universidade de aveiro
theoria poiesis praxis

Arquitetura de Redes

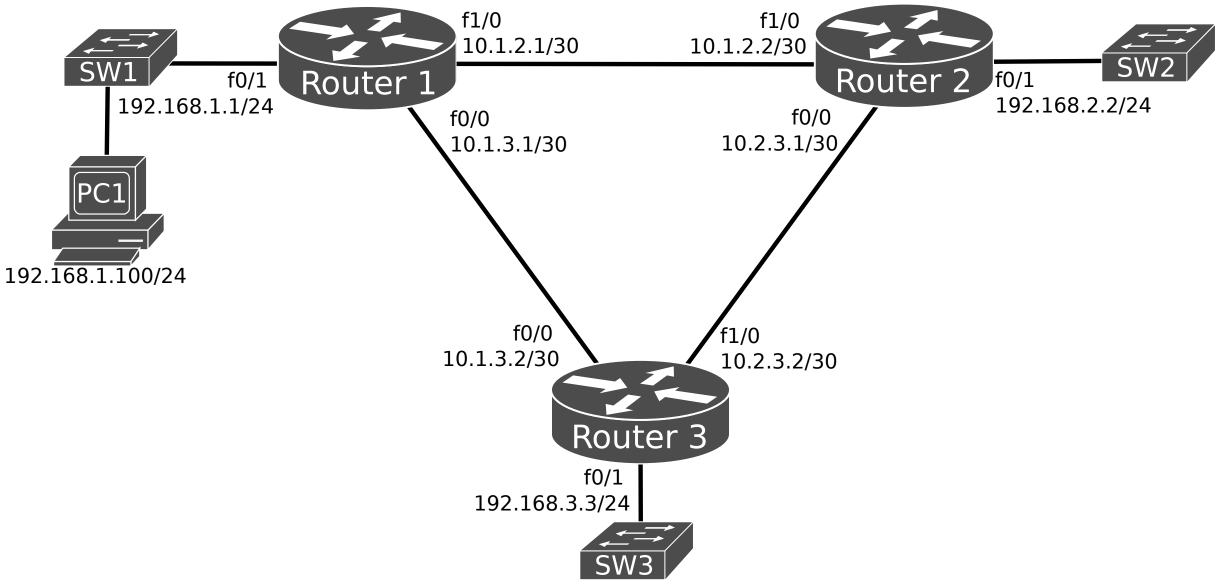
Laboratory Guide

Objectives

- Study of the IPv4 and IPv6 internal routing protocols and mechanisms.
  - OSPFv2
  - OSPFv3
- Default routes.
- Route redistribution between different routing processes.

IPv4 Internal Routing

OSPFv2 with a Single Area



1. Set up a network including 3 routers interconnected by Ethernet networks as specified in the previous figure. Configure the IP addresses of the router interfaces. Verify the configured interfaces and IPv4 routing table with the commands:

```
Router# show ip route
Router# show ip interface brief
```

2. Configure the OSPF protocol (IPv4) **in all routers** in such a way that all networks belong to a single area (area 0). Register sequence of routers that you used in configuring OSPF (this information will be used in the next experience). In Router 1:

```
Router1(config)# router ospf 1
Router1(config-router)# network 10.0.0.0 0.255.255.255 area 0
                                      !Activates OSPFv2 for all 10.0.0.0/8 subnets.
                                      !Uses wildcard mask (binary inverted mask)
                                      !      255.0.0.0 → 0.255.255.255
Router1(config-router)# network 192.168.1.0 0.0.0.255 area 0
                                      !      255.255.255.0 → 0.0.0.255
```

Wait a few seconds to OSPFv2 converge. Analyse and justify the routing table of all routers.

3. Verify if all IP addresses can be reached from Router 2. Using the commands:

```
Router# show ip ospf
Router# show ip ospf interface
Router# show ip ospf interface brief
Router# show ip ospf neighbor
Router# show ip ospf neighbor detail
```

verify the OSPF router IDs, identify the DR and BDR of each LAN, and if the cost values assigned by default to each interface agree with the costs of the routing table paths. Explain the choice of DR/BDR.

4. Save all configurations, stop the routers, and restart all routers. Re-verify the OSPF router IDs and re-identify the DR and BDR of each LAN. Explain the differences on the choice of DR/BDR.
Manually define OSPF router IDs:

```
Router1(config)# router ospf 1
Router1(config-router)# router-id 1.1.1.1
--
Router2(config)# router ospf 1
Router2(config-router)# router-id 2.2.2.2
--
Router3(config)# router ospf 1
Router3(config-router)# router-id 3.3.3.3
```

Save all configurations, stop the routers, and restart all routers. Re-verify the OSPF router IDs and re-identify the DR and BDR of each LAN. Explain the differences (if any) on the choice of DR/BDR.

5. Start a capture on link Router1-Router3. In order to verify the bootstrap process of OSPF, reset the OSPFv2 process in Router1 with the command:

```
Router1# clear ip ospf 1 process
```

Analyze the exchanged OSPFv2 packets (with emphasis on the LS types) and explain their contents.
Wait for 1 minute and shutdown the FastEthernet0/1 interface on Router1 (SW1 network). Wait for 1 minute and reactivate (`no shutdown`) the interface on Router1. Analyze the exchanged OSPFv2 packets.

6. Analyze the *Router Link States* and *Network Link States* database information. To view the OSPF databases use the commands:

```
show ip ospf database                 !for a database summary
show ip ospf database router          !for the  Router Link States
show ip ospf database network         !for Network Link States
```

Identify all network topology elements within OSPF database. Compare the contents of the OSPF database with the contents of the observed OSPF LS Update packets.

7. Configure PC1 IPv4 address and default gateway with the address of the appropriate Router1 interface. Start a new capture in the network 10.1.3.0/24 and configure the OSPF costs of the router interfaces in such a way that, when executing a ping command from the PC1 to Router2's f0/1 interface, the ICMP Echo Request and ICMP Echo Reply packets always follow a counterclockwise path (R1-R3-R2 and R2-R1). Register and justify your procedure. Use the following commands to adjust the interfaces' OSPF costs:

```
Router(config)# interface FastEthernet 0/1
Router(config-if)# ip ospf cost x      !for an OSPF cost of x
```

Confirm the correct implementation of your solution by checking the routing tables. Analyze the captured OSPF packets during the network changes.

8. Re-adjust the OSPF interfaces costs in order to have two equal costs paths from Router1 to network 192.168.2.0/24. Confirm the correct implementation of your solution by checking the routing tables and performing a trace route from Router1: `Router1# traceroute 192.168.2.2`

9. OSPF can be activated by network or by interface. Remove network commands from OSPF configuration:

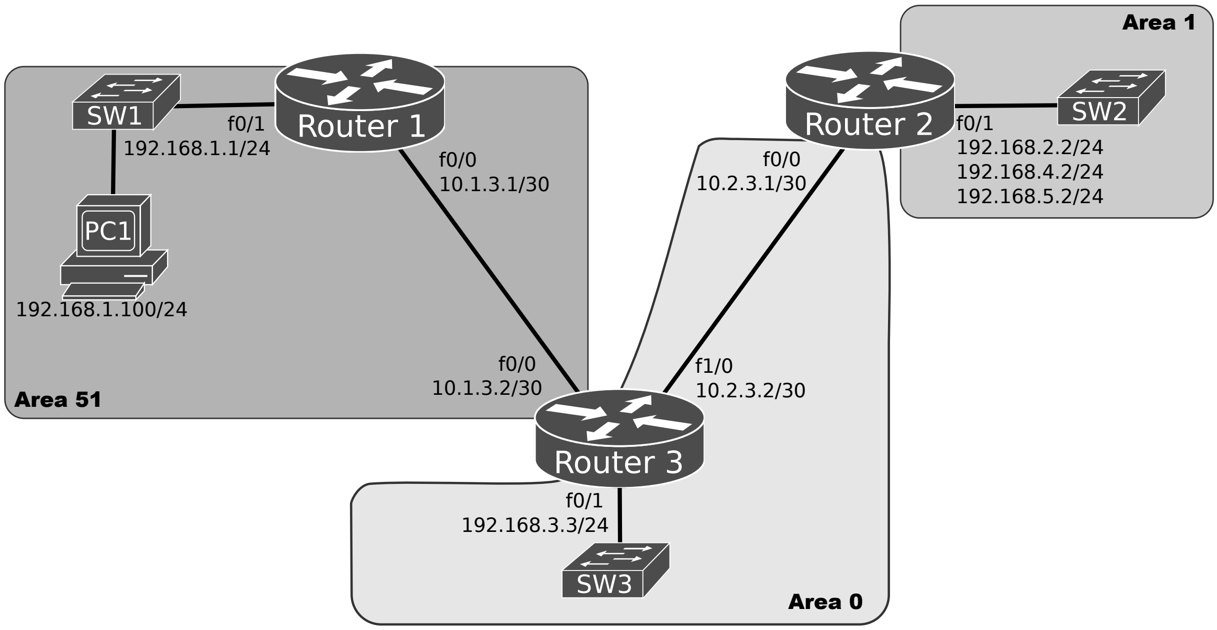
```
Router1(config)# router ospf 1
Router1(config-router)# no network 10.0.0.0 0.255.255.255 area 0
Router1(config-router)# no network 192.168.10.0 0.0.0.255 area 0
```

Analyze all routing tables. Activate OSPF in <u>all</u> interfaces. E.g.:

```
Router(config)# interface FastEthernet 0/0
Router(config-if)# ip ospf 1 area 0
```

Confirm the correct activation of OSPF by interfaces by analyzing all routing tables.

OSPFv2 with Multiple Areas



10. Reconfigure the network according to the above figure:
- Remove the network 10.1.2.0/30.
- Keep networks 10.2.3.0/30 and 192.168.3.0/24 as area 0:
- Redefine network 192.168.2.0/24 as area 1, and add two subnetworks in Router1 as area 1:

```
Router2(config)# interface FastEthernet 0/1
Router2(config-if)# ip address 192.168.4.2 255.255.255.0 secondary
Router2(config-if)# ip address 192.168.5.2 255.255.255.0 secondary
Router2(config-if)# ip ospf 1 area 1
```

- Redefine networks 10.1.3.0/30 and 192.168.1.0/24 as area 51:

```
Router3(config)# interface FastEthernet 0/0
Router3(config-if)# ip ospf 1 area 51
---
Router1(config)# interface FastEthernet 0/0
Router1(config-if)# ip ospf 1 area 51
Router1(config)# interface FastEthernet 0/1
Router1(config-if)# ip ospf 1 area 51
```

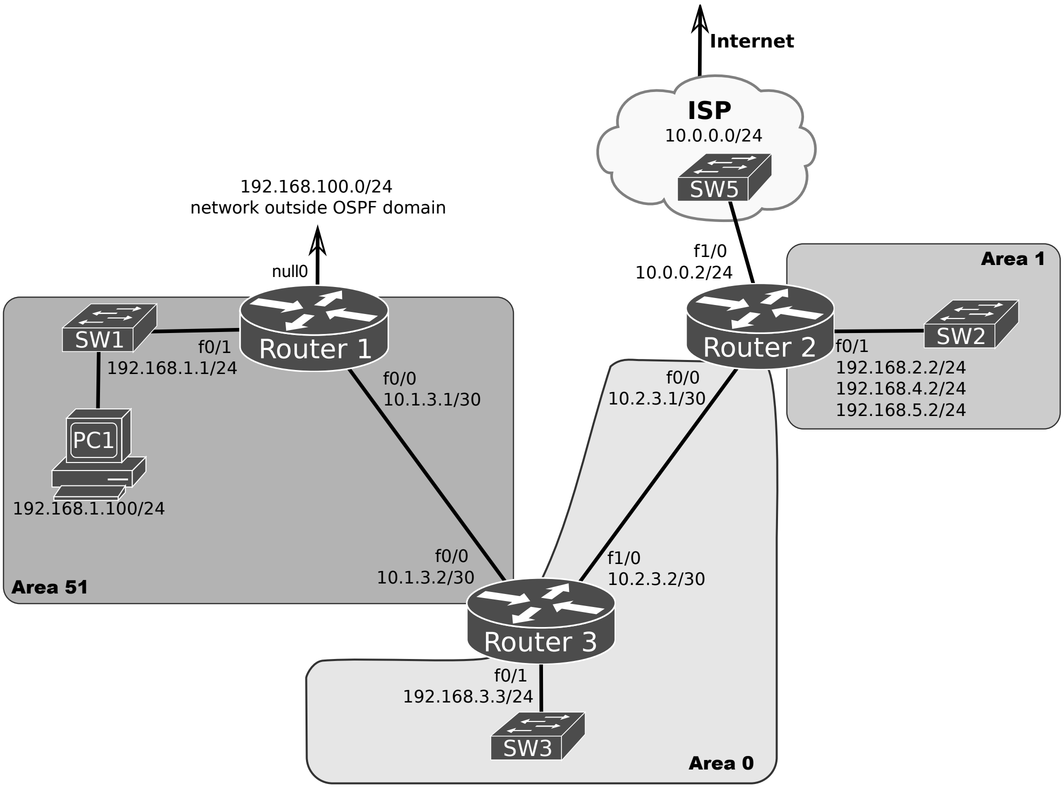
Re-verify the routing tables and re-analyze the OSPF database including the *Summary Net Link States* information with the command: `show ip ospf database summary` .
Explain the contents of the database link states, and the advantages/disadvantages of using multiple OSPF areas.

11. Configure Router2 to summarize the networks for Area 1 and advertise this summary route to Area 0 by issuing the following commands:

```
Router2(config)# router ospf 1
Router2(config-router)# area 1 range 192.168.4.0 255.255.254.0
```

Re-verify the routing tables of Router1 and Router3 and explain the obtained results.

OSPFv2 External Routes Redistribution



12. Configure an external route from Router1 to outside the OSPF domain (using the null0 interface for testing purposes) and redistribute it into the OSPF process. Simulate the Router1 connection to the outside LAN 192.168.100.0/24 by configuring a static route using the following command:

```
Router1(config)# ip route 192.168.100.0 255.255.255.0 null0
```

Configure Router1 to redistribute static routes into the OSPF process using the following commands:

```
Router1(config)# router ospf 1
Router1(config-router)# redistribute static subnets
                                !subnets - forces the redistribution of classless networks
```

By using the `show ip ospf` command verify what type of OSPF routers are Router1, Router2 and Router3. Re-verify the routing tables of Router2 and Router3 and explain the results obtained, particularly their Type 2 (E2) routes. Do they have the same cost? How can you interpret that since both paths are different?

13. On Router1 configure the static routes redistribution as Type 1 (E1) routes, using the following commands:

```
Router1(config)# router ospf 1
Router1(config-router)# redistribute static subnets metric-type 1
```

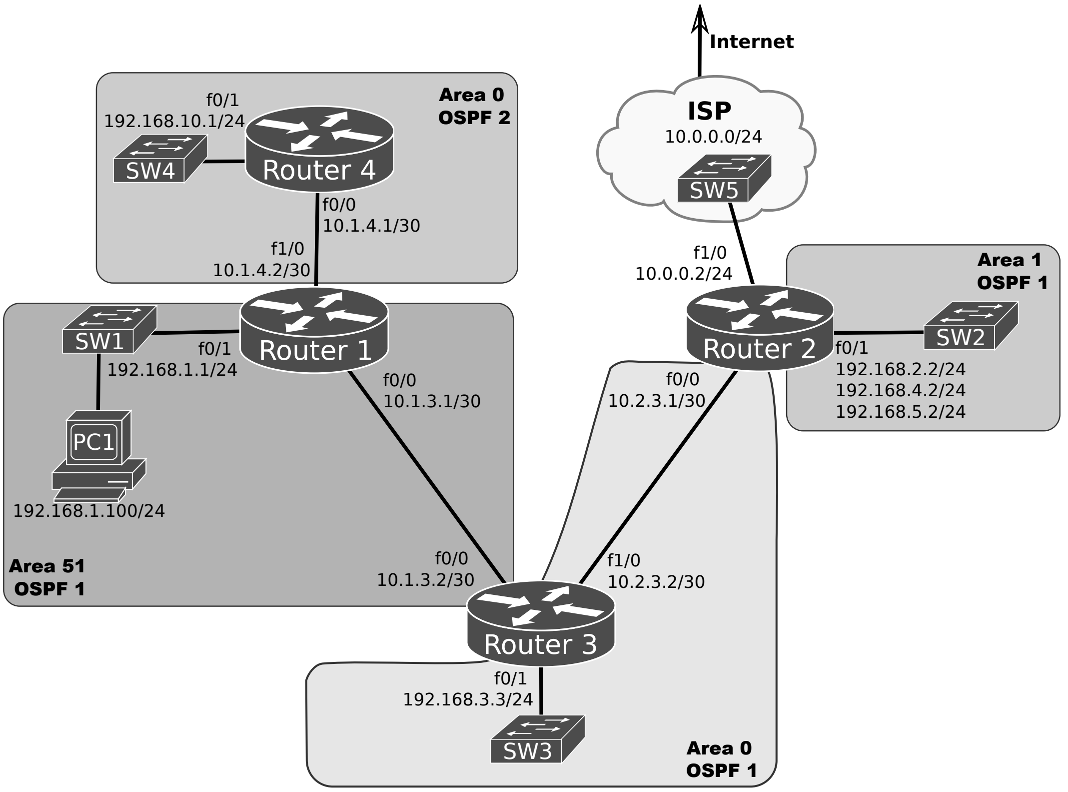
Re-verify again the routing tables of Router2 and Router3. What are the new metrics for this route? Explain the different results.

14. On Router2, configure another interface that simulate Internet connectivity via an ISP (previous figure). Create and advertise a default route using the following commands:

```
Router2(config)# interface FastEthernet 1/0
Router2(config-if)# ip address 10.0.0.2 255.255.255.0
Router2(config)# router ospf 1
Router2(config-router)# default-information originate always
```

Check the routing tables on Router1 and Router3 and explain what type of OSPF route has been added and what its metric is. At PC1, confirm that the default route is working properly by performing a ping to 10.0.0.2.

External Routing Process Redistribution



15. Add and connect a new router (Router 4) as depicted in the previous figure. Configure the IPv4 addresses and a second OSPF process (process 2) in Router 4 and Router 1:

```
Router1(config)# router ospf 2
Router1(config-router)# router-id 1.1.1.2          !ID must be different from process 1
Router1(config)# interface FastEthernet 1/0
Router1(config-if)# ip ospf 2 area 0
-
Router4(config)# router ospf 2
Router4(config-router)# router-id 4.4.4.4
Router4(config)# interface FastEthernet 0/0
Router4(config-if)# ip ospf 2 area 0
Router4(config)# interface FastEthernet 0/1
Router4(config-if)# ip ospf 2 area 0
```

Analise the routing tables of all routers. Explain why Router 2 and Router 3 do not learned the network 192.168.10.0/24 (SW4 network), and why Router 4 only knows the directly connected networks.

16. Configure Router 1 do redistribute the networks learned from OSPFv2 process 2 into OSPFv2 process1:

```
Router1(config)# router ospf 1
Router1(config-router)# redistribute ospf 2 subnets
```

Analise the routing tables of all routers. Verify that Router 2 and Router 3 learned the networks 192.168.10.0/24 (SW4 network) and 10.1.4.0/30, and explain why Router 4 still does not know the remote networks.

17. <u>Bi-directional redistributions should be avoided</u>, therefore, to allow full connectivity configure Router 1 to announce a default route (0.0.0.0/0) to Router 4 using OSPFv3 process 2.

```
Router1(config)# router ospf 2
Router1(config-router)# default-information originate always
```

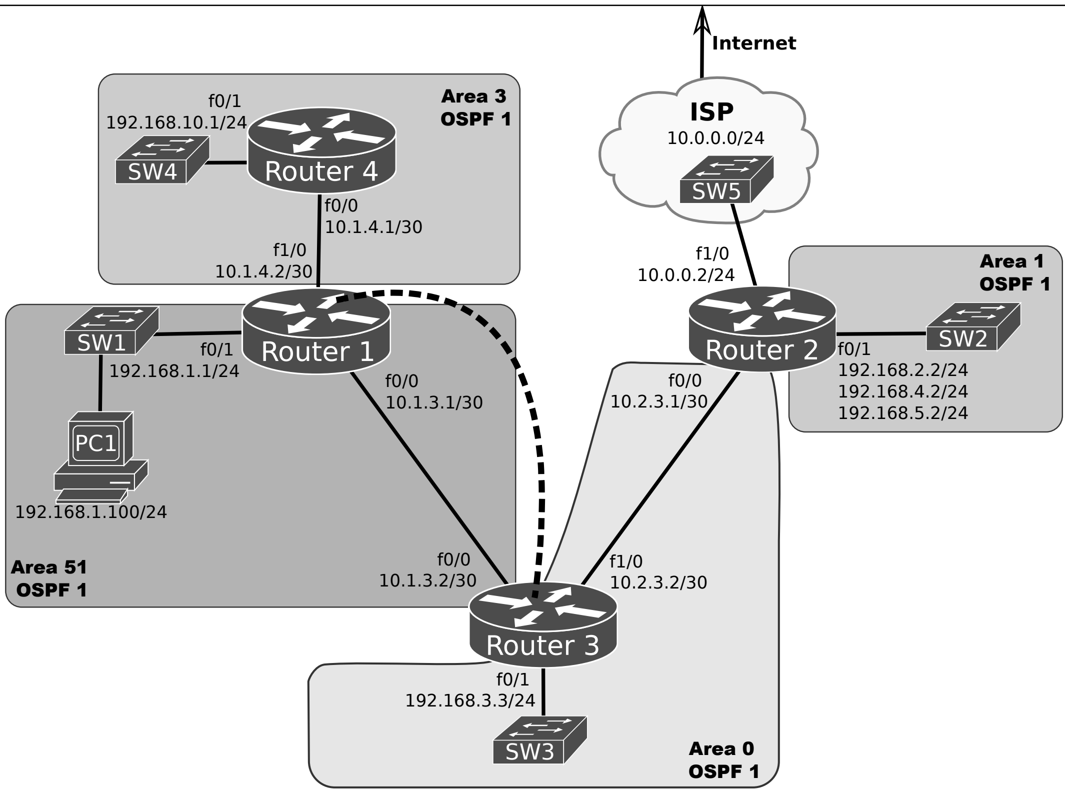
Analise the routing tables of all routers. Test and explain how full connectivity was chieved.

OSPFv2 Area Virtual Links

18. Remove OSPFv2 process from Router 1 and Router 4.

```
Router1(config)# no router ospf 2
-
Router4(config)# no router ospf 2
```

Reconfigure OSPFv2 process 1 to include networks 192.168.10.0/24 (SW4 network) and 10.1.4.0/30 as area 3. Check the routing table at Router 4. Does it contain any OSPF routes? Why? Using the `show ip ospf neighbor` command, verify that Router1 and Router4 established successful adjacencies between them.



19. To enable full connectivity (Area3 must have a direct virtual connection to Area0), configure a virtual link between Router 1 and Router 3 (Router 1 is the ABR for Area 3 and Router 3 is the ABR for Area 0, therefore, the transit area between Area 3 and Area 0 will be Area 51) using the following configuration commands:

```
Router1(config)# router ospf 1
outer1(config-router)# area 51 virtual-link <Router3_ID>
```

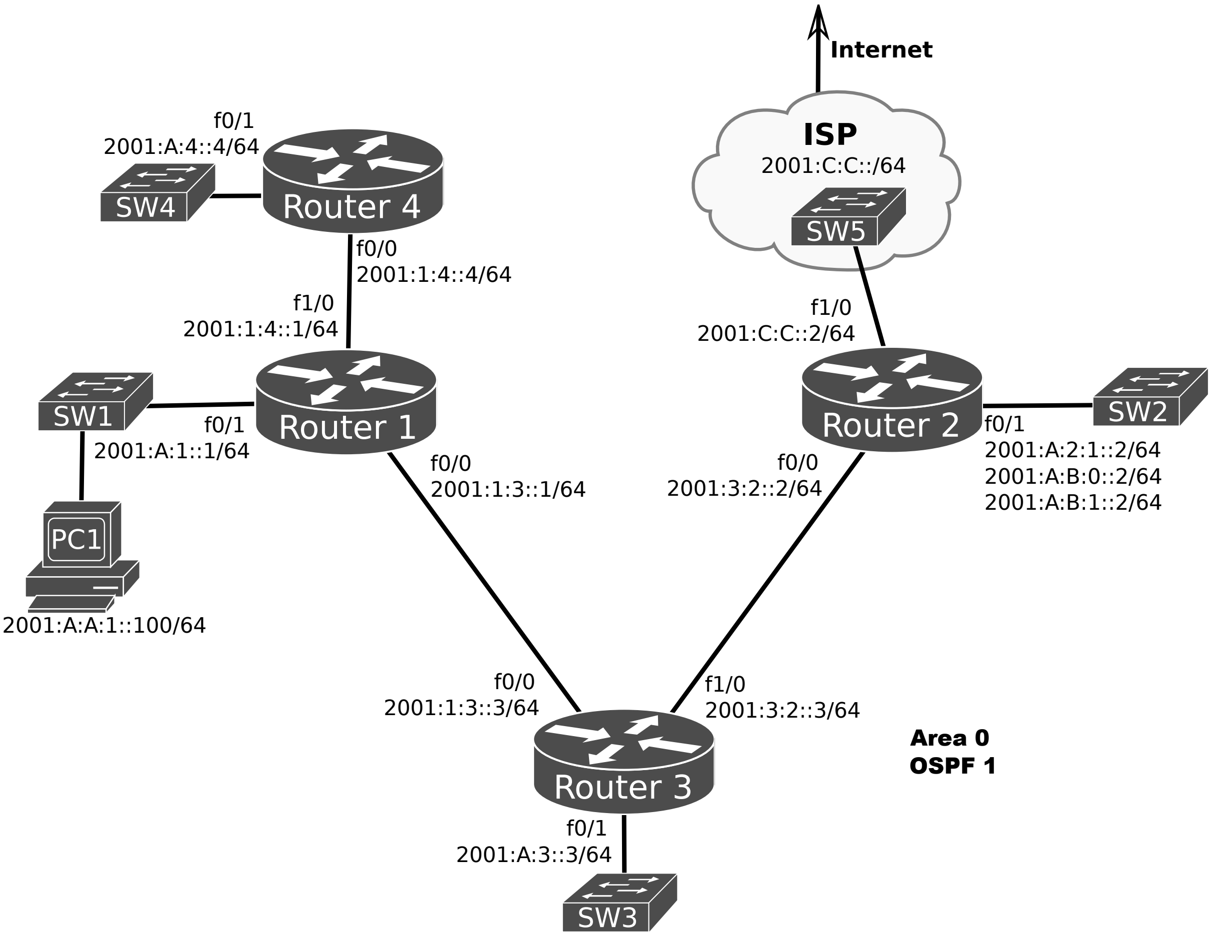
Note that Router 3 must be identified by its router ID.

```
Router3(config)# router ospf 1
Router3(config-router)# area 51 virtual-link <Router1_ID>
```

Using `show ip ospf virtual-links` command on Router1, verify the state of the virtual link.
Re-verify all routing tables and confirm full connectivity.

IPv6 Internal Routing

OSPFv3 with a Single Area



20. Configure all IPv6 addresses on router interfaces. Activate OSPFv3 (process number 1) in all routers and interfaces (<u>consider a single area - Area0</u>):

```
Router1(config)#ipv6 router ospf 1          !The process identifier can be any string
Router1(config-rtr)# router-id <n.n.n.n>          !Manually define OSPFv3 RID
Router1(config)# interface <if-name>
Router1(config-if)# ipv6 ospf 1 area 0
```

Verify and analyze the OSPFv3 database information in routers:

```
show ipv6 ospf 1
show ipv6 ospf 1 database
show ipv6 ospf 1 database network
show ipv6 ospf 1 database router
show ipv6 ospf 1 database prefix        !New OSPFv3 database
```

Verify the routing tables and retest the connectivity between the equipments.

21. Start a capture on link Router1-Router3. In order to verify the bootstrap process of OSPFv3, reset the OSPFv3 process in Router1 with the command:

```
Router1# clear ipv6 ospf 1 process
```

Analyze the exchanged OSPFv3 packets (with emphasis on the LS types) and explain their contents.
Wait for 1 minute and shutdown the FastEthernet0/1 interface on Router1 (SW1 network). Wait for 1 minute and reactivate (`no shutdown`) the interface on Router1. Analyze the exchanged OSPFv3 packets.