LAB No: 7

Configuration of Dynamic Routing using OSPF

Objectives:

- To be familiar with OSPF and its configuration

Environmental Setup:

- Network simulation tool: Packet Tracer

Theory:

OSPF:

- An Interior Gateway Protocol (IGP)
- Uses a link-state algorithm to build and calculate the shortest path to all known destinations
- Propagates link-state advertisements rather than routing table updates
- Because only LSAs are exchanged instead of the entire routing tables, OSPF networks converge more quickly than RIP networks
- Each router in an OSPF area contains an identical link-state database, which is a list of each of the router usable interfaces and reachable neighbors

Wildcard Masks:

- It is 32 bits long like a subnet mask, and used to specify a range of network addresses
- With wildcard mask, the zero bits indicate that the corresponding bit position must match the same bit position in the IP address and the one bits indicate that the corresponding bit position doesn't have to match the bit position in the IP address
- Used with routing protocols (like OSPF) and ACLs

[Activity A]

Created the network topology as shown in figure 1 and performed the following activities:

1. Given an IP address of 200.100.100.0/24. Divided this address range for different LANs i.e. LAN1, LAN2, LAN3 and LAN4 interconnected as the network topology having 55, 25, 10 and 45 numbers of hosts respectively. In addition to this there were few networks having only two hosts in each (i.e. connection between two routers). Allocated the IP address range for each of the sub-networks with their network address, broadcast address and subnet mask. Also listed out the unused range of IP addresses (if any).

200.100.100.0 /24

Departments	Hosts	Network Address	Broadcast Address	Subnet Mask	Unused Range
LAN1	55	200.100.100.0	200.100.100.63	255.255.255.192	.56 - .62
LAN4	45	200.100.100.64	200.100.100.127	255.255.255.192	.110 - .126
LAN2	25	200.100.100.128	200.100.100.159	255.255.255.224	.154 - 158
LAN3	10	200.100.100.160	200.100.100.175	255.255.255.240	.171 - .174
G	2	200.100.100.176	200.100.100.179	255.255.255.252	0
H	2	200.100.100.180	200.100.100.183	255.255.255.252	0
I	2	200.100.100.184	200.100.100.187	255.255.255.252	0

FastEthernet	Routers			
	Mamata_01	Mamata_02	Mamata_03	Mamata_03
0/0	200.100.100.1	200.100.100.178	200.100.100.182	200.100.100.186
1/0	200.100.100.177	200.100.100.129	200.100.100.161	200.100.100.65
2/0	---	200.100.100.181	200.100.100.185	---

2. On the basis of your designed subnets, configured IP addresses for each interface of routers. Also configured the IP address and default gateway of each PC & server.

3. Enabled routing in between LANs using **OSPF**. All networks were considered in **area 0**.

4. Ping command showed proper connectivity assuming all the networks are in a single area of “area 0”.

5. Using `tracert` command from PC0 to PC3 displayed the shortest route from PC0 to PC3 and There were proper allocation of the routing direction as intended shown when the show ip route was commanded.

[Activity B]

Now Connected additional router in topology of activity A:

1. Configured the interfaces of Router4 with appropriate IP addresses and enabled **OSPF** in it. And noted down the result of `tracert` command from PC0 to PC3. Here the packet first traveled to the default router and then again returned to the newly connected router for the shorter journey to the destination.

```
Tracert from pc0 to pc 3

[1] Tracing route to 200.100.100.67 over a maximum of 30 hops:
 1   1 ms     0 ms     0 ms     200.100.100.1
 2   0 ms     0 ms     0 ms     200.100.100.56
 3   0 ms     0 ms     0 ms     200.100.100.67
Trace complete.
```

2. `show ip route` command displayed the newly connected router as well.
3. Removed a link i.e. the link between router 4 and switch 0 and then observed the result of traceroute command from PC0 to PC3 and routing table in each router. And the routing table had a new router but not the network that was assigned to the link.

```
[3] Tracing route to 200.100.100.67 over a maximum of 30 hops:
 1   0 ms     0 ms     0 ms     200.100.100.1
 2   0 ms     0 ms     0 ms     200.100.100.178
 3   0 ms     0 ms     0 ms     200.100.100.182
 4   0 ms     0 ms     0 ms     200.100.100.186
 5   0 ms     0 ms     1 ms     200.100.100.67
Trace complete.
```

4. Again connected the link and observed the routing table of each router. Also observed the result of `tracert` command from PC0 to PC1.

```
[4] Tracing route to 200.100.100.129 over a maximum of 30 hops:
 1   0 ms     0 ms     0 ms     200.100.100.1
 2   0 ms     0 ms     0 ms     200.100.100.129
Trace complete.
```

5. Removed another link between Router0 and Router1.
6. Observed the routing table of each router as well as the result of `tracert` command from PC0 to PC1.

[6] Tracing route to 200.100.100.129 over a maximum of 30 hops:

1	0 ms	0 ms	0 ms	200.100.100.1
2	0 ms	0 ms	0 ms	200.100.100.56
3	0 ms	0 ms	1 ms	200.100.100.65
4	0 ms	0 ms	0 ms	200.100.100.185
5	0 ms	0 ms	0 ms	200.100.100.129

Trace complete.

7. Similarly the routing was observed removing other links.

[Activity C]

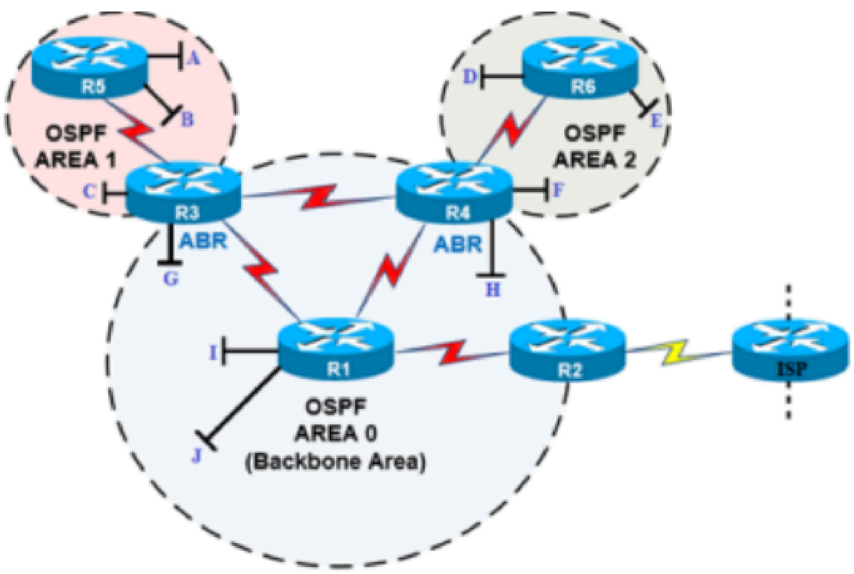

Figure 3: Network Topology 3

Given, IP addresses of 24.24.24.0/21 from APNIC.

Department's Name	A	B	C	D	E	F	G	H	I	J
No. of hosts	400	500	90	100	80	200	40	20	110	120

Departments	Hosts	Network Address	Broadcast Address	Subnet Mask	Unused Range
B	500	24.24.24.0	24.24.25.255	255.255.254.0	25.245 - 25.254
A	400	24.24.26.0	24.24.27.255	255.255.254.0	27.144 - 27.254
F	200	24.24.28.0	24.24.28.255	255.255.255.0	28.201 - 28.254
J	120	24.24.29.0	24.24.29.127	255.255.255.128	29.121 - 29.126
I	110	24.24.29.128	24.24.29.255	255.255.255.128	29.38 - 29.254
D	100	24.24.30.0	24.24.30.127	255.255.255.128	30.101 - 30.126
C	90	24.24.30.128	24.24.30.255	255.255.255.128	30.219 - 30.254
E	80	24.24.31.0	24.24.31.127	255.255.255.128	31.81 - 31.126
G	40	24.24.31.128	24.24.31.191	255.255.255.192	31.169 - 31.190
H	20	24.24.31.192	24.24.31.223	255.255.255.224	31.213 - 31.222

K	2	24.24.31.224	24.24.31.227	255.255.255.252	0
L	2	24.24.31.228	24.24.31.231	255.255.255.252	0
M	2	24.24.31.232	24.24.31.235	255.255.255.252	0
N	2	24.24.31.236	24.24.31.239	255.255.255.252	0
O	2	24.24.31.240	24.24.31.243	255.255.255.252	0
P	2	24.24.31.244	24.24.31.247	255.255.255.252	0
Q	2	24.24.31.1248	24.24.31.251	255.255.255.252	0

```
000.00000000 - 001.11111111 (0 - 511)
010.00000000 - 011.11111111 (512 - 1023)
100.00000000 - 100.11111111 (1024 - 1279)
101.00000000 - 101.01111111 (1280 - 1407)
101.10000000 - 101.11111111 (1408 - 1535)
110.00000000 - 110.01111111 (1536 - 1663)
110.10000000 - 110.11111111 (1664 - 1791)
111.00000000 - 111.01111111 (1792 - 1919)
111.10000000 - 111.10111111 (1920 - 1983)
111.11000000 - 111.11011111 (1984 - 2015)
```

1. Created the network as shown in figure 3, in which for each network used at least one PC connected to the router via a switch.
2. On the basis of my designed subnet, I configured each interface of the router with appropriate IP addresses & subnet masks. Similarly configured the appropriate IP address, subnet mask and default gateway on each computer. Used an IP network of **/30** to connect router R2 with ISP router.

[2]

Router area 1 before ospf

```
24.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C       24.24.24.0/23 is directly connected, FastEthernet0/0
C       24.24.26.0/23 is directly connected, FastEthernet1/0
C       24.24.31.224/30 is directly connected, Serial2/0
```

ARB 1

```
   24.0.0.0/8 is variably subnetted, 5 subnets, 3 masks
C       24.24.30.128/25 is directly connected, FastEthernet0/0
C       24.24.31.128/26 is directly connected, FastEthernet1/0
C       24.24.31.224/30 is directly connected, Serial2/0
C       24.24.31.228/30 is directly connected, Serial3/0
C       24.24.31.232/30 is directly connected, Serial4/0
```

3. Observed and noted down the output of the command `show ip route` in each router.

4. Configured the OSPF in all routers with respective networks and areas (refer figure 3).
5. Observed and noted down the output of the command `show ip route` in each router.

```
[3] OSPF

Area 1 to 1.1.1.1
Pinging 1.1.1.2 with 32 bytes of data:
Request timed out.
Reply from 1.1.1.2: bytes=32 time=4ms TTL=123
Reply from 1.1.1.2: bytes=32 time=4ms TTL=123
Reply from 1.1.1.2: bytes=32 time=106ms TTL=123
Ping statistics for 1.1.1.2:
  Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
  Minimum = 4ms, Maximum = 106ms, Average = 38ms
```

6. Tested the connectivity from the computer of each network to the computer of each other networks and there was a proper connection between them.
7. Observed the output of traceroute from a computer of network A to the computer of each other networks and each IP of routers. Similarly, observed from the computers of other networks such as D, J and so on.

```
Tracing route to 1.1.1.1 over a maximum of 30 hops:
 1   0 ms     1 ms     0 ms     24.24.24.1
 2   0 ms     16 ms    0 ms     24.24.31.226
 3   18 ms    39 ms    50 ms    24.24.31.230
 4   1 ms     1 ms     50 ms    24.24.31.242
 5   0 ms     2 ms     4 ms     1.1.1.1
Trace complete.

[From D to B]
Tracing route to 24.24.24.2 over a maximum of 30 hops:
 1   0 ms     0 ms     0 ms     24.24.30.1
 2   0 ms     0 ms     1 ms     24.24.31.245
 3   2 ms     1 ms     80 ms    24.24.31.233
 4   1 ms     81 ms    2 ms     24.24.31.225
 5   2 ms     1 ms     46 ms    24.24.24.2
Trace complete.
```

8. Observed the output of tracert from the computer of network A to 1.1.1.1. Similarly, observe from the computers of other networks such as D, J and so on.

Tracert from D to 1.1.1.1
Tracing route to 1.1.1.1 over a maximum of 30 hops:

```
 1   0 ms     0 ms     0 ms     24.24.30.1
 2   0 ms     6 ms     29 ms    24.24.31.245
 3   0 ms     71 ms    1 ms     24.24.31.237
 4   47 ms    2 ms     130 ms   24.24.31.242
 5   1 ms     1 ms     2 ms     1.1.1.1
```

Trace complete.

Show ip Route for ABR 1 After ospf

```
O IA 1.0.0.0/8 [110/193] via 24.24.31.230, 00:06:41, Serial3/0
   24.0.0.0/8 is variably subnetted, 16 subnets, 5 masks
O      24.24.24.0/23 [110/65] via 24.24.31.225, 00:07:58, Serial2/0
O      24.24.26.0/23 [110/65] via 24.24.31.225, 00:07:58, Serial2/0
O      24.24.29.0/25 [110/65] via 24.24.31.230, 00:06:41, Serial3/0
O      24.24.29.128/25 [110/65] via 24.24.31.230, 00:06:41, Serial3/0
O IA   24.24.30.0/25 [110/129] via 24.24.31.234, 00:07:29, Serial4/0
C      24.24.30.128/25 is directly connected, FastEthernet0/0
O IA   24.24.31.0/25 [110/129] via 24.24.31.234, 00:07:29, Serial4/0
C      24.24.31.128/26 is directly connected, FastEthernet1/0
O      24.24.31.192/27 [110/65] via 24.24.31.234, 00:07:29, Serial4/0
C      24.24.31.224/30 is directly connected, Serial2/0
C      24.24.31.228/30 is directly connected, Serial3/0
C      24.24.31.232/30 is directly connected, Serial4/0
O      24.24.31.236/30 [110/128] via 24.24.31.230, 00:06:41, Serial3/0
                      [110/128] via 24.24.31.234, 00:06:41, Serial4/0
O      24.24.31.240/30 [110/128] via 24.24.31.230, 00:06:41, Serial3/0
O IA   24.24.31.244/30 [110/128] via 24.24.31.234, 00:07:29, Serial4/0
O IA   24.24.31.248/30 [110/192] via 24.24.31.230, 00:06:41, Serial3/0
```

9. Now configured the default route in each router to forward any Internet traffic toward ISP Router. Also configured a static route in the ISP router to forward the packets destined for our network.
10. Observed and noted down the output of the command `show ip route` in each router.

    With the addition of the new default route with the next hop as the address of the ISP router the network address that are not present in the network is directed towards the isp router.

```
Router 1 ip route after ospf
O IA 1.0.0.0/8 [110/129] via 24.24.31.242, 00:15:31, Serial4/0
   24.0.0.0/8 is variably subnetted, 16 subnets, 5 masks
O IA    24.24.24.0/23 [110/129] via 24.24.31.229, 00:08:01, Serial2/0
O IA    24.24.26.0/23 [110/129] via 24.24.31.229, 00:08:01, Serial2/0
C       24.24.29.0/25 is directly connected, FastEthernet1/0
C       24.24.29.128/25 is directly connected, FastEthernet0/0
O IA    24.24.30.0/25 [110/129] via 24.24.31.238, 00:29:24, Serial3/0
O IA    24.24.30.128/25 [110/65] via 24.24.31.229, 00:08:01, Serial2/0
O IA    24.24.31.0/25 [110/129] via 24.24.31.238, 00:29:00, Serial3/0
O       24.24.31.128/26 [110/65] via 24.24.31.229, 00:08:01, Serial2/0
O       24.24.31.192/27 [110/65] via 24.24.31.238, 00:31:53, Serial3/0
O IA    24.24.31.224/30 [110/128] via 24.24.31.229, 00:08:01, Serial2/0
C       24.24.31.228/30 is directly connected, Serial2/0
O       24.24.31.232/30 [110/128] via 24.24.31.238, 00:08:01, Serial3/0
                 [110/128] via 24.24.31.229, 00:08:01, Serial2/0
C       24.24.31.236/30 is directly connected, Serial3/0
C       24.24.31.240/30 is directly connected, Serial4/0
O IA    24.24.31.244/30 [110/128] via 24.24.31.238, 00:32:28, Serial3/0
O IA    24.24.31.248/30 [110/128] via 24.24.31.242, 00:34:41, Serial4/0

Router of area 0

O IA 1.0.0.0/8 [110/129] via 24.24.31.242, 00:28:03, Serial4/0
   24.0.0.0/8 is variably subnetted, 16 subnets, 5 masks
O IA    24.24.24.0/23 [110/129] via 24.24.31.229, 00:20:33, Serial2/0
O IA    24.24.26.0/23 [110/129] via 24.24.31.229, 00:20:33, Serial2/0
C       24.24.29.0/25 is directly connected, FastEthernet1/0
C       24.24.29.128/25 is directly connected, FastEthernet0/0
O IA    24.24.30.0/25 [110/129] via 24.24.31.238, 00:41:56, Serial3/0
O IA    24.24.30.128/25 [110/65] via 24.24.31.229, 00:20:33, Serial2/0
O IA    24.24.31.0/25 [110/129] via 24.24.31.238, 00:41:32, Serial3/0
O       24.24.31.128/26 [110/65] via 24.24.31.229, 00:20:33, Serial2/0
O       24.24.31.192/27 [110/65] via 24.24.31.238, 00:44:25, Serial3/0
O IA    24.24.31.224/30 [110/128] via 24.24.31.229, 00:20:33, Serial2/0
C       24.24.31.228/30 is directly connected, Serial2/0
O       24.24.31.232/30 [110/128] via 24.24.31.238, 00:20:33, Serial3/0
                 [110/128] via 24.24.31.229, 00:20:33, Serial2/0
C       24.24.31.236/30 is directly connected, Serial3/0
C       24.24.31.240/30 is directly connected, Serial4/0
O IA    24.24.31.244/30 [110/128] via 24.24.31.238, 00:45:00, Serial3/0
O IA    24.24.31.248/30 [110/128] via 24.24.31.242, 00:47:13, Serial4/0
S*   0.0.0.0/0 [1/0] via 24.24.31.250
```

11. Removed the link between router R1 and R3 and observe the routing table of routers in area 0. Also the output of tracert from the computer of network A to 1.1.1.1.
    Now when the tracert command was called in pc 1 for the 1.1.1.1 it went through other

network as the connection between router 1 and router 3 was removed

```
Tracing route to 1.1.1.1 over a maximum of 30 hops:
 1  0 ms     0 ms     0 ms     24.24.24.1
 2  0 ms     0 ms     0 ms     24.24.31.226
 3  1 ms     4 ms     1 ms     24.24.31.234
 4  0 ms     70 ms    1 ms     24.24.31.237
 5  129 ms   60 ms    3 ms     24.24.31.242
 6  80 ms    2 ms     100 ms   1.1.1.1
Trace complete.
```

Exercise:

5. What is OSPF? How does it differ from RIP? Explain OSPF configurations with examples.

   OSPF (Open Shortest Path First):

   OSPF is a link-state routing protocol used to find the best path for data through a network. It is widely used in large enterprise networks due to its scalability and fast convergence.

   Difference from RIP (Routing Information Protocol):

   Algorithm: OSPF uses Dijkstra's algorithm, while RIP uses the Bellman-Ford algorithm.

   Convergence: OSPF converges faster than RIP.

   Hop Count: RIP has a maximum hop count of 15, whereas OSPF has no such limit.

   Routing Updates: OSPF sends event-driven updates, whereas RIP sends periodic updates every 30 seconds.

   OSPF Configuration Example:

   Enable OSPF on the router:

   router(config)# router ospf 1

   Define networks and associated areas:

   router(config-router)# network 192.168.1.0 0.0.0.255 area 0

   router(config-router)# network 192.168.2.0 0.0.0.255 area 0

6. What is multi-area OSPF? Why is it used? How can the multi-area OSPF be configured? Explain with examples.

   Multi-Area OSPF:

   Multi-area OSPF is used to divide a large OSPF network into smaller, more manageable areas. This reduces the size of the routing table and limits the scope of route updates, enhancing scalability and performance.

   It is used for its

   Scalability: Reduces routing table size and update traffic.

Organization: Simplifies management by segmenting the network.

Multi-Area OSPF Configuration Example:

Enable OSPF on the router and define areas:

router(config)# router ospf 1

router(config-router)# network 192.168.1.0 0.0.0.255 area 0

router(config-router)# network 192.168.2.0 0.0.0.255 area 1

router(config-router)# network 192.168.3.0 0.0.0.255 area 2

Configure an ABR (Area Border Router):

router(config-router)# network 192.168.1.0 0.0.0.255 area 0

router(config-router)# network 192.168.2.0 0.0.0.255 area 1

7. How can dynamic routing address the changing topology of the network? Explain with reference to the observation of the lab exercise.

   Dynamic Routing:

   Dynamic routing protocols, such as OSPF, automatically adjust routes when there are changes in the network topology. This adaptability ensures network resilience and efficiency.

   Lab Exercise Observation:

   Topology Changes: When a link was removed, OSPF quickly recalculated the best path using Dijkstra's algorithm, ensuring minimal disruption.

   Scalability: As new routers are added, OSPF integrated them without manual intervention, maintaining optimal routing.

   Efficiency: OSPF minimized routing loops and stale routes by maintaining a consistent network topology view across all routers.

Conclusion:

This Lab Exercise was really helpful for understanding dynamic routing with OSPF. It was really easy to remove or add additional routing links as the OSPF dynamically searched for the shortest path to the destination upon any update.