CSE 4512 [Computer Networks Lab]

Lab # 07

1. Objectives:

- Describe the concept of OSPF and related terminologies
- Explain advantages of OSPF over RIP
- Configure OSPF in a network topology following given specifications

2. Theory:

In the previous lab you learnt the concept of dynamic routing, Routing Information Protocol (RIP) and how to configure RIP in a network. In this lab, you'll learn about OSPF which is one of the most commonly used dynamic routing protocols and you'll also see how to configure OSPF in a simple network topology.

Open Shortest Path First (OSPF) Routing Protocol:

As you know already, OSPF uses Link State Routing (LSR) algorithm. In OSPF, each router sends its link information to the directly connected routers, known as neighbors, which in turn sends the info to other neighbors. After that each router runs the Shortest Path Algorithm on the received information to determine the optimal route to different networks. The running of the algorithm is one of the reason why OSPF is a CPU-intensive protocol as whenever there's a change the algorithm is run. Still OSPF is better than RIP due to its fast convergence and better load-balancing. Remember that, RIP sends the whole routing table to its neighbors whereas OSPF only sends the link information with various optimizations in place. You can learn more about OSPF and RIP here.

There's a plethora of terminologies and concepts related to OSPF that one needs to know for full understanding of the protocol. Some most common ones are listed here. But for our purpose, we'll just cover the ones necessary for our lab.

- **Area**: OSPF networks are divided into **areas** which are a logical collection of routers, links having the *same area identification*. A router within an area must maintain a topological database *for the area to which it belongs*. The router does not have detailed information about network topology outside of its area, which thereby reduces the size of its database. There's a special area called the **backbone area** (*area 0*) to which all other areas must be connected. Different areas can communicate with each other through area 0.
- **Area Border Router (ABR)**: A router with interfaces in two areas is called an ABR. This router is the boundary between two areas.
- **Autonomous System (AS):** OSPF operates within a single Autonomous System which is a collection of areas. AS is basically a group of networks running under a single administrative control. It controls how far the routing information should be propagated and facilitates filtering of information for sharing with other AS.
- **Designated Router (DR):** A router is elected as the Designated Router (DR) and another as Backup Designated Router (BDR) on a multi-access network (like LAN) in OSPF. DR and BDR

serve as the *central point* for exchanging OSPF routing information. Each non-DR or non-BDR router will exchange routing information *only* with the DR and BDR, instead of exchanging updates with every router on the network segment. DR will then distribute topology information to every other router inside the same area, which greatly reduces OSPF traffic. For more, you can read on here.

- **Router ID**: Each router running the OSPF protocol is assigned a router ID to **uniquely identify that router within an AS**. This is a 32 bit number and can be set *manually* by using the `router-id` command. If router ID is not set manually then the highest IP address of the router's *loopback address* will be the router ID. If there's no loopback address then the highest *active IP address* on any of the router's interface will be the router ID. Remember to restart the router to reflect the new router-id assignment. The `reload` command will restart the router. Also, the `clear ip ospf process` command will work for new router-id assignment.
- **Cost**: The cost in OSPF is calculated as **Reference Bandwidth / Interface Bandwidth**. The default value of reference bandwidth is *100 Mbps* but it can be set manually. The command to manually set the reference bandwidth is `auto-cost reference-bandwidth <value>`. Note that, `value` here is in units of *Mbps*. So, `value`=100 would mean 100 Mbps. You can change the interface bandwidth with the `bandwidth <value>` command. But, here the `value` is in units of *kbps*.
- **Wildcard Mask:** The command to configure which networks to advertise is `network <ip_address> <wildcard_mask> area <area_id>`. Unlike RIP, the `network` command in OSPF supports classless routing and that support is achieved by the `wildcard_mask`. This mask is like an inverted subnet_mask but with different interpretation. The **0** bits in the mask indicate the corresponding bit positions that *must match* the same bit positions in the IP address. The **1** bits indicate the corresponding bit positions *don't need to match* the same bit positions in the IP address. Its best understood by an example. Suppose, there's a `10.0.1.0` directly connected subnet to our router that we want to advertise in the OSPF routing process. The command to include that subnet in the advertisement would be:

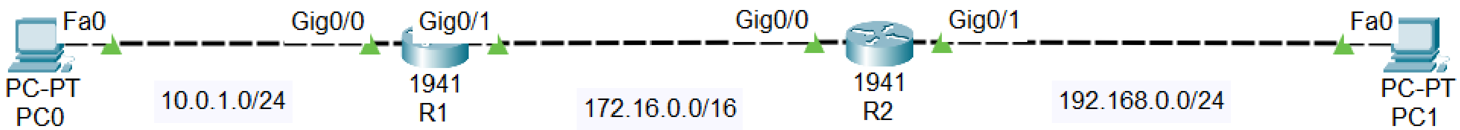
  ```
  network 10.0.1.0 0.0.0.255 area 0
  ```

  According to the wildcard_mask used in the above command, first 24 bits of the addresses must match and rest 8 bits don't need to match. So, any interface having IP address in the format **`10.0.1.X`** will match in this case. A more detailed explanation of wildcard_mask with more examples can be found here.
- **Process ID**: When enabling OSPF in a router, you need to mention a process ID. All OSPF functions will then be performed under that process. OSPF configuration mode is entered using the command `router ospf <process_id>`. You can have more than one OSPF processes in a single router. The process IDs will be different for different processes. Each OSPF process has its separate database, topology table etc. More on process ID can be read from here.

Now lets mention some key concepts in OSPF. OSPF enabled routers send *hello* packets to each other in certain intervals known as the *hello interval*. This is required to establish neighbor relationship and to let other router know the availability of the router. For example, if the *hello interval* is 5 seconds, then each router will send *hello* packets to the neighboring router in every 5 seconds. There's another interval known as the *dead interval* which is usually `4 times` of the hello interval. If a router doesn't receive *hello* packets from its neighbors then after this *dead interval* amount of time that neighbor will be declared *non-operational* and the routing table will be updated accordingly.

In OSPF, some interfaces are configured as passive-interfaces. Passive interfaces don't send hello packets. This is usually done for the local-LAN facing interfaces. Note that, the network connected with the passive interface will still be advertised as OSPF has been enabled in that interface. Check out this to learn more about passive interfaces.

3. Configure OSPF:



I. **Configure R1 Interfaces**

```
R1(config)# int g0/0
R1(config-if)# ip address 10.0.1.1 255.255.255.0
R1(config-if)# no shutdown
R1(config-if)# exit

R1(config)# int g0/1
R1(config-if)# ip address 172.16.0.1 255.255.0.0
R1(config-if)# no shutdown
R1(config-if)# exit

R1# copy running-config startup-config
```

II. **Configure R2 Interfaces**

```
R2(config)# int g0/1
R2(config-if)# ip address 192.168.0.1 255.255.255.0
R2(config-if)# no shutdown
R2(config-if)# exit

R2(config)# int g0/0
R2(config-if)# ip address 172.16.0.2 255.255.0.0
R2(config-if)# no shutdown
R2(config-if)# exit

R2# copy running-config startup-config
```

III. Configure PC0

```
IP: 10.0.1.10
Mask: 255.255.255.0
Gateway: 10.0.1.1
```

IV. Configure PC1

```
IP: 192.168.0.10
Mask: 255.255.255.0
Gateway: 192.168.0.1
```

V. **Configure OSPF in R1**

```
R1(config)# router ospf 1
R1(config-router)# network 10.0.1.0 0.0.0.255 area 0
R1(config-router)# network 172.16.0.0 0.0.255.255 area 0
```

VI. **Configure OSPF in R2**

```
R2(config)# router ospf 1
R2(config-router)# network 192.168.0.0 0.0.0.255 area 0
R2(config-router)# network 172.16.0.0 0.0.255.255 area 0
```

VII. **Verify**

```
R1# show ip ospf neighbor
R2# show ip ospf neighbor

Ping PC1 from PC0
```

4. Tasks:

I. Implement the given network topology with the provided address specifications as described in the pdf ***Task-1_OSPF***. Answer the questions accordingly. You're ***not*** provided a .pka file for this task. Make sure you've properly read on the *theory section of this handout* to understand the concepts mentioned in ***Task-1_OSPF***. Otherwise, you'll face difficulties and might not get everything that's introduced there.

II. You will answer the given questions in this task and implement very small portion of OSPF. The task description for this task is provided in the pdf ***Task-2_verify-single-area-ospfv2***. You're provided a .pka file for this task. As with task 1, make sure you've read on the theory section properly. Our suggestion would be to attempt task 2 after you've completed task 1 as many of the concepts of OSPF is explained and shown in task 1.