

BIRZEIT UNIVERSITY

Faculty of Engineering & Technology  
Department of Electrical & Computer Engineering  
ENCS4130-Computer network laboratory

Report #1

**Experiment 4 : Dynamic Routing 2 (Link State Routing Protocols)**  
**Open Shortest Path First (OSPF)**

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## **Abstract:**

This experiment aimed at learning and applying IP routing configurations on Cisco routers, with a specific focus on dynamic routing using the Open Shortest Path First protocol which is an example of the internal dynamic routing protocol that belongs to the link state protocol. The experiment's objectives include configuring IP routing, verifying routing tables, and examining the behavior of Open Shortest Path First as a dynamic routing protocol in a network environment using Cisco Packet Tracer. Key steps involved setting up routers, establishing Open Shortest Path First areas, and ensuring proper communication between network devices. The experiment also evaluates the efficiency of Open Shortest Path First in dynamically adapting to changes within the network topology, ensuring optimal and shortest routing paths. The results provide valuable insights into the practical application of Open Shortest Path First, demonstrating how to configure, implement, and verify dynamic routing protocols on Cisco devices.

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**Acronyms and Abbreviations:**

- OSPF : Open Shortest Path First
- IGP : Interior Gateway Protocol
- RIP: Routing Information Protocol
- CLI : Command line interface

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## 1. Theory

Interior Gateway Protocol (IGP) is a dynamic routing protocol used by routers in a single autonomous system to convey information about IP routes. This flexibility in the case of routing data dissemination is provided by interior gateway protocol, a road which is connected by different routers in a TCP/IP network. Routing Information Protocol (RIP), Open Shortest Path First (OSPF), Intermediate System to Intermediate System (IS-IS), and Enhanced Interior Gateway Routing Protocol (EIGRP) are some of the common examples of IGPs [\[1\]](#).

### 1.1 Open Shortest Path First (OSPF)

Open Shortest Path First (OSPF) is a link-state routing protocol meant for the routing of Internet Protocol (IP) networks using the Shortest Path First (SPF) algorithm. It is an IGP, allowing multiple routers within one area to work off of the same link-state database, essentially a description of the network topology within that area. This database is built from link-state advertisements (LSAs) sent and received by routers, containing information with relation to neighboring routers and their associated path costs. Once received, each router computes its own shortest-path spanning tree via an SPF algorithm, with itself the root of that tree.

OSPF has its great assets. Unlike distance-vector protocols such as RIP, OSPF suits itself to large, heterogeneous topologies with considerable scalability and can respond fast if it has had to re-provision any routes on failure. Moreover, OSPF provides partitioning of the Autonomous System (AS) into several areas-a feature that lowers the amount of routing update traffic and thus reduces the size of the link-state database. Another virtue is that OSPF permits implementation of equal-cost multipath routing; one or more paths exhibiting equal cost can, thus, be used simultaneously with different next-hop routers by forwarding traffic along that multilink path [\[2\]](#).

#### 1.1.1. OSPF Configuration

To configure OSPF on a Cisco router, its need to start by entering the router's global configuration mode and enabling OSPF using the `router ospf` command, followed by a process ID (a locally significant number). After that, define the network areas by specifying which networks should participate in OSPF and associate them with an area using the `network` command. This requires identifying the network address, wildcard mask, and OSPF area ID [\[6\]](#).

Once OSPF is configured, you can check the status using these commands :

```
show ip route,  
show ip ospf neighbor  
show ip protocols
```

## **1.2 Route Summarization**

Route summarization is also known as route aggregation or supernetting and it summarize several networks or subnets into a single summary route. Advantages include fewer entries in the routing table, thus lowering the memory usage ,reduced usage of bandwidth because fewer routes have to be advertised and optimization of the CPU, given that fewer packets are processed and the sizes of routing tables are made smaller. Furthermore, it enhances the performance of the network by stabilizing the routing table and avoiding flapping due to a newly adopted route. Certain disadvantages should also be noted, one such disadvantage is the router forwarding packets meant for a subnet that is inactive, resulting in, at times, unnecessary traffic being sent to routers advertising the summary route, continuing until an entry point to the given summary route is closed. Besides, the choice of a route when there is a summary route may not always be an optimal one for some routers, as a router will by preference always match the longest prefix; such selection may lead to a lesser efficient one. Denoting all covered networks with the same metric might also not reflect the actual optimal path of each one of the individual networks [\[3\]](#).

## **1.3 Routing Hierarchy**

Hierarchical routing involves organizing routers in a layered structure, which can be exemplified by a corporate intranet. Typically, corporate intranets have a high-speed backbone network, with routers connected to this backbone, each serving a specific workgroup. Each workgroup operates within a unique local area network (LAN). This setup is efficient because, despite having numerous workgroups, the maximum hop count between any two hosts in the network remains low, typically 2. Even if the LANs are further subdivided, the hop count might only increase to 4 in such cases

When compared to other configurations, such as connecting every router directly to each other or having each router connect to just two others, hierarchical routing proves to be more advantageous. It simplifies the network topology, enhances routing efficiency, and reduces network congestion by limiting the number of routing advertisements. In a hierarchical system, only the core routers connected to the backbone are aware of all the network routes, while routers within a LAN only manage local routes. For any unknown destinations, traffic is forwarded to the default route [\[4\]](#).

## **1.4 OSPF Neighbor Relationships**

The OSPF neighbor relationship involves two routers forming a connection by exchanging Hello packets to verify network parameters. Once compatibility is confirmed, the routers transition through various states such as "Init" and "2-Way" before establishing full adjacency. In full adjacency, routers share complete routing information. Not all neighbors become fully adjacent; some remain in the 2-Way state. Core routers in designated roles, like Designated Routers (DR) and Backup Designated Routers (BDR), typically form full adjacencies to optimize network efficiency. This hierarchical structure helps reduce network congestion and complexity [\[5\]](#).

## **1.5 Router ID**

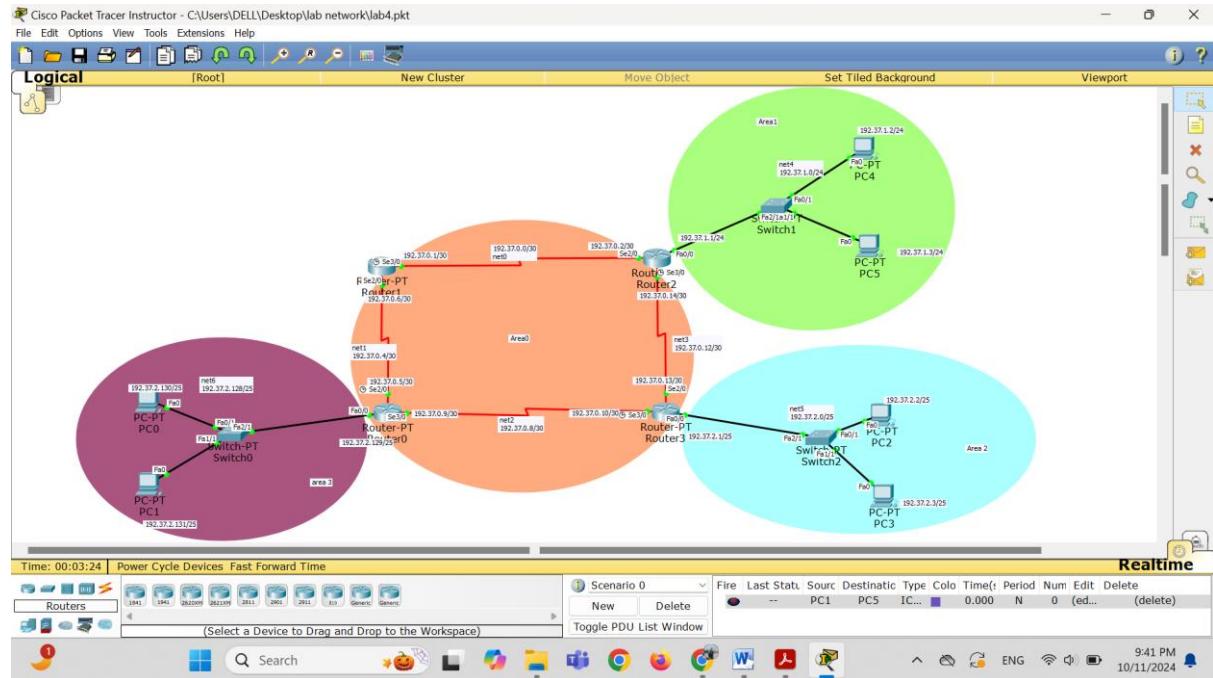
In OSPF, each router is assigned a unique Router ID (RID) to distinguish itself within the network. This RID must be unique across the OSPF domain, as duplicate RIDs can lead to network reachability issues. If two routers share the same RID, they will not establish a neighbor relationship. However, duplicated RIDs may still exist between routers that are not directly connected. OSPF selects the RID using a specific order of criteria: first, a manually configured RID is used if set. If not, the highest IP address on any loopback interface is chosen. In the absence of a loopback interface, OSPF uses the highest IP address from a non-loopback interface [\[7\]](#).

## **1.6 loopback interface**

A loopback interface is a virtual interface on a switch that remains up and reachable as long as at least one physical IP interface on the device is operational. This makes it highly reliable for tasks like debugging, as its IP address can always be pinged when other interfaces are up. The loopback interface can also be used to establish Telnet, SNMP, SSH, and HTTP (WebAgent) sessions. It has further relevance in routing protocols where the loopback IP can be configured as the router ID, especially in OSPF, and guaranteeing that the router ID is stable and not impacted by physical interface failures [\[8\]](#).

## 2. Procedure And Data Analysis

### 2.1 Building the Topology



**Figure 2- 1:Topology**

For the topology in figure 2-1 , I used four routers from type Router-Pt , 3 switches from type Switch-Pt , 6 Pc from type PC-Pt and For the connections between the PCs, switches and routers use Automatically use connection type.

This is the IP address for the topology requirements:

**Table 2-1:IP address in the topology**

Area /Summarization	Network	Devices	Interface	IP	Subnet mask	Wildcard mask
Area 0	Network 0 192.37.0.0/30	Router1	Se 3/0	192.37.0.1/30	255.255.255.252	0.0.0.3
		Router2	Se 2/0	192.37.0.2/30	255.255.255.252	0.0.0.3
	Network 1 192.37.0.4/30	Router0	Se 2/0	192.37.0.5/30	255.255.255.252	0.0.0.3
		Router1	Se 2/0	192.37.0.6/30	255.255.255.252	0.0.0.3
	Network 2 192.37.0.8/30	Router0	Se 3/0	192.37.0.9/30	255.255.255.252	0.0.0.3
		Router3	Se 3/0	192.37.0.10/30	255.255.255.252	0.0.0.3
	Network 3 192.37.0.12/30	Router3	Se 2/0	192.37.0.13/30	255.255.255.252	0.0.0.3
		Router0	Se 2/0	192.37.0.14/30	255.255.255.252	0.0.0.3

					2	
<b>Area 1</b>	Network 4 192.37.1.0/24	Router0	Fa 0/0	192.37.1.1/24	255.255.255.0	0.0.0.2 55
		PC4	Fa 0	192.37.1.2/24	255.255.255.0	0.0.0.2 55
		PC5	Fa 0	192.37.1.3/24	255.255.255.0	0.0.0.2 55
<b>Area 2</b>	Network 5 192.37.2.0/25	Router2	Fa 0/0	192.37.2.1/25	255.255.255.12 8	0.0.0.1 27
		PC2	Fa 0	192.37.2.2/25	255.255.255.12 8	0.0.0.1 27
		PC3	Fa 0	192.37.2.3/25	255.255.255.12 8	0.0.0.1 27
<b>Area 3</b>	Network 6 192.37.2.128/2 5	Router0	Fa 0/0	192.37.2.129/2 5	255.255.255.12 8	0.0.0.1 27
		PC0	Fa 0	192.37.2.130/2 5	255.255.255.12 8	0.0.0.1 27
		PC1	Fa 0	192.37.2.131/2 5	255.255.255.12 8	0.0.0.1 27
<b>Summarization 172.16.0.0/22</b>	172.16.0.0/24	Router2	Loopback0	172.16.0.1/24	255.255.255.0	0.0.0.2 55
	172.16.1.0/24	Router2	Loopback1	172.16.1.1/24	255.255.255.0	0.0.0.2 55
	172.16.2.0/24	Router2	Loopback2	172.16.2.1/24	255.255.255.0	0.0.0.2 55
	172.16.3.0/24	Router2	Loopback3	172.16.3.1/24	255.255.255.0	0.0.0.2 55
<b>Summarization 172.16.4.0/23</b>	172.16.4.0/24	Router2	Loopback4	172.16.4.1/24	255.255.255.0	0.0.0.2 55
	172.16.5.0/24	Router2	Loopback5	172.16.5.1/24	255.255.255.0	0.0.0.2 55

Adding the serial numbers and the FastEthernet numbers done by open the CLI for each router then enter each interface, add the IP address, and activate the interface. As such (this step I made it in lab so this how I did it ):

```
Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int fa 0/0
Router(config-if)#no shut
Router(config-if)#ip address 192.37.2.129 255.255.255.128
Router(config-if)#exit
Router(config)#int se 2/0
Router(config-if)#no shut
Router(config-if)#ip address 192.37.0.5 255.255.255.252
Router(config-if)#exit
Router(config)#int se 3/0
Router(config-if)#no shut
Router(config-if)#ip address 192.37.0.9 255.255.255.252
Router(config-if)#exit
Router(config)#

```



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Figure 2- 2:Adding serial numbers and FastEthernet for router0

And this step done for each router with their correct IPs and subnetmasks

Then using command **show running-config** in privilege mode to show the interfaces connection for each router :

```
!
interface FastEthernet0/0
ip address 192.37.2.129 255.255.255.128
duplex auto
speed auto
!
interface FastEthernet1/0
no ip address
duplex auto
speed auto
shutdown
!
interface Serial2/0
bandwidth 20000
ip address 192.37.0.5 255.255.255.252
clock rate 200000
!
interface Serial3/0
ip address 192.37.0.9 255.255.255.252
!
interface FastEthernet4/0
no ip address
shutdown
!
interface FastEthernet5/0
no ip address
shutdown
!
```



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Figure 2- 3:Running configuration for router0

```
!
interface FastEthernet0/0
no ip address
duplex auto
speed auto
shutdown
!
interface FastEthernet1/0
no ip address
duplex auto
speed auto
shutdown
!
interface Serial2/0
ip address 192.37.0.6 255.255.255.252
!
interface Serial3/0
ip address 192.37.0.1 255.255.255.252
clock rate 200000
!
interface FastEthernet4/0
no ip address
shutdown
!
interface FastEthernet5/0
no ip address
shutdown
!
router ospf 1

```



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Figure 2- 4:Running configuration for router1

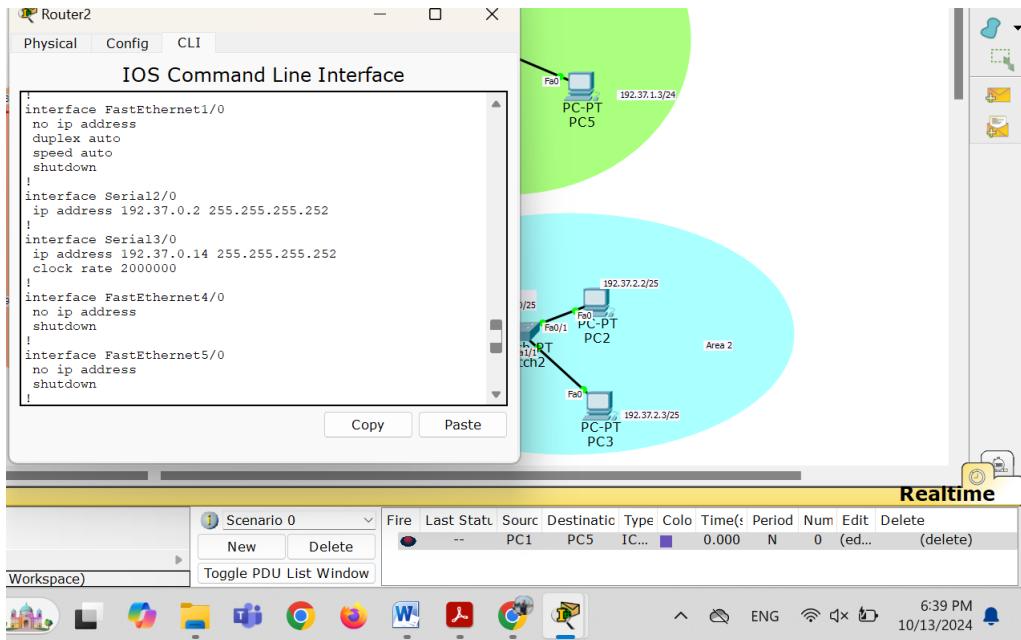


Figure 2- 5:Running configuration for router2

```

!interface FastEthernet0/0
ip address 192.37.2.1 255.255.255.128
duplex auto
speed auto
!
!interface FastEthernet1/0
no ip address
duplex auto
speed auto
shutdown
!
!interface Serial2/0
ip address 192.37.0.13 255.255.255.252
!
!interface Serial3/0
ip address 192.37.0.10 255.255.255.252
clock rate 2000000
!
!interface FastEthernet4/0
no ip address
shutdown
!
!interface FastEthernet5/0
no ip address
shutdown
!
```

Figure 2- 6:Running configruion for router3

Then for PCs, the FastEathernet is done by the ip configuration from the desktop in the PC

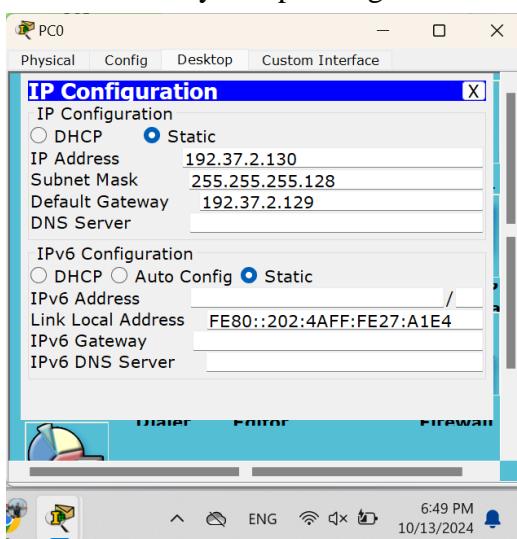


Figure 2- 7:IP Configruition for PC0

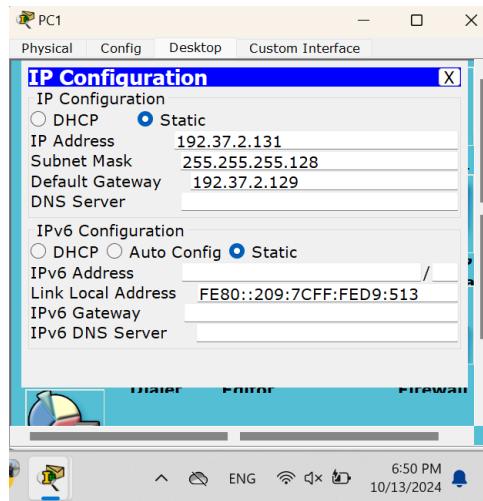


Figure 2- 8:IP Configuration for PC1

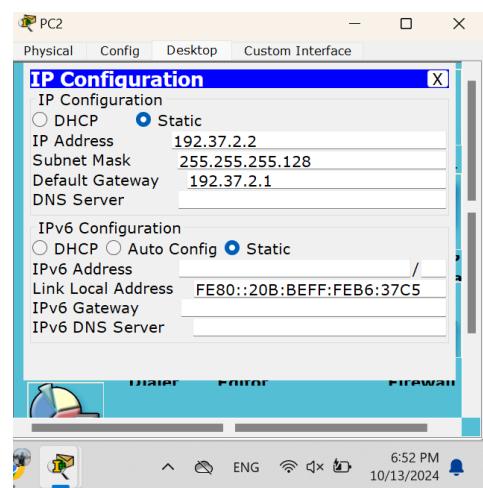


Figure 2- 9:IP Configuration for PC2

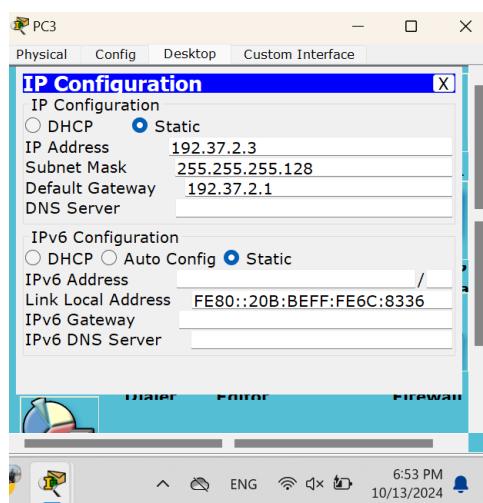
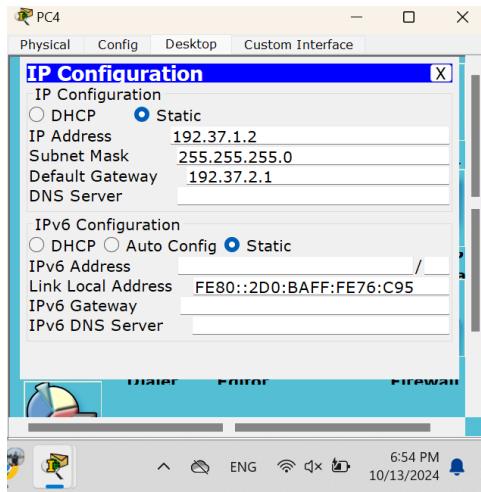
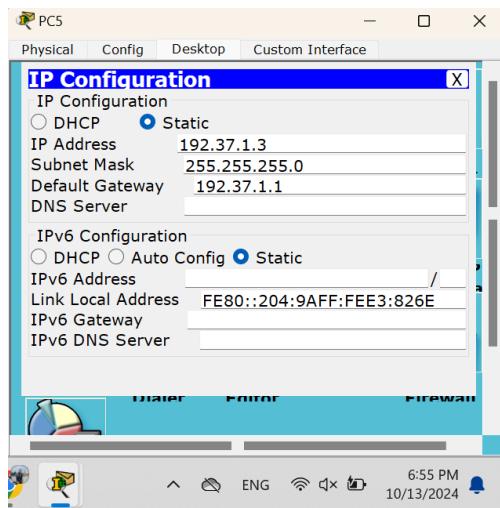


Figure 2- 10:IP Configuration for PC3



**Figure 2- 11:IP Configuration for PC4**



**Figure 2- 12:IP Configuration for PC5**

Then I configure the loopback IPs, but first need to create a loopback interface and then add the IP address to the loopback

```

Router#config t
Enter configuration commands, one per line. End with
CTRL/Z.
Router(config)#int loopback 0
Router(config-if)#ip address 172.16.0.1 255.255.255.0
Router(config-if)#ex
Router(config)#int loopback 1
Router(config-if)#ip address 172.16.1.1 255.255.255.0
Router(config-if)#ex
Router(config)#int loopback 2
Router(config-if)#ip address 172.16.2.1 255.255.255.0
Router(config-if)#ex
Router(config)#int loopback 3
Router(config-if)#ip address 172.16.3.1 255.255.255.0
Router(config-if)#ex
Router(config)#int loopback 4
Router(config-if)#ip address 172.16.4.1 255.255.255.0
Router(config-if)#ex
Router(config)#int loopback 5
Router(config-if)#ip address 172.16.5.1 255.255.255.0
Router(config-if)#ex
Router(config)#

```

**Figure 2- 13:configuration the loopback in router2**

## 2.2 Configuring OSPF Routing

Once the topology is built, the network is ready for the implementation of any routing protocol. In this experiment, OSPF is the chosen routing protocol. It is applied by configuring the network IDs along with their wildcard masks.

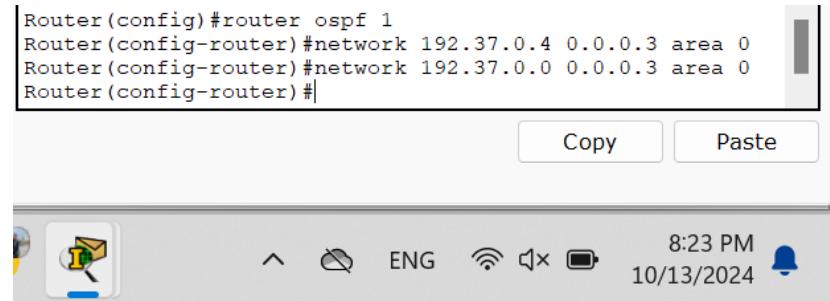


Figure 2- 14:OSPF configurating for router1

Figure 2-14 show the OSPF configuration for router1 , and I did that for all routers

Then use command **show ip route** in privilege mode to see the configuration of OSPF in each router.

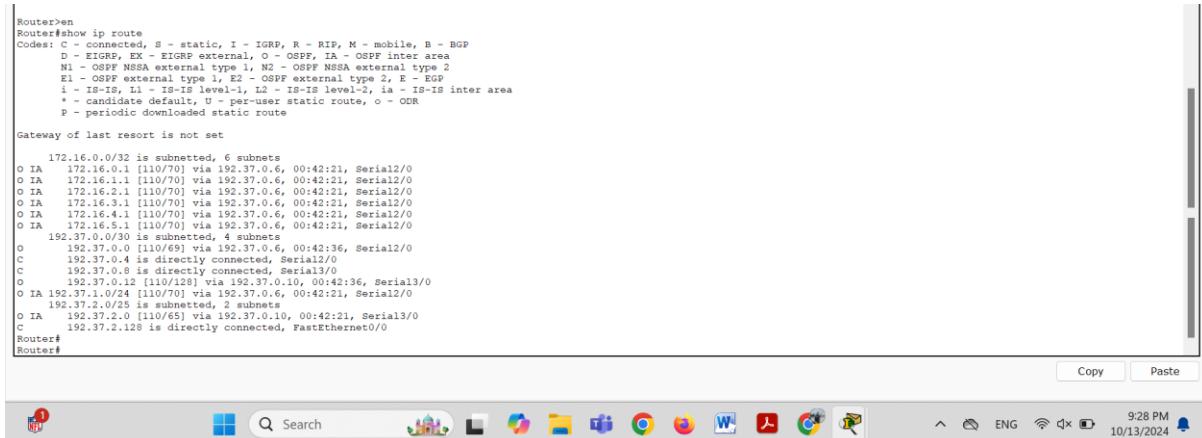


Figure 2- 15:Routing table for router0

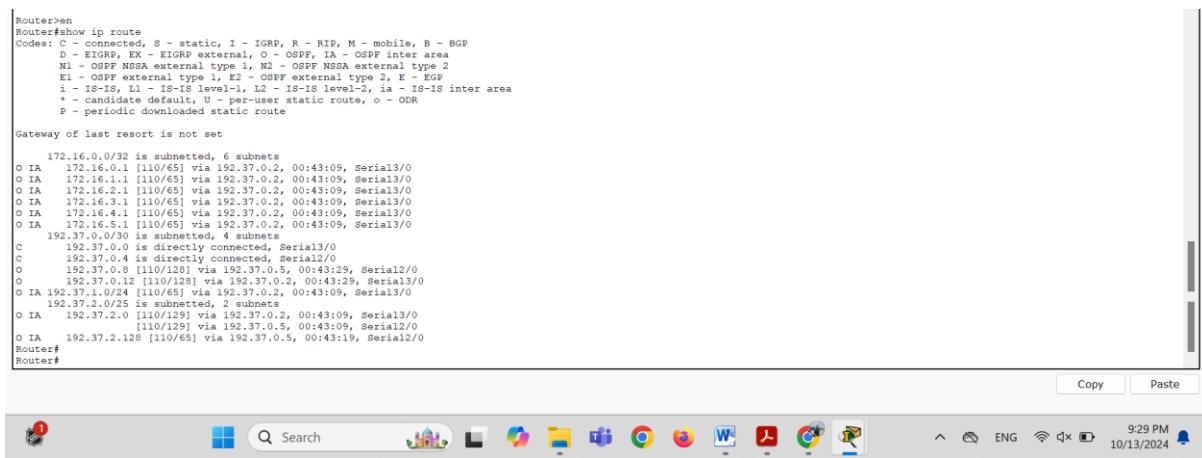


Figure 2- 16:Routing table for router1

```

Router>
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

172.16.0.0/24 is subnetted, 6 subnets
c 172.16.0.0 is directly connected, Loopback0
c 172.16.1.0 is directly connected, Loopback1
c 172.16.2.0 is directly connected, Loopback2
c 172.16.3.0 is directly connected, Loopback3
c 172.16.4.0 is directly connected, Loopback4
c 172.16.5.0 is directly connected, Loopback5
192.37.0.0/24 is subnetted, 4 subnets
c 192.37.0.0 is directly connected, Serial2/0
o 192.37.0.1 [110/128] via 192.37.0.13, 00:43:59, serial2/0
o 192.37.0.8 [110/128] via 192.37.0.13, 00:43:59, serial3/0
c 192.37.0.12 is directly connected, Serial1/0
c 192.37.1.0/24 is directly connected, FastEthernet0/0
o 192.37.2.0 [110/65] via 192.37.0.13, 00:43:49, serial3/0
o 192.37.2.128 [110/129] via 192.37.0.13, 00:43:59, serial2/0
          [110/129] via 192.37.0.1, 00:43:59, Serial3/0
Router#
Router#

```

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**Figure 2- 17:Routing table for router2**

```

Router>
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

172.16.0.0/32 is subnetted, 6 subnets
o IA 172.16.0.1 [110/65] via 192.37.0.14, 00:44:47, Serial2/0
o IA 172.16.1.1 [110/65] via 192.37.0.14, 00:44:47, Serial3/0
o IA 172.16.2.1 [110/65] via 192.37.0.14, 00:44:47, Serial2/0
o IA 172.16.3.1 [110/65] via 192.37.0.14, 00:44:47, Serial2/0
o IA 172.16.4.1 [110/65] via 192.37.0.14, 00:44:47, Serial2/0
o IA 172.16.5.1 [110/65] via 192.37.0.14, 00:44:47, Serial2/0
192.37.0.0/30 is subnetted, 6 subnets
o 192.37.0.0 [110/128] via 192.37.0.14, 00:44:47, Serial2/0
o 192.37.0.8 [110/65] via 192.37.0.9, 00:44:47, Serial3/0
c 192.37.0.8 is directly connected, Serial3/0
c 192.37.0.12 is directly connected, Serial2/0
o IA 192.37.0.12 [110/65] via 192.37.0.14, 00:44:47, Serial2/0
192.37.2.0/25 is subnetted, 2 subnets
c 192.37.2.0 is directly connected, FastEthernet0/0
o 192.37.2.128 [110/65] via 192.37.0.9, 00:44:47, Serial3/0
Router#
Router#

```

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**Figure 2- 18:Routing table for router3**

### 2.3 Changing the Cost

This section requires modifying the cost between two routers by adjusting the bandwidth on the serial interface. To change the cost between Router 1 and Router 2:

$$\text{Cost} = \frac{\text{reference bandwidth}}{\text{interface bandwidth}}$$

$$5 = \frac{100\text{Mbps}}{\text{interface bandwidth}} \rightarrow \text{interface bandwidth} = 20\text{Mbps}$$

If we make this its reduce the cost for going from PC0 to PC4 through Routers R0 → R1 → R2.

```

Router#
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int se 2/0
Router(config-if)#bandwidth 20000
Router(config-if)#exit
Router(config)#

```

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**Figure 2- 19:Changing the cost**

Router0

Physical Config CLI

## IOS Command Line Interface

```
shutdown
!
interface Serial2/0
bandwidth 20000
ip address 192.37.0.5 255.255.255.252
clock rate 2000000
!
interface Serial3/0
ip address 192.37.0.9 255.255.255.252
!
interface FastEthernet4/0
no ip address
shutdown
!
interface FastEthernet5/0
no ip address
shutdown
!
router ospf 1
log-adjacency-changes
network 192.37.0.8 0.0.0.3 area 0
```

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**Figure 2- 20:show the change of bandwidth in se 2/0 router0**

Figure 2-20 is done by command `show running-config` in privilege mode.

To verify that the cost change , we can use the command **traceroute** any Pc in area 1 in privilege mode:

**Figure 2- 21:The way from area 3 to area 1 by traceroute command**

And also we can see the cost directly by using the command `show ip ospf interface` in privilege mode

```
Router0
Physical Config CLI
IOS Command Line Interface
1 192.37.0.6    7 msec   16 msec  1 msec
2 192.37.0.2    1 msec   12 msec  7 msec
3 192.37.1.2    13 msec  2 msec   13 msec
Router0#show ip ospf interface
Serial2/0 is up, line protocol is up
  Internet address is 192.37.0.5/30, Area 0
  Process ID 1, Router ID 192.37.2.129, Network Type
POINT-TO-POINT, Cost: 5
  Transmit Delay is 1 sec, State POINT-TO-POINT, Priority
0
  No designated router on this network
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40,
Retransmit 5
    Hello due in 00:00:09
    Index 1/1, flood queue length 0
    Next t1 (0)@0x0(0)
    Last flood scan length is 1, maximum is 1
    Last flood scan time is 0 msec, maximum is 0 msec
    Neighbor Count is 1 , Adjacent neighbor count is 1
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```

**Figure 2- 22:The cost of se 2/0 router0**

## 2.4 Summarization

To add the loopback networks to the OSPF on router 2 we can do it in several way

First one by one:

```
Router(config)#router ospf 1
Router(config-router)#network 172.16.0.0 0.0.0.255 area 1
Router(config-router)#network 172.16.1.0 0.0.0.255 area 1
Router(config-router)#network 172.16.2.0 0.0.0.255 area 1
Router(config-router)#network 172.16.3.0 0.0.0.255 area 1
Router(config-router)#network 172.16.4.0 0.0.0.255 area 1
Router(config-router)#network 172.16.5.0 0.0.0.255 area 1
```

**Figure 2-23:add loopback networks to the OSPF One by One [9]**

But we can combine the first networks with one large network that include them all which is 172.16.0.0/22

```
Router(config)#router ospf 1
Router(config-router)#network 172.16.0.0 0.0.3.255 area 1
Router(config-router)#network 172.16.4.0 0.0.0.255 area 1
Router(config-router)#network 172.16.5.0 0.0.0.255 area 1
```

**Figure 2- 24:Add loopback networks to the OSPF by replace the first four networks with one ID [9]**

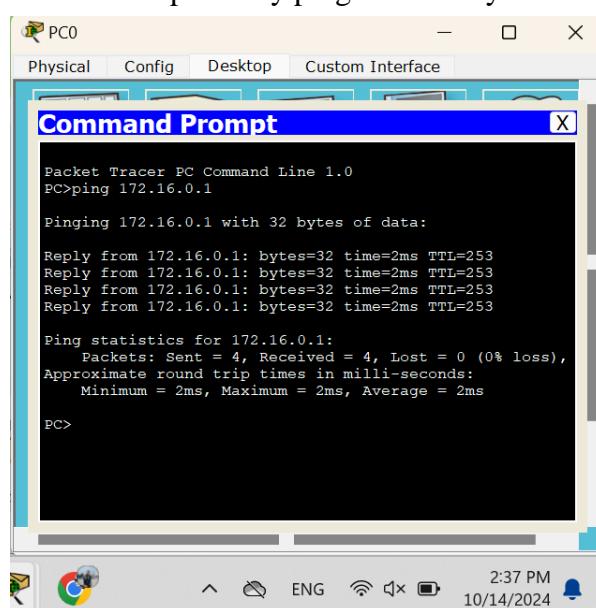
Also we can combined the last two networks to 172.16.4.0/23 :

```
Router(config)#router ospf 1
Router(config-router)#network 172.16.0.0 0.0.3.255 area 1
Router(config-router)#network 172.16.4.0 0.0.1.255 area 1
```

**Figure 2- 25:Summrization for all loopbacks**

And any one of them is correct but the last one is very useful to reduce the CPU execution and not dealing with 6 networks but with only two.

And we can verify the OSPF for loopback by ping it from any PC in different area like this:



**Figure 2- 26:Ping the loopback from PC0**

## 2.5 important Questions

### 2.5.1 First Question

Why do we need for loopback interfaces?

In any network configuration, loopback interfaces play an important role in the identification and testing of devices as well as in internal communications. They allow for a constant IP address for specific devices like routers regardless of the operational state of the physical interfaces which is very important for routing protocols such OSPF and BGP. Also, loopback interfaces have an application in the testing of networks, for instance, allowing services running on the computer to be tested locally (e.g. `ping 127.0.0.1`) and allowing a web server or database service to connect locally without risk of connecting to the public network. They remain available and work where virtual networks are provided even if the actual physical hardware is non-existent or has broken down which makes them important even in service restoration [8].

### 2.5.2 Second Question

What is the router-id for OSPF? And why do we need it?

In OSPF, each router is assigned a unique Router ID (RID) to distinguish itself within the network. This RID must be unique across the OSPF domain, as duplicate RIDs can lead to network reachability issues. If two routers share the same RID, they will not establish a neighbor relationship. However, duplicated RIDs may still exist between routers that are not directly connected. OSPF selects the RID using a specific order of criteria: first, a manually configured RID is used if set. If not, the highest IP address on any loopback interface is chosen. In the absence of a loopback interface, OSPF uses the highest IP address from a non-loopback interface [7].

### 2.5.3 Third Question

Hardcode the router-id for R1, R2, and R3 as 1.1.1.1, 2.2.2.2, and 3.3.3.3 respectively.

And Verify that.

```
Router>en
Router#config
Configuring from terminal, memory, or network [terminal]? t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#router ospf 1
Router(config-router)#router-id 1.1.1.1
Router(config-router)#Reload or use "clear ip ospf process" command, for this to take effect

Router(config-router)#ex
Router(config)#x
Router#
%SYS-5-CONFIG_I: Configured from console by console
Router#clear ip ospf process
Reset ALL OSPF processes? [no]: y

Router#
00:43:49: %OSPF-5-ADJCHG: Process 1, Nbr 192.37.2.129 on Serial2/0 from FULL to DOWN, Neighbor Down: Adjacency forced to reset
00:43:49: %OSPF-5-ADJCHG: Process 1, Nbr 192.37.2.129 on Serial2/0 from FULL to DOWN, Neighbor Down: Interface down or detached
00:43:49: %OSPF-5-ADJCHG: Process 1, Nbr 172.16.5.1 on Serial3/0 from FULL to DOWN, Neighbor Down: Adjacency forced to reset
00:43:49: %OSPF-5-ADJCHG: Process 1, Nbr 172.16.5.1 on Serial3/0 from FULL to DOWN, Neighbor Down: Interface down or detached
Router#
Router#
00:43:53: %OSPF-5-ADJCHG: Process 1, Nbr 192.37.2.129 on Serial2/0 from LOADING to FULL, Loading Done
00:44:00: %OSPF-5-ADJCHG: Process 1, Nbr 172.16.5.1 on Serial3/0 from LOADING to FULL, Loading Done

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```



Figure 2- 27:Set router-id for router1

```

Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#router ospf 1
Router(config-router)#router-id 2.2.2.2
Router(config-router)#reload or use "clear ip ospf process" command, for this to take effect

Router(config-router)*#
Router#
#SYS-5-CONFIG_I: Configured from console by console
Router#clear ip ospf process
Reset ALL OSPF processes? [no]: y
Router#
01:02:08: %OSPF-5-ADJCHG: Process 1, Nbr 1.1.1.1 on Serial2/0 from FULL to DOWN, Neighbor Down: Adjacency forced to reset
01:02:08: %OSPF-5-ADJCHG: Process 1, Nbr 1.1.1.1 on Serial2/0 from FULL to DOWN, Neighbor Down: Interface down or detached
01:02:08: %OSPF-5-ADJCHG: Process 1, Nbr 192.37.2.1 on Serial3/0 from FULL to DOWN, Neighbor Down: Adjacency forced to reset
01:02:08: %OSPF-5-ADJCHG: Process 1, Nbr 192.37.2.1 on Serial3/0 from FULL to DOWN, Neighbor Down: Interface down or detached
Router#

```



**Figure 2- 28:Set router-id for router2**

```

Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#router ospf 1
Router(config-router)#router-id 3.3.3.3
Router(config-router)#reload or use "clear ip ospf process" command, for this to take effect

Router(config-router)*#
Router#
#SYS-5-CONFIG_I: Configured from console by console
Router#clear ip ospf process
Reset ALL OSPF processes? [no]: y
Router#
01:03:11: %OSPF-5-ADJCHG: Process 1, Nbr 192.37.2.129 on Serial3/0 from FULL to DOWN, Neighbor Down: Adjacency forced to reset
01:03:11: %OSPF-5-ADJCHG: Process 1, Nbr 192.37.2.129 on Serial3/0 from FULL to DOWN, Neighbor Down: Interface down or detached
01:03:11: %OSPF-5-ADJCHG: Process 1, Nbr 2.2.2.2 on Serial2/0 from FULL to DOWN, Neighbor Down: Adjacency forced to reset
01:03:11: %OSPF-5-ADJCHG: Process 1, Nbr 2.2.2.2 on Serial2/0 from FULL to DOWN, Neighbor Down: Interface down or detached
Router#
01:03:16: %OSPF-5-ADJCHG: Process 1, Nbr 2.2.2.2 on Serial2/0 from LOADING to FULL, Loading Done
Router#
01:03:22: %OSPF-5-ADJCHG: Process 1, Nbr 192.37.2.129 on Serial3/0 from LOADING to FULL, Loading Done
Router#

```



**Figure 2- 29:Set router-id for router2**

Then use the command show ip protocols in privilege mode to see the router-id for each router:

```

Router#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 3.3.3.3
  Number of areas in this router is 2. 2 normal 0 stub 0 nssa
  Maximum path length is 4
  Routing for Networks:
    192.37.0.0 0.0.0.3 area 0
    192.37.0.12 0.0.0.3 area 0
    192.37.2.0 0.0.0.127 area 2
  Routing Information Sources:
    Gateway          Distance      Last Update
    1.1.1             110          00:10:46
    1.2.2.2           110          00:09:46
    3.3.3.3           110          00:09:40
    172.16.5.1        110          00:28:46
    192.37.0.6        110          00:41:58
    192.37.2.1        110          00:10:37
    192.37.2.129      110          00:09:40
  Distance: (default is 110)
Router#

```



**Figure 2- 30:router-id for router 3**

```

Router>en
Router#show ip protocols

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID is 1.1.1.1
    Number of areas in this router is 2. 2 normal 0 stub 0 nssa
    Maximum path: 4
    Routing for Networks:
      192.37.0.0 0.0.0.3 area 0
      192.37.0.12 0.0.0.3 area 0
      192.37.0.16 0.0.0.3 area 1
      192.16.0.0 0.0.3.255 area 1
      192.16.4.0 0.0.1.255 area 1
      172.16.0.0 0.0.3.255 area 1
      172.16.4.0 0.0.1.255 area 1
    Routing Information Sources:
      Gateway         Distance      Last Update
      1.1.1.1          110          00:12:22
      2.2.2.2          110          00:11:02
      3.3.3.3          110          00:11:16
      172.16.5.1       110          00:30:22
      192.37.0.6       110          00:43:34
      192.37.2.1       110          00:12:13
      192.37.2.129    110          00:11:16
    Distance: (default is 110)
Router#

```

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**Figure 2- 31:router-id for router 2**

```

Router>en
Router#show ip protocols

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID is 1.1.1.1
    Number of areas in this router is 1. 1 normal 0 stub 0 nssa
    Maximum path: 4
    Routing for Networks:
      192.37.0.0 0.0.0.3 area 0
      192.37.0.0 0.0.0.3 area 0
    Routing Information Sources:
      Gateway         Distance      Last Update
      1.1.1.1          110          00:14:18
      2.2.2.2          110          00:13:18
      3.3.3.3          110          00:11:12
      172.16.5.1       110          00:32:18
      192.37.0.6       110          00:45:30
      192.37.2.1       110          00:14:09
      192.37.2.129    110          00:13:12
    Distance: (default is 110)
Router#

```

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**Figure 2- 32:router-id for router 1**

### 3. Results

The results for each section mentioned earlier are placed next to their corresponding descriptions. This section includes the routing table for each router and PC, along with the testing results using the "Ping" command.

#### 3.1 Routing Tables

```
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
      E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
      L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
      * - candidate default, ? - 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, 6 subnets
O IA 172.16.0.1 [110/70] via 192.37.0.6, 00:00:27, Serial2/0
O IA 172.16.1.1 [110/70] via 192.37.0.6, 00:00:27, Serial2/0
O IA 172.16.2.1 [110/70] via 192.37.0.6, 00:00:27, Serial2/0
O IA 172.16.3.1 [110/70] via 192.37.0.6, 00:00:27, Serial2/0
O IA 172.16.4.1 [110/70] via 192.37.0.6, 00:00:27, Serial2/0
O IA 172.16.5.1 [110/70] via 192.37.0.6, 00:00:27, Serial2/0
  192.37.0.0/24 is subnetted, 1 subnets
o 192.37.0.0 [110/65] via 192.37.0.6, 00:40:55, Serial2/0
  192.37.0.8 is directly connected, Serial2/0
  192.37.0.12 is subnetted, 1 subnets
o 192.37.0.12 [110/128] via 192.37.0.6, 00:21:29, Serial2/0
  192.37.0.25 is subnetted, 1 subnets
c 192.37.0.25 is directly connected, FastEthernet0/0
Router#
```



Figure 3- 1:routing table for R0

```
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
      E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
      L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
      * - candidate default, ? - 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, 6 subnets
O IA 172.16.1.1 [110/70] via 192.37.0.6, 00:01:15, Serial2/0
O IA 172.16.2.1 [110/70] via 192.37.0.6, 00:01:15, Serial2/0
O IA 172.16.3.1 [110/70] via 192.37.0.6, 00:01:15, Serial2/0
O IA 172.16.4.1 [110/70] via 192.37.0.6, 00:01:15, Serial2/0
O IA 172.16.5.1 [110/70] via 192.37.0.6, 00:01:15, Serial2/0
  192.37.0.0/24 is subnetted, 1 subnets
o 192.37.0.0 [110/65] via 192.37.0.6, 00:41:43, Serial2/0
  192.37.0.4 is directly connected, Serial2/0
  192.37.0.8 is directly connected, Serial2/0
  192.37.0.12 is subnetted, 1 subnets
o 192.37.0.12 [110/128] via 192.37.0.6, 00:22:16, Serial2/0
  192.37.0.25 is subnetted, 1 subnets
C 192.37.0.25 is directly connected, FastEthernet0/0
Router#
```

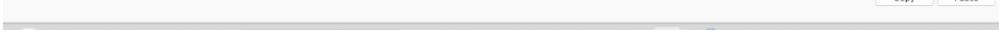


Figure 3- 2:routing table for R1

```
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
      E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
      L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
      * - candidate default, ? - per-user static route, o - ODR
      p - periodic downloaded static route

Gateway of last resort is not set

 172.16.0.0/24 is subnetted, 6 subnets
c 172.16.1.0 is directly connected, Loopback0
c 172.16.1.1 is directly connected, Loopback1
c 172.16.2.0 is directly connected, Loopback2
c 172.16.3.0 is directly connected, Loopback3
c 172.16.4.0 is directly connected, Loopback4
c 172.16.5.0 is directly connected, Loopback5
  192.37.0.0/30 is subnetted, 4 subnets
c 192.37.0.1 [110/128] via 192.37.0.0, 00:40:35, Serial2/0
  192.37.0.4 [110/128] via 192.37.0.13, 00:21:08, Serial2/0
  192.37.0.8 [110/128] via 192.37.0.13, 00:21:08, Serial2/0
  192.37.0.12 [110/128] via 192.37.0.1, 00:21:08, Serial2/0
  192.37.1.0/24 is subnetted, 1 subnets
o 192.37.1.0 [110/128] via 192.37.0.13, 00:21:08, Serial2/0
  192.37.2.25 is directly connected, FastEthernet0/0
  192.37.2.25 is subnetted, 1 subnets
o 192.37.2.25 [110/128] via 192.37.0.1, 00:21:08, Serial2/0
Router#
```



Figure 3- 3:routing table for R2

```
Router#show ip route
Codes: C - connected, S - static, I - ISGP, 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 - EIGRP
      i - IS-IS level-1, L1 - IS-IS level-1, L2 - IS-IS level-2, L1-2 - IS-IS inter area
      * - candidate default, U - per-user static route, o - ODR
      F - periodical downloaded static route
Gateway of last resort is not set

172.16.0.0/32 is subnetted, 6 subnets
O IA 172.16.0.1 [110/65] via 192.37.0.14, 00:03:09, Serial1/0
O IA 172.16.1.1 [110/65] via 192.37.0.14, 00:03:09, Serial1/0
O IA 172.16.2.1 [110/65] via 192.37.0.14, 00:03:09, Serial1/0
O IA 172.16.3.1 [110/65] via 192.37.0.14, 00:03:09, Serial1/0
O IA 172.16.4.1 [110/65] via 192.37.0.14, 00:03:09, Serial1/0
O IA 172.16.5.1 [110/65] via 192.37.0.14, 00:03:09, Serial1/0
192.37.0.0/24 is subnetted, 2 subnets
O 192.37.0.0 [110/128] via 192.37.0.14, 00:25:09, Serial2/0
192.37.0.1/30 is directly connected, Serial3/0
C 192.37.0.2/32 is directly connected, Serial3/0
C 192.37.0.12/32 is directly connected, Serial1/0
IA 192.37.0.25/32 is subnetted, 2 subnets
O 192.37.0.25 [110/65] via 192.37.0.9, 00:03:09, Serial3/0
O 192.37.0.2/32 is directly connected, FastEthernet0/0
C 192.37.0.2/128 [110/65] via 192.37.0.9, 00:24:10, Serial3/0
Router#
Router#
```

**Figure 3- 4: routing table for R3**

### **3.2 PC Testing:**

This section is to test sending packet between the areas in the topology:

**Figure 3-5:Ping from PC0 to PC4 and PC2**

```
PCs Physical Config Desktop Custom Interface

Command Prompt

PC>
PCping 192.37.2.3

Pinging 192.37.2.3 with 32 bytes of data:
Reply from 192.37.2.3: bytes=32 time<1ms TTL=126
Reply from 192.37.2.3: bytes=32 time<1ms TTL=126
Reply from 192.37.2.3: bytes=32 time=17ms TTL=126
Reply from 192.37.2.3: bytes=32 time=17ms TTL=126
Reply from 192.37.2.3: bytes=32 time=17ms TTL=126

Ping statistics for 192.37.2.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip time in milli-seconds:
        Minimum = 1ms, Maximum = 17ms, Average = 5ms

PCping 192.37.2.131

Pinging 192.37.2.131 with 32 bytes of data:
Reply from 192.37.2.131: bytes=32 time<1ms TTL=125

Ping statistics for 192.37.2.131:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 1ms, Maximum = 2ms, Average = 1ms

PC>
```

**Figure 3- 6:Ping from PC5 to PC3 and PC1**

```

PC2
Physical Config Desktop Custom Interface
Command Prompt
PCping 192.37.2.130 with 32 bytes of data:
Pinging 192.37.2.130 with 32 bytes of data:
Reply from 192.37.2.130: bytes=32 time=1ms TTL=126
Ping statistics for 192.37.2.130:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 1ms, Maximum = 1ms, Average = 1ms
PCping 192.37.2.2
Pinging 192.37.2.2 with 32 bytes of data:
Reply from 192.37.2.2: bytes=32 time=1ms TTL=126
Ping statistics for 192.37.2.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 1ms, Maximum = 1ms, Average = 1ms
PC>

```

Figure 3- 7:Ping from PC2 to PC0 and PC2

### 3.3 loopback Testing:

To verify that OSPF for loopbacks set correctly we can ping it from any PC in different areas:

```

PC0
Physical Config Desktop Custom Interface
Command Prompt
PCping 172.16.1.1 with 32 bytes of data:
Pinging 172.16.1.1 with 32 bytes of data:
Reply from 172.16.1.1: bytes=32 time=2ms TTL=253
Reply from 172.16.1.1: bytes=32 time=2ms TTL=253
Reply from 172.16.1.1: bytes=32 time=2ms TTL=253
Reply from 172.16.1.1: bytes=32 time=1ms TTL=253
Ping statistics for 172.16.1.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 2ms, Maximum = 2ms, Average = 12ms
PCping 172.16.2.1
Pinging 172.16.2.1 with 32 bytes of data:
Reply from 172.16.2.1: bytes=32 time=2ms TTL=253
Reply from 172.16.2.1: bytes=32 time=2ms TTL=253
Reply from 172.16.2.1: bytes=32 time=2ms TTL=253
Reply from 172.16.2.1: bytes=32 time=3ms TTL=253
Ping statistics for 172.16.2.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 2ms, Maximum = 3ms, Average = 2ms
PCping 172.16.3.1
Pinging 172.16.3.1 with 32 bytes of data:
Reply from 172.16.3.1: bytes=32 time=2ms TTL=253
Reply from 172.16.3.1: bytes=32 time=2ms TTL=253
Reply from 172.16.3.1: bytes=32 time=2ms TTL=253
Reply from 172.16.3.1: bytes=32 time=30ms TTL=253
Ping statistics for 172.16.3.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 2ms, Maximum = 35ms, Average = 16ms
PCping 172.16.4.1 with 32 bytes of data:

```

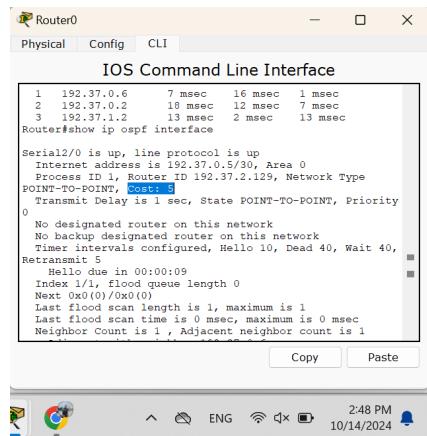
```

PC0
Physical Config Desktop Custom Interface
Command Prompt
PCping 172.16.4.1 with 32 bytes of data:
Pinging 172.16.4.1 with 32 bytes of data:
Reply from 172.16.4.1: bytes=32 time=52ms TTL=253
Reply from 172.16.4.1: bytes=32 time=2ms TTL=253
Reply from 172.16.4.1: bytes=32 time=2ms TTL=253
Reply from 172.16.4.1: bytes=32 time=2ms TTL=253
Ping statistics for 172.16.4.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 2ms, Maximum = 52ms, Average = 14ms
PCping 172.16.5.1
Pinging 172.16.5.1 with 32 bytes of data:
Reply from 172.16.5.1: bytes=32 time=2ms TTL=253
Ping statistics for 172.16.5.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 2ms, Maximum = 3ms, Average = 2ms
PCping 172.16.0.1
Pinging 172.16.0.1 with 32 bytes of data:
Reply from 172.16.0.1: bytes=32 time=2ms TTL=253
Reply from 172.16.0.1: bytes=32 time=2ms TTL=253
Reply from 172.16.0.1: bytes=32 time=1ms TTL=253
Reply from 172.16.0.1: bytes=32 time=23ms TTL=253
Ping statistics for 172.16.0.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 1ms, Maximum = 23ms, Average = 4ms
PC>

```

Figure 3- 8:Ping from PC0 to all loopbacks

### 3.3 Cost and road (from area3 to area1 )Testing:



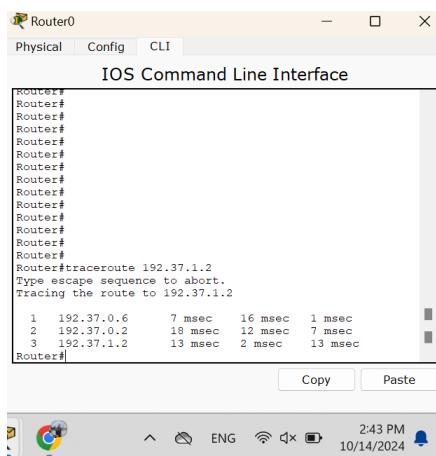
Router#show ip ospf interface

```
1 192.37.0.6      7 msec   16 msec   1 msec
2 192.37.0.2      18 msec   12 msec   7 msec
3 192.37.1.2      13 msec   2 msec    13 msec
Router#show ip ospf interface
Serial2/0 is up, line protocol is up
Internet address is 192.37.0.5/30, Area 0
Process ID 1, Router ID 192.37.2.129, Network Type
POINT-TO-POINT [output]
Transmit Delay is 1 sec, State POINT-TO-POINT, Priority
0
No designated router on this network
No backup designated router on this network
Timer intervals configured, Hello 10, Dead 40,
Retransmit 5
Hello due in 00:00:09
Index 1/1, flood queue length 0
Next 0x0() /0x0()
Last flood scan length is 1, maximum is 1
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor count is 1, Adjacent neighbor count is 1
```

Copy Paste

Router0 2:48 PM 10/14/2024

Figure 3- 9:The cost of se 2/0 in router0 after change the bandwidth



```
Router#
Router#traceroute 192.37.1.2
Type escape sequence to abort.
Tracing the route to 192.37.1.2
1  192.37.0.6      7 msec   16 msec   1 msec
2  192.37.0.2      18 msec   12 msec   7 msec
3  192.37.1.2      13 msec   2 msec    13 msec
```

Router#

Router0 2:43 PM 10/14/2024

Figure 3- 10:The road from area3 to area1

## 4. Problem

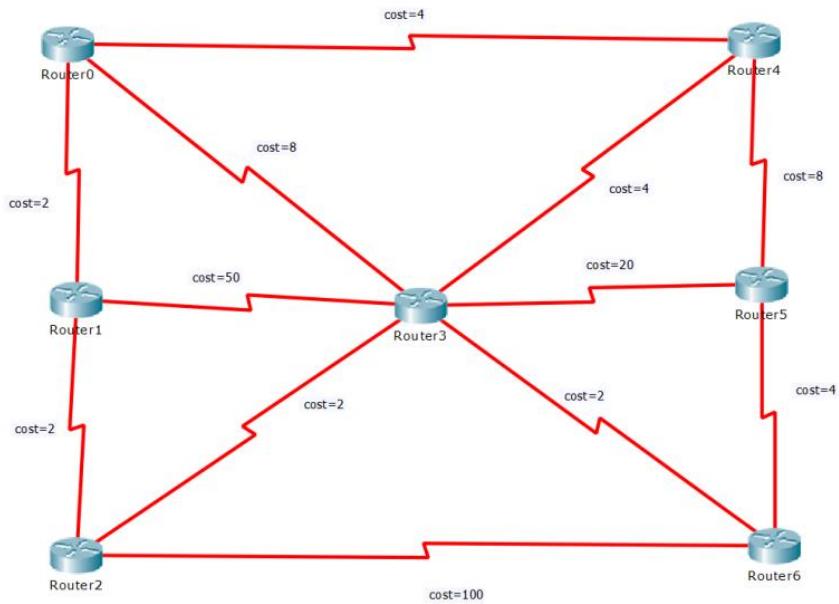


Figure 4-1: Problem Topology

### 4.1 Part One

#### 4.1.1 Question:

1. find the shortest path from router 0 to router 6 using Dijkstra's algorithm
2. what is the cost of the shortest path from router 0 to router 6?

#### 4.1.2 Solution:

to find shortest path from  $R_0$  to  $R_6$

step	$R_0$	$R_1$	$R_2$	$R_3$	$R_4$	$R_5$	$R_6$
0	0	$\infty$	$\infty$	$\infty$	$\infty$	$\infty$	$\infty$
1		$2, R_0$	$\infty$	$8, R_0$	$4, R_0$	$\infty$	$\infty$
2			$4, R_1$	$8, R_0$	$4, R_0$	$\infty$	$\infty$
3				$8, R_0$	$12, R_4$	$\infty$	
4					$12, R_4$	$104, R_2$	
5						$12, R_4$	$8, R_3$

so Shortest Path is

$R_0(0) \rightarrow R_1(2) \rightarrow R_2(2) \rightarrow R_3(2) \rightarrow R_6(2)$

and the cost for this path is  $0 + 2 + 2 + 2 + 2 = 8$

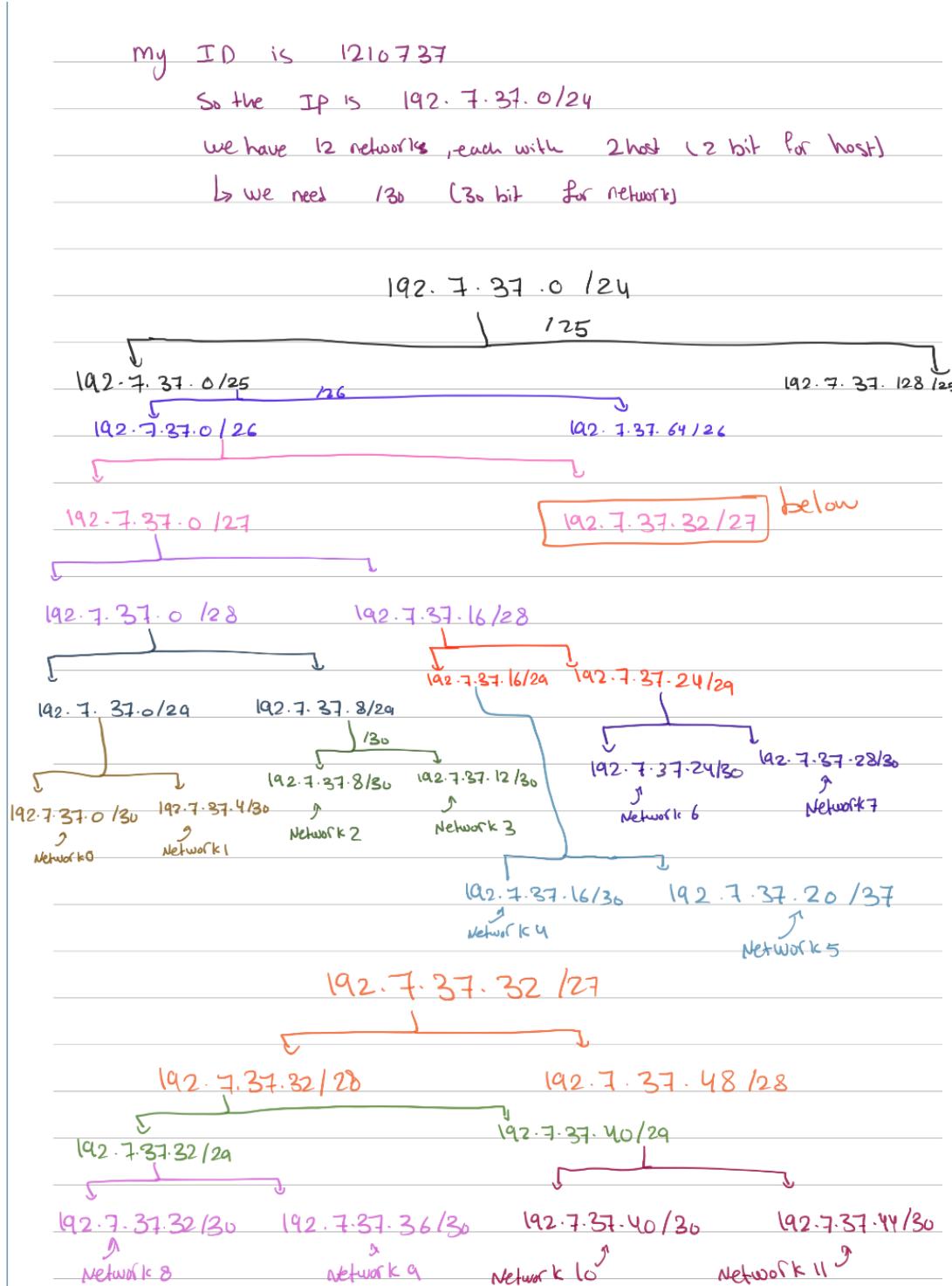
Figure 4-2: Part one solution (by hand)

## 4.2 Part Two

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

### 4.2.1 requirement 1:

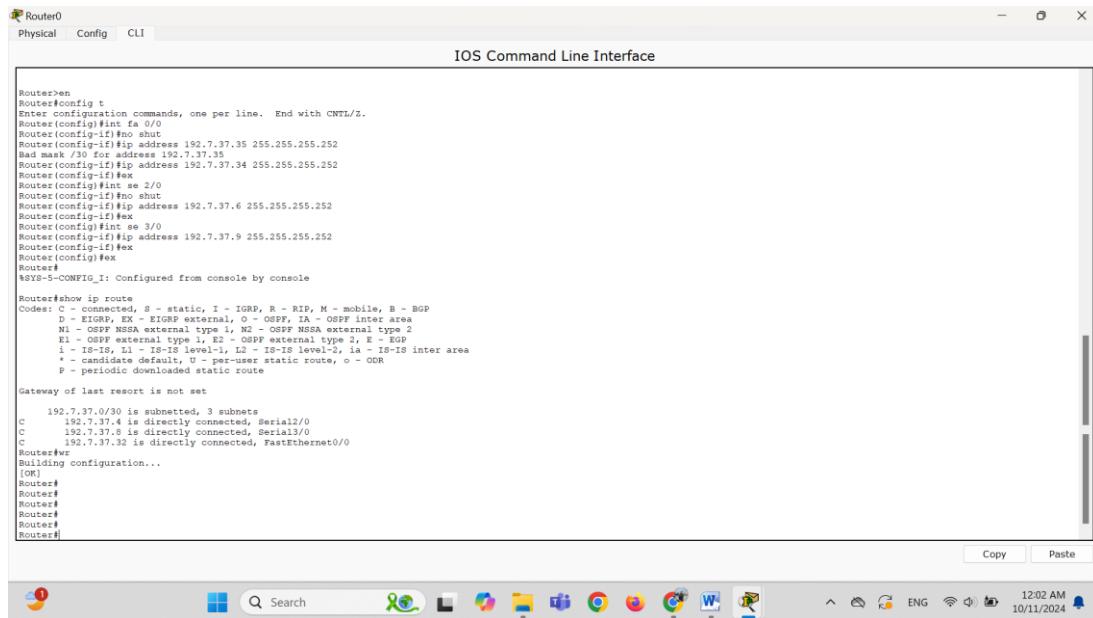
For addressing the above network use the class C address 192.A.B.0 and use it to create networks (subnets) of 2 hosts each. A, and B represent the last four digits of your university ID. For example: if your university ID 1140302 then (A = 03 = 3) and (B = 02 = 2)



**Table 4-1:Networks IPs**

<b>Network</b>	<b>Device</b>	<b>Interface</b>	<b>IP</b>	<b>Subnet mask</b>	<b>Wildcard mask</b>
Network 0 192.7.37.0/30	Router 2	Se 2/0	192.7.37.1/30	255.255.255.252	0.0.0.3
	Router 1	Se 3/0	192.7.37.2/30	255.255.255.252	0.0.0.3
Network 1 192.7.37.4/30	Router 1	Se 2/0	192.7.37.5/30	255.255.255.252	0.0.0.3
	Router 0	Se 2/0	192.7.37.6/30	255.255.255.252	0.0.0.3
Network 2 192.7.37.8/30	Router 0	Se 3/0	192.7.37.9/30	255.255.255.252	0.0.0.3
	Router 4	Se 2/0	192.7.37.10/30	255.255.255.252	0.0.0.3
Network 3 192.7.37.12/30	Router 4	Fa 0/0	192.7.37.14/30	255.255.255.252	0.0.0.3
	Router 5	Fa 1/0	192.7.37.13/30	255.255.255.252	0.0.0.3
Network 4 192.7.37.16/30	Router 5	Se 2/0	192.7.37.18/30	255.255.255.252	0.0.0.3
	Router 6	Se 2/0	192.7.37.17/30	255.255.255.252	0.0.0.3
Network 5 192.7.37.20/30	Router 6	Fa 0/0	192.7.37.22/30	255.255.255.252	0.0.0.3
	Router 2	Fa 0/0	192.7.37.21/30	255.255.255.252	0.0.0.3
Network 6 192.7.37.24/30	Router 2	Se 3/0	192.7.37.25/30	255.255.255.252	0.0.0.3
	Router 3	Se 2/0	192.7.37.26/30	255.255.255.252	0.0.0.3
Network 7 192.7.37.28/30	Router 1	Fa 4/0	192.7.37.29/30	255.255.255.252	0.0.0.3
	Router 3	Fa 4/0	192.7.37.30/30	255.255.255.252	0.0.0.3
Network 8 192.7.37.32/30	Router 3	Fa 1/0	192.7.37.33/30	255.255.255.252	0.0.0.3
	Router 0	Fa 0/0	192.7.37.34/30	255.255.255.252	0.0.0.3
Network 9 192.7.37.36/30	Router 3	Se 3/0	192.7.37.37/30	255.255.255.252	0.0.0.3
	Router 4	Se 3/0	192.7.37.38/30	255.255.255.252	0.0.0.3
Network 10 192.7.37.40/30	Router 3	Fa 0/0	192.7.37.41/30	255.255.255.252	0.0.0.3
	Router 5	Fa 0/0	192.7.37.42/30	255.255.255.252	0.0.0.3
Network 11 192.7.37.44/30	Router 6	Fa 4/0	192.7.37.45/30	255.255.255.252	0.0.0.3
	Router 3	Fa 5/0	192.7.37.46/30	255.255.255.252	0.0.0.3

And below example of how to set the IPs for interfaces



```

Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int fa 0/0
Router(config-if)#no shut
Router(config-if)#ip address 192.7.37.35 255.255.255.252
Bad mask /30 for address 192.7.37.35
Router(config-if)#ip address 192.7.37.34 255.255.255.252
Router(config-if)#exit
Router(config)#int fa 2/0
Router(config-if)#no shut
Router(config-if)#ip address 192.7.37.6 255.255.255.252
Router(config-if)#exit
Router(config)#int fa 3/0
Router(config-if)#ip address 192.7.37.9 255.255.255.252
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
       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

      192.7.37.0/30 is subnetted, 3 subnets
C    192.7.37.4 is directly connected, Serial2/0
C    192.7.37.8 is directly connected, Serial3/0
C    192.7.37.32 is directly connected, FastEthernet0/0

Router#wr
Building configuration...
[OK]
Router#
Router#
Router#
Router#
Router#
Router#

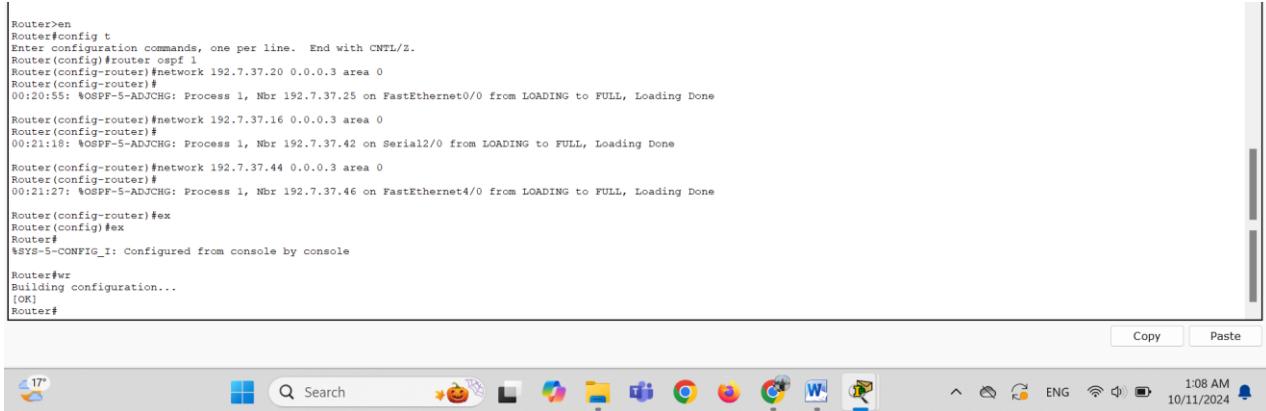
```

Figure 4-3:Setting IPs for interfaces in router0

#### 4.2.2 requirement 2:

Enable OSPF routing. Assume all routers are in area 0 (backbone)

The figure below show how to do it for router 6 , and the same step with different IPs done for all routers



```

Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#router ospf 1
Router(config-router)#network 192.7.37.20 0.0.0.3 area 0
Router(config-router)#
00:20:55: %OSPF-5-ADJCHG: Process 1, Nbr 192.7.37.25 on FastEthernet0/0 from LOADING to FULL, Loading Done
Router(config-router)#network 192.7.37.16 0.0.0.3 area 0
Router(config-router)#
00:21:08: %OSPF-5-ADJCHG: Process 1, Nbr 192.7.37.42 on Serial2/0 from LOADING to FULL, Loading Done
Router(config-router)#network 192.7.37.44 0.0.0.3 area 0
Router(config-router)#
00:21:27: %OSPF-5-ADJCHG: Process 1, Nbr 192.7.37.46 on FastEthernet4/0 from LOADING to FULL, Loading Done
Router(config-router)#
Router(config-router)#
Router(config-router)#
%SYS-5-CONFIG_I: Configured from console by console
Router#wr
Building configuration...
[OK]
Router#

```

Figure 4-4:Enable OSPF for router6

#### 4.2.3 requirement 3:

Configure Router 6 with a loopback IP address 7.7.7.7/24. Advertise this network into OSPF process.

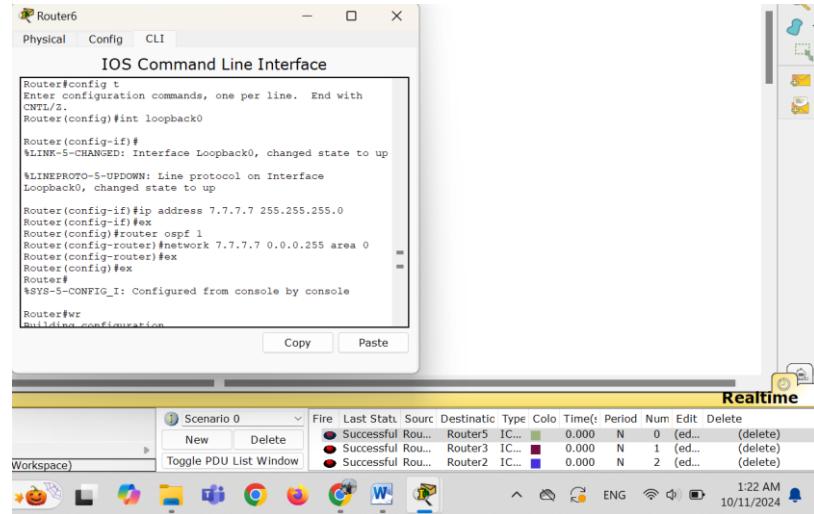


Figure 4-5:add the loopback0 7.7.7.7/24 to router6 and enable OSPF for it

```
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

    7.0.0.0/32 is subnetted, 1 subnets
o  7.7.7.7 [110/3] via 192.7.37.33, 00:02:13, FastEthernet0/0
  192.7.37.0/30 is subnetted, 12 subnets
o  192.7.37.1 [110/3] via 192.7.37.33, 00:17:28, FastEthernet0/0
o  192.7.37.4 is directly connected, Serial2/0
c  192.7.37.8 is directly connected, Serial3/0
o  192.7.37.12 [110/3] via 192.7.37.33, 00:13:19, FastEthernet0/0
o  192.7.37.16 [110/66] via 192.7.37.33, 00:13:19, FastEthernet0/0
o  192.7.37.24 [110/3] via 192.7.37.33, 00:17:28, FastEthernet0/0
o  192.7.37.28 [110/3] via 192.7.37.33, 00:17:28, FastEthernet0/0
c  192.7.37.32 is directly connected, FastEthernet0/0
o  192.7.37.36 [110/65] via 192.7.37.33, 00:17:18, FastEthernet0/0
o  192.7.37.40 [110/2] via 192.7.37.33, 00:13:29, FastEthernet0/0
o  192.7.37.44 [110/2] via 192.7.37.33, 00:17:08, FastEthernet0/0
Router#
Router#
```

Figure 4- 6:Routing table after OSPF for router0

```
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

    7.0.0.0/32 is subnetted, 1 subnets
o  7.7.7.7 [110/3] via 192.7.37.30, 00:02:40, FastEthernet4/0
  192.7.37.0/30 is subnetted, 12 subnets
o  192.7.37.1 is directly connected, Serial1/3/0
c  192.7.37.4 is directly connected, Serial2/0
o  192.7.37.12 [110/66] via 192.7.37.30, 00:17:56, FastEthernet4/0
o  192.7.37.16 [110/31] via 192.7.37.30, 00:13:46, FastEthernet4/0
o  192.7.37.16 [110/66] via 192.7.37.30, 00:13:46, FastEthernet4/0
o  192.7.37.24 [110/3] via 192.7.37.30, 00:18:59, FastEthernet4/0
o  192.7.37.28 [110/65] via 192.7.37.30, 00:18:16, FastEthernet4/0
c  192.7.37.32 is directly connected, FastEthernet4/0
o  192.7.37.40 [110/2] via 192.7.37.30, 00:17:56, FastEthernet4/0
o  192.7.37.36 [110/65] via 192.7.37.30, 00:17:46, FastEthernet4/0
o  192.7.37.44 [110/2] via 192.7.37.30, 00:17:36, FastEthernet4/0
Router#
Router#
```

Figure 4- 7:Routing table after OSPF for router1

```

Router# Router# show ip route
Codes: c - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
      D - EIGRP, Ex - external, L - loopback, O - OSPF inter area
      N1 - OSPF external type 1, N2 - OSPF 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

7.0.0.0/32 is subnetted, 1 subnets
o 7.7.7.7 [110/2] via 192.7.37.22, 00:02:57, FastEthernet0/0
  192.7.37.0/32 is subnetted, 12 subnets
c 192.7.37.0/24 is directly connected, Serial3/0
o 192.7.37.1 [110/3] via 192.7.37.22, 00:11:12, FastEthernet0/0
o 192.7.37.8 [110/6] via 192.7.37.22, 00:11:12, FastEthernet0/0
o 192.7.37.12 [110/4] via 192.7.37.22, 00:11:12, FastEthernet0/0
o 192.7.37.16 [110/65] via 192.7.37.22, 00:11:32, FastEthernet0/0
c 192.7.37.20 is directly connected, FastEthernet0/0
c 192.7.37.24 is directly connected, Serial3/0
o 192.7.37.25 [110/5] via 192.7.37.22, 00:11:12, FastEthernet0/0
o 192.7.37.32 [110/3] via 192.7.37.22, 00:11:12, FastEthernet0/0
o 192.7.37.36 [110/66] via 192.7.37.22, 00:11:12, FastEthernet0/0
o 192.7.37.40 [110/6] via 192.7.37.22, 00:11:12, FastEthernet0/0
o 192.7.37.44 [110/2] via 192.7.37.22, 00:11:12, FastEthernet0/0

Router#
```



**Figure 4- 8:Routing table after OSPF for router2**

```

Router# show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, N - OSPF inter area
      N1 - OSPFv1 external type 1, N2 - OSPFv2 NSSA external type 2
      E1 - EIGRP external type 1, E2 - EIGRP external type 2, E - EGP
      * - candidate default, U - per-user static route, o - QDR
      P - periodic downloaded static route

Gateway of last resort is not set

7.0.0.0/32 is subnetted, 1 subnets
o 7.7.7.7 [110/2] via 192.7.37.45, 00:03:14, FastEthernet5/0
  192.7.37.0/30 is subnetted, 12 subnets
o 192.7.37.0 [110/65] via 192.7.37.29, 00:18:45, FastEthernet4/0
  o 192.7.37.4 [110/65] via 192.7.37.29, 00:18:35, FastEthernet4/0
    o 192.7.37.8 [110/65] via 192.7.37.34, 00:18:35, FastEthernet1/0
    o 192.7.37.12 [110/2] via 192.7.37.42, 00:14:00, FastEthernet3/0
    o 192.7.37.16 [110/65] via 192.7.37.42, 00:11:33, FastEthernet0/0
  o 192.7.37.20 [110/2] via 192.7.37.45, 00:11:33, FastEthernet5/0
  o 192.7.37.24 [110/2] via 192.7.37.45, 00:11:33, FastEthernet4/0
  o 192.7.37.32 is directly connected, FastEthernet7/0
  o 192.7.37.36 is directly connected, Serial3/0
  o 192.7.37.40 is directly connected, FastEthernet0/0
  o 192.7.37.44 is directly connected, FastEthernet5/0

```



Figure 4- 9: Routing table after OSPF for router3

```

Router# Router> show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       E - EIGRP, E1 - EIGRP external, E2 - EIGRP external, E3 - EGP
       N1 - OSPF external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 2, L1 - OSPF external type 2, ia - IS-IS inter area
       * - candidate default, U - user per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

  7.0.0.0/32 is subnetted, 1 subnets
O 7.7.7.0 [110/0] via 192.7.37.13, 00:00:19, FastEthernet0/0
  192.7.37.0/24 [110/0] via 192.7.37.13, 00:00:19, FastEthernet0/0
O 192.7.37.0 [110/67] via 192.7.37.13, 00:11:30, FastEthernet0/0
O 192.7.37.4 [110/67] via 192.7.37.13, 00:11:30, FastEthernet0/0
C 192.7.37.8 is directly connected, Serial1/2
O 192.7.37.12 is directly connected, FastEthernet0/0
O 192.7.37.13 is directly connected, FastEthernet0/0
O 192.7.37.20 [110/4] via 192.7.37.13, 00:08:32, FastEthernet0/0
O 192.7.37.24 [110/66] via 192.7.37.13, 00:11:30, FastEthernet0/0
O 192.7.37.38 [110/3] via 192.7.37.13, 00:11:30, FastEthernet0/0
O 192.7.37.40 is directly connected, Serial1/0
O 192.7.37.41 [110/2] via 192.7.37.13, 00:08:30, FastEthernet0/0
O 192.7.37.44 [110/3] via 192.7.37.13, 00:11:30, FastEthernet0/0

Router#
```



Figure 4- 10: Routing table after OSPF for router4

```

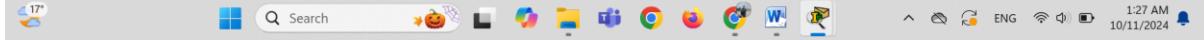
Router>en
Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2, 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

7.0.0.0/32 is subnetted, 1 subnets
o 7.7.7.7 [110/3] via 192.7.37.41, 00:03:59, FastEthernet0/0
  192.7.37.0/30 is subnetted, 12 subnets
o 192.7.37.0 [110/31] via 192.7.37.41, 00:15:15, FastEthernet0/0
o 192.7.37.4 [110/66] via 192.7.37.41, 00:15:15, FastEthernet0/0
o 192.7.37.8 [110/65] via 192.7.37.14, 00:15:05, FastEthernet1/0
c 192.7.37.12 is directly connected, FastEthernet1/0
c 192.7.37.16 is directly connected, Serial2/0
c 192.7.37.20 [110/31] via 192.7.37.41, 00:12:17, FastEthernet0/0
o 192.7.37.24 [110/65] via 192.7.37.41, 00:15:15, FastEthernet0/0
o 192.7.37.28 [110/3] via 192.7.37.41, 00:15:15, FastEthernet0/0
o 192.7.37.32 [110/2] via 192.7.37.41, 00:15:15, FastEthernet0/0
o 192.7.37.36 [110/65] via 192.7.37.41, 00:15:05, FastEthernet0/0
c 192.7.37.40 [110/65] via 192.7.37.14, 00:15:05, FastEthernet1/0
o 192.7.37.44 [110/2] via 192.7.37.41, 00:15:15, FastEthernet0/0
Router#

```

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**Figure 4- 11:Routing table after OSPF for router5**

```

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

7.0.0.0/24 is subnetted, 1 subnets
C 7.7.7.0 is directly connected, Loopback0
  192.7.37.0/24 is subnetted, 12 subnets
o 192.7.37.0 [110/65] via 192.7.37.21, 00:08:51, FastEthernet0/0
o 192.7.37.4 [110/66] via 192.7.37.46, 00:08:18, FastEthernet4/0
o 192.7.37.8 [110/66] via 192.7.37.46, 00:08:18, FastEthernet4/0
o 192.7.37.12 [110/3] via 192.7.37.46, 00:08:18, FastEthernet4/0
c 192.7.37.16 is directly connected, FastEthernet0/0
o 192.7.37.24 [110/65] via 192.7.37.21, 00:08:18, FastEthernet0/0
o 192.7.37.28 [110/65] via 192.7.37.46, 00:08:18, FastEthernet4/0
o 192.7.37.32 [110/2] via 192.7.37.46, 00:08:18, FastEthernet4/0
o 192.7.37.36 [110/65] via 192.7.37.46, 00:08:18, FastEthernet4/0
o 192.7.37.40 [110/2] via 192.7.37.46, 00:08:18, FastEthernet4/0
c 192.7.37.44 is directly connected, FastEthernet4/0
Router#
Router#
Router#

```

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**Figure 4- 12:Routing table after OSPF for router6**

#### 4.2.4 requirement 4:

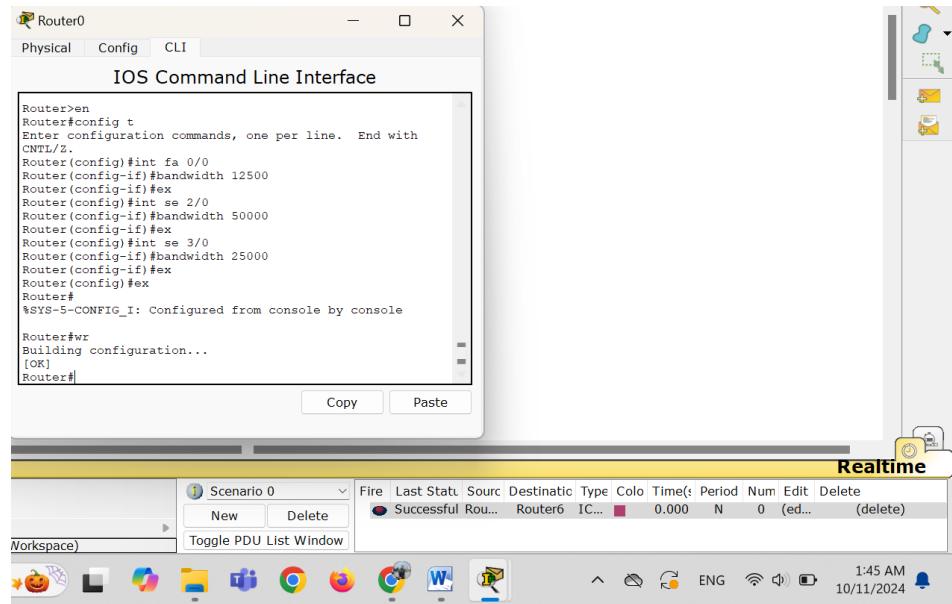
Don't forget to configure bandwidth values between links. These values should reflect the costs that are shown in the network diagram

To find interface bandwidth we should use this row → cost =  $\frac{\text{refrence bandwidth}=100Mbps}{\text{interface bandwidth}}$

**Table 4-2:Cost and Bandwidth**

Cost	Bandwidth
2	50000 MBPS
4	25000 MBPS
8	12500 MBPS
20	5000 MBPS
50	2000 MBPS
100	1000 MBPS

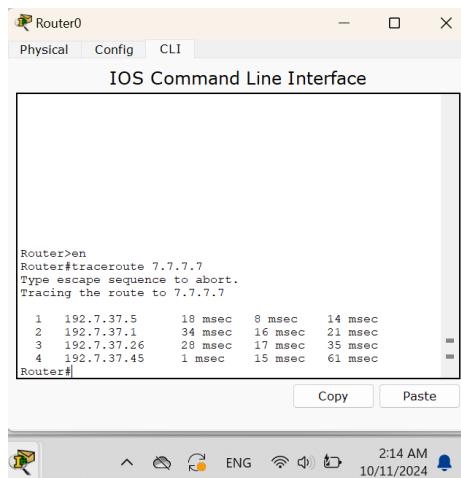
And the figure below show how to do it for router0 , in same step but with different bandwidth are done for all routers:



**Figure 4-13:set Bandwidth for interfaces in router0**

#### 4.2.5 requirement 5:

If a packet is sent from Router 0 to Router 7 (i.e. loopback 7.7.7.7). What routers it passes through until it reaches its destination? Use the traceroute command to test that.



**Figure 4-14:traceroute (send packet from router0 to router 6)**

The path is exactly the one that I found in part 1 which is :

R0→R1→R2→R3→R6

#### 4.2.6 requirement 6:

Run the show IP route command on Router 0. From the output result. What is the cost (metric) to get from Router 0 to Router 6? Explain that.

The screenshot shows the Cisco IOS Command Line Interface (CLI) window titled "Router0". The "Physical" tab is selected. The main pane displays the output of the "show ip route" command. The output shows the routing table with various routes learned via OSPF (1), static routes (o), and direct connections (c). The route to 192.7.37.44 [110/8] is highlighted in yellow, indicating it is the path from Router 0 to Router 6. The cost (metric) for this route is 8. The bottom status bar shows the time as 2:23 AM and the date as 10/11/2024.

```
Router>en
Router#traceroute 7.7.7.7
Type escape sequence to abort.
Tracing the route to 7.7.7.7

 1  192.7.37.5      18 msec   8 msec   14 msec
 2  192.7.37.1      34 msec   16 msec   21 msec
 3  192.7.37.26     28 msec   17 msec   35 msec
 4  192.7.37.45     1 msec    15 msec   61 msec

Router#show ip route
Codes: * - candidate default, S - static, I - ISGRP, 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

    7.0.0.0/32 is subnetted, 1 subnets
o    7.7.7.7 [110/9] via 192.7.37.5, 00:08:52, Serial2/0
  192.7.37.0/30 is subnetted, 12 subnets
o    192.7.37.0 [110/4] via 192.7.37.5, 00:17:49, Serial2/0
c    192.7.37.4 is directly connected, Serial2/0
c    192.7.37.8 is directly connected, Serial2/0
c    192.7.37.12 [110/12] via 192.7.37.10, 00:08:52, Serial3/0
o    192.7.37.16 [110/16] via 192.7.37.5, 00:08:46, Serial2/0
o    192.7.37.20 [110/104] via 192.7.37.5, 00:04:38, Serial2/0
o    192.7.37.24 [110/6] via 192.7.37.5, 00:11:41, Serial2/0
o    192.7.37.28 [110/52] via 192.7.37.5, 00:14:31, Serial2/0
c    192.7.37.32 is directly connected, FastEthernet0/0
o    192.7.37.36 [110/8] via 192.7.37.10, 00:09:02, Serial13/0
o    192.7.37.40 [110/26] via 192.7.37.5, 00:07:01, Serial2/0
o    192.7.37.44 [110/8] via 192.7.37.5, 00:08:52, Serial2/0

Router#
Router#
```

Figure 4- 15:the cost (metric) to get from router0 to router6 from rouuting table for router0

The cost (metric) in OSPF is B in [A/B]

The cost to get from router0 to router6 is 8 which found from 192.7.37.44 [110/8] where 110 is AD for OSPF and 8 is the cost which equal to the one that I found in part1.

#### 4.2.7 requirement 7:

What is the router-id for Router 0, and Router 6? Verify your answers

To find the router-id we use command **show ip protocols** in privilege mode.

The screenshot shows the Cisco IOS Command Line Interface (CLI) window titled "Router0". The "Physical" tab is selected. The main pane displays the output of the "show ip protocols" command. The output shows that the routing protocol is OSPF version 1 (ospf 1). It lists the Router ID as 192.7.37.34 and the number of areas in the router as 1. The Routing Information Sources table shows the metrics for various routes. The bottom status bar shows the time as 2:29 AM and the date as 10/11/2024.

```
Router#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.7.37.34
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.7.37.4 0.0.0.3 area 0
    192.7.37.8 0.0.0.3 area 0
    192.7.37.32 0.0.0.3 area 0
  Routing Information Sources:
    Gateway        Distance      Last Update
    192.7.37.25    110          00:17:29
    192.7.37.29    110          00:23:22
    192.7.37.34    110          00:25:34
    192.7.37.38    110          00:14:55
    192.7.37.42    110          00:12:37
    192.7.37.45    110          00:10:21
    192.7.37.46    110          00:19:31
  Distance: (default is 110)

Router#
```

Figure 4- 16:Find router-id for router0

Router-id for router0 → 192.7.37.34 which is the highest IP for the physical interface in router0

-for Router6 which it have loopback so the router-id must be the highest IP in loopbacks

```

Router(config)#
Router(config)#
Router(config)#do show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 7.7.7.7
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.7.37.20 0.0.0.3 area 0
    192.7.37.16 0.0.0.3 area 0
    192.7.37.44 0.0.0.3 area 0
    7.7.7.0 0.0.0.255 area 0
  Routing Information Sources:
    Gateway          Distance      Last Update
    7.7.7.7           110          00:05:06
    192.7.37.25       110          00:05:08
    192.7.37.29       110          00:19:21
    192.7.37.34       110          00:21:34
    192.7.37.38       110          00:10:54
    192.7.37.42       110          00:05:06
    192.7.37.45       110          00:06:22
    192.7.37.46       110          00:05:07
  Distance: (default is 110)
Router(config)#

```

Figure 4- 17:Find router-id for router6

Router-id for router6 → 7.7.7.7

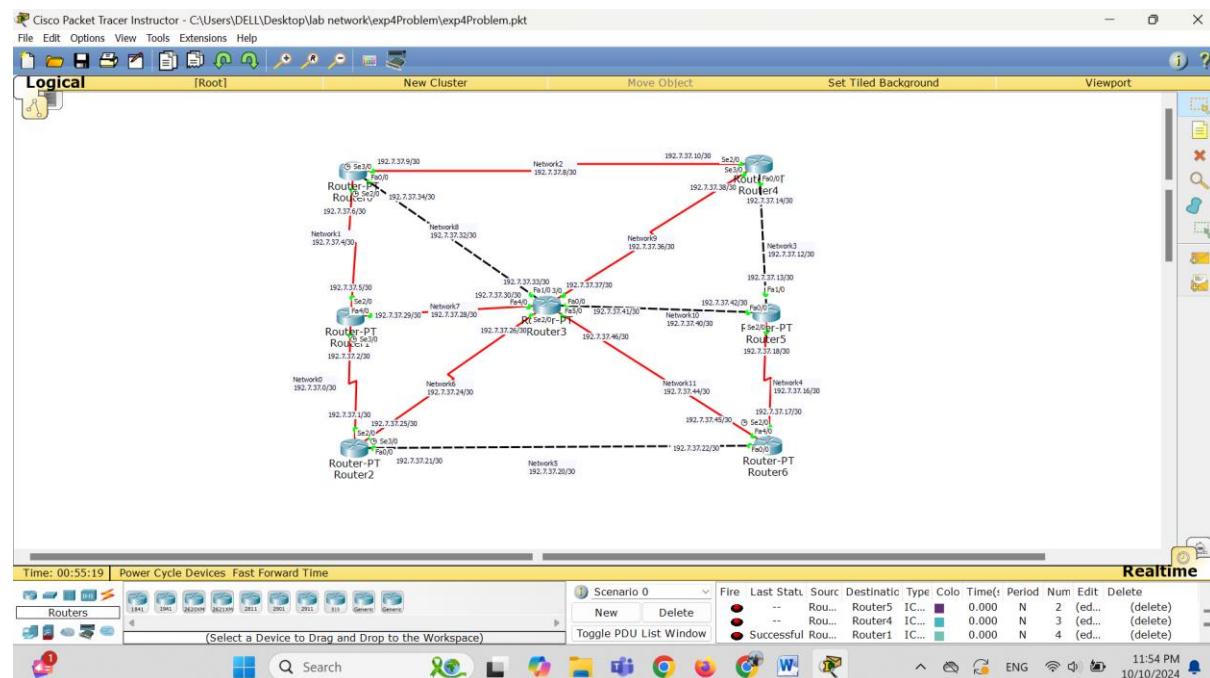


Figure 4- 18:Final topology

## **5. Conclusion**

In this experiment, I successfully built a network topology and applied essential networking concepts such as loopback interfaces, route summarization, and OSPF configuration. By working with the OSPF routing protocol, I gained a comprehensive understanding of its significance in dynamic routing within an autonomous system. Additionally, I explored router IDs and their impact on network communication, as well as the practical importance of adjusting cost metrics for optimal routing. Through hands-on tasks like configuring OSPF and calculating routing paths with Dijkstra's algorithm, this experiment reinforced key theoretical principles and demonstrated their application in real-world networking scenarios. The integration of these concepts not only optimized network efficiency but also enhanced our understanding of large-scale network management.

## **6. Feedback**

This experiment was helpful in learning how the OSPF routing protocol works and how to set it up. Using Cisco Packet Tracer made it easier to understand the concepts by actually building and testing the network. The steps were clear, and the time given for the experiment was just right to complete everything without feeling rushed. Overall, it was a good learning experience and helped to understand dynamic routing better.

## 7. References

- [1] [https://www.benocs.com/glossary/igp/#:~:text=An%20Interior%20Gateway%20Protocol%20\(IGP,exchange%20information%20about%20IP%20routes](https://www.benocs.com/glossary/igp/#:~:text=An%20Interior%20Gateway%20Protocol%20(IGP,exchange%20information%20about%20IP%20routes). [Accessed in 11/10/2024 at 16:06]
- [2] <https://www.ibm.com/docs/en/i/7.4?topic=routing-open-shortest-path-first> [Accessed in 11/10/2024 at 16:29]
- [3] <https://networklessons.com/rip/introduction-route-summarization> [Accessed in 11/10/2024 at 16:57]
- [4] [https://en.wikipedia.org/wiki/Hierarchical\\_routing](https://en.wikipedia.org/wiki/Hierarchical_routing) [Accessed in 11/10/2024 at 18:03]
- [5] <https://www.cisco.com/c/en/us/support/docs/ip/open-shortest-path-first-ospf/13685-13.html> [Accessed in 11/10/2024 at 18:11]
- [6] <https://study-ccna.com/ospf-configuration/> [Accessed in 11/10/2024 at 18:25]
- [7] <https://networklessons.com/ospf/ospf-router-id> [Accessed in 11/10/2024 at 18:46]
- [8] [https://support.hpe.com/techhub/eginfolib/networking/docs/switches/common/15-18/5998-8158\\_bog/content/ch06s03.html](https://support.hpe.com/techhub/eginfolib/networking/docs/switches/common/15-18/5998-8158_bog/content/ch06s03.html) [Accessed in 11/10/2024 at 20:37]
- [9] Lab Manual