Experiment 4

OSPF Routing

Basic Implementation

Introduction:

Open shortest path first (OSPF) is an Interior Gateway Protocol. Designed expressly for IP networks, OSPF supports variable length subnet masks (VLSM), making it a classless routing protocols. OSPF also allows packet authentication and uses IP multicast when sending/receiving packets.

OSPF routing protocol has two primary characteristics. The first is that the protocol is open. The second is that it is based on SPF algorithm (*Dijkstra* algorithm)

OSPF is the routing protocol of choice when:

1) There are routers from vendors other that Cisco in the network.
2) The network requires segmentation into areas or zones.

OSPF is a link-state routing protocol. That calls for sending of *link-state advertisements* (LSAs) to all other routers within the same area. As OSPF routers accumulate link-state information, they use the SPF algorithm to calculate the shortest path to each node.

As a link-state routing protocol, OSPF contrasts with RIP, which is distance-vector routing protocol. Routers running RIP send all of their routing tables in routing-update messages to their neighbors.

OSPF uses bandwidth as metric (cost). It uses a reference bandwidth of 100 Mbps for cost calculation. The formula to calculate the cost is reference bandwidth divided by interface bandwidth. Thus, a 100Mbps link has a metric of 1; a 10Mbps link has a metric of 10; a 1Gbps (or faster) link also has a cost of 1 because the cost cannot be lower than 1. **The cost for each link in the path is added together to form a metric for the route.**

Route Summarization:

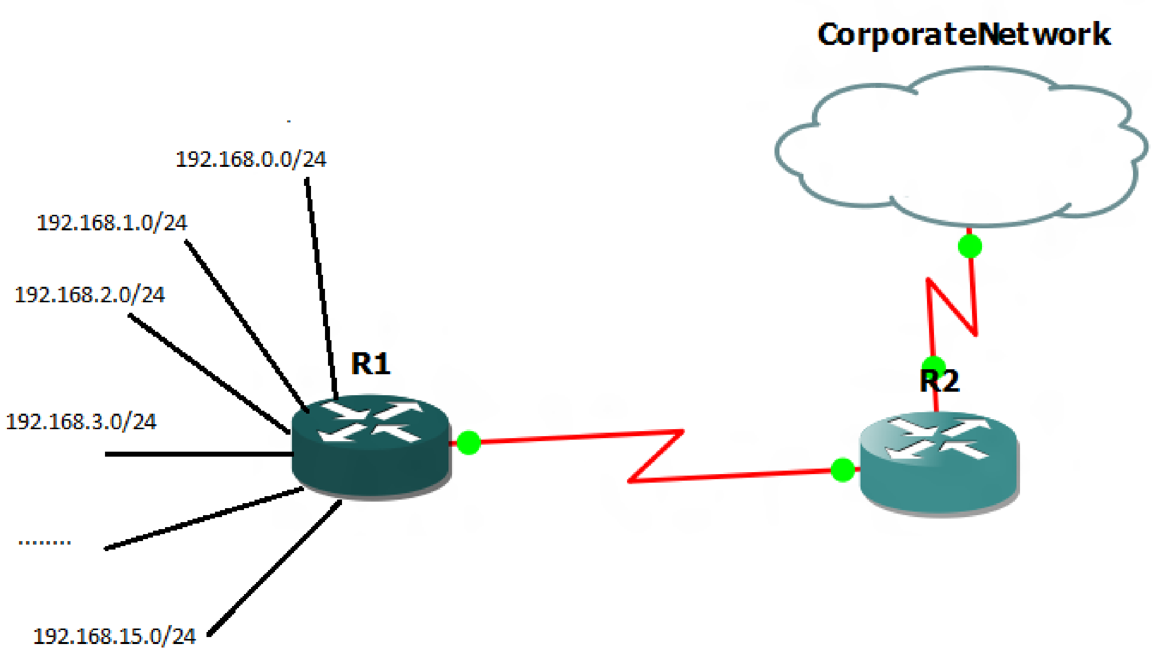


Figure 1: Route Summarization Example

Route summarization is the process of replacing a series of routes with a summary route and a mask. This lessens the size of routing update packet itself and also makes the routing table smaller, yet still allow for complete IP connectivity when done correctly. In Figure 1, the 16 more specific routes in R1 (i.e. 192.168.0.0/24, 192.168.1.0/24, 192.168.2.0 ….. and 192.168.15.0/24) can be replaced by a single summary route which is **192.168.0.0/20**

In OSPF, to summarize routes from one area to another, you can use this command in OSPF routing process mode:

```
Router(config-router)#area AREA-ID range SUMMARRY-ADDRESS SUBNET-MASK
```

Routing hierarchy:

Unlike RIP, OSPF can operate within a hierarchy. The largest entity within the hierarchy is the *autonomous system* (AS), which is a collection of networks under a common administration that share a common routing strategy. OSPF is an intra-AS (interior gateway) routing protocol, although it is capable of receiving routes from and sending routes to other ASs.

An AS can be divided into a number of areas, which are groups of contiguous networks and attached hosts. Routers with multiple interfaces can participate in multiple areas. These routers, which are called *Area Border Routers (ABRs)*, maintain separate topological databases for each area.

An area's topology is invisible to entities outside the area. By keeping area topologies separate, OSPF passes less routing traffic than it would if the AS were not partitioned. Area partitioning creates two different types of OSPF routing, depending on whether the source and destination are in the same or different areas. *Intra-area* routing occurs when the source and destination are in the same area; *inter-area* routing occurs when they are in different areas.

An OSPF backbone which is called area 0 is responsible for distributing routing information between areas. It consists of all area border routers, networks not wholly contained in any area, and their attached routers.

Figure 2 shows an area design diagram.

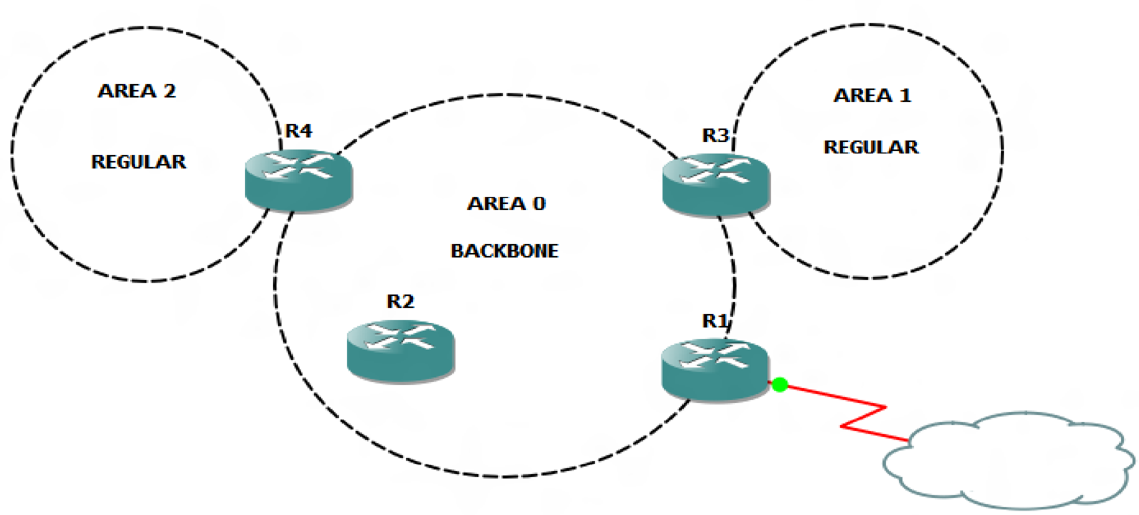


Figure 2: Area Design

You can notice that all areas connect to back to AREA 0. This implies that both R3 and R4 are Area Border Routers (ABRs). R1 is an Autonomous System Boundary Router (ASBR).

Understanding OSPF Neighbor Relationships:

Figure 3: OSPF Neighbor Relationship

Hello messages are sent on chosen interfaces once every 10 seconds on broadcast / point to point networks. These messages contain all sort of information:

* Router ID
* **Hello and dead timers**
* **Network mask**
* **Area id**
* Neighbors
* Router priority
* DR/BDR IP addresses
* **Authentication password**

The parameters in bold must match between the routers to form the OSPF neighbor relationship.

Enabling OSPF:

As with other routing protocols, enabling OSPF requires that you create an OSPF routing process, specify the range of IP addresses to be associated with the routing process, and assign area IDs to be associated with that range of IP addresses. Use the following commands, starting in global configuration mode:

<u>Step 1:</u>

```
Router(config)# router ospf  PROCESS-ID
```

This command starts the OSPF routing process with your process number. The process number is an arbitrary number. It is recommended that the number match on all routers but it is not required.

Step 2:

`Router(config-router)# network` *`ADDRESS WILDCARD-MASK`* `area` *`AREA-ID`*

This command defines an interface on which OSPF runs and defines the area ID for that interface.

Once OSPF is configured, you can check the status using the `show ip route`, `show ip ospf neighbor` and `show ip protocols` commands.

Understanding the Router ID

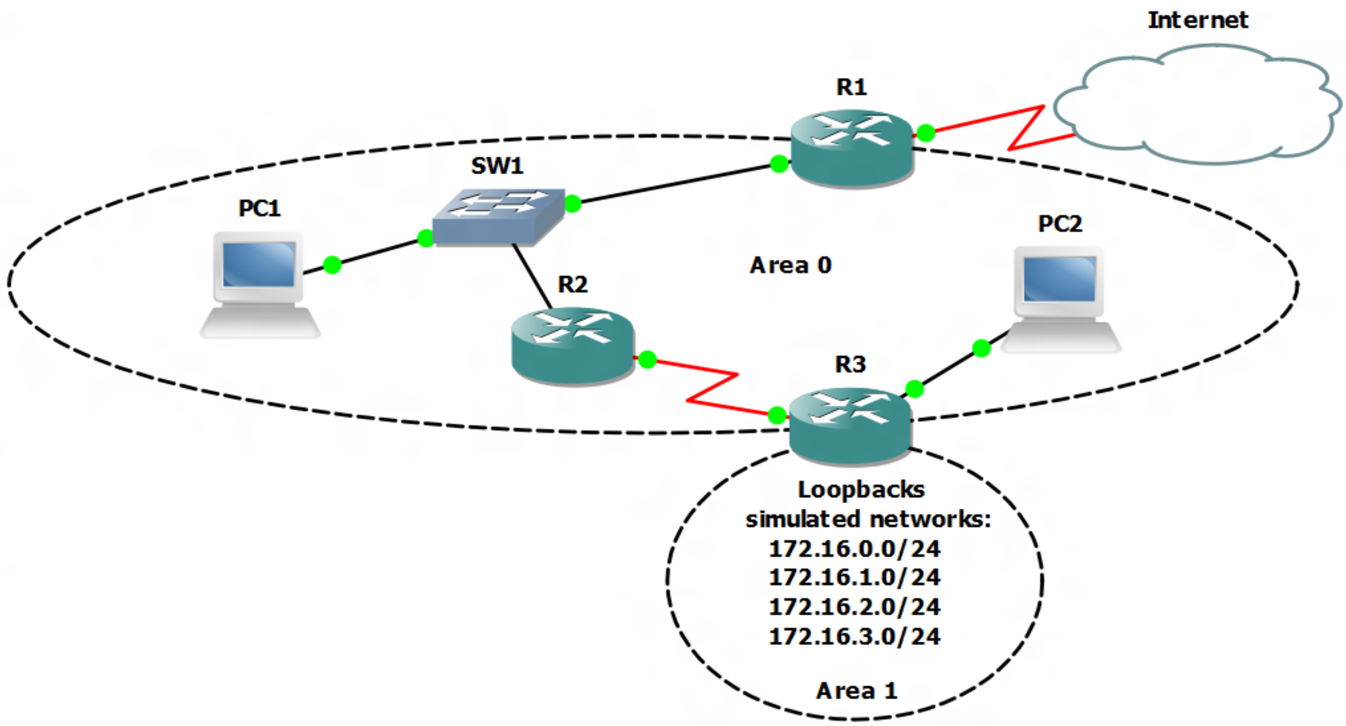
The OSPF router id identifies the router to OSPF neighbors. It's in IP format. The default value is highest physical interface at startup. However; loopback interfaces beat physical interfaces.

There is a command to hardcode the router id value which beats all:

`Router(config-router)#router-id` *`A.B.C.D`*

Procedure:

Scenario: Build and configure the following topology based on the following requirements.



Requirements:

To help guide this initial configuration, you've assembled a list of requirements.

- Configure Routers R1, R2, and R3 with the following configuration:

Interface	R1	R2	R3
Fast Ethernet IP/SM	192.168.1.1/24	192.168.1.2/24	192.168.3.1/24
Serial IP/SM	N/A	192.168.2.1/30	192.168.2.2/30

- Configure Router R3 with the following configuration:

Interface	IP/SM
Loopback 0	172.16.0.1/24
Loopback 1	172.16.1.1/24
Loopback 2	172.16.2.1/24
Loopback 3	172.16.3.1/24

- Configure PC1 and PC2 with the following configuration:

	PC1	PC2
Interface:	NIC	NIC
IP Address:	192.168.1.3/24	192.168.3.2/24
Gateway:	192.168.1.1	192.168.3.1

- Enable OSPF routing on R1 by running the following commands:

```
R1(config)#router ospf 1
R1(config-router)#network 192.168.1.0 0.0.0.255
area 0
```

Another way (specific interface):

```
R1(config-router)#network 192.168.1.1 0.0.0.0
area 0
```

- Enable OSPF routing on R2 and R3. Note that networks 172.16.0.0/24, 172.16.1.0/24, 172.16.2.0/24, and 172.16.3.0/24 are in area 1.

- Testing

1. R1 should be able to ping R3
2. PC1 should be able to ping PC2.
3. PC1 and PC2 should both be able to ping loopback interfaces 0 to 3
4. Run `show ip route` command on R1

```
R1#
R1#
R1#
R1#show ip route
Codes: C - connected, S - static, 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
       i - IS-IS, su - IS-IS summary, 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

     172.16.0.0/32 is subnetted, 4 subnets
O IA    172.16.1.1 [110/75] via 192.168.1.3, 00:01:34, FastEthernet0/0
O IA    172.16.0.1 [110/75] via 192.168.1.3, 00:01:34, FastEthernet0/0
O IA    172.16.3.1 [110/75] via 192.168.1.3, 00:01:34, FastEthernet0/0
O IA    172.16.2.1 [110/75] via 192.168.1.3, 00:01:34, FastEthernet0/0
C    192.168.1.0/24 is directly connected, FastEthernet0/0
     192.168.2.0/30 is subnetted, 1 subnets
O       192.168.2.0 [110/74] via 192.168.1.3, 00:01:34, FastEthernet0/0
O    192.168.3.0/24 [110/84] via 192.168.1.3, 00:01:36, FastEthernet0/0
R1#
```

Tasks:

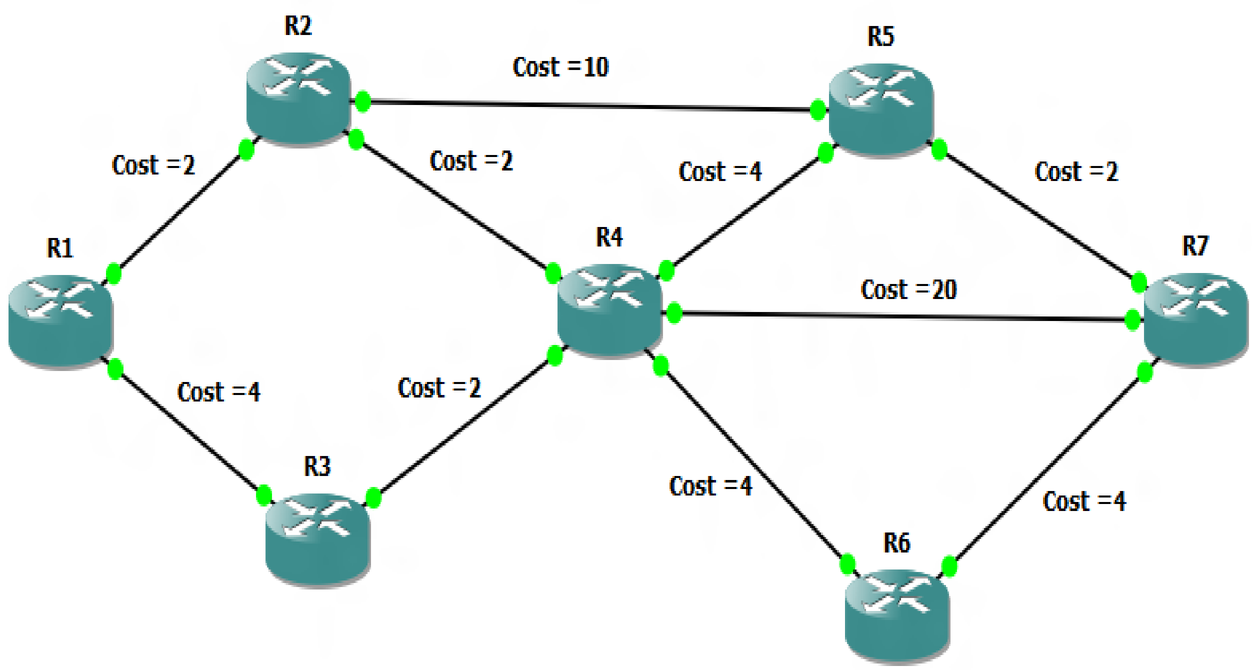
1) Implement route summarization at the ABR router (R3) to make the routing tables throughout the network as efficient as possible.

2) What is the router-id for R1, R2, and R3? Verify your answers by running the command `show ip protocols`.

3) Hardcore the router-id for R1, R2, and R3 as 1.1.1.1, 2.2.2.2, and 3.3.3.3 respectively. Verify that.

Problem

Given the following topology:



- Part One:
  1. Find the shortest path from R1 to R7 using Dijkstra's algorithm. Show your steps.
  2. What is the cost of the shortest path from R1 to R7?

- Part Two:

Build and configure the above topology using Packet Tracer software based on the following requirements.

<u>Requirements:</u>

To help guide this initial configuration, you've assembled a list of requirements.

1) For addressing the above network 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.**
   For example: if your university ID 1080579
   then A = 05 = 5 and B =79
2) Enable OSPF routing. Assume all routers are in area 0 (backbone)
3) Configure Router R7 with a loopback IP address 7.7.7.7/24. Advertise this network into OSPF process.
4) Don't forget to configure bandwidth values between links. These values should reflect the costs that are shown in the network diagram.
5) If a packet is sent from R1 to R7 (i.e. loopback 7.7.7.7). What routers it passes through until it reaches its destination? Use the `traceroute` command to test that.
6) Run the `show ip route` command on R1. From the output result. What is the cost (metric) to get from R1 to R7? Explain that.
7) What is the router-id for R1, and R7? Verify your answers