OSPF Multi-Area With Virtual Links, EIGRP Redistribution

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Advanced Applied Routing, 7.5 hp
Halmstad University
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February 2011

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***Abstract*— In this report we demonstrate the task of implementing a network consist of multi-area OSPF, including virtual link between OSPF areas with EIGRP redistribution .**

We accomplished this with four routers and six OSPF areas while two routers are working with both [EIGRP and OSPF] and two are dealing with OSPF. For establish connectivity between areas we use virtual links and redistribution to handle traffic between two different protocols.

***Index Terms*— OSPF, EIGRP, Redistribution, Virtual Links, Multi-area**

I. Introduction

To interconnect networks we need to use routing protocols. Providing routing protocol makes the networks more scalable. There are two basic types of routing protocols: 1.Interior Gateway Protocols (link state such as OSPF and IS-IS), (distance vector such as RIP and EIGRP), 2.Exterior Gateway Routing Protocol (such as BGP between two AS systems).

OSPF is a protocol which can be used in large networks. To make OSPF more scalable and efficient it can be divided into multiple areas so called multi-area OSPF. But multi-area OSPF has a limitation too, all areas need to be physically connected to area 0 (Backbone area) to make it operational. This is the first problem we faced in our project.

EIGRP is a Cisco proprietary protocol for connecting different networks. The second problem is how to make these two protocols exchange their routing tables and interact with each other.

In this project we will cope with these problem. The solution for the first one is using virtual links to ensure connectivity of all areas with area zero and the second can be resolved by redistribution technique causing both protocols have knowledge about each other's routing table information.

II. Background

A. *OSPF*

Open shortest path first is a link state protocol that falls in interior gateway protocols. Widely used in large enterprise networks, it uses Dijkstra shortest path first algorithm to converge network and has these features [1]:

- Knowledge of full network per each router.
- Short convergence time (seconds).
- VLSM support.
- No automatic route summarization.
- Suitable for heterogeneous networks.
- Using multicast instead of broadcast.
- Using cost as metric.
  (cost=100,000,000/link speed)
- Sending updates based on topology changes.
- Equal load balancing.
- Hello/Dead intervals in LAN: 10/40, WAN: 30/120.
- Authentication support.
- Administrative distance: 110.

1. *OSPF Tables*

- Neighbor table (adjacency table): the information about the OSPF neighbor routers.
- Topology table (link state database): comprises information of all links in whole network.
- Routing table (Forwarding Database): contains the list of best paths to the destination.

2. OSPF areas

Multi-area OSPF is used to reduce the size of routing table and overhead on routers and making network more scalable. Each area includes 50-100 routers in maximum and has some advantages as follows [1]:

- Each router in an area just need to save the routes from its own area to his routing database. It will reduce memory overhead.
- Knowing just about its own area, router doesn't need to recalculate route every time there is a change in the other areas, so it will reduce CPU overhead.
- Summarizing each area routes will decreases the size of routing table.
- Having multi-area OSPF enables to use hierarchical network design.

OSPF area can be split to Backbone area and regular areas. Backbone Area(transit area, area 0) is an area that all other areas must be physically connected to Exchange routing information, but sometimes it is not possible. Therefore, we use virtual links to ensure connectivity.

3. Virtual links:

It is part of OSPF standard which uses to temporarily solve problem in the network. It is a logical path between two routers which has two purposes:

- Connecting OSPF areas which don't have a physical connection to area 0.
- Connecting partitioned backbone area.

4. OSPF router types:

OSPF includes four types of routers [4]:

- Backbone router: the router which has at least one interface configured in area 0.
- Internal router: all interfaces of router are inside the same area.
- Area border router (ABR): the router which its interfaces are in distinct areas.
- Autonomous system boundary router (ASBR): the router that has one interface in another autonomous system running another routing protocol.

5. OSPF Summarization

The biggest advantage of route summarization is to reduce the size of routing tables for routers in different OSPF areas. Thus, by decreasing SPF algorithm calculations it saves memory and CPU usage on every router and the bandwidth taken by routing update packets will decrease too. There are two types of summarization [3]:

- Inter-area route summarization: it is created on ABR routers for other OSPF areas.
- External route summarization: it is created on ASBR routers and inserts external routes to OSPF.

B. EIGRP

Enhanced interior gateway routing protocol is a distance vector protocol which is only supported by cisco devices and uses the diffusing update algorithm (DUAL) to converge network. EIGRP routing protocol has following features [1]:

- Knowledge of connected neighbors per each router.
- Short convergence time (seconds).
- VLSM support.
- Automatic route summarization.
- Suitable for homogeneous Cisco networks.
- Using multicast and unicast.
- Mixed metric based on bandwidth and delay.
- Multi network and data link protocol support.
- Equal and Un-equal load balancing.
- Hello/Dead intervals in LAN: 5/15, WAN: 60/180.
- Authentication support.
- Administrative distance for summarized route: 5, internal route: 90, external route: 170.

1. EIGRP Summarization

EIGRP automatically summarize routes by default. In order to use manual summarization, auto summary must be disabled.

C. REDISTRIBUTION

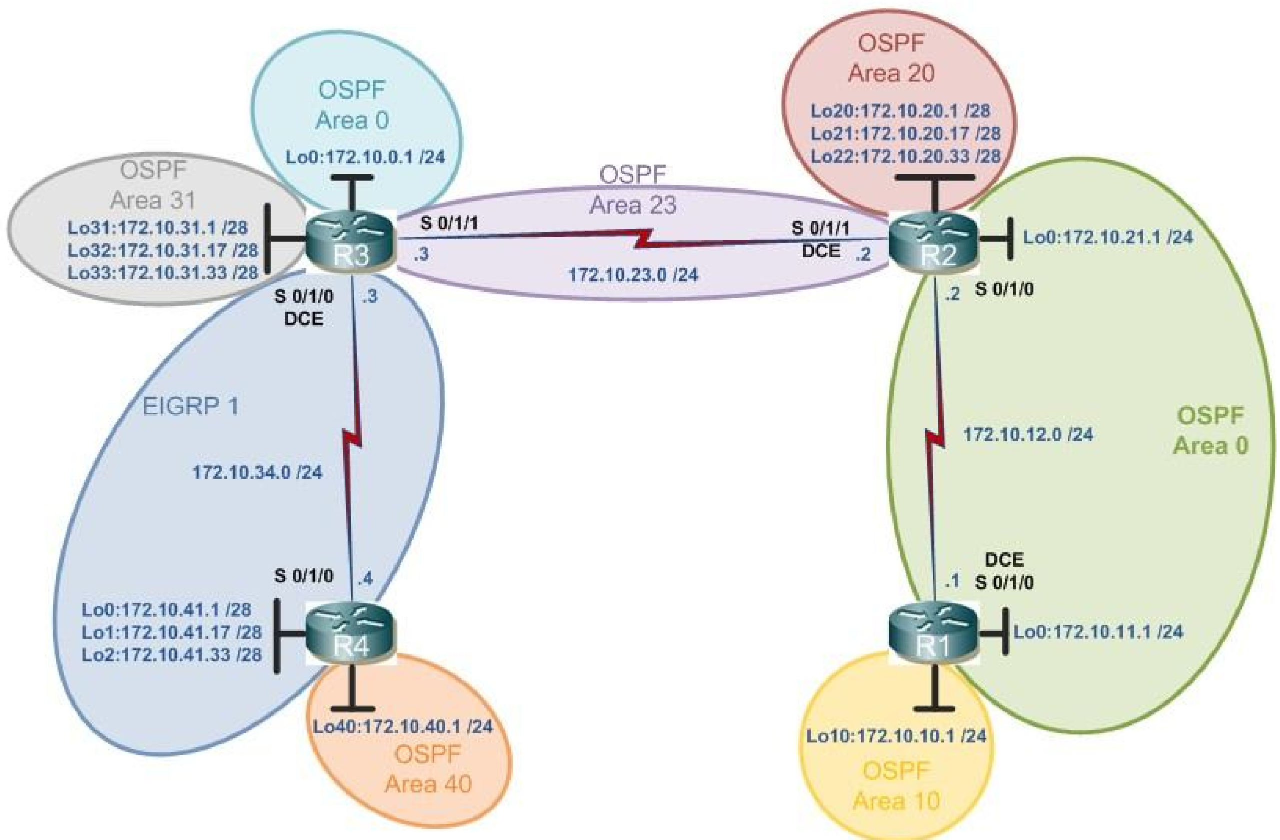
There are some circumstances which the need to redistribution is sensed, including:

- Using different protocols in the network which need to communicate with each other.
- When specific routing protocol is needed to be able to run a certain application in the network.
- To connect separate areas of a network that are under distinct authorities.
- When different types of devices in a network needs to work under certain routing protocols.

III. DESIGN

The next figure illustrates the topology implementation for solving OSPF multi-area with virtual links and EIGRP redistribution .

OSPF multi-area with virtual links, EIGRP redistribution



A. SCENARIO:

This figure shows the international oil company 's network schema. This great company has two main office: one in north and another in south of country. It contains different branches and departments which all use OSPF as their routing protocol, the only exception is industrial part of company that uses EIGRP.

B. TOPOLOGY DESIGN

We implement this scenario with four routers. R1 has three interfaces, one in area 10 and the others in area 0. R2 has four interfaces, two in area 0, one in area 20 and a serial link in area 23. R3 with three interfaces, each one belonging to different areas (area 23, 31, 0) and one interface inside EIGRP AS 1. R4 has one interface in area 40 and two inside EIGRP AS 1.

IV. METHOD

A. OBJECTIVES

- Configure multi-area OSPF on routers.
- Summarization in OSPF areas.
- Configure EIGRP on routers.
- Summarization of routes in EIGRP.
- Redistribution between OSPF and EIGRP mutually.
- Create an OSPF virtual link.

B. CONFIGURATIONS

1. Basic Router Configurations

In first step we configure hostname, Telnet and console lines, passwords and interfaces IP addresses as it is shown in topology.

2. OSPF Configurations

To enable OSPF on routers we must use these commands on routers which have interfaces in OSPF areas [3]:

```
Hostname(config)# router ospf <process-id>
Hostname(config-router)# network <network/ IP address>
< wildcard mask> <area-id>
```

In command above *network/IP address* stands for directly connected networks to the router interfaces and *area-id* is the area number which network belongs to.

In this topology our configurations for routers are as follows:

R1:
```
router ospf 1
 network 172.10.10.0 0.0.0.255 area 10
 network 172.10.11.0 0.0.0.255 area 0
 network 172.10.12.0 0.0.0.255 area 0
```

R2:
```
router ospf 1
 network 172.10.12.0 0.0.0.255 area 0
 network 172.10.20.0 0.0.0.63 area 20
 network 172.10.21.0 0.0.0.255 area 0
 network 172.10.23.0 0.0.0.255 area 23
```

R3:
```
router ospf 1
 network 172.10.23.0 0.0.0.255 area 23
 network 172.10.0.0 0.0.0.255 area 0
 network 172.10.31.0 0.0.0.63 area 31
```

R4:
```
router ospf 1
 network 172.10.40.0 0.0.0.255 area 40
```

3. EIGRP Configurations

To enable EIGRP on routers we must use these commands on routers which have interfaces in EIGRP AS [1]:

```
Hostname(config)# router eigrp <autonomous-system>
Hostname(config-router)# network <network/ IP address> <wildcard mask>
```

In commands above *autonomous-system* stands for group of routers which are under the control of same authority and *network/IP address* indicates directly connected networks to the router interfaces in that autonomous-system.

In our topology the configurations for routers are as follows:

R3:
```
router eigrp 1
 network 172.10.34.0 0.0.0.255
```

R4:
```
router eigrp 1
 network 172.10.34.0 0.0.0.255
 network 172.10.41.0 0.0.0.63
```

4. Mutual Redistribution between OSPF and EIGRP

In order to make connectivity between two routing protocols, we need to exchange their routes. To do this we used redistribution commands on routers which their interfaces are involved in both routing protocol OSPF and EIGRP.

Redistribution routes from EIGRP into OSPF [2]:

```
Hostname(config)# router eigrp <AS>
Hostname(config-router)# redistribute eigrp <AS> subnets
```

Here, *AS* means autonomous-system. The *subnet* command is to force ospf to redistribute all networks (classless networks and suppernets).

Redistribution routes from OSPF into EIGRP [2]:

```
Hostname(config)# router ospf <process-id>
Hostname(config-router)# redistribute ospf <process-id> metric <bandwidth> <delay> <reliability> <load> <MTU>
```

In order to pass routes from another routing protocol to EIGRP, we need to define the metrics. The only exception for this is static routes and connected networks.

In above topology our configurations for routers are as follows:

R3:
```
router eigrp 1
 redistribute ospf 1 metric 10000 100 255 1 1500
router ospf 1
 redistribute eigrp 1 subnets
```

R4:
```
router eigrp 1
 redistribute ospf 1 metric 10000 100 255 1 1500
router ospf 1
 redistribute eigrp 1 subnets
```

5. Virtual Links

To make full connectivity between all OSPF areas we need to use virtual links to tie two partitioned backbone areas together. To do this we need to configure virtual link between the routers which each has an interface connected to one of the backbone areas as follow [3]:

```
Hostname(config)# router ospf <process-id>
Hostname(config-router)# area <transit-area> virtual-link <router-id>
```

Above, *transit-area* is a none backbone area which is connected to area 0 and transfer the routes from/to the areas which are not connected to area 0 and *router-id* is the ID of the neighbor router on the other side of transit-area.

In our topology our configurations for routers are as follows:

R2:
```
router ospf 1
 area 23 virtual-link 172.10.31.33
```

R3:
```
router ospf 1
 area 23 virtual-link 172.10.21.1
```

6. Summarization

In order to limit sending extra routes to other areas or routing protocols, we used route summarization in EIGRP and OSPF configuration. The EIGRP manual summarization command is as bellow [1]:

```
Hostname(config)# router eigrp <autonomous-system>
Hostname(config-router)# no auto-summary
Hostname(config)# interface serial <number>
Hostname(config-if)# ip summary-address eigrp <AS> <network> <subnet mask>
```

The *number* refer to the serial interface which the routes are being sent through. The *network* is the network addresses that we are going to summarize and the new subnet mask for the summarized network must be mentioned (CIDR).

Summarization between areas for OSPF [3]:

```
Hostname(config)# router ospf <process-id>
Hostname(config-router)# area <AS> range <network> <subnet mask>
```

like EIGRP, the *network* is referring to the summarized networks and the new subnet mask for them.

In our topology the configurations for routers are as follows:

R2:

```
router ospf 1
 area 20 range 172.10.20.0 255.255.255.0
```

R3:

```
router ospf 1
 area 31 range 172.10.31.0 255.255.255.0
```

R4:

```
router eigrp 1
 no auto-summary
interface Serial0/1/0
 ip summary-address eigrp 1 172.10.41.0 255.255.255.0 5
```

V. Analysis

Having done the basic configurations on all routers, we discovered that some routes are missing on R1 and R2, belonging to area 40, 31 and area 0 (attached to R3). R3 does not have any connection with area 40 and R4 cannot access other areas except EIGRP AS 1.

```
R1#show ip route ospf
    172.10.0.0/16 is variably subnetted, 6 subnets, 3 masks
O IA    172.10.23.0/24 [110/3124] via 172.10.12.2, 00:03:49, Serial0/0
O       172.10.21.1/32 [110/1563] via 172.10.12.2, 00:03:49, Serial0/0
O IA    172.10.20.0/24 [110/1563] via 172.10.12.2, 00:03:49, Serial0/0
R1#
```

```
R2#show ip route ospf
    172.10.0.0/16 is variably subnetted, 9 subnets, 3 masks
O       172.10.11.1/32 [110/1563] via 172.10.12.1, 00:05:05, Serial0/0
O IA    172.10.10.1/32 [110/1563] via 172.10.12.1, 00:05:05, Serial0/0
O       172.10.20.0/24 is a summary, 00:05:05, Null0
R2#
```

```
R3#show ip route ospf
    172.10.0.0/16 is variably subnetted, 12 subnets, 3 masks
O IA    172.10.12.0/24 [110/3124] via 172.10.23.2, 00:06:07, Serial0/1
O IA    172.10.11.1/32 [110/3125] via 172.10.23.2, 00:06:07, Serial0/1
O IA    172.10.10.1/32 [110/3125] via 172.10.23.2, 00:06:07, Serial0/1
O IA    172.10.21.1/32 [110/1563] via 172.10.23.2, 00:06:07, Serial0/1
O IA    172.10.20.0/24 [110/1563] via 172.10.23.2, 00:06:07, Serial0/1
R3#
```

```
R3#show ip route eigrp
    172.10.0.0/16 is variably subnetted, 12 subnets, 3 masks
D       172.10.41.0/24 [90/40640000] via 172.10.34.4, 00:45:14, Serial0/0
R3#
```

```
R4#show ip route eigrp
    172.10.0.0/16 is variably subnetted, 6 subnets, 2 masks
D       172.10.41.0/24 is a summary, 00:47:12, Null0
R4#
```

Therefore, we did redistribution between EIGRP and OSPF protocols to make them exchange their routes. But it seems it is not sufficient yet. We were not able to see OSPF area 0 (attached to R3) and 31 from R1 and R2.

```
R1#show ip route ospf
    172.10.0.0/16 is variably subnetted, 9 subnets, 3 masks
O E2    172.10.34.0/24 [110/20] via 172.10.12.2, 00:00:47, Serial0/0
O E2    172.10.40.0/24 [110/20] via 172.10.12.2, 00:00:20, Serial0/0
O E2    172.10.41.0/24 [110/20] via 172.10.12.2, 00:00:47, Serial0/0
O IA    172.10.23.0/24 [110/3124] via 172.10.12.2, 00:06:28, Serial0/0
O       172.10.21.1/32 [110/1563] via 172.10.12.2, 00:06:28, Serial0/0
O IA    172.10.20.0/24 [110/1563] via 172.10.12.2, 00:06:28, Serial0/0
R1#
```

```
R2#show ip route ospf
    172.10.0.0/16 is variably subnetted, 12 subnets, 3 masks
O E2    172.10.34.0/24 [110/20] via 172.10.23.3, 00:01:28, Serial0/1
O E2    172.10.40.0/24 [110/20] via 172.10.23.3, 00:00:56, Serial0/1
O E2    172.10.41.0/24 [110/20] via 172.10.23.3, 00:01:28, Serial0/1
O       172.10.11.1/32 [110/1563] via 172.10.12.1, 00:41:18, Serial0/0
O IA    172.10.10.1/32 [110/1563] via 172.10.12.1, 00:01:28, Serial0/0
O       172.10.20.0/24 is a summary, 01:10:01, Null0
R2#
```

```
R3#show ip route ospf
    172.10.0.0/16 is variably subnetted, 13 subnets, 3 masks
O IA    172.10.12.0/24 [110/3124] via 172.10.23.2, 00:01:59, Serial0/1
O IA    172.10.11.1/32 [110/3125] via 172.10.23.2, 00:01:59, Serial0/1
O IA    172.10.10.1/32 [110/3125] via 172.10.23.2, 00:01:59, Serial0/1
O IA    172.10.21.1/32 [110/1563] via 172.10.23.2, 00:01:59, Serial0/1
O IA    172.10.20.0/24 [110/1563] via 172.10.23.2, 00:01:59, Serial0/1
R3#
```

```
R3#show ip route eigrp
    172.10.0.0/16 is variably subnetted, 13 subnets, 3 masks
D EX 172.10.40.0/24 [170/40537600] via 172.10.34.4,00:01:50,Serial0/0
D       172.10.41.0/24 [90/40640000] via 172.10.34.4, 00:39:44, Serial0/0
R3#
```

```
R4#show ip route eigrp
    172.10.0.0/16 is variably subnetted, 15 subnets, 3 masks
D       172.10.41.0/24 is a summary, 01:50:07, Null0
D EX    172.10.31.32/28 [170/40537600] via 172.10.34.3, 00:03:07, Serial0/0
D EX    172.10.31.16/28 [170/40537600] via 172.10.34.3, 00:03:07, Serial0/0
D EX    172.10.12.0/24 [170/40537600] via 172.10.34.3, 00:03:07, Serial0/0
D EX    172.10.11.1/32 [170/40537600] via 172.10.34.3, 00:03:07, Serial0/0
D EX    172.10.10.1/32 [170/40537600] via 172.10.34.3, 00:03:07, Serial0/0
D EX    172.10.23.0/24 [170/40537600] via 172.10.34.3, 00:03:07, Serial0/0
D EX    172.10.21.1/32 [170/40537600] via 172.10.34.3, 00:03:07, Serial0/0
```

```
D EX    172.10.20.0/24 [170/40537600] via 172.10.34.3, 00:03:07, Serial0/0
D EX    172.10.31.0/28 [170/40537600] via 172.10.34.3, 00:03:07, Serial0/0
R4#
```

To solve this problem we configured virtual link between R2 and R3. After applying this solution, eventually we achieved the full connectivity in our topology.

```
R1#show ip route ospf
     172.10.0.0/16 is variably subnetted, 11 subnets, 3 masks
O E2    172.10.34.0/24 [110/20] via 172.10.12.2, 00:00:07, Serial0/0
O E2    172.10.40.0/24 [110/20] via 172.10.12.2, 00:00:07, Serial0/0
O E2    172.10.41.0/24 [110/20] via 172.10.12.2, 00:00:07, Serial0/0
O       172.10.0.1/32 [110/3125] via 172.10.12.2, 00:00:07, Serial0/0
O IA    172.10.23.0/24 [110/3124] via 172.10.12.2, 00:00:07, Serial0/0
O       172.10.21.1/32 [110/1563] via 172.10.12.2, 00:00:07, Serial0/0
O IA    172.10.20.0/24 [110/1563] via 172.10.12.2, 00:00:07, Serial0/0
O IA    172.10.31.0/24 [110/3125] via 172.10.12.2, 00:00:07, Serial0/0
R1#
```

```
R2#show ip route ospf
     172.10.0.0/16 is variably subnetted, 14 subnets, 3 masks
O E2    172.10.34.0/24 [110/20] via 172.10.23.3, 00:00:12, Serial0/1
O E2    172.10.40.0/24 [110/20] via 172.10.23.3, 00:00:12, Serial0/1
O E2    172.10.41.0/24 [110/20] via 172.10.23.3, 00:00:12, Serial0/1
O       172.10.0.1/32 [110/1563] via 172.10.23.3, 00:00:12, Serial0/1
O       172.10.11.1/32 [110/1563] via 172.10.12.1, 00:00:12, Serial0/0
O IA    172.10.10.1/32 [110/1563] via 172.10.12.1, 00:00:12, Serial0/0
O       172.10.20.0/24 is a summary, 01:20:39, Null0
O IA    172.10.31.0/24 [110/1563] via 172.10.23.3, 00:00:12, Serial0/1
R2#
```

```
R3#show ip route ospf
     172.10.0.0/16 is variably subnetted, 14 subnets, 3 masks
O       172.10.12.0/24 [110/3124] via 172.10.23.2, 00:00:15, Serial0/1
O       172.10.11.1/32 [110/3125] via 172.10.23.2, 00:00:15, Serial0/1
O IA    172.10.10.1/32 [110/3125] via 172.10.23.2, 00:00:15, Serial0/1
O       172.10.21.1/32 [110/1563] via 172.10.23.2, 00:00:15, Serial0/1
O IA    172.10.20.0/24 [110/1563] via 172.10.23.2, 00:00:15, Serial0/1
O       172.10.31.0/24 is a summary, 00:02:02, Null0
R3#
```

```
R3#show ip route eigrp
     172.10.0.0/16 is variably subnetted, 14 subnets, 3 masks
D EX    172.10.40.0/24 [170/40537600] via 172.10.34.4, 00:11:46, Serial0/0
D       172.10.41.0/24 [90/40640000] via 172.10.34.4, 00:49:41, Serial0/0
R3#
```

```
R4#show ip route eigrp
     172.10.0.0/16 is variably subnetted, 17 subnets, 3 masks
D       172.10.41.0/24 is a summary, 01:59:18, Null0
D EX    172.10.31.32/28 [170/40537600] via 172.10.34.3, 00:12:18, Serial0/0
D EX    172.10.0.0/24 [170/40537600] via 172.10.34.3, 00:00:35, Serial0/0
D EX    172.10.31.16/28 [170/40537600] via 172.10.34.3, 00:12:18, Serial0/0
D EX    172.10.12.0/24 [170/40537600] via 172.10.34.3, 00:02:18, Serial0/0
D EX    172.10.11.1/32 [170/40537600] via 172.10.34.3, 00:02:18, Serial0/0
D EX    172.10.10.1/32 [170/40537600] via 172.10.34.3, 00:02:02, Serial0/0
D EX    172.10.23.0/24 [170/40537600] via 172.10.34.3, 00:12:18, Serial0/0
D EX    172.10.21.1/32 [170/40537600] via 172.10.34.3, 00:02:18, Serial0/0
D EX    172.10.20.0/24 [170/40537600] via 172.10.34.3, 00:02:02, Serial0/0
D EX    172.10.31.0/28 [170/40537600] via 172.10.34.3, 00:12:18, Serial0/0
D EX    172.10.31.0/24 [170/40537600] via 172.10.34.3, 00:02:18, Serial0/0
R4#
```

VI. Conclusion

Design is a very significant issue that must be taken into consideration when you implement networks. It may be dependent on different factors. One of these is the protocol to use in the network. For instance, the ideal design for a network running OSPF is a hierarchical approach. In this form, the designer can guarantee the connectivity of all areas to area 0 and the continuity of it. But due to some limitations it is not always applicable, as in our project. To solve this problems, we used virtual link.

Another factor which affect network design is scalability. In this project we faced an enterprise network with decentralized administration running different routing protocols. As a solution we used mutual redistribution between OSPF and EIGRP.

As it mentioned before, it is not always feasible to have the best design for a network. So you have to use some techniques to make that network consistent and operational.

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Last Update: 2010/3/25

[4] W. Edwards, *CCNP Complete Study Guide*, SYBEX Inc., 2005, pp. 177-179, 193-194.

Appendices

In this Section you can find the whole configurations of all routers in this topology.

Router 1:

```
hostname R1
!
enable secret 5 $1$NL.p$EWq5FuBuRf3Y1c6n0TMTa0
!
no ip domain lookup
!
interface Loopback0
 ip address 172.10.11.1 255.255.255.240
!
interface Loopback10
 ip address 172.10.10.1 255.255.255.0
!
interface Serial0/0
 bandwidth 64
 ip address 172.10.12.1 255.255.255.0
 clock rate 64000
!
router ospf 1
 log-adjacency-changes
 network 172.10.10.0 0.0.0.255 area 10
 network 172.10.11.0 0.0.0.255 area 0
 network 172.10.12.0 0.0.0.255 area 0
!
line con 0
 exec-timeout 0 0
 password 7 104D000A0618
 logging synchronous
 login
line aux 0
line vty 0 4
 password 7 110A1016141D
 login
end
```

Router 2:

```
hostname R2
!
enable secret 5 $1$JRk.$7uyr16f8aHH5c0b/.fvGR/
!
no ip domain lookup
!
interface Loopback0
 ip address 172.10.21.1 255.255.255.0
!
interface Loopback20
 ip address 172.10.20.1 255.255.255.240
!
interface Loopback21
 ip address 172.10.20.17 255.255.255.240
!
interface Loopback22
 ip address 172.10.20.33 255.255.255.240
!
interface Serial0/0
 bandwidth 64
 ip address 172.10.12.2 255.255.255.0
 clock rate 2000000
!
interface Serial0/1
 bandwidth 64
 ip address 172.10.23.2 255.255.255.0
 clock rate 64000
!
router ospf 1
 log-adjacency-changes
 area 20 range 172.10.20.0 255.255.255.0
 area 23 virtual-link 172.10.31.33
 network 172.10.12.0 0.0.0.255 area 0
 network 172.10.20.0 0.0.0.63 area 20
 network 172.10.21.0 0.0.0.255 area 0
 network 172.10.23.0 0.0.0.255 area 23
!
line con 0
 exec-timeout 0 0
 password 7 0822455D0A16
 logging synchronous
 login
line aux 0
line vty 0 4
 password 7 14141B180F0B
 login
!
end
```

Router 3:

```
hostname R3
!
enable secret 5 $1$CnrX$NTir7CM.WtEzURePTuUok0
!
no ip domain lookup
!
interface Loopback0
 ip address 172.10.0.1 255.255.255.0
!
interface Loopback31
 ip address 172.10.31.1 255.255.255.240
!
interface Loopback32
 ip address 172.10.31.17 255.255.255.240
!
interface Loopback33
 ip address 172.10.31.33 255.255.255.240
!
interface Serial0/0
 bandwidth 64
 ip address 172.10.34.3 255.255.255.0
 no fair-queue
 clock rate 64000
!
interface Serial0/1
 bandwidth 64
 ip address 172.10.23.3 255.255.255.0
 clock rate 2000000
!
router eigrp 1
 redistribute ospf 1 metric 10000 100 255 1 1500
 network 172.10.34.0 0.0.0.255
 no auto-summary
!
router ospf 1
 log-adjacency-changes
 area 23 virtual-link 172.10.21.1
 area 31 range 172.10.31.0 255.255.255.0
 redistribute eigrp 1 subnets
 network 172.10.0.0 0.0.0.255 area 0
 network 172.10.23.0 0.0.0.255 area 23
 network 172.10.31.0 0.0.0.63 area 31
!
line con 0
 exec-timeout 0 0
 password 7 121A0C041104
 logging synchronous
 login
line aux 0
line vty 0 4
 password 7 121A0C041104
 login
!
end
```

Router 4:

```
hostname R4
!
enable secret 5 $1$bimt$ZnaHh2FfIGpp5V6nwHnAS/
!
no ip domain lookup
!
interface Loopback0
 ip address 172.10.41.1 255.255.255.240
!
interface Loopback1
 ip address 172.10.41.17 255.255.255.240
!
interface Loopback2
 ip address 172.10.41.33 255.255.255.240
!
interface Loopback40
 ip address 172.10.40.1 255.255.255.0
!
interface Serial0/0
 bandwidth 64
 ip address 172.10.34.4 255.255.255.0
 ip summary-address eigrp 1 172.10.41.0 255.255.255.0 5
 clock rate 2000000
!
router eigrp 1
 redistribute ospf 1 metric 10000 100 255 1 1500
 network 172.10.34.0 0.0.0.255
 network 172.10.41.0 0.0.0.63
 no auto-summary
!
router ospf 1
 log-adjacency-changes
 redistribute eigrp 1 subnets
 network 172.10.40.0 0.0.0.255 area 40

line con 0
 exec-timeout 0 0
 password 7 030752180500
 logging synchronous
 login
line aux 0
line vty 0 4
 password 7 14141B180F0B
 login
!
end
```