

**COMPUTER SYSTEMSENGINEERING DEPARTMENT**

**COMPUTER NETWORKS LABARATORY**

**(ENCS 413)**

***Report***

*Experiments 7*

***OSPF Routing***

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1. Abstract

In the last experiments we see an overview about one type of dynamic routing protocols which called RIP protocol. In This experiment we will study another dynamic routing protocol which more complex than RIP which called Open Shortest Path First (OSPF) protocol.

1. Introduction

Open Shortest Path First (OSPF) is a link-state routing protocol that was developed for IP networks and is based on the Shortest Path First (SPF) algorithm. The main difference between it and the distance vector protocols is that a *linked-state protocol* does not send its routing table in the form of updates, but only shared its connectivity configuration. By collecting connectivity information from all of the devices on the network, OSPF can store all this information in a database and use that information to build a topology map.

**2.1 What are OSPF**

OSPF (Open Shortest Path First) is a router protocol used within larger autonomous system(AS's) networks in preference to the Routing Information Protocol (RIP), an older routing protocol that is installed in many of today's corporate networks .It developed by the Interior Gateway Protocol (IGP) working group of the Internet Engineering Task Force (IETF). [1]

**2.2 How OSPF works**

### The main difference between OSPF and RIP is that RIP only keeps track of the closest router for each destination address, while OSPF keeps track of a complete topological database of all connections in the local network. The OSPF algorithm works as described below. [2]

### Startup. When a router is turned on it sends Hello packets to all of its neighbors, receives their Hello packets in return, and establishes routing connections by synchronizing databases with adjacent routers that agree to synchronize.

### Update. At regular intervals each router sends an update message called its "link state" describing its routing database to all the other routers, so that all routers have the same description of the topology of the local network.

### Shortest path tree. Each router then calculates a mathematical data structure called a "shortest path tree" that describes the shortest path to each destination address and therefore indicates the closest router to send to for each communication; in other words -- "open shortest path first".

### 2.3 Splitting an OSPF AS into areas

The router type is an attribute of an OSPF process. A given physical router may have one or more OSPF processes. For example, a router that is connected to more than one area, and which receives routes from a BGP process connected to another AS, is both an area border router and an autonomous system boundary router. [3]

**Area border router**

An area border router (ABR) is a kind of router that is located near the border between one or more Open Shortest Path First (OSPF) areas. It is used to establish a connection between backbone networks and the OSPF areas. It is a member of both the main backbone network and the specific areas to which it connects, so it stores and maintains separate routing information or routing tables regarding the backbone and the topologies of the area to which it is connected.

**Autonomous system boundary router**

A router that exchanges routing information with routers belonging to other Autonomous Systems. Such a router has AS external routes that are advertised throughout the Autonomous System. The path to each AS boundary router is known by every router in the AS. This classification is completely independent of the previous classifications: AS boundary routers may be internal or area border routers, and may or may not participate in the backbone.

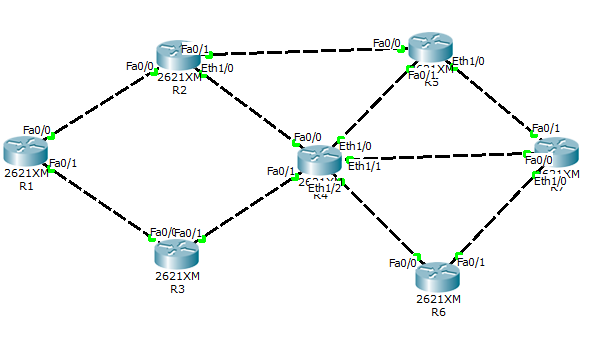
**Internal router**

An internal router is a router that has OSPF neighbor relationships with interfaces in the same area. An internal router has all its interfaces in a single area.

**Backbone router**

The backbone is the first area you should always build in any network using OSPF and the backbone is always Area 0 (zero). All areas are connected directly to the OSPF backbone area. When designing an OSPF backbone area, you should make sure there is little or no possibility of the backbone area being split into two or more parts by a router or link failure. If the OSPF backbone is split due to hardware failures or access lists, sizeable areas of the network will become unreachable. [4]

1. Procedure:

In our experiment we used the following topology to understand how OSPF work: 

### Part One:

We will find the shortest path from R1 to R7 using Dijkstra’s algorithm as showing in the following table:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Path** | **R2** | **R3** | **R4** | **R5** | **R6** | **R7** |
| R1 | 2(R1) | 4(R1) | ∞ | ∞ | ∞ | ∞ |
| R2 | - | 4(R1) | 4 (R2) | 12 (R2) | ∞ | ∞ |
| R3 | - | - | 4 (R2) | 12 (R2) | ∞ | ∞ |
| R4 | - | - | - | 8 (R4) | 8 (R4) | 24 (R4) |
| R5 | - | - | - | - | 8 (R4) | 10 (R5) |
| R6 | - | - | - | - | - | 10 (R5) |
| R7 | - | - | - | - | - | - |

So the path (R1, R2, R4, R5, R7) is the shortest path from R1 to R7 and the cost of this path = 10 as showing in the table.

### Part Two:

-We will build and configure the above topology using Packet Tracer software based on the following requirements.

1. For addressing the above network we will use the class C address 192.A.B.0 and use it to create networks (subnets) of 2 hosts each. A, and B represent the last four digits of your university ID. University ID 1102083 then A = 20 and B =83.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Router | IP Address | | | | | | | |
| R1 | Fa0/0 | | | | Fa0/1 | | | |
| 192.20.83.1/30 | | | | 192.20.83.5 /30 | | | |
| R2 | Fa0/0 | | Fa0/1 | | | | Eth1/0 | |
| 192.20.83.2 /30 | | 192.20.83.9/30 | | | | 192.20.83.13/30 | |
| R3 | Fa0/0 | | | | Fa0/1 | | | |
| 192.20.83.6 /30 | | | | 192.20.83.17 /30 | | | |
| R4 | Fa0/0 | Fa0/1 | | Eth1/0 | | Eth1/1 | | Eth1/2 |
| 192.20.83.14/30 | 192.20.83.18 /30 | | 192.20.83.21 /30 | | 192.20.83.25 /30 | | 192.20.83.29 /30 |
| R5 | Fa0/0 | | Fa0/1 | | | | Eth1/0 | |
| 192.20.83.10/30 | | 192.20.83.22 /30 | | | | 192.20.83.33 /30 | |
| R6 | Fa0/0 | | Fa0/1 | | | | | |
| 192.20.83.30 /30 | | 192.20.83.37 /30 | | | | | |
| R7 | Fa0/0 | | Fa0/1 | | | | Eth1/0 | |
| 192.20.83.26 /30 | | 192.20.83.34 /30 | | | | 192.20.83.38 /30 | |

And configuration will be as following:

|  |  |  |  |
| --- | --- | --- | --- |
| R1 | R1(config)#interface FastEthernet0/0  R1(config-if)#ip address 192.20.83.1 255.255.255.252  R1(config-if)#no shutdown  R1(config)#interface FastEthernet0/1  R1(config-if)#ip address 192.20.83.5 255.255.255.252  R1(config-if)#no shutdown | R4 | R4(config)#interface FastEthernet0/0  R4(config-if)#ip address 192.20.83.14 255.255.255.252  R4(config-if)#no shutdown  R4(config)#interface FastEthernet0/1  R4(config-if)#ip address 192.20.83.18 255.255.255.252  R4(config-if)#no shutdown  R4(config)#interface Ethernet1/0  R4(config-if)#ip address 192.20.83.21 255.255.255.252  R4(config-if)#no shutdown  R4(config)#interface Ethernet1/1  R4(config-if)#ip address 192.20.83.25 255.255.255.252  R4(config-if)#no shutdown  R4(config)#interface Ethernet1/2  R4(config-if)#ip address 192.20.83.29 255.255.255.252 R4(config-if)#no shutdown |
| R2 | R2(config)#interface FastEthernet0/0  R2(config-if)#ip address 192.20.83.2 255.255.255.252  R2(config-if)#no shutdown  R2(config)#interface FastEthernet0/1  R2(config-if)#ip address 192.20.83.9 255.255.255.252  R2(config-if)#no shutdown  R2(config)#interface Ethernet1/0  R2(config-if)#ip address 192.20.83.13 255.255.255.252  R2(config-if)#no shutdown |
| R3 | R3(config)#interface FastEthernet0/0  R3(config-if)#ip address 192.20.83.6 255.255.255.252  R3(config-if)#no shutdown  R3(config)#interface FastEthernet0/1  R3(config-if)#ip address 192.20.83.17 255.255.255.252  R3(config-if)#no shutdown | R6 | R6(config)#interface FastEthernet0/0  R6(config-if)#ip address 192.20.83.30 255.255.255.252  R6(config-if)#no shutdown  R6(config)#interface FastEthernet0/1  R6(config-if)#ip address 192.20.83.37 255.255.255.252  R6(config-if)#no shutdown |
| R5 | R5(config)#interface FastEthernet0/0  R5(config-if)#ip address 192.20.83.10 255.255.255.252  R5(config-if)#no shutdown  R5(config)#interface FastEthernet0/1  R5(config-if)#ip address 192.20.83.22 255.255.255.252  R5(config-if)#no shutdown  R5(config)#interface Ethernet1/0  R5(config-if)#ip address 192.20.83.33 255.255.255.252  R5(config-if)#no shutdown | R7 | R7(config)#interface FastEthernet0/0  R7(config-if)#ip address 192.20.83.26 255.255.255.252  R7(config-if)#no shutdown  R7(config)#interface FastEthernet0/1  R7(config-if)#ip address 192.20.83.34 255.255.255.252  R7(config-if)#no shutdown  R7(config)#interface Ethernet1/0  R7(config-if)#ip address 192.20.83.38 255.255.255.252  R7(config-if)#no shutdown |

2) We will enable OSPF routing. The configuration on each router will be as the following:

|  |  |  |  |
| --- | --- | --- | --- |
| R1 | R1(config)#router ospf 1  R1(config-router)#network 192.20.83.0 0.0.0.3 area 0  R1(config-router)#network 192.20.83.4 0.0.0.3 area 0 | R4 | R4(config)#router ospf 1  R4(config-router)#network 192.20.83.12 0.0.0.3 area 0  R4(config-router)#network 192.20.83.16 0.0.0.3 area 0  R4(config-router)#network 192.20.83.20 0.0.0.3 area 0  R4(config-router)#network 192.20.83.24 0.0.0.3 area 0  R4(config-router)#network 192.20.83.28 0.0.0.3 area 0 |
| R2 | R2(config)#router ospf 1  R2(config-router)#network 192.20.83.0 0.0.0.3 area 0  R2(config-router)#network 192.20.83.8 0.0.0.3 area 0  R2(config-router)#network 192.20.83.12 0.0.0.3 area 0 |
| R3 | R3(config)#router ospf 1  R3(config-router)#network 192.20.83.4 0.0.0.3 area 0  R3(config-router)#network 192.20.83.16 0.0.0.3 area 0 | R6 | R6(config)#router ospf 1  R6(config-router)#network 192.20.83.28 0.0.0.3 area 0  R6(config-router)#network 192.20.83.36 0.0.0.3 area 0 |
| R5 | R5(config)#router ospf 1  R5(config-router)#network 192.20.83.8 0.0.0.3 area 0  R5(config-router)#network 192.20.83.20 0.0.0.3 area 0  R5(config-router)#network 192.20.83.32 0.0.0.3 area 0 | R7 | R7(config)#router ospf 1  R7(config-router)#network 192.20.83.24 0.0.0.3 area 0  R7(config-router)#network 192.20.83.32 0.0.0.3 area 0  R7(config-router)#network 192.20.83.36 0.0.0.3 area 0 |

3) We will configure Router R7 with a loopback IP address 7.7.7.7/24. Advertise this network into OSPF process.

R7(config)#interface loopback 1

R7(config-if)#ip address 7.7.7.7 255.255.255.0

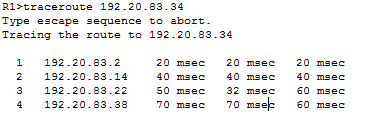
R7(config)#router ospf 1

R7(config-router)#network 7.7.7.0 0.0.0.255 area 0

4) We also need to configure bandwidth values between links. These values should reflect the costs that are shown in the network diagram.

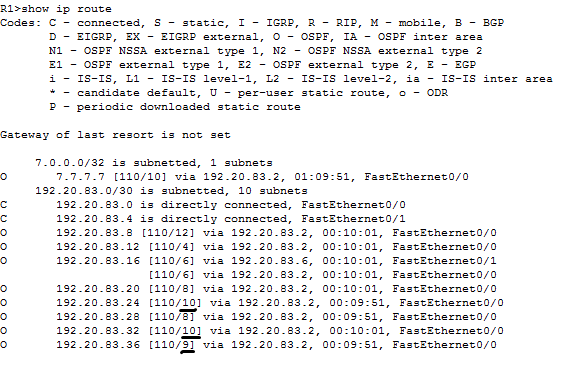
|  |  |  |  |
| --- | --- | --- | --- |
| R1 | R1(config)#interface FastEthernet0/0  R1(config-if)#bandwidth 50000  R1(config)#interface FastEthernet0/1  R1(config-if)#bandwidth 25000 | R4 | R4(config)#interface FastEthernet0/0  R4(config-if)#bandwidth 50000  R4(config)#interface FastEthernet0/1  R4(config-if)#bandwidth 50000  R4(config)#interface Ethernet1/0  R4(config-if)#bandwidth 25000  R4(config)#interface Ethernet1/1  R4(config-if)#bandwidth 5000  R4(config)#interface Ethernet1/2  R4(config-if)#bandwidth 25000 |
| R2 | R2(config)#interface FastEthernet0/0  R2(config-if)#bandwidth 50000  R2(config)#interface FastEthernet0/1  R2(config-if)#bandwidth 10000  R2(config)#interface Ethernet1/0  R2(config-if)#bandwidth 50000 |
| R3 | R3(config)#interface FastEthernet0/0  R3(config-if)#bandwidth 25000  R3(config)#interface FastEthernet0/1  R3(config-if)#bandwidth 50000 | R6 | R6(config)#interface FastEthernet0/0  R6(config-if)#bandwidth 25000  R6(config)#interface FastEthernet0/1  R6(config-if)#bandwidth 25000 |
| R5 | R5(config)#interface FastEthernet0/0  R5(config-if)#bandwidth 10000  R5(config)#interface FastEthernet0/1  R5(config-if)#bandwidth 25000  R5(config)#interface Ethernet1/0  R5(config-if)#bandwidth 50000 | R7 | R7(config)#interface FastEthernet0/0  R7(config-if)#bandwidth 5000  R7(config)#interface FastEthernet0/1  R7(config-if)#bandwidth 50000  R7(config)#interface Ethernet1/0  R7(config-if)#bandwidth 25000 |

5) We will use the traceroute command to know what routers it passes through until it reaches its destination If a packet is sent from R1 to R7.



So, it will go throw R1, R2, R4, R5 and R7.

6) We will use show ip route command on R1 to find the cost (metric) to get from R1 to R7.



As we see we can reach router 7 with minimum cost = 9.

7) The router-id for R1 is 192.20.83.5, and for R7 is 192.20.83.38 because these are the highest IP in each router.

### now we will implement the following topology :

### 

### First of all we will set up the IP configuration for the pc's

|  |  |  |  |
| --- | --- | --- | --- |
| Pc# | IP address | Subnet mask | Default gateway |
| 0 | 192.168.10.2 | 255.255.255.0 | 192.168.10.1 |
| 1 | 192.168.20.2 | 255.255.255.0 | 192.168.20.1 |
| 2 | 192.168.30.2 | 255.255.255.0 | 192.168.30.1 |
| 3 | 192.168.40.2 | 255.255.255.0 | 192.168.40.1 |
| 4 | 192.168.50.2 | 255.255.255.0 | 192.168.50.1 |
| 5 | 192.168.60.2 | 255.255.255.0 | 192.168.60.1 |
| 6 | 192.168.70.2 | 255.255.255.0 | 192.168.70.1 |
| 7 | 192.168.80.2 | 255.255.255.0 | 192.168.80.1 |

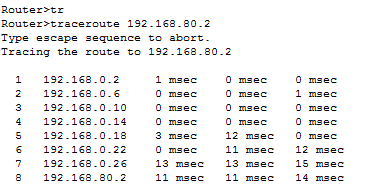
Second step will configure the routers as the following:

|  |  |  |  |
| --- | --- | --- | --- |
| R0 | R0(config)#interface FastEthernet0/0  R0(config-if)#ip address 192.168.10.1 255.255.255.0  R0(config-if)#no shutdown  R0(config)#interface FastEthernet0/1  R0(config-if)#ip address 192.168.0.1 255.255.255.252  R0(config-if)#no shutdown | R4 | R4(config)#interface FastEthernet0/0  R4(config-if)#ip address 192.168.0.14 255.255.255.252  R4(config-if)#no shutdown  R4(config)#interface FastEthernet0/1  R4(config-if)#ip address 192.168.50.1 255.255.255.0  R4(config-if)#no shutdown  R4(config)#interface Ethernet1/0  R4(config-if)#ip address 192.168.0.17 255.255.255.252  R4(config-if)#no shutdown |
| R1 | R1(config)#interface FastEthernet0/1  R1(config-if)#ip address 192.168.0.2 255.255.255.252  R1(config-if)#no shutdown  R1(config)#interface FastEthernet0/0  R1(config-if)#ip address 192.168.20.1 255.255.255.0  R1(config-if)#no shutdown  R1(config)#interface Ethernet1/0  R1(config-if)#ip address 192.168.0.5 255.255.255.252  R1(config-if)#no shutdown |
| R2 | R2(config)#interface FastEthernet0/1  R2(config-if)#ip address 192.168.0.6 255.255.255.252  R2(config-if)#no shutdown  R2(config)#interface FastEthernet0/0  R2(config-if)#ip address 192.168.30.1 255.255.255.0  R2(config-if)#no shutdown  R2(config)#interface Ethernet1/0  R2(config-if)#ip address 192.168.0.9 255.255.255.252  R2(config-if)#no shutdown | R5 | R5(config)#interface Ethernet1/0  R5(config-if)#ip address 192.168.0.18 255.255.255.252  R5(config-if)#no shutdown  R5(config)#interface FastEthernet0/0  R5(config-if)#ip address 192.168.60.1 255.255.255.0  R5(config-if)#no shutdown  R5(config)#interface FastEthernet0/1  R5(config-if)#ip address 192.168.0.21 255.255.255.252  R5(config-if)#no shutdown |
| R3 | R3(config)#interface FastEthernet0/1  R3(config-if)#ip address 192.168.0.10 255.255.255.252  R3(config-if)#no shutdown  R3(config)#interface FastEthernet0/0  R3(config-if)#ip address 192.168.40.1 255.255.255.0  R3(config-if)#no shutdown  R3(config)#interface Ethernet1/0  R3(config-if)#ip address 192.168.0.13 255.255.255.252  R3(config-if)#no shutdown | R6 | R6(config)#interface FastEthernet0/0  R6(config-if)#ip address 192.168.70.1 255.255.255.0  R6(config-if)#no shutdown  R6(config)#interface FastEthernet0/1  R6(config-if)#ip address 192.168.0.25 255.255.255.252  R6(config-if)#no shutdown  R6(config)#interface Ethernet1/0  R6(config-if)#ip address 192.168.0.22 255.255.255.252  R6(config-if)#no shutdown |
| R7 | R7(config)#interface FastEthernet0/1  R7(config-if)#ip address 192.168.0.26 255.255.255.252  R7(config-if)#no shutdown  R7(config)#interface FastEthernet0/0  R7(config-if)#ip address 192.168.80.1 255.255.255.0  R7(config-if)#no shutdown | | |

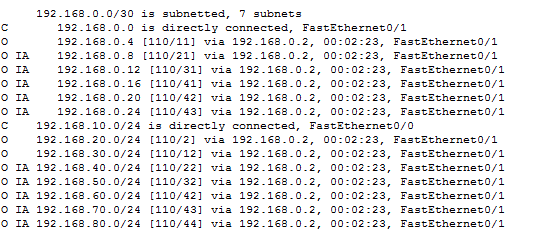
now We will enable OSPF routing. The configuration on each router will be as the following:

|  |  |  |  |
| --- | --- | --- | --- |
| R0 | R0(config)#router ospf 1  R0(config-router)#network 192.168.0.0 0.0.0.3 area 2  R0(config-router)#network 192.168.10.0 0.0.0.255 area 2 | R4 | R4(config)#router ospf 1  R4(config-router)#network 192.168.0.12 0.0.0.3 area 0  R4(config-router)#network 192.168.0.16 0.0.0.3 area 0  R4(config-router)#network 192.168.50.0 0.0.0.255 area 0 |
| R1 | R1(config)#router ospf 1  R1(config-router)#network 192.168.0.4 0 0.0.0.3 area 2  R1(config-router)#network 192.168.0.0 0.0.0.3 area 2  R1(config-router)#network 192.168.20.0 0.0.0.255 area 2 |
| R2 | R2(config)#router ospf 1  R2(config-router)#network 192.168.0.4 0.0.0.3 area 2  R2(config-router)#network 192.168.0.8 0.0.0.3 area 0  R2(config-router)#network 192.168.30.0 0.0.0.255 area 2 | R5 | R5config)#router ospf 1  R5(config-router)#network 192.168.0.16 0.0.0.3 area 0  R5(config-router)#network 192.168.0.20 0.0.0.3 area 1  R5(config-router)#network 192.168.60.0 0.0.0.255 area 1 |
| R3 | R3(config)#router ospf 1  R3(config-router)#network 192.168.0.8 0.0.0.3 area 0  R3(config-router)#network 192.168.0.12 0.0.0.3 area 0  R3(config-router)#network 192.168.40.0 0.0.0.255 area 0 | R6 | R6(config)#router ospf 1  R6(config-router)#network 192.168.0.20 0.0.0.3 area1  R6(config-router)#network 192.168.0.24 0.0.0.3 area 1  R6(config-router)#network 192.168.70.0 0.0.0.255 area1 |
| R7 | R7(config)#router ospf 1  R7config-router)#network 192.168.0.24 0.0.0.3 area 1  R7(config-router)#network 192.168.80.0 0.0.0.255 area 1 | | |

To ensure our work we use "traceroute" command from R0 to PC7



also we use "show ip route" command in R0 to ensure that our work is true as shown in the following figure:



1. Discussion

The main advantage of a link state routing protocol like OSPF is that the complete knowledge of topology allows routers to calculate routes that satisfy particular criteria. This can be useful for traffic engineering purposes, where routes can be constrained to meet particular quality of service requirements. The main disadvantage of a link state routing protocol is that it does not scale well as more routers are added to the routing domain. Increasing the number of routers increases the size and frequency of the topology updates, and also the length of time it takes to calculate end-to-end routes. This lack of scalability means that a link state routing protocol is unsuitable for routing across the Internet at large, which is the reason why IGPs only route traffic within a single AS.

5. Conclusion

In this experiment we learn that OSPF is a dynamic routing protocol that is used a lot in the networks today, and that protocol can support many important features such as authentication using passwords and other methods, route summarization, VLSM (Variable Length Subnetting). And it considered one of fastest dynamic routing protocols.

Also, we concluded that OSPF is better than other dynamic routing protocols since it can operate within a hierarchy Unlike RIP, so we can manage the network easier. also It converges quicker than RIP since routing updates are sent immediately instead of periodically.

6. References

1. OSPF; <http://searchenterprisewan.techtarget.com/definition/OSPF>; 24/4/2014.
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