Final Project

Dynamic Routing Configuration
OSPF & EIGRP

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Overview

In this project, we are configuring efficient network infrastructure and implementing an optimal connection between multi branch organization using dynamic routing with multiple features to achieve scalability, efficiency and optimal routing.

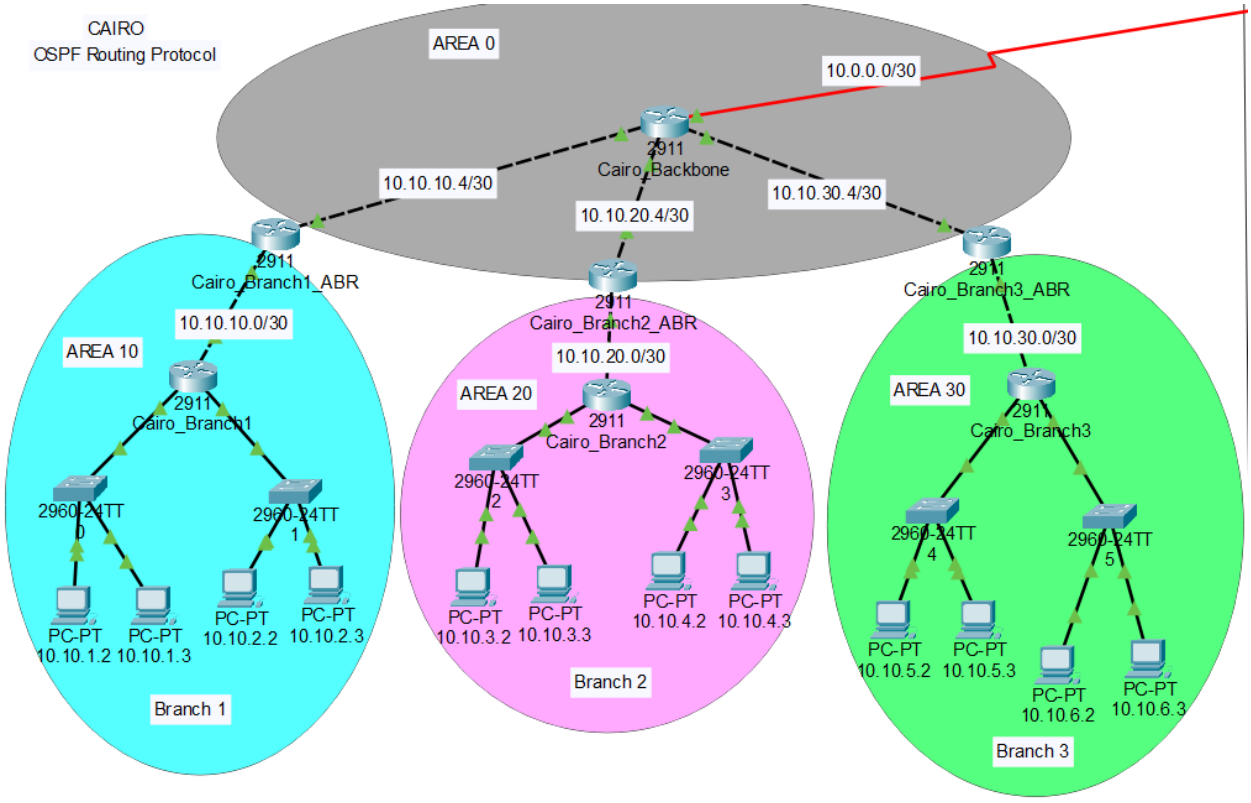
This report highlights the architecture, configuration strategies, and verification of OSPF routing protocol with multi-area configuration, EIGRP and summarization feature and configuring Redistribution between the two routing protocols to connect networks learned by each protocol and allow communication between them.

Our design ensures seamless communication between multiple branches and regions while maintaining performance through multi-area, route summarization and redistribution policies.

OSPF

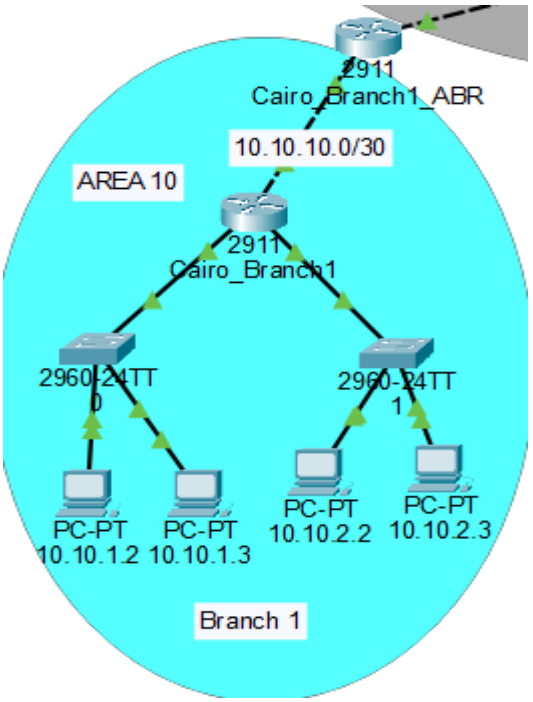
For OSPF configurations, we have multiple area network consists of 3 different areas connected to the backbone area which is Area 0 that allows neighbourship between different areas devices.

Each area contains a branch router connected to access switches for each LAN network, and Area Boundary Router (ABR) which connects the area to the backbone area (area 0).



OSPF

OSPF Configurations



Branch 1 (area 10):

The branch router advertises the 2 LANs directly connected to it (10.10.1.0/24 and 10.10.2.0/24) and the point-to-point network with the branch ABR (10.10.10.0/30).

router ospf 1
network 10.10.1.0 0.0.0.255 area 10
network 10.10.2.0 0.0.0.255 area 10
network 10.10.10.0 0.0.0.3 area 10

Branch 1 ABR:

This router advertises 2 point-to-point routes which are connected to the branch router and backbone router in area 0.

router ospf 1
network 10.10.10.4 0.0.0.3 area 0
network 10.10.10.0 0.0.0.3 area 10

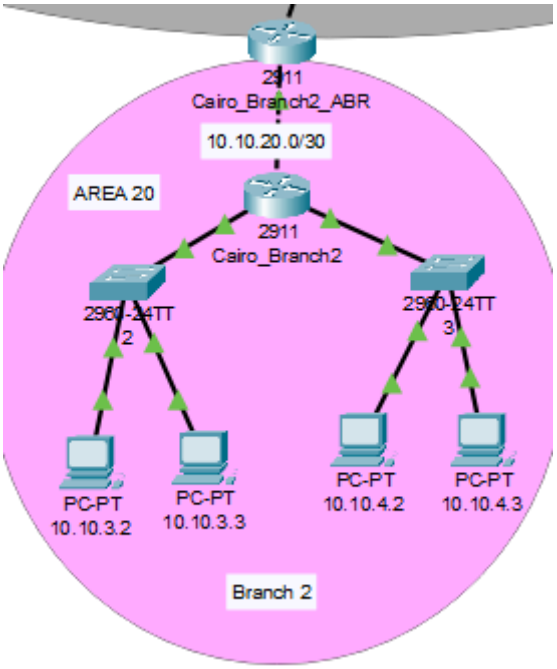
area verification:

```
cairo1#sh ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           1   FULL/BDR        00:00:34    10.10.10.2      GigabitEthernet0/0
```

```
cairo1_edge#sh ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
7.7.7.7           1   FULL/DR         00:00:39    10.10.10.6      GigabitEthernet0/1
2.2.2.2           1   FULL/DR         00:00:39    10.10.10.1      GigabitEthernet0/0
```

OSPF

Branch 2 (area 20):



The branch router advertises the 2 LANs directly connected to it (10.10.3.0/24 and 10.10.4.0/24) and the point-to-point network with the branch ABR (10.10.20.0/30).

router ospf 1
network 10.10.3.0 0.0.0.255 area 20
network 10.10.4.0 0.0.0.255 area 20
network 10.10.20.0 0.0.0.3 area 20

Branch 2 ABR:

This router advertises 2 point-to-point routes which are connected to the branch router and backbone router in area 0.

router ospf 1
network 10.10.20.0 0.0.0.3 area 20
network 10.10.20.4 0.0.0.3 area 0

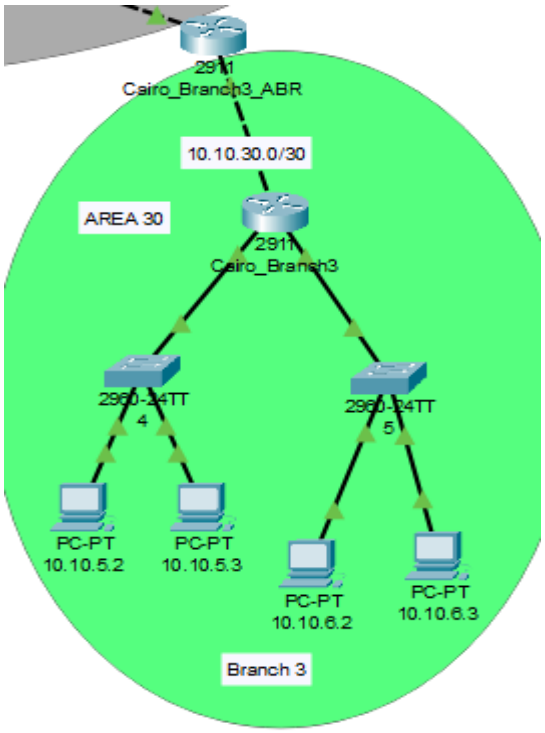
area verification:

```
cairo2#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           1   FULL/BDR        00:00:31    10.10.20.2      GigabitEthernet0/0
```

```
cairo2_edge#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
4.4.4.4           1   FULL/DR         00:00:32    10.10.20.1      GigabitEthernet0/0
7.7.7.7           1   FULL/DR         00:00:32    10.10.20.6      GigabitEthernet0/1
```

OSPF

Branch 3(area 30):



The branch router advertises the 2 LANs directly connected to it (10.10.5.0/24 and 10.10.6.0/24) and the point-to-point network with the branch ABR (10.10.30.0/30).

router ospf 1
network 10.10.5.0 0.0.0.255 area 30
network 10.10.6.0 0.0.0.255 area 30
network 10.10.30.0 0.0.0.3 area 30

Branch 3 ABR:

This router advertises 2 point-to-point routes which are connected to the branch router and backbone router in area 0.

router ospf 1
network 10.10.30.0 0.0.0.3 area 30
network 10.10.30.4 0.0.0.3 area 0

area verification:

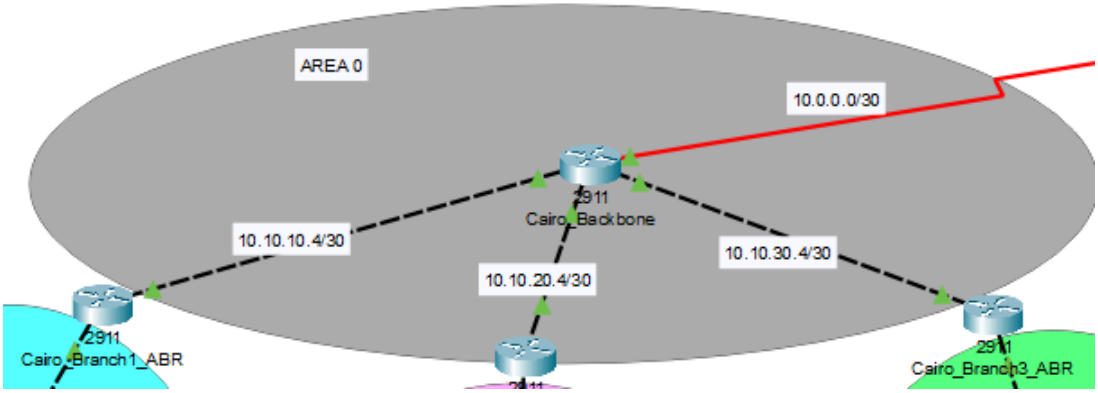
```
cairo3#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
5.5.5.5           1   FULL/BDR        00:00:30    10.10.30.2      GigabitEthernet0/0
```

```
cairo3_edge#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
6.6.6.6           1   FULL/DR         00:00:33    10.10.30.1      GigabitEthernet0/0
7.7.7.7           1   FULL/DR         00:00:33    10.10.30.6      GigabitEthernet0/1
```

OSPF

Backbone router:

This is the edge router of Cairo branches. Its connected to all ABRs of different areas and manages the sharing of routing information and Link-state advertisements (LSAs) between Inter-area devices. Its has the highest Router-Id to be the DR to all ABRs and centralize hello packets and LSAs in routing updates.



Also the backbone router is connected with a serial link to an autonomous system boundary router which connects Cairo branches to the other branch.

router ospf 1
router-id 7.7.7.7
network 10.0.0.0 0.0.0.3 area 0
network 10.10.10.4 0.0.0.3 area 0
network 10.10.20.4 0.0.0.3 area 0
network 10.10.30.4 0.0.0.3 area 0

```
cairo_backbone#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
1.2.3.4           0   FULL/  -        00:00:35    10.0.0.1        Serial0/0/0
5.5.5.5           1   FULL/BDR        00:00:35    10.10.30.5      GigabitEthernet0/0
3.3.3.3           1   FULL/BDR        00:00:35    10.10.20.5      GigabitEthernet0/1
1.1.1.1           1   FULL/BDR        00:00:35    10.10.10.5      GigabitEthernet0/2
```

OSPF

OSPF total verification

Routing table of OSPF network of Cairo branches:

Branch2 router:

```
cairo2#show 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
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 16 subnets, 3 masks
O IA    10.0.0.0/30 [110/66] via 10.10.20.2, 02:08:36, GigabitEthernet0/0
O IA    10.10.1.0/24 [110/5] via 10.10.20.2, 02:08:36, GigabitEthernet0/0
O IA    10.10.2.0/24 [110/5] via 10.10.20.2, 02:08:36, GigabitEthernet0/0
C       10.10.3.0/24 is directly connected, GigabitEthernet0/1
L       10.10.3.1/32 is directly connected, GigabitEthernet0/1
C       10.10.4.0/24 is directly connected, GigabitEthernet0/2
L       10.10.4.1/32 is directly connected, GigabitEthernet0/2
O IA    10.10.5.0/24 [110/5] via 10.10.20.2, 02:08:26, GigabitEthernet0/0
O IA    10.10.6.0/24 [110/5] via 10.10.20.2, 02:08:26, GigabitEthernet0/0
O IA    10.10.10.0/30 [110/4] via 10.10.20.2, 02:08:36, GigabitEthernet0/0
O IA    10.10.10.4/30 [110/3] via 10.10.20.2, 02:08:36, GigabitEthernet0/0
C       10.10.20.0/30 is directly connected, GigabitEthernet0/0
L       10.10.20.1/32 is directly connected, GigabitEthernet0/0
O IA    10.10.20.4/30 [110/2] via 10.10.20.2, 02:08:46, GigabitEthernet0/0
O IA    10.10.30.0/30 [110/4] via 10.10.20.2, 02:08:26, GigabitEthernet0/0
O IA    10.10.30.4/30 [110/3] via 10.10.20.2, 02:08:36, GigabitEthernet0/0
```

ABR of branch2:

```
Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 15 subnets, 3 masks
O       10.0.0.0/30 [110/65] via 10.10.20.6, 00:32:09, GigabitEthernet0/1
O IA    10.10.1.0/24 [110/4] via 10.10.20.6, 00:32:09, GigabitEthernet0/1
O IA    10.10.2.0/24 [110/4] via 10.10.20.6, 00:32:09, GigabitEthernet0/1
O       10.10.3.0/24 [110/2] via 10.10.20.1, 02:16:21, GigabitEthernet0/0
O       10.10.4.0/24 [110/2] via 10.10.20.1, 02:16:21, GigabitEthernet0/0
O IA    10.10.5.0/24 [110/4] via 10.10.20.6, 00:32:09, GigabitEthernet0/1
O IA    10.10.6.0/24 [110/4] via 10.10.20.6, 00:32:09, GigabitEthernet0/1
O IA    10.10.10.0/30 [110/3] via 10.10.20.6, 00:32:09, GigabitEthernet0/1
O       10.10.10.4/30 [110/2] via 10.10.20.6, 00:32:09, GigabitEthernet0/1
C       10.10.20.0/30 is directly connected, GigabitEthernet0/0
L       10.10.20.2/32 is directly connected, GigabitEthernet0/0
C       10.10.20.4/30 is directly connected, GigabitEthernet0/1
L       10.10.20.5/32 is directly connected, GigabitEthernet0/1
O IA    10.10.30.0/30 [110/3] via 10.10.20.6, 00:32:09, GigabitEthernet0/1
O       10.10.30.4/30 [110/2] via 10.10.20.6, 00:32:09, GigabitEthernet0/1
```

OSPF

Backbone router:

```
Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 17 subnets, 3 masks
C       10.0.0.0/30 is directly connected, Serial0/0/0
L       10.0.0.2/32 is directly connected, Serial0/0/0
O IA    10.10.1.0/24 [110/3] via 10.10.10.5, 02:18:29, GigabitEthernet0/2
O IA    10.10.2.0/24 [110/3] via 10.10.10.5, 02:18:29, GigabitEthernet0/2
O IA    10.10.3.0/24 [110/3] via 10.10.20.5, 02:18:29, GigabitEthernet0/1
O IA    10.10.4.0/24 [110/3] via 10.10.20.5, 02:18:29, GigabitEthernet0/1
O IA    10.10.5.0/24 [110/3] via 10.10.30.5, 02:18:19, GigabitEthernet0/0
O IA    10.10.6.0/24 [110/3] via 10.10.30.5, 02:18:19, GigabitEthernet0/0
O IA    10.10.10.0/30 [110/2] via 10.10.10.5, 02:18:29, GigabitEthernet0/2
C       10.10.10.4/30 is directly connected, GigabitEthernet0/2
L       10.10.10.6/32 is directly connected, GigabitEthernet0/2
O IA    10.10.20.0/30 [110/2] via 10.10.20.5, 02:18:29, GigabitEthernet0/1
C       10.10.20.4/30 is directly connected, GigabitEthernet0/1
L       10.10.20.6/32 is directly connected, GigabitEthernet0/1
O IA    10.10.30.0/30 [110/2] via 10.10.30.5, 02:18:19, GigabitEthernet0/0
C       10.10.30.4/30 is directly connected, GigabitEthernet0/0
L       10.10.30.6/32 is directly connected, GigabitEthernet0/0
```

Tracing route between 2 devices in different areas:

From 10.10.1.2 (area 10) to 10.10.6.5 (area 30)

```
C:\>tracert 10.10.6.5

Tracing route to 10.10.6.5 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      10.10.1.1
  2    0 ms      0 ms      0 ms      10.10.10.2
  3    0 ms      0 ms      0 ms      10.10.10.6
  4    0 ms      0 ms      0 ms      10.10.30.5
  5    0 ms      0 ms      0 ms      10.10.30.1
  6    0 ms      2 ms      0 ms      10.10.6.5

Trace complete.
```

From 10.10.4.2 (area 20) to 10.10.2.4 (area 10)

```
C:\>tracert 10.10.2.4

Tracing route to 10.10.2.4 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      10.10.4.1
  2    0 ms      0 ms      0 ms      10.10.20.2
  3    0 ms      1 ms      1 ms      10.10.20.6
  4    0 ms      0 ms      0 ms      10.10.10.5
  5    0 ms      1 ms      0 ms      10.10.10.1
  6    0 ms      0 ms      11 ms     10.10.2.4

Trace complete.
```

EIGRP Configuration

For EIGRP network, we have 3 routers for 3 different branches in process-Id 1. Each router connects 2 LANs of branch devices.

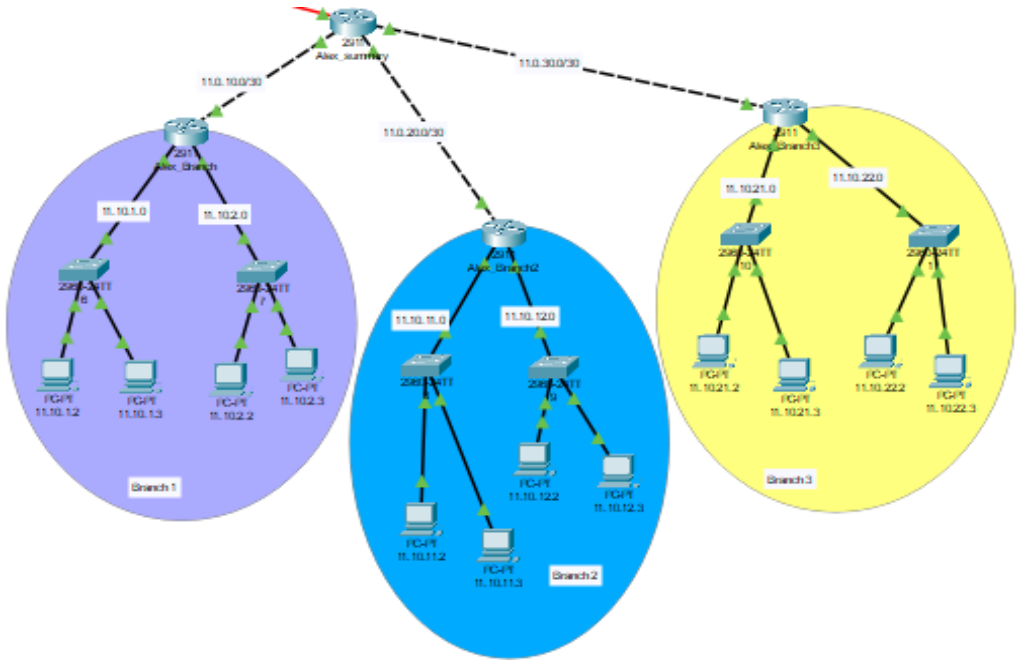
Summarization is applied in each branch router to reduce the number of advertised networks with other branches and so reduce the exchanging packets of routing updates between routers.

Routing metric:

The metric equation of EIGRP consists of some K values multiplied by different factors:

- **K1** (Bandwidth)
- **K2** (Load)
- **K3** (Delay)
- **K4** (Reliability
- **K5** (MTU)

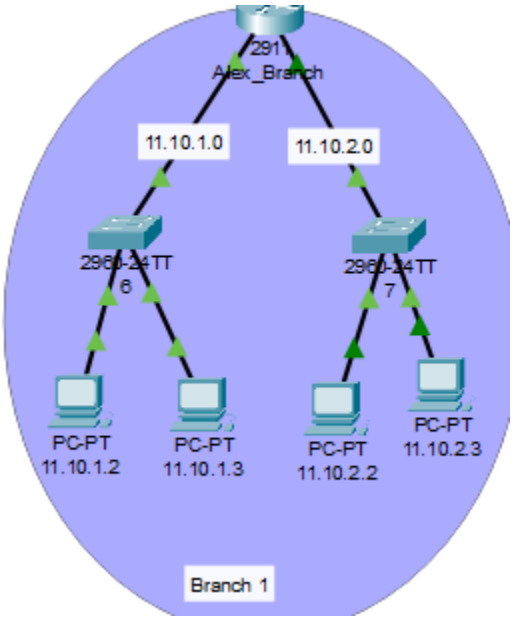
We are applying the default metric configuration where (K1=1, K3=1) and the other values are set to 0 to prevent the continuous changing of metric values and make undesired routing updates.



EIGRP

Branch 1 configuration:

The router is connected with 2 LANs (11.10.1.0/24 , 11.10.2.0/24) and with the edge router of Alex branches. We applied summarization on the outside interface to summarize the 2 inside networks into one summary network (11.10.0.0/21).



Router configurations:

```
router eigrp 1
network 11.0.10.0 0.0.0.3
network 11.10.1.0 0.0.0.255
network 11.10.2.0 0.0.0.255
```

```
interface GigabitEthernet0/2
ip summary-address eigrp 1 11.10.0.0 255.255.248.0
```

show ip eigrp neighbor:

```
alex1#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address         Interface       Hold Uptime    SRTT   RTO   Q   Seq
                                    (sec)          (ms)       Cnt  Num
0   11.0.10.2       Gig0/2          10   01:01:32  40     1000  0   348
```

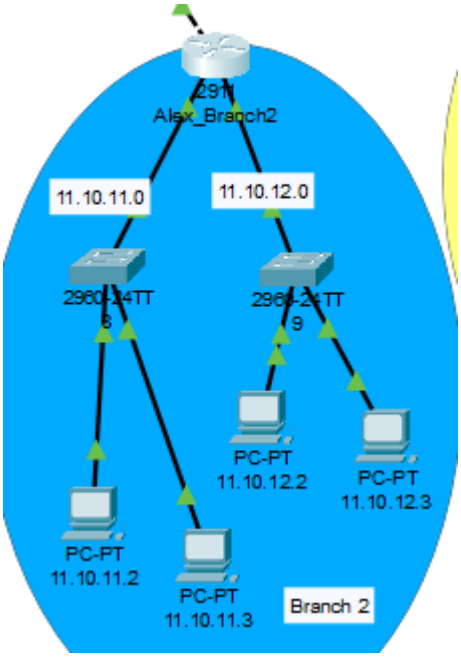
branch1 routing table:

```
D       11.0.0.0/30 [90/2170112] via 11.0.10.2, 00:58:23, GigabitEthernet0/2
C       11.0.10.0/30 is directly connected, GigabitEthernet0/2
L       11.0.10.1/32 is directly connected, GigabitEthernet0/2
D       11.0.20.0/30 [90/3072] via 11.0.10.2, 00:58:23, GigabitEthernet0/2
D       11.0.30.0/30 [90/3072] via 11.0.10.2, 00:58:23, GigabitEthernet0/2
D       11.10.0.0/21 is a summary, 09:16:54, Null0
C       11.10.1.0/24 is directly connected, GigabitEthernet0/0
L       11.10.1.1/32 is directly connected, GigabitEthernet0/0
C       11.10.2.0/24 is directly connected, GigabitEthernet0/1
L       11.10.2.1/32 is directly connected, GigabitEthernet0/1
D       11.10.8.0/21 [90/5632] via 11.0.10.2, 00:58:20, GigabitEthernet0/2
D       11.10.16.0/21 [90/5632] via 11.0.10.2, 00:58:23, GigabitEthernet0/2
```

EIGRP

Branch 2 configuration:

The router is connected with 2 LANs and with the edge router of Alex branches. We applied summarization on the outside interface to summarize the 2 inside networks (11.10.11.0/24, 11.10.12.0/24) into one summary network (11.10.8.0/21).



Router configurations:

router eigrp 1
network 11.0.20.0 0.0.0.3
network 11.10.11.0 0.0.0.255
network 11.10.12.0 0.0.0.255

interface GigabitEthernet0/2
ip summary-address eigrp 1 11.10.8.0 255.255.248.0

show ip eigrp neighbor:

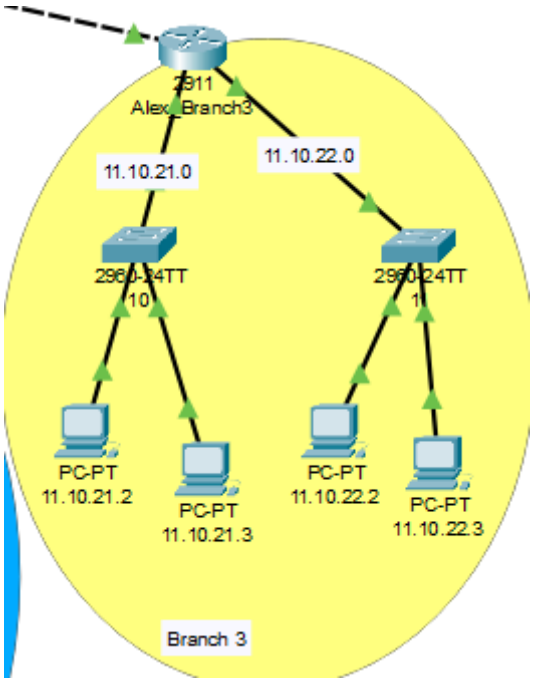
```
alex2#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address         Interface       Hold Uptime    SRTT   RTO   Q   Seq
                                    (sec)          (ms)       Cnt  Num
0   11.0.20.2       Gig0/2          14   01:23:25  40     1000  0   348
```

Branch2 routing table:

```
D       11.0.0.0/30 [90/2170112] via 11.0.20.2, 01:24:01, GigabitEthernet0/2
D       11.0.10.0/30 [90/3072] via 11.0.20.2, 01:24:01, GigabitEthernet0/2
C       11.0.20.0/30 is directly connected, GigabitEthernet0/2
L       11.0.20.1/32 is directly connected, GigabitEthernet0/2
D       11.0.30.0/30 [90/3072] via 11.0.20.2, 01:24:01, GigabitEthernet0/2
D       11.10.0.0/21 [90/5632] via 11.0.20.2, 01:24:01, GigabitEthernet0/2
D       11.10.8.0/21 is a summary, 09:42:32, Null0
C       11.10.11.0/24 is directly connected, GigabitEthernet0/0
L       11.10.11.1/32 is directly connected, GigabitEthernet0/0
C       11.10.12.0/24 is directly connected, GigabitEthernet0/1
L       11.10.12.1/32 is directly connected, GigabitEthernet0/1
D       11.10.16.0/21 [90/5632] via 11.0.20.2, 01:24:01, GigabitEthernet0/2
```

EIGRP

Branch 3 configuration:



The router is connected with 2 LANs and with the edge router of Alex branches. We applied summarization on the outside interface to summarize the 2 inside networks (11.10.21.0/24, 11.10.22.0/24) into one summary network (11.10.16.0/21).

Router configurations:

router eigrp 1
network 11.0.30.0 0.0.0.3
network 11.10.21.0 0.0.0.255
network 11.10.22.0 0.0.0.255

interface GigabitEthernet0/2
ip summary-address eigrp 1 11.10.16.0 255.255.248.0

show ip eigrp neighbor:

```
alex3#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address         Interface       Hold Uptime    SRTT   RTO   Q   Seq
                                    (sec)          (ms)       Cnt  Num
0   11.0.30.2       Gig0/2          14   01:28:22  40     1000  0   348
```

Branch3 routing table:

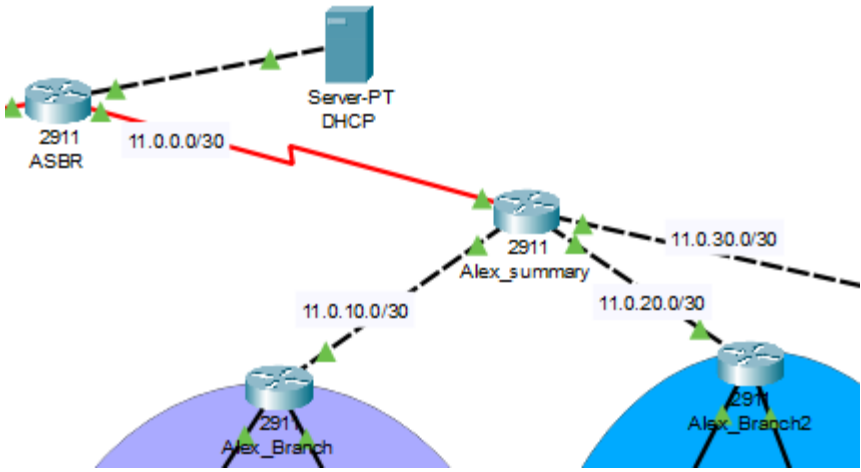
```
D       11.0.0.0/30 [90/2170112] via 11.0.30.2, 01:29:02, GigabitEthernet0/2
D       11.0.10.0/30 [90/3072] via 11.0.30.2, 01:29:05, GigabitEthernet0/2
D       11.0.20.0/30 [90/3072] via 11.0.30.2, 01:29:05, GigabitEthernet0/2
C       11.0.30.0/30 is directly connected, GigabitEthernet0/2
L       11.0.30.1/32 is directly connected, GigabitEthernet0/2
D       11.10.0.0/21 [90/5632] via 11.0.30.2, 01:29:02, GigabitEthernet0/2
D       11.10.8.0/21 [90/5632] via 11.0.30.2, 01:29:01, GigabitEthernet0/2
D       11.10.16.0/21 is a summary, 09:47:36, Null0
C       11.10.21.0/24 is directly connected, GigabitEthernet0/0
L       11.10.21.1/32 is directly connected, GigabitEthernet0/0
C       11.10.22.0/24 is directly connected, GigabitEthernet0/1
L       11.10.22.1/32 is directly connected, GigabitEthernet0/1
```

EIGRP

Alex edge router:

This router allows the routing between the 3 branches through point-to-point links to share their advertised networks.

Also its connected with the ASBR to communicate with Cairo branches and access the DHCP server.



Router configurations:

router eigrp 1
network 11.0.10.0 0.0.0.3
network 11.0.20.0 0.0.0.3
network 11.0.30.0 0.0.0.3
network 11.0.0.0 0.0.0.3

ip route 192.168.1.0 255.255.255.0 11.0.0.2

EIGRP neighbors:

```
alex_edge#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address         Interface       Hold Uptime    SRTT   RTO   Q   Seq
                                    (sec)          (ms)       Cnt Num
0   11.0.10.1       Gig0/0          14   01:42:10  40     1000  0   268
1   11.0.30.1       Gig0/2          11   01:42:10  40     1000  0   270
2   11.0.0.2        Se0/0/0         10   01:42:10  40     1000  0   355
3   11.0.20.1       Gig0/1          13   01:42:10  40     1000  0   271
```

```
C       11.0.0.0/30 is directly connected, Serial0/0/0
L       11.0.0.1/32 is directly connected, Serial0/0/0
C       11.0.10.0/30 is directly connected, GigabitEthernet0/0
L       11.0.10.2/32 is directly connected, GigabitEthernet0/0
C       11.0.20.0/30 is directly connected, GigabitEthernet0/1
L       11.0.20.2/32 is directly connected, GigabitEthernet0/1
C       11.0.30.0/30 is directly connected, GigabitEthernet0/2
L       11.0.30.2/32 is directly connected, GigabitEthernet0/2
D       11.10.0.0/21 [90/5376] via 11.0.10.1, 01:44:11, GigabitEthernet0/0
D       11.10.8.0/21 [90/5376] via 11.0.20.1, 01:44:11, GigabitEthernet0/1
D       11.10.16.0/21 [90/5376] via 11.0.30.1, 01:44:11, GigabitEthernet0/2
S    192.168.1.0/24 [1/0] via 11.0.0.2
```

EIGRP

EIGRP Verification

Tracing route between devices in different branches:

From branch 1 to branch 2:

```
C:\>tracert 11.10.11.2

Tracing route to 11.10.11.2 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      11.10.1.1
  2    0 ms      0 ms      0 ms      11.0.10.2
  3    1 ms      14 ms     0 ms      11.0.20.1
  4    0 ms      0 ms      11 ms     11.10.11.2

Trace complete.
```

From branch 2 to branch 3:

```
C:\>tracert 11.10.22.2

Tracing route to 11.10.22.2 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      11.10.12.1
  2    1 ms      0 ms      0 ms      11.0.20.2
  3    2 ms      0 ms      0 ms      11.0.30.1
  4    0 ms      0 ms      1 ms      11.10.22.2

Trace complete.
```

From branch 3 to branch 1:

```
C:\>tracert 11.10.1.3

Tracing route to 11.10.1.3 over a maximum of 30 hops:

  1    0 ms      0 ms      1 ms      11.10.21.1
  2    0 ms      1 ms      0 ms      11.0.30.2
  3    0 ms      10 ms     0 ms      11.0.10.1
  4    0 ms      0 ms      0 ms      11.10.1.3

Trace complete.
```

Redistribution

Redistribution is a feature that allow routes learned by one routing protocol (e.g., OSPF) to be advertised into the other protocol (e.g., EIGRP), enabling interoperability between different routing domains.

During redistribution, metrics must be converted, as EIGRP uses bandwidth and delay, while OSPF uses cost based on link bandwidth. Proper filtering and metric settings are essential to avoid routing loops and ensure optimal route propagation. We must configure EIGRP with the metric values which are used in calculating each path's metric, but OSPF automatically calculate the cost of the redistributed routes.

To configure redistribution, we added a router between the edge routers of OSPF and EIGRP networks which called autonomous system boundary router (ASBR). This router has 1 link configured with ospf and the other with eigrp to learn all the routes in both networks and see routing configurations.

Redistribution

Configurations:

For OSPF redistribution:

```
router ospf 1
redistribute eigrp 1 subnets
```

For EIGRP redistribution:

```
router eigrp 1
redistribute ospf 1 metric 10000 100 255 1 1500
```

here we are assigning values for the eigrp metric equation which are (Bandwidth in Kbps, Delay in microSeconds, Reliability in scale of 255, Load in a scale of 255 and MTU) respectively. But the EIGRP default equation uses only bandwidth and delay values.

Here in the ASBR routing table, the router has learned all the routes of both protocols dynamically and can allow redistribution of both networks to each other's.

```
center#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
7.7.7.7           0   FULL/  -        00:00:32    10.0.0.2        Serial0/0/0
center#show ip eigrp neighbor
IP-EIGRP neighbors for process 1
H   Address         Interface       Hold Uptime    SRTT   RTO   Q   Seq
                                    (sec)          (ms)       Cnt  Num
0   11.0.0.1        Se0/0/1         12   02:23:34  40     1000  0   349
```

Redistribution

```
     10.0.0.0/8 is variably subnetted, 14 subnets, 3 masks
C       10.0.0.0/30 is directly connected, Serial0/0/0
L       10.0.0.1/32 is directly connected, Serial0/0/0
O IA    10.10.1.0/24 [110/67] via 10.0.0.2, 02:19:24, Serial0/0/0
O IA    10.10.2.0/24 [110/67] via 10.0.0.2, 02:19:24, Serial0/0/0
O IA    10.10.3.0/24 [110/67] via 10.0.0.2, 02:19:24, Serial0/0/0
O IA    10.10.4.0/24 [110/67] via 10.0.0.2, 02:19:24, Serial0/0/0
O IA    10.10.5.0/24 [110/67] via 10.0.0.2, 02:19:24, Serial0/0/0
O IA    10.10.6.0/24 [110/67] via 10.0.0.2, 02:19:24, Serial0/0/0
O IA    10.10.10.0/30 [110/66] via 10.0.0.2, 02:19:24, Serial0/0/0
O       10.10.10.4/30 [110/65] via 10.0.0.2, 02:19:24, Serial0/0/0
O IA    10.10.20.0/30 [110/66] via 10.0.0.2, 02:19:24, Serial0/0/0
O       10.10.20.4/30 [110/65] via 10.0.0.2, 02:19:24, Serial0/0/0
O IA    10.10.30.0/30 [110/66] via 10.0.0.2, 02:19:24, Serial0/0/0
O       10.10.30.4/30 [110/65] via 10.0.0.2, 02:19:24, Serial0/0/0
     11.0.0.0/8 is variably subnetted, 8 subnets, 3 masks
C       11.0.0.0/30 is directly connected, Serial0/0/1
L       11.0.0.2/32 is directly connected, Serial0/0/1
D       11.0.10.0/30 [90/2170112] via 11.0.0.1, 02:19:39, Serial0/0/1
D       11.0.20.0/30 [90/2170112] via 11.0.0.1, 02:19:39, Serial0/0/1
D       11.0.30.0/30 [90/2170112] via 11.0.0.1, 02:19:39, Serial0/0/1
D       11.10.0.0/21 [90/2172672] via 11.0.0.1, 02:19:37, Serial0/0/1
D       11.10.8.0/21 [90/2172672] via 11.0.0.1, 02:19:36, Serial0/0/1
D       11.10.16.0/21 [90/2172672] via 11.0.0.1, 02:19:39, Serial0/0/1
     192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.1.0/24 is directly connected, GigabitEthernet0/0
L       192.168.1.1/32 is directly connected, GigabitEthernet0/0
```

Routing table of OSPF area0 router:

The E2 indicates that the routes are learned using ospf externally

```
     10.0.0.0/8 is variably subnetted, 17 subnets, 3 masks
C       10.0.0.0/30 is directly connected, Serial0/0/0
L       10.0.0.2/32 is directly connected, Serial0/0/0
O IA    10.10.1.0/24 [110/3] via 10.10.10.5, 10:43:25, GigabitEthernet0/2
O IA    10.10.2.0/24 [110/3] via 10.10.10.5, 10:43:25, GigabitEthernet0/2
O IA    10.10.3.0/24 [110/3] via 10.10.20.5, 10:43:25, GigabitEthernet0/1
O IA    10.10.4.0/24 [110/3] via 10.10.20.5, 10:43:25, GigabitEthernet0/1
O IA    10.10.5.0/24 [110/3] via 10.10.30.5, 10:43:15, GigabitEthernet0/0
O IA    10.10.6.0/24 [110/3] via 10.10.30.5, 10:43:15, GigabitEthernet0/0
O IA    10.10.10.0/30 [110/2] via 10.10.10.5, 10:43:25, GigabitEthernet0/2
C       10.10.10.4/30 is directly connected, GigabitEthernet0/2
L       10.10.10.6/32 is directly connected, GigabitEthernet0/2
O IA    10.10.20.0/30 [110/2] via 10.10.20.5, 10:43:25, GigabitEthernet0/1
C       10.10.20.4/30 is directly connected, GigabitEthernet0/1
L       10.10.20.6/32 is directly connected, GigabitEthernet0/1
O IA    10.10.30.0/30 [110/2] via 10.10.30.5, 10:43:15, GigabitEthernet0/0
C       10.10.30.4/30 is directly connected, GigabitEthernet0/0
L       10.10.30.6/32 is directly connected, GigabitEthernet0/0
     11.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
O E2    11.0.0.0/30 [110/20] via 10.0.0.1, 02:25:30, Serial0/0/0
O E2    11.0.10.0/30 [110/20] via 10.0.0.1, 02:25:30, Serial0/0/0
O E2    11.0.20.0/30 [110/20] via 10.0.0.1, 02:25:30, Serial0/0/0
O E2    11.0.30.0/30 [110/20] via 10.0.0.1, 02:25:30, Serial0/0/0
O E2    11.10.0.0/21 [110/20] via 10.0.0.1, 02:25:30, Serial0/0/0
O E2    11.10.8.0/21 [110/20] via 10.0.0.1, 02:25:30, Serial0/0/0
O E2    11.10.16.0/21 [110/20] via 10.0.0.1, 02:25:30, Serial0/0/0
S    192.168.1.0/24 [1/0] via 10.0.0.1
```

Redistribution

Routing table of EIGRP edge router:

The EX indicates that these routes are learned using eigrp externally from other protocol

```
      10.0.0.0/8 is variably subnetted, 13 subnets, 2 masks
D EX     10.0.0.0/30 [170/2195456] via 11.0.0.2, 02:29:27, Serial0/0/0
D EX     10.10.1.0/24 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
D EX     10.10.2.0/24 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
D EX     10.10.3.0/24 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
D EX     10.10.4.0/24 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
D EX     10.10.5.0/24 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
D EX     10.10.6.0/24 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
D EX     10.10.10.0/30 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
D EX     10.10.10.4/30 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
D EX     10.10.20.0/30 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
D EX     10.10.20.4/30 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
D EX     10.10.30.0/30 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
D EX     10.10.30.4/30 [170/2195456] via 11.0.0.2, 02:29:12, Serial0/0/0
      11.0.0.0/8 is variably subnetted, 11 subnets, 3 masks
C        11.0.0.0/30 is directly connected, Serial0/0/0
L        11.0.0.1/32 is directly connected, Serial0/0/0
C        11.0.10.0/30 is directly connected, GigabitEthernet0/0
L        11.0.10.2/32 is directly connected, GigabitEthernet0/0
C        11.0.20.0/30 is directly connected, GigabitEthernet0/1
L        11.0.20.2/32 is directly connected, GigabitEthernet0/1
C        11.0.30.0/30 is directly connected, GigabitEthernet0/2
L        11.0.30.2/32 is directly connected, GigabitEthernet0/2
D        11.10.0.0/21 [90/5376] via 11.0.10.1, 02:29:27, GigabitEthernet0/0
D        11.10.8.0/21 [90/5376] via 11.0.20.1, 02:29:27, GigabitEthernet0/1
D        11.10.16.0/21 [90/5376] via 11.0.30.1, 02:29:27, GigabitEthernet0/2
S     192.168.1.0/24 [1/0] via 11.0.0.2
```

Tracing the route of devices from different cities:

```
C:\>tracert 11.10.11.2

Tracing route to 11.10.11.2 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      10.10.1.1
  2    0 ms      2 ms      0 ms      10.10.10.2
  3    0 ms      0 ms      0 ms      10.10.10.6
  4    0 ms      0 ms      0 ms      10.0.0.1
  5    0 ms      10 ms     1 ms      11.0.0.1
  6    0 ms      0 ms      1 ms      11.0.20.1
  7    2 ms      10 ms     2 ms      11.10.11.2

Trace complete.
```

from 10.10.1.4 (ospf area10) to

11.10.11.2(eigrp branch 2)

```
C:\>tracert 10.10.5.5

Tracing route to 10.10.5.5 over a maximum of 30 hops:

  1    0 ms      1 ms      0 ms      11.10.21.1
  2    1 ms      0 ms      1 ms      11.0.30.2
  3    2 ms      0 ms      6 ms      11.0.0.2
  4    2 ms      3 ms      10 ms     10.0.0.2
  5    3 ms      1 ms      1 ms      10.10.30.5
  6    2 ms      29 ms     0 ms      10.10.30.1
  7    11 ms     1 ms      1 ms      10.10.5.5

Trace complete.
```

from 11.10.21.3(eigrp branch3) to

10.10.5.5 (ospf area 30)

Dynamic Host Configuration Protocol (DHCP)

DHCP is a network management protocol used to automatically assign IP addresses and other network configuration settings (such as subnet mask, gateway, and DNS servers) to devices on a network. It eliminates the need for manual IP configuration by dynamically leasing IP addresses from a centralized DHCP server to clients, ensuring efficient address allocation and management.

DHCP plays a crucial role in simplifying network administration, especially in large and dynamic environments where devices frequently join and leave the network and for large subnets and branches like our project.

In this project, we implemented 1 DHCP server connected to the ASBR router, and to define the server route in all the network routers we used static routing to the network of the server:

In OSPF area0 router:

```
ip route 192.168.1.0 255.255.255.0 10.0.0.1
```

In EIGRP edge router:

```
ip route 192.168.1.0 255.255.255.0 11.0.0.2
```

DHCP

to configure the DHCP server to assign dynamic IP address to devices in each different subnet, we must configure different Pools for each subnet and the default gateway of each subnet must be identical to the gateway ip of devices in this subnet.

Also we should exclude the IP of default gateway from each pool to avoid any misconfiguration or IP duplication.

Cairo branches IP Pools:

Pool Name	Default Gateway	DNS Server	Start IP Address	Subnet Mask	Max User
cairo3_LAN2	10.10.6.1	0.0.0.0	10.10.6.2	255.255.255.0	254
cairo3_LAN1	10.10.5.1	0.0.0.0	10.10.5.2	255.255.255.0	254
cairo2_LAN2	10.10.4.1	0.0.0.0	10.10.4.2	255.255.255.0	254
cairo2_LAN1	10.10.3.1	0.0.0.0	10.10.3.2	255.255.255.0	254
cairo1_LAN2	10.10.2.1	0.0.0.0	10.10.2.2	255.255.255.0	254
cairo1_LAN1	10.10.1.1	0.0.0.0	10.10.1.2	255.255.255.0	254

Alex branches IP Pools:

Pool Name	Default Gateway	DNS Server	Start IP Address	Subnet Mask	Max User
alex3_LAN2	11.10.22.1	0.0.0.0	11.10.22.2	255.255.255.0	254
alex3_LAN1	11.10.21.1	0.0.0.0	11.10.21.2	255.255.255.0	254
alex2_LAN2	11.10.12.1	0.0.0.0	11.10.12.2	255.255.255.0	254
alex2_LAN1	11.10.11.1	0.0.0.0	11.10.11.2	255.255.255.0	254
alex1_LAN2	11.10.2.1	0.0.0.0	11.10.2.2	255.255.255.0	254
alex1_LAN1	11.10.1.1	0.0.0.0	11.10.1.2	255.255.255.0	254

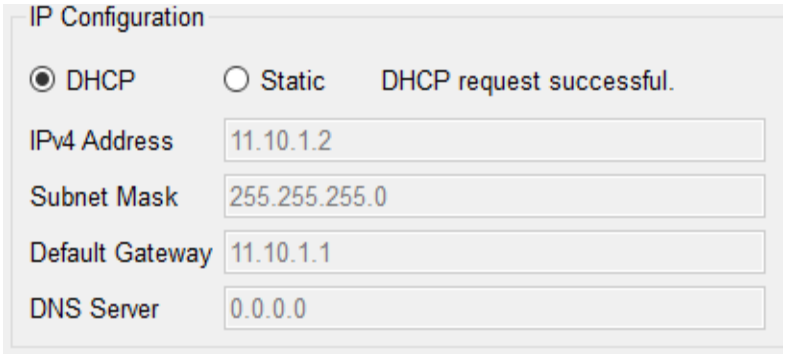
DHCP

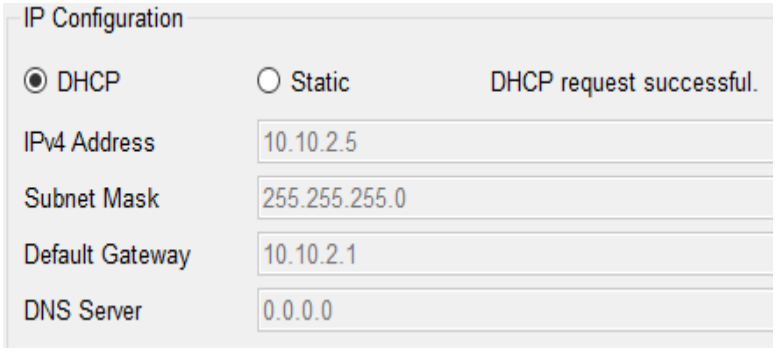
To allow each router to route the devices to the DHCP server and request ip addresses, we must write this command in all router interfaces connected to LANs:

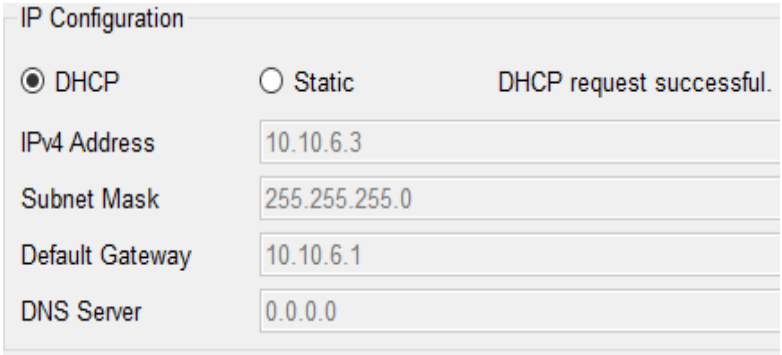
```
interface GigabitEthernet0/0
ip helper-address 192.168.1.50

interface GigabitEthernet0/1
ip helper-address 192.168.1.50
```

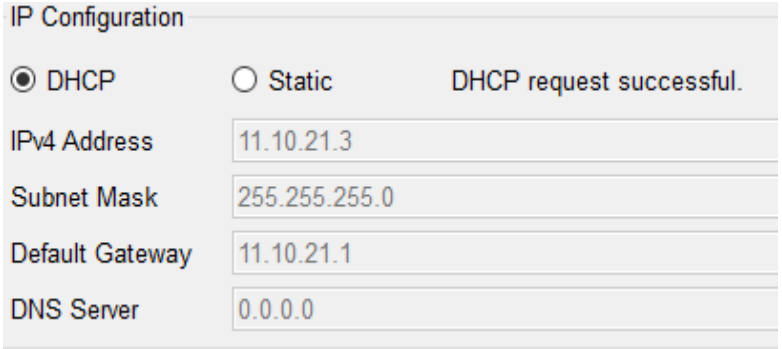
this allows each LAN device to request ip address from 192.168.1.50 which is the server IP address.

Here are the IP configuration on different network devices assigned from the centralized DHCP server:









The full project design