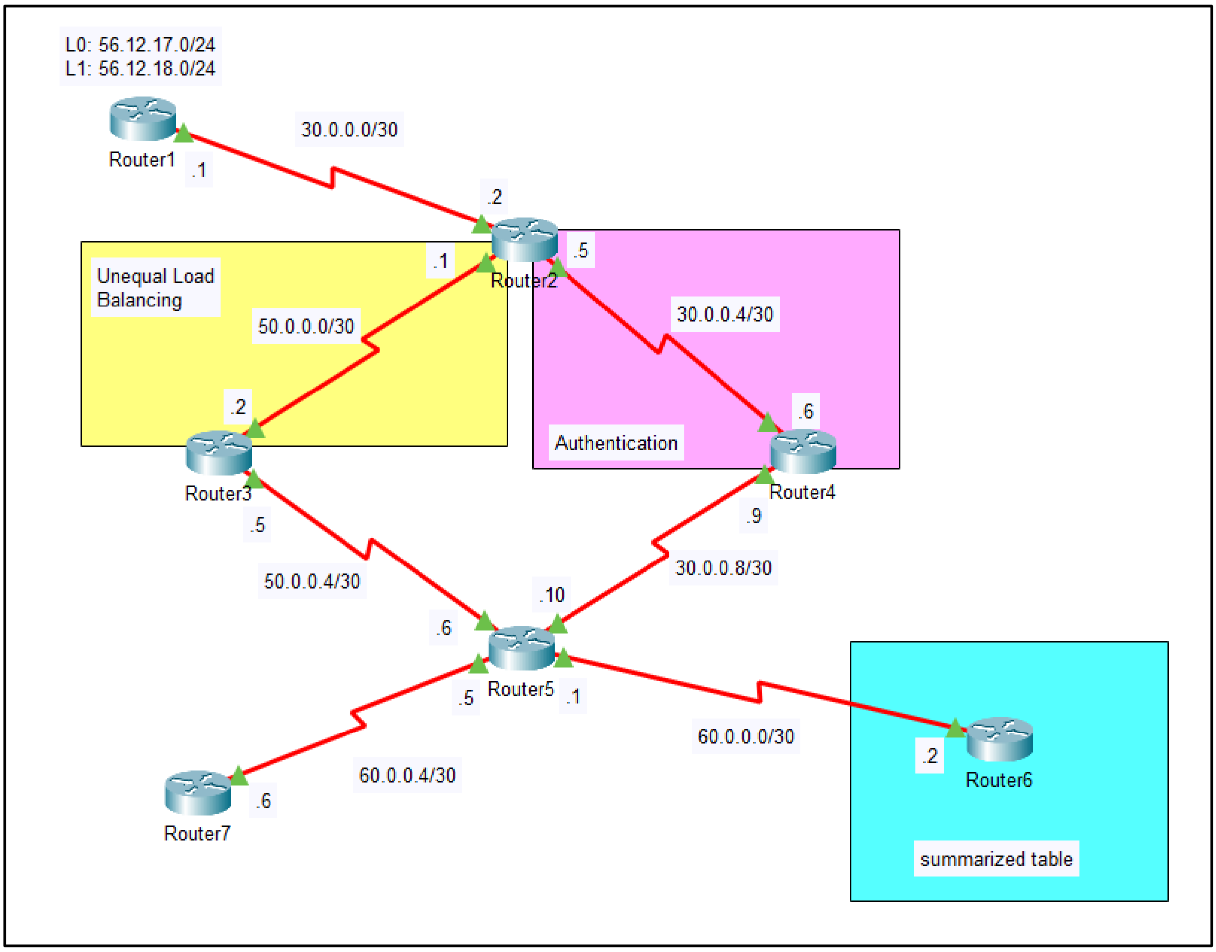
This implementation reflects real-world enterprise routing design principles, focusing on efficiency, security, scalability, and optimized path selection.

Objective

The objective of this project is to design and implement an EIGRP-based routing environment to demonstrate key advanced routing concepts, including manual route summarization, EIGRP authentication, and unequal load balancing. The project focuses on controlling route advertisement, securing router adjacencies, and optimizing traffic flow through metric manipulation and variance, using a loopback-based topology to emphasize routing behaviour over end-host connectivity.

Topology Design

The topology consists of seven routers interconnected through serial WAN links. Router5 acts as a core aggregation router where route summarization is implemented. Router2 and Router4 are configured with EIGRP authentication to demonstrate secure adjacency formation. Multiple redundant paths are intentionally designed between routers to demonstrate unequal load balancing using delay manipulation and variance configuration.



1. Configure Router IP

Router1:

R1> en
R1# conf t
R1(config)# int l0
R1(config-if)# ip addr 56.12.17.1 255.255.255.0
R1(config-if)# int l1
R1(config-if)# ip addr 56.12.18.1 255.255.255.0
R1(config-if)# int s 0/1/0
R1(config-if)# ip addr 30.0.0.1 255.255.255.252
R1(config-if)# no shut
ctrl+z
wr

Router2:

R2> en
R2# conf t
R2(config)# int s 0/1/0
R2(config-if)# ip addr 30.0.0.2 255.255.255.252
R2(config-if)# no shut
R2(config-if)# int s 0/2/0
R2(config-if)# ip addr 30.0.0.5 255.255.255.252
R2(config-if)# no shut
R2(config-if)# int s 0/2/1
R2(config-if)# ip addr 50.0.0.1 255.255.255.252
R2(config-if)# no shut
ctrl+z
wr

Router3
R3> en
R3# conf t
R3(config)# int s 0/1/0
R3(config-if)# ip addr 50.0.0.2 255.255.255.252
R3(config-if)# no shut
R3(config-if)# int s 0/1/1
R3(config-if)# ip addr 50.0.0.5 255.255.255.252
R3(config-if)# no shut
ctrl+z
wr

Router4
R4> en
R4# conf t
R4(config)# int s 0/1/0
R4(config-if)# ip addr 30.0.0.6 255.255.255.252
R4(config-if)# no shut
R4(config-if)# int s 0/1/1
R4(config-if)# ip addr 30.0.0.9 255.255.255.252
R4(config-if)# no shut
ctrl+z
wr

Router5
R5> en
R5# conf t
R5(config)# int s 0/1/0
R5(config-if)# ip addr 30.0.0.10 255.255.255.252

R5(config-if)# no shut
R5(config-if)# int s 0/1/1
R5(config-if)# ip addr 50.0.0.6 255.255.255.252
R5(config-if)# no shut
R5(config-if)# int s 0/2/0
R5(config-if)# ip addr 60.0.0.1 255.255.255.252
R5(config-if)# no shut
R5(config-if)# int s 0/2/1
R5(config-if)# ip addr 60.0.0.5 255.255.255.252
R5(config-if)# no shut
ctrl+z
wr

Router6
R6> en
R6# conf t
R6(config)# int s 0/1/0
R6(config-if)# ip addr 60.0.0.2 255.255.255.252
R6(config-if)# no shut
ctrl+z
wr

Router7
R7> en
R7# conf t
R7(config)# int s 0/1/0
R7(config-if)# ip addr 60.0.0.6 255.255.255.252
R7(config-if)# no shut
ctrl+z
wr

2. EIGRP Configuration

Router1:
R1(config)# router eigrp 1
R1(config-router)# eigrp router-id 1.1.1.1
R1(config-router)# network 56.12.17.0 0.0.0.255
R1(config-router)# network 56.12.18.0 0.0.0.255
R1(config-router)# network 30.0.0.0 0.0.0.3
R1(config-router)# no auto-summary
ctrl+z
wr

Router2:

R2(config)# router eigrp 1
R2(config-router)# eigrp router-id 2.2.2.2
R2(config-router)# network 30.0.0.0 0.0.0.3
R2(config-router)# network 30.0.0.4 0.0.0.3
R2(config-router)# network 50.0.0.0 0.0.0.3
R2(config-router)# no auto-summary
ctrl+z
wr

Router3:

R3(config)# router eigrp 1
R3(config-router)# eigrp router-id 3.3.3.3
R3(config-router)# network 50.0.0.0 0.0.0.3
R3(config-router)# network 50.0.0.4 0.0.0.3
R3(config-router)# no auto-summary
ctrl+z
wr

Router4:

R4(config)# router eigrp 1
R4(config-router)# eigrp router-id 4.4.4.4
R4(config-router)# network 30.0.0.4 0.0.0.3
R4(config-router)# network 30.0.0.8 0.0.0.3
R4(config-router)# no auto-summary
ctrl+z
wr

Router5:

R5(config)# router eigrp 1
R5(config-router)# eigrp router-id 5.5.5.5
R5(config-router)# network 30.0.0.8 0.0.0.3
R5(config-router)# network 50.0.0.4 0.0.0.3
R5(config-router)# network 60.0.0.0 0.0.0.3
R5(config-router)# network 60.0.0.4 0.0.0.3
R5(config-router)# no auto-summary
ctrl+z
wr

Router6:

R6(config)# router eigrp 1
R6(config-router)# eigrp router-id 6.6.6.6
R6(config-router)# network 60.0.0.0 0.0.0.3

R6(config-router)# no auto-summary
ctrl+z
wr

Router7:
R7(config)# router eigrp 1
R7(config-router)# eigrp router-id 7.7.7.7
R7(config-router)# network 60.0.0.4 0.0.0.3
R7(config-router)# no auto-summary
ctrl+z
wr

3. Manual Route Summarization

Route summarization is performed on the outbound interface of Router5 to reduce the routing table size observed on Router6.
In this scenario, Router6 is used to observe the impact of route summarization, while Router7 serves as a comparison point without summarization.

Router5:
R5(config)# int s 0/2/0
R5(config-if)# ip summary-address eigrp 1 56.12.16.0 255.255.252.0
R5(config-if)# ip summary-address eigrp 1 30.0.0.0 255.255.255.240
R5(config-if)# ip summary-address eigrp 1 50.0.0.0 255.255.255.248
R5(config-if)# ip summary-address eigrp 1 60.0.0.0 255.255.255.248
ctrl+z
wr

Verification

Router7: Routing table without manual summarization.

```
Router>sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     30.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
D       30.0.0.0/8 [90/3705856] via 60.0.0.5, 02:16:49, Serial0/1/0
D       30.0.0.0/30 [90/3705856] via 60.0.0.5, 02:16:49, Serial0/1/0
D       30.0.0.4/30 [90/3193856] via 60.0.0.5, 02:16:51, Serial0/1/0
D       30.0.0.8/30 [90/2681856] via 60.0.0.5, 02:16:51, Serial0/1/0
     50.0.0.0/30 is subnetted, 2 subnets
D       50.0.0.0/30 [90/3193856] via 60.0.0.5, 02:16:49, Serial0/1/0
D       50.0.0.4/30 [90/2681856] via 60.0.0.5, 02:16:50, Serial0/1/0
     56.0.0.0/24 is subnetted, 2 subnets
D       56.12.17.0/24 [90/3833856] via 60.0.0.5, 02:16:49, Serial0/1/0
D       56.12.18.0/24 [90/3833856] via 60.0.0.5, 02:16:49, Serial0/1/0
     60.0.0.0/8 is variably subnetted, 4 subnets, 3 masks
D       60.0.0.0/8 [90/3705856] via 60.0.0.5, 02:16:49, Serial0/1/0
D       60.0.0.0/30 [90/2681856] via 60.0.0.5, 02:16:53, Serial0/1/0
C       60.0.0.4/30 is directly connected, Serial0/1/0
L       60.0.0.6/32 is directly connected, Serial0/1/0
```

Router6: The routing table on Router6 is smaller compared to Router7.

```
Router>sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     30.0.0.0/28 is subnetted, 1 subnets
D       30.0.0.0/28 [90/2681856] via 60.0.0.1, 00:01:54, Serial0/1/0
     50.0.0.0/29 is subnetted, 1 subnets
D       50.0.0.0/29 [90/2681856] via 60.0.0.1, 00:01:54, Serial0/1/0
     56.0.0.0/22 is subnetted, 1 subnets
D       56.12.16.0/22 [90/2681856] via 60.0.0.1, 00:01:52, Serial0/1/0
     60.0.0.0/8 is variably subnetted, 3 subnets, 3 masks
D       60.0.0.0/29 [90/2681856] via 60.0.0.1, 00:01:54, Serial0/1/0
C       60.0.0.0/30 is directly connected, Serial0/1/0
L       60.0.0.2/32 is directly connected, Serial0/1/0
```

4. Authentication

Router Authentication between R2 and R4.

Router2:
R2(config)# key chain R2_Auth
R2(config-keychain)# key 1
R2(config-keychain-key)# key-string pass@123
R2(config-keychain-key)# exit
R2(config-keychain)# exit
R2(config)# int s 0/2/0
R2(config-if)# ip authentication key-chain eigrp 1 R2_Auth
R2(config-if)# ip authentication mode eigrp 1 md5
ctrl+z
wr

```
%DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 30.0.0.5 (Serial0/1/0) is down: authentication mode
changed
```

Router4:
R4(config)# key chain R4_Auth
R4(config-keychain)# key 1
R4(config-keychain-key)# key-string pass@123
R4(config-keychain-key)# exit
R4(config-keychain)# exit
R4(config)# int s 0/1/0
R4(config-if)# ip authentication key-chain eigrp 1 R4_Auth
R4(config-if)# ip authentication mode eigrp 1 md5
ctrl+z
wr

```
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 30.0.0.5 (Serial0/1/0) is up: new adjacency
```

<u>Verification</u>

Use commands like:
“show ip eigrp neighbor” OR “show run”

Router2:
R2# show ip eigrp neighbor

```
Router#sh ip eigrp neighbors
IP-EIGRP neighbors for process 1
H    Address          Interface       Hold Uptime    SRTT    RTO    Q    Seq
                                      (sec)          (ms)          Cnt   Num
0    30.0.0.1         Se0/1/0         13   00:15:51  40      1000   0    34
1    50.0.0.2         Se0/2/1         13   00:15:51  40      1000   0    42
2    30.0.0.6         Se0/2/0         14   00:02:20  40      1000   0    64
```

R2# show run

```
interface Serial0/2/0
 ip address 30.0.0.5 255.255.255.252
 ip authentication mode eigrp 1 md5
 ip authentication key-chain eigrp 1 R2_Auth
!
```

Router4:

R4# show ip eigrp neighbor

```
Router#sh ip eigrp nei
IP-EIGRP neighbors for process 1
H    Address          Interface       Hold Uptime    SRTT    RTO    Q    Seq
                                      (sec)          (ms)          Cnt   Num
0    30.0.0.10        Se0/1/1         11   00:05:55  40      1000   0    39
1    30.0.0.5         Se0/1/0         13   00:01:18  40      1000   0    29
```

R4# show run

```
interface Serial0/1/0
 ip address 30.0.0.6 255.255.255.252
 ip authentication mode eigrp 1 md5
 ip authentication key-chain eigrp 1 R4_Auth
 clock rate 2000000
!
```

5. Unequal Load Balance

Unequal Load Balancing at Router2 between authenticated and alternate paths

Router2:

R2(config)# int s 0/2/1

R2(config-if)# delay 20000

ctrl+z

wr

Router3:
R3(config)# int s 0/1/0
R3(config-if)# delay 20000
ctrl+z
wr

After this the topology table of Router2 will look like:

```
Router#sh ip eigrp topology
IP-EIGRP Topology Table for AS 1/ID(2.2.2.2)

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

P 30.0.0.0/8, 1 successors, FD is 4217856
         via 30.0.0.6 (4217856/3705856), Serial0/2/0
         via 50.0.0.2 (7801856/2681856), Serial0/2/1
P 30.0.0.0/30, 1 successors, FD is 2169856
         via Connected, Serial0/1/0
P 30.0.0.4/30, 1 successors, FD is 2169856
         via Connected, Serial0/2/0
P 30.0.0.8/30, 1 successors, FD is 2681856
         via 30.0.0.6 (2681856/2169856), Serial0/2/0
P 50.0.0.0/30, 1 successors, FD is 6777856
         via Connected, Serial0/2/1
P 50.0.0.4/30, 1 successors, FD is 3193856
         via 30.0.0.6 (3193856/2681856), Serial0/2/0
         via 50.0.0.2 (7289856/2169856), Serial0/2/1
P 56.12.17.0/24, 1 successors, FD is 2297856
         via 30.0.0.1 (2297856/128256), Serial0/1/0
P 56.12.18.0/24, 1 successors, FD is 2297856
         via 30.0.0.1 (2297856/128256), Serial0/1/0
P 60.0.0.0/8, 1 successors, FD is 4217856
         via 30.0.0.6 (4217856/3705856), Serial0/2/0
         via 50.0.0.2 (7801856/2681856), Serial0/2/1
P 60.0.0.0/30, 1 successors, FD is 3193856
         via 30.0.0.6 (3193856/2681856), Serial0/2/0
         via 50.0.0.2 (7801856/2681856), Serial0/2/1
P 60.0.0.4/30, 1 successors, FD is 3193856
         via 30.0.0.6 (3193856/2681856), Serial0/2/0
         via 50.0.0.2 (7801856/2681856), Serial0/2/1
```

After increasing the delay on the alternate path, the authenticated path became the EIGRP successor. The topology table confirms this by showing the lowest Feasible Distance (FD) on the authenticated link.

Router2:
R2(config)# router eigrp 1
R2(config-router)# variance 2
ctrl+z

wr

Verification

Router2:

```
Router#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     30.0.0.0/8 is variably subnetted, 6 subnets, 3 masks
D       30.0.0.0/8 [90/4217856] via 30.0.0.6, 00:00:23, Serial0/2/0
                   [90/7801856] via 50.0.0.2, 00:00:24, Serial0/2/1
C       30.0.0.0/30 is directly connected, Serial0/1/0
L       30.0.0.2/32 is directly connected, Serial0/1/0
C       30.0.0.4/30 is directly connected, Serial0/2/0
L       30.0.0.5/32 is directly connected, Serial0/2/0
D       30.0.0.8/30 [90/2681856] via 30.0.0.6, 00:00:23, Serial0/2/0
     50.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C       50.0.0.0/30 is directly connected, Serial0/2/1
L       50.0.0.1/32 is directly connected, Serial0/2/1
D       50.0.0.4/30 [90/3193856] via 30.0.0.6, 00:00:23, Serial0/2/0
     56.0.0.0/24 is subnetted, 2 subnets
D       56.12.17.0/24 [90/2297856] via 30.0.0.1, 00:00:22, Serial0/1/0
D       56.12.18.0/24 [90/2297856] via 30.0.0.1, 00:00:22, Serial0/1/0
     60.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
D       60.0.0.0/8 [90/4217856] via 30.0.0.6, 00:00:23, Serial0/2/0
                   [90/7801856] via 50.0.0.2, 00:00:24, Serial0/2/1
D       60.0.0.0/30 [90/3193856] via 30.0.0.6, 00:00:23, Serial0/2/0
D       60.0.0.4/30 [90/3193856] via 30.0.0.6, 00:00:23, Serial0/2/0
```

After applying the variance command, unequal load balancing is achieved, allowing traffic to be distributed across both paths while favoring the preferred path.

Conclusion

This project successfully implemented and analyzed advanced EIGRP routing features within a multi-router topology. The configuration demonstrated how EIGRP can be optimized for scalability, security, and efficient traffic engineering in an enterprise network environment.

Manual route summarization significantly reduced the routing table size, improving routing efficiency and minimizing unnecessary route advertisements. MD5-based EIGRP authentication was successfully configured to secure router adjacencies, ensuring that only trusted devices could participate in the routing process. Additionally, metric manipulation using interface delay and the variance command effectively demonstrated unequal load balancing, allowing traffic distribution across multiple feasible paths while prioritizing the preferred route.

Through verification using routing tables, neighbor tables, and topology tables, the project validated EIGRP’s DUAL algorithm behavior, including successor and feasible successor selection based on Feasible Distance (FD).

Overall, this project strengthened practical understanding of advanced EIGRP operations and demonstrated how routing performance, scalability, and security can be enhanced through proper configuration and design.