Department of Computer Science and Engineering

Islamic University of Technology (IUT)

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Laboratory Report

CSE 4412: Data Communication and Networking Lab

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Section	**: 1**
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Academic Year	**: 2021-2022**
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Title: Configuration of OSPF in a network topology.

Objective:

1. Understand Link State Routing Protocol
2. Understand OSPF
3. Understand the difference between DV and LS routing

Devices/ Software Used: 4 Routers, 4 Switches, 1 PC, 1 Server

Theory:

Link State (LS) Routing

Link State (LS) Routing is a type of routing protocol used in computer networks to determine the best path for data to take from one device to another. In this protocol, each router in the network keeps a detailed map of the network topology, which includes information about the routers, links between them, and the status of those links. Whenever a network change occurs, such as a link failure or the addition of a new router, each router updates its network map and shares this information with its neighboring routers. Based on the current state of the network, this allows each router to calculate the shortest path to all other routers in the network. While Link State Routing protocols are faster and more reliable than other types of routing protocols, they are also more difficult to configure and manage.

Link-State Database (LSDB)

The LSDB (Link State Database) is a memory component of a router used by Link State Routing protocols in a computer network. It keeps an up-to-date and detailed map of the entire network topology, including information on all routers and links and their current status. To ensure consistency and accuracy, each router in the network maintains its own LSDB and exchanges information with neighboring routers. Routers can determine the best and most efficient path for data to travel through the network by analyzing the data in the LSDB. The LSDB is essential for Link State Routing because it enables routers to make informed routing decisions based on the most up-to-date information.

Link State Packet

A Link State Packet (LSP) is a type of data packet used in computer networks' Link State Routing protocols. LSPs contain information about the current state of a router as well as the status of its links to other routers. This data includes the router's identifier, the date and time the LSP was created, and a sequence number that is used to track changes over time.

Each router in the network creates and shares its own LSP on a regular basis or when the network topology changes significantly. When a router receives an LSP from a neighboring router, it updates its LSDB and shares the information in the LSP with other neighboring routers. This process is repeated until the LSP has been received and processed by every router in the network.

LSPs are critical for maintaining an accurate and up-to-date network topology map, which is required for making informed routing decisions. Link State Routing protocols use mechanisms such as checksums and sequence numbers to ensure the reliability and consistency of LSPs. When an LSP is lost or corrupted, it can cause network inconsistencies and routing errors.

Open Shortest Path First (OSPF)

OSPF (Open Shortest Path First) is a Link State Routing protocol that determines the shortest path for data in a computer network. It is an open protocol that can be used with a variety of hardware and software implementations. OSPF operates by keeping a Link State Database (LSDB) on each router, which contains an up-to-date and detailed map of the network topology, including information on all routers and links. This data is exchanged with neighboring routers in order to determine the shortest path to all other routers in the network. OSPF can be configured with various metrics to prioritize traffic and supports a variety of network types. It also includes network security features such as route summarization and authentication.

Metric: The metric used in OSPF is called Cost, and it is based on the bandwidth of each network link. The lower the cost, the greater the bandwidth. The cost is calculated as Cost = Reference Bandwidth / Link Bandwidth, with 100Mbps as the default reference bandwidth. The cost of a path is the sum of the costs of all its links. For routing traffic, OSPF selects the path with the lowest cumulative cost, resulting in the shortest path and improved network performance. Other metrics supported by OSPF include delay, reliability, and load, but cost is the most commonly used.

Areas: An area in OSPF is a logical grouping of network devices with similar characteristics and routing policies. Each router in an area keeps a complete copy of the area's LSDB, reducing the amount of routing information that needs to be exchanged between routers in different areas. OSPF allows for a hierarchical network design, with areas organized in a tree-like structure and a backbone area (Area 0) connecting all other areas. Areas increase network scalability, lessen the impact of topology changes, and allow for finer control over routing policies. To optimize routing for different parts of the network, they can be assigned different metrics and routing policies.

Link State Advertisement (LSA): OSPF exchanges information between routers using Link State Advertisements (LSAs) to create a complete and accurate view of the network topology. There are various types of LSAs, each with its own set of information about routers, network links, and a summary of network topology. Routers keep their own Link State Database (LSDB) in which they store all LSAs received from neighboring routers. LSAs are strewn across the network, and routers use them to determine the shortest path to each network destination. When the network topology changes, routers generate new LSAs to reflect the change, which are then flooded to other routers to ensure that all routers have the most up-to-date view of the network topology.

OSPF Implementation:

Each router involved in the OSPF routing protocol must be configured using the following commands:
Router ospf <process id>
Network <network id> <wildcard> area <area id>

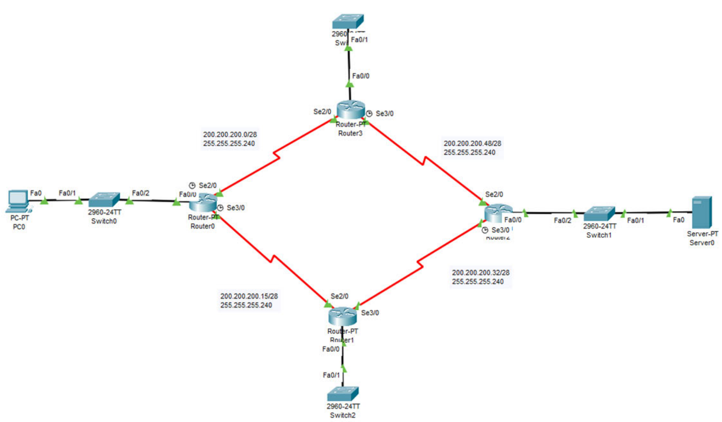
After each router in the system has been configured, they will exchange LSA with their neighboring routers and collect their states. In this manner, the Router will calculate the shortest path to send data/packets using the LSDB**.**

Performance:

Update Message: When there is a change in the network, routers immediately send updates to their neighbors, who then spread the updates throughout the network. When a router sends an update packet to the DR, the DR distributes it to all other routers on the network segment. The update will be accepted by the other routers only if it comes from the DR or BDR. If the update comes from a router that is not a DR/BDR, it will be ignored.

Convergence of Forwarding Tables: The use of LSDB and LSAs by OSPF enables fast and efficient convergence of forwarding tables when the network topology changes. Routers generate and distribute LSAs throughout the network, which each router uses to update its own LSDB and recalculate the shortest path to each destination network. Even if the topology changes, routers can quickly determine the best path for forwarding packets. By confining changes to a specific area or part of the network, OSPF's hierarchical network design and areas can further reduce the impact of topology changes. Overall, OSPF is a scalable and efficient protocol for achieving fast-forwarding table convergence.

Diagram of the experiment:



Configuration of Routers:

Commands for configuring OSPF
For Router 0
en
conf t
router ospf 10
network 200.200.200.15 0.0.0.15 area 1
network 200.200.200.0 0.0.0.15 area 1
network 192.168.10.0 0.0.0.255 area 1

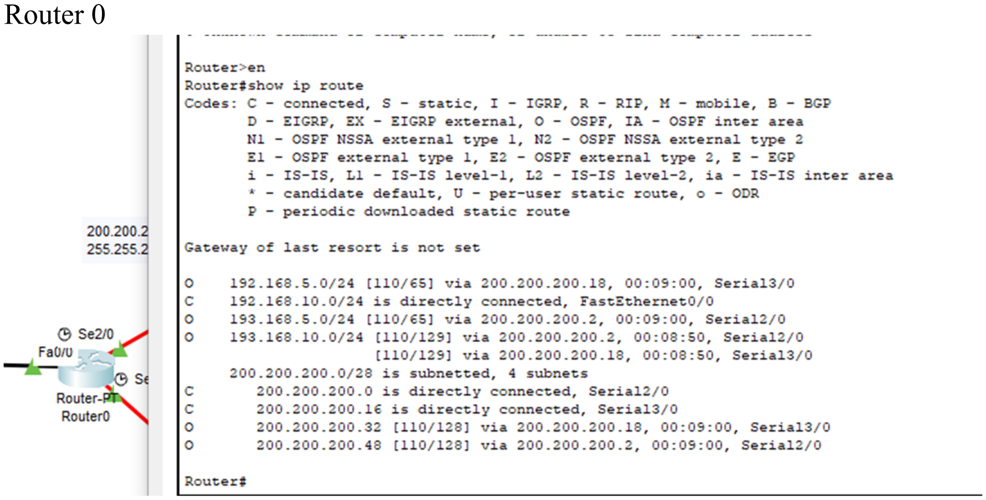
For Router 1
en
conf t
router ospf 10
network 200.200.200.15 0.0.0.15 area 1
network 200.200.200.32 0.0.0.15 area 1
network 192.168.5.0 0.0.0.255 area 1

For Router 2
en
conf t
router ospf 10
network 200.200.200.48 0.0.0.15 area 1
network 200.200.200.32 0.0.0.15 area 1
network 193.168.10.0 0.0.0.255 area 1

For Router 3
en
conf t
router ospf 10
network 200.200.200.0 0.0.0.15 area 1
network 200.200.200.48 0.0.0.15 area 1
network 193.168.5.0 0.0.0.255 area 1
.

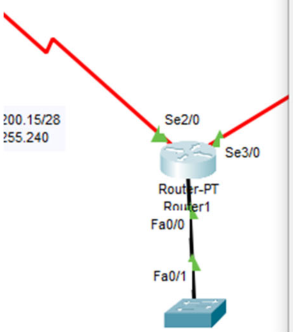
Observation:

The screenshots of routing table of each router is shown below:
Router 0



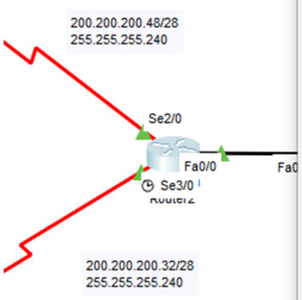
```
Router>en
Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

O    192.168.5.0/24 [110/65] via 200.200.200.18, 00:09:00, Serial3/0
C    192.168.10.0/24 is directly connected, FastEthernet0/0
O    193.168.5.0/24 [110/65] via 200.200.200.2, 00:09:00, Serial2/0
O    193.168.10.0/24 [110/129] via 200.200.200.2, 00:08:50, Serial2/0
                     [110/129] via 200.200.200.18, 00:08:50, Serial3/0
     200.200.200.0/28 is subnetted, 4 subnets
C       200.200.200.0 is directly connected, Serial2/0
C       200.200.200.16 is directly connected, Serial3/0
O       200.200.200.32 [110/128] via 200.200.200.18, 00:09:00, Serial3/0
O       200.200.200.48 [110/128] via 200.200.200.2, 00:09:00, Serial2/0

Router#
```

Router 1




```
Router>en
Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.5.0/24 is directly connected, FastEthernet0/0
O    192.168.10.0/24 [110/65] via 200.200.200.17, 00:11:25, Serial2/0
O    193.168.5.0/24 [110/129] via 200.200.200.34, 00:11:15, Serial3/0
                    [110/129] via 200.200.200.17, 00:11:15, Serial2/0
O    193.168.10.0/24 [110/65] via 200.200.200.34, 00:11:25, Serial3/0
     200.200.200.0/28 is subnetted, 4 subnets
O       200.200.200.0 [110/128] via 200.200.200.17, 00:11:25, Serial2/0
C       200.200.200.16 is directly connected, Serial2/0
C       200.200.200.32 is directly connected, Serial3/0
O       200.200.200.48 [110/128] via 200.200.200.34, 00:11:25, Serial3/0

Router#
```

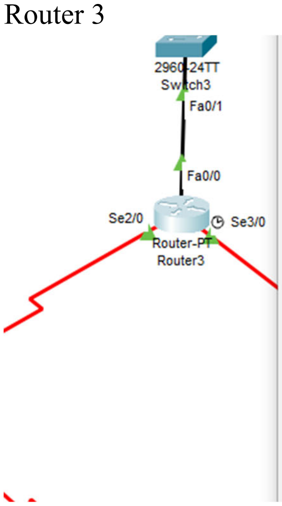
Router 2




```
Router>en
Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

O    192.168.5.0/24 [110/65] via 200.200.200.33, 00:10:09, Serial3/0
O    192.168.10.0/24 [110/129] via 200.200.200.33, 00:10:09, Serial3/0
                     [110/129] via 200.200.200.50, 00:10:09, Serial2/0
O    193.168.5.0/24 [110/65] via 200.200.200.50, 00:10:09, Serial2/0
C    193.168.10.0/24 is directly connected, FastEthernet0/0
     200.200.200.0/28 is subnetted, 4 subnets
O       200.200.200.0 [110/128] via 200.200.200.50, 00:10:09, Serial2/0
O       200.200.200.16 [110/128] via 200.200.200.33, 00:10:09, Serial3/0
C       200.200.200.32 is directly connected, Serial3/0
C       200.200.200.48 is directly connected, Serial2/0

Router#
```

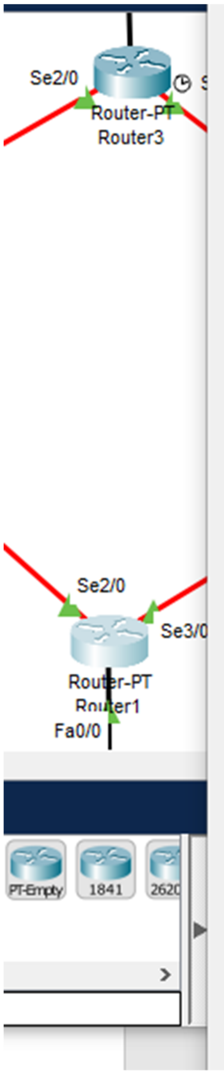
Copy Pas

Router 3




```
Router>en
Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

O    192.168.5.0/24 [110/129] via 200.200.200.49, 00:09:35, Serial3/0
                    [110/129] via 200.200.200.1, 00:09:35, Serial2/0
O    192.168.10.0/24 [110/65] via 200.200.200.1, 00:09:45, Serial2/0
C    193.168.5.0/24 is directly connected, FastEthernet0/0
O    193.168.10.0/24 [110/65] via 200.200.200.49, 00:09:45, Serial3/0
     200.200.200.0/28 is subnetted, 4 subnets
C       200.200.200.0 is directly connected, Serial2/0
O       200.200.200.16 [110/128] via 200.200.200.1, 00:09:45, Serial2/0
O       200.200.200.32 [110/128] via 200.200.200.49, 00:09:45, Serial3/0
C       200.200.200.48 is directly connected, Serial3/0

Router#
```

To check the convergence of the forwarding table property, we change the bandwidth of Se3/0 of Router 1 to 1. We can see the following changes in the ip route:




```
Gateway of last resort is not set

C    192.168.5.0/24 is directly connected, FastEthernet0/0
O    192.168.10.0/24 [110/65] via 200.200.200.17, 07:44:33, Serial2/0
O    193.168.5.0/24 [110/129] via 200.200.200.34, 07:44:23, Serial3/0
                    [110/129] via 200.200.200.17, 07:44:23, Serial2/0
O    193.168.10.0/24 [110/65] via 200.200.200.34, 07:44:33, Serial3/0
     200.200.200.0/28 is subnetted, 4 subnets
O       200.200.200.0 [110/128] via 200.200.200.17, 07:44:33, Serial2/0
C       200.200.200.16 is directly connected, Serial2/0
C       200.200.200.32 is directly connected, Serial3/0
O       200.200.200.48 [110/128] via 200.200.200.34, 07:44:33, Serial3/0

Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#int Se3/0
Router(config-if)#bandwidth 1
Router(config-if)#exit
Router(config)#exit
Router#
%SYS-5-CONFIG_I: Configured from console by console

Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.5.0/24 is directly connected, FastEthernet0/0
O    192.168.10.0/24 [110/65] via 200.200.200.17, 07:50:19, Serial2/0
O    193.168.5.0/24 [110/129] via 200.200.200.17, 00:04:55, Serial2/0
O    193.168.10.0/24 [110/193] via 200.200.200.17, 00:04:55, Serial2/0
     200.200.200.0/28 is subnetted, 4 subnets
O       200.200.200.0 [110/128] via 200.200.200.17, 07:50:19, Serial2/0
C       200.200.200.16 is directly connected, Serial2/0
C       200.200.200.32 is directly connected, Serial3/0
O       200.200.200.48 [110/192] via 200.200.200.17, 00:04:55, Serial2/0
```

193.168.10.0 was previously being routed through Se 3/0, but after increasing the cost significantly and fast forward a little bit, the routing table has been updated so that the packets are sent to 192.168.10.0 through Se2/0 in router 1.

Similar changes can be observed by shutting down a port completely. The routing table essentially adjusts itself for the changes made.

Challenges:

- Understanding the concepts of OSPF took a longer time than intended.
- Understanding all the different terms involved with OSPF
- Understanding how the LSDB at each router is updated and when.