Lab 7: Configuration of Dynamic Routing using OSPF

Objectives:

- To be familiar with OSPF and its configuration.

Requirements:

- Network simulation tool: Packet Tracer

Procedure:

A: The network topology depicted in Figure 1 was created, and the following steps were performed: The IP address 200.100.100.0/24 was divided into different subnets for LAN1, LAN2, LAN3, and LAN4, each catering to 55, 25, 10, and 45 hosts, respectively. Additional subnets were assigned for point-to-point connections between routers. The IP addresses for each router interface and the default gateways for each PC and server were configured according to the designed subnets. Routing between LANs was enabled using OSPF, with all networks in area 0. Connectivity between PCs in different LANs was tested using the ping command, and the results of traceroute from PC0 to PC3 were noted. Finally, the routing tables in each router were observed using the show ip route command.

B: An additional router was connected as shown in Figure 2, and the following steps were executed: The interfaces of Router4 were configured with appropriate IP addresses, and OSPF was enabled. The results of the tracert command from PC0 to PC3 were noted and compared with those from Activity A. The routing tables in each router were observed and compared. The link between Router4 and Switch0 was removed, and the resulting changes in the routing tables and tracert results were noted. The link was reconnected, and the routing tables and tracert results were observed again. The link between Router0 and Router1 was removed, and the resulting changes were observed and compared with previous results. Other links were similarly tested, and comparisons with RIP from previous lab exercises were made.

C: The IP address range 24.24.24.0/21 obtained from APNIC was divided into subnets for different departments, each with the required number of hosts as given in the table. The network topology shown in Figure 3 was created, with each network using at least one PC connected to a router via a switch. Serial links were used for point-to-point connections between routers. Each router interface was configured with appropriate IP addresses and subnet masks, and the PCs were configured with appropriate IP addresses, subnet masks, and default gateways. The output of the show ip route command was observed in each router. OSPF was configured in all routers with respective networks and areas. Connectivity was tested between computers of different networks, and the results of traceroute were observed from a computer in network A to computers in other networks and IPs of routers. Default routes were configured in each router to forward internet traffic toward the ISP router, and a static route was configured in the ISP router. The routing tables and traceroute results were observed and compared before and after removing and reconnecting links between routers to understand the working of dynamic routing.

Observation:

Activity A

The given IP address range of 200.100.100.0/24 from the ISP was divided into the following networks: The unused IP addresses are as follows:

Departments	Net ID	Range	Broadcast	Subnet Mask
LAN1	200.100.100.0	1-62	200.100.100.63	255.255.255.192
LAN4	200.100.100.64	65-126	200.100.100.127	255.255.255.192
LAN2	200.100.100.128	129-158	200.100.100.159	255.255.255.224
LAN3	200.100.100.160	161-174	200.100.100.175	255.255.255.240
A	200.100.100.176	177-178	200.100.100.179	255.255.255.252
B	200.100.100.180	181-182	200.100.100.183	255.255.255.252
C	200.100.100.184	185-186	200.100.100.187	255.255.255.252

Table 1: Network Division

- Network LAN1: 64-2-55
- Network LAN4: 64-2-45
- Network LAN2: 32-2-25
- Network LAN3: 16-2-10
- Network A: 4-2-2
- Network B: 4-2-2
- Network C: 4-2-2

Answer for 1-2: The IP division and allocation among LAN1, LAN2, LAN3, and LAN4 were done as above, with their respective default gateway for every PC and server.

Answer for 3: Routing was configured using OSPF, considering all networks in area 0.

Answer for 4: The `ping` command was executed, and the reply was obtained.

Answer for 5: The result of the `tracert` command from PC0 to PC3 is shown in the figure below:

```
C:\>tracert 200.100.100.66

Tracing route to 200.100.100.66 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      200.100.100.1
  2   0 ms      0 ms      1 ms      200.100.100.178
  3   0 ms      0 ms      0 ms      200.100.100.186
  4   0 ms      0 ms      11 ms     200.100.100.181
  5   10 ms     11 ms     10 ms     200.100.100.66

Trace complete.
```

Figure 1: Tracert result from PC0 to PC3

Activity B

Answer for 1: Router 4 was configured and OSPF was enabled. Then, the `tracert` command from PC0 to PC3 was executed, and the output is shown in the figure below:

```
C:\>tracert 200.100.100.66

Tracing route to 200.100.100.66 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      200.100.100.1
  2   0 ms      0 ms      0 ms      200.100.100.4
  3   0 ms      0 ms      0 ms      200.100.100.66

Trace complete.
```

Figure 2: Tracert result from PC0 to PC3 after configuring Router 4

Answer for 3: The link was removed, simulating a cut wire. It took time for the network to reestablish the connection, and the initial path without Router 4 was observed during the `tracert` command.

Answer for 8: Compared to RIP, OSPF demonstrated faster convergence and more efficient handling of network topology changes, as evidenced by the dynamic update of routing tables and faster recovery from link failures.

Activity C

The given IP address range of 24.24.24.0/21 from the ISP was divided into the following networks: The

Departments	Net ID	Broadcast	Subnet Mask
B	24.24.24.0	24.24.25.255	255.255.254.0
A	24.24.26.0	24.24.27.255	255.255.254.0
F	24.24.28.0	24.24.28.255	255.255.255.0
J	24.24.29.0	24.24.29.127	255.255.255.128
I	24.24.29.128	24.24.29.255	255.255.255.128
D	24.24.30.0	24.24.30.127	255.255.255.128
C	24.24.30.128	24.24.30.255	255.255.255.128
E	24.24.31.0	24.24.31.127	255.255.255.128
G	24.24.31.128	24.24.31.191	255.255.255.192
H	24.24.31.192	24.24.31.223	255.255.255.224

Table 2: Network Division

unused IP addresses are as follows:

- Network B: 512-2-500
- Network A: 512-2-400
- Network F: 256-2-200
- Network J: 128-2-120
- Network I: 128-2-110
- Network D: 128-2-100
- Network C: 128-2-90
- Network E: 128-2-80
- Network G: 64-2-40
- Network H: 32-2-20

Answer for 1-6: The network was created as shown in the figure. The IPs were assigned to different networks, and routing was configured using OSPF by setting areas 0, 1, and 2 as in the figure.

Answer for 7: The `ping` and `tracert` commands were successful for each PC and router in the designed network.

Answer for 8: When `tracert` was run to 1.1.1.1, the response was "Request timed out."

Answer for 11: After setting the default route, the `tracert` to 1.1.1.1 showed the route reaching up to the ISP server, followed by "Request timed out."
Answer for 12: By removing links between routers, the routing table updated dynamically. The packets traveled up to the last connected default router, followed by "Request timed out."

Conclusion:

In conclusion, the lab exercises demonstrated the effective configuration and operation of OSPF as a dynamic routing protocol in various network topologies. Through activities involving subnetting, IP addressing, and OSPF configuration across multiple routers and areas, the practical understanding of OSPF's advantages, such as quicker convergence and efficient network management, was reinforced. The exercises highlighted the importance of hierarchical network design in larger deployments and the dynamic adaptability of OSPF to changing network conditions. Comparisons with RIP underscored OSPF's superior performance. Overall, the hands-on experience provided a comprehensive insight into the complexities and benefits of implementing OSPF in real-world networking scenarios.

Exercises:

Question 1: What is OSPF? How does it differ from RIP? Explain OSPF configurations with examples.
Open Shortest Path First (OSPF) is an Interior Gateway Protocol (IGP) used for routing within an Autonomous System (AS). It uses a link-state routing algorithm to determine the shortest path to all known destinations. Unlike the Routing Information Protocol (RIP), which uses a distance-vector algorithm and updates routing tables by exchanging the entire table, OSPF propagates only link-state advertisements (LSAs), which contain information about directly connected links. This leads to faster convergence and more efficient use of network resources. **Differences between OSPF and RIP:**

- **Algorithm:** OSPF uses a link-state algorithm, while RIP uses a distance-vector algorithm.
- **Convergence:** OSPF converges more quickly than RIP because it exchanges only LSAs.
- **Scalability:** OSPF can support larger and more complex networks due to its hierarchical design and efficient routing updates, whereas RIP is limited to smaller networks.
- **Metric:** OSPF uses cost (usually based on bandwidth), while RIP uses hop count as the metric.

- **Updates:** RIP sends periodic updates every 30 seconds, while OSPF sends updates only when there is a change in the topology.

Example of OSPF Configuration: To enable OSPF on a router, the following commands can be used:

```
R1> enable
R1# configure terminal
R1(config)# router ospf 1
R1(config-router)# network 192.168.1.0 0.0.0.255 area 0
R1(config-router)# end
```

In this example:

- `router ospf 1` starts the OSPF process with process ID 1.
- `network 192.168.1.0 0.0.0.255 area 0` specifies the network to be advertised and the area ID.

Question 2: What is multi-area OSPF? Why is it used? How can multi-area OSPF be configured? Explain with examples.

Multi-area OSPF is an extension of OSPF that divides an OSPF domain into multiple areas to optimize the processing and memory overhead for routing. It is useful for larger network deployments, as it helps in minimizing the size of the routing tables and limits the frequency of SPF calculations. In multi-area OSPF, there is a backbone area (Area 0) to which all other areas must connect. An Area Border Router (ABR) connects the backbone area to non-backbone areas, and an Autonomous System Boundary Router (ASBR) connects an OSPF area to other autonomous systems. **Example of Multi-Area OSPF Configuration:**

```
R3(config)# router ospf 1
R3(config-router)# network 192.168.1.0 0.0.0.255 area 0
R3(config-router)# network 192.168.2.0 0.0.0.255 area 1
R3(config-router)# network 192.168.3.0 0.0.0.255 area 2
```

In this example:

- `network 192.168.1.0 0.0.0.255 area 0` defines a network in the backbone area.
- `network 192.168.2.0 0.0.0.255 area 1` defines a network in Area 1.

- `network 192.168.3.0 0.0.0.255 area 2` defines a network in Area 2.

Question 3: How can dynamic routing address the changing topology of the network? Explain with reference to the observation of your lab exercise.

Dynamic routing protocols like OSPF adapt to changes in network topology by automatically recalculating the best paths and updating routing tables across the network. In our lab exercises, we observed this dynamic adaptability by introducing and removing links between routers and noting how OSPF recalculated routes to maintain connectivity. For example, when a link between Router4 and Switch0 was removed, the OSPF protocol quickly identified the change, updated the routing tables, and found alternative paths for data transmission. The `show ip route` command allowed us to observe the updated routes, and the `tracert` command verified that data packets were still able to reach their destinations through new paths. This real-time adaptation ensures minimal disruption in network services, highlighting the robustness of dynamic routing in managing network changes efficiently.