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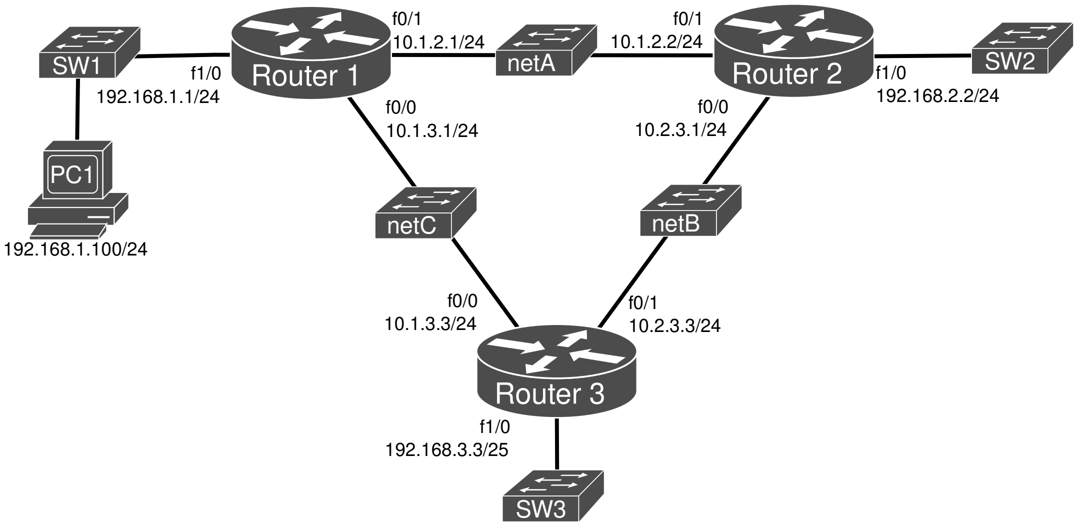
Redes de Comunicações 2

IPv4 Dynamic Routing with RIPv2



1.1 Assemble the above depicted network **using GNS3** and configure all IPv4 addresses. Verify the interfaces' configurations and IPv4 routing tables in all routers:

```
Router1# show ip interface brief
Router1# show ip route
```

>> Analyze the routing tables. **Note that network 192.168.3.0 has mask /25 and the other 192.168.*.0 networks have mask /24.**

1.2. Configure the RIPv1 protocol at all routers. For Router 1, activate RIPv1 in all networks:

```
Router1(config)# router rip
Router1(config-router)# version 1
Router1(config-router)# network 10.1.2.0
Router1(config-router)# network 10.1.3.0
Router1(config-router)# network 192.168.1.0
```

Repeat similar configurations on Routers 2 and 3. Verify that the network has full connectivity.
>> Verify the router configuration RIP section (`show run`) and explain why the `network` command changed.
>> Verify and justify the routing tables obtained at all routers.
>> Explain why network 192.168.3.0/25 appears with the wrong mask in Router 1 and 2.
>> Explain how routers define the network masks of the networks announced with RIPv1.

1.3. **Start a packet capture in all networks** and captured at least 6 RIP packets in each network. Analyze the captured packets
>> Determine the type of RIP packets sent by each router and its periodicity.
>> Determine the IPv4 destination address, transport protocol and port numbers used by RIPv1.
>> Determine if *split-horizon* is being used or not (default setting).
>> Explain how RIPv1 works.

1.4. Change the RIP version to version 2 at all routers. For Router 1:

```
Router1(config)# router rip
Router1(config-router)# version 2
Router1(config-router)# no auto-summary
```

Repeat similar configurations on Routers 2 and 3. Verify that the network has full connectivity.
>> Verify and justify the routing tables obtained at all routers.
>> Explain why all network mask appear correctly in all routing tables.
Note: Cisco routers announce classful networks, the command "no auto-summary" disables that behavior.

1.5. **Start a packet capture in all 10.*.*.0/24 networks (one of the Router-SW connections)** and capture at least 6 RIP packets in each network. Analyze the captured packets
>> Determine the type of RIP packets sent by each router and its periodicity.
>> Determine the IPv4 destination address, transport protocol and port numbers used by RIPv2.
>> Identify the RIP Update packet fields from RIPv2 that were nor present in RIPv1.

>> Determine if *split-horizon* is being used or not (default setting).
>> Explain how RIPv2 works.

1.6. Invert the *split-horizon* configuration at the routers' interfaces that are connected to network A.

To turn *split-horizon* on an interface:

```
Router1(config)# interface F0/0
Router1(config-if)# ip split-horizon
```

To turn *split-horizon* off on an interface:

```
Router1(config)# interface F0/0
Router1(config-if)# no ip split-horizon
```

Capture again at least 6 packets. Analyze the captured packets and compare their content with the packets captured in the previous experiment.

>> Justify the content of RIPv2 packets when *split-horizon* is used and when it is not used.

Restore the *split-horizon* default configuration at the router interfaces connected to network A.

1.7. **Start a packet capture in network A (10.1.2.0/24).** Disable (with command `shutdown`) the interface of Router 1 with network C (10.1.3.0/24).
>> Register and justify the routing tables obtained at all routers.
>> By analyzing the captured packets, explain how RIP protocol propagated the information after the network failure.

1.8. **Start a packet capture in network A (10.1.2.0/24).** Re-enable (with command `no shutdown`) the interface of Router 1 with network C
>> Register and justify the routing tables obtained at all routers.
>> By analyzing the captured packets, explain how RIP protocol propagated the information after the failure recovery.

1.9. Configure at Router1 a static route to network B via Router2:

```
Router1(config)# ip route 10.2.3.0 255.255.255.0 10.1.2.2
```

>> Register and justify the routing tables obtained at all routers.
>> Explain why Router 1 does not have any routes to network B learned with RIP.
>> Explain the importance of the administrative distance metric.

1.10. Re-configure at Router1 the static route to network B via Router2 to have an administrate distance of 200:

```
Router1(config)# no ip route 10.2.3.0 255.255.255.0 10.1.2.2
Router1(config)# ip route 10.2.3.0 255.255.255.0 10.1.2.2 200
```

>> Register and justify the routing tables obtained at all routers.
>> Explain how the administrative distance works.

1.11. **Start a packet capture in all networks (Router-SW connection)** and captured at least 6 RIP packets in each network. Assuming that Router 1 provides Internet connectivity, configure it to announce a default route via RIPv2:

```
Router1(config)# router rip
Router1(config-router)# default-information originate
```

>> Register and justify the routing tables obtained at all routers.
>> Explain how an IPv4 packet destined to a network not known by the routers is routed.
>> Analyze the captured RIPv2 packets and explain how the default route is announced.
Note: the announcement of a default route must be configured only in the router that provides connection to an external routing domain (e.g., Internet).

1.12. **Disable RIP protocol in all routers:**

```
      Router1(config)# no router rip
--
      Router2(config)# no router rip
--
      Router3(config)# no router rip
```

IPv4 Dynamic Routing with OSPFv2

2.1. Activate OSPFv2 protocols (process number 1, single area) in all routers interfaces:

```
Router1(config)# interface F0/0
Router1(config-if)# ip ospf 1 area 0
```

Repeat similar configurations on other interfaces and Routers 2 and 3.
>> Analyze and justify the routing table of all routers.
>> Retest the connectivity between the equipment.

2.2. Run the following commands in all routers:

```
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 each router 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.
Note: DR → Designated Router and BDR→ Backup Designated Router.

2.3. 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.

2.4 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.
>> Explain how the network topology (routers and networks) is propagated, by identifying the LSA Type 1 and Type 2 within the OSPF Update packets.

2.5. 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 the OSPF database.

2.6. Change the OSPF cost of Router2's interface F0/0 to 50:

```
Router2(config)# interface FastEthernet 0/0
Router2(config-if)# ip ospf cost 50
```

>> Analyze and justify the changes in the routing tables of all routers.
>> Analyze the captured OSPF packets during the network changes.

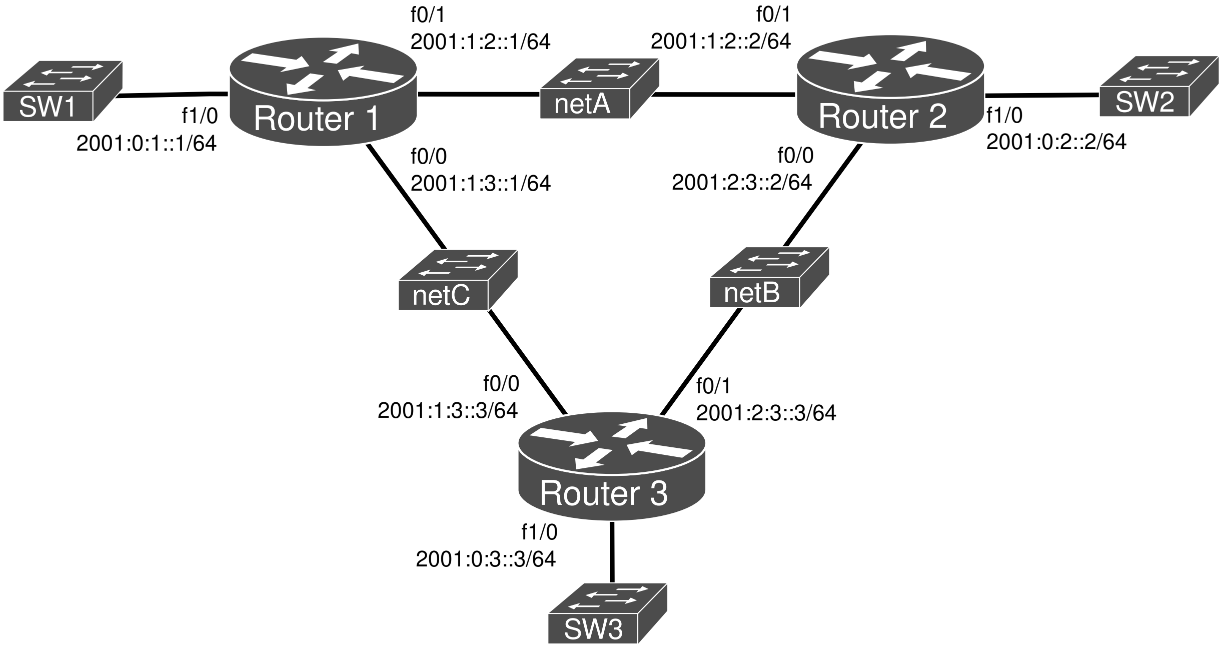
2.7. Configure Router 1 to announce a default IPv4 route:

```
Router1(config)# router ospf 1
Router1(config-router)# default-information originate always
```

>> Re-verify the routing tables and identify the default route being announced by Router1.

>> Explain how the default route is propagated, by identifying the LSA Type 5 within the OSPF Update packets.

IPv6 Dynamic Routing with RIPng



3.1. Configure all IPv6 addresses and activate IPv6 routing with the command:

```
Router1(config)# ipv6 unicast-routing
Router1(config)# int f0/1
Router1(config-if)# ipv6 address 2001:1:2::1/64
...
```

Verify the interfaces' IPv6 addresses and status, routing tables, IPv6 neighbors and running IPv6 protocols:

```
Router1# show ipv6 interface brief
Router1# show ipv6 route
Router1# show ipv6 neighbors
Router1# show ipv6 protocols
```

Start a packet capture in all networks (Router-SW connection), and execute multiple ping commands to test the connectivity between the different equipment's interfaces.
>> Explain the reasons to have connectivity between some interfaces and not others.

3.2. Activate the RIPng protocol (process named proc1) in all routers interfaces:

```
Router1(config)# interface range F0/0 - 1
Router1(config-if-range)# ipv6 rip proc1 enable
Router1(config)# interface F1/0
Router1(config-if)# ipv6 rip proc1 enable
```

Repeat similar configurations on Routers 2 and 3.
Verify also the RIPng information in routers:

```
show ipv6 rip proc1
show ipv6 rip proc1 database
show ipv6 rip proc1 next-hops
```

>> Re-verify the routing tables and retest the connectivity between the network devices.
>> Explain the path cost of each route learned using RIPng. How it is different from RIPv1/v2?

3.3. Change Router 1 interface (F0/0) RIPng cost from 1 to 10, and observed how the routing tables change.

```
Router1(config)# interface range F0/0
Router1(config-if)# ipv6 rip cost 10
```

>> Explain the advantage of using interface costs to calculate the overall cost of a path.

3.4. **Start a packet capture in all networks (Router-SW connection)** and captured at least 6 RIPng packets in each network. Analyze the captured packets
>> Determine the type of RIPng packets sent by each router and its periodicity.
>> Determine the IPv6 source and destination addresses, transport protocol and port numbers used by RIPng.
>> Explain how RIPng works.

3.5. **<u>Start a packet capture in all networks (Router-SW connection)</u>** and disable the *split-horizon* configuration in Router 1.

To turn *split-horizon* off:

```
Router1(config)# ipv6 router rip proc1
Router1(config-rtr)# no split-horizon
```

Capture again at least 6 packets. Analyze the captured packets and compare their content with the packets captured in the previous experiment.

>> Justify the content of RIPng packets when *split-horizon* is used and when it is not used.

<u>Restore the *split-horizon* default configuration in Router 1.</u>

3.6. **<u>Start a packet capture in all networks (Router-SW connection)</u>** and captured at least 6 RIPng packets in each network. Assuming that Router 1 provides Internet connectivity, configure it to announce a default route via RIPng:

```
Router1(config)# interface range F0/0 - 1
Router1(config-if-range)# ipv6 rip proc1 default-information originate
```

>> Register and justify the routing tables obtained at all routers.

>> Explain how an IPv6 packet destined to a network not known by the routers is routed.

>> Analyze the captured RIPng packets and explain how the default route is announced

IPv6 Dynamic Routing with OSPFv3

4.1. Activate OSPFv3 protocols (process number 1, single area) in all routers interfaces:

```
Router1(config)# interface F0/0
Router1(config-if)# ipv6 ospf 1 area 0
```

Repeat similar configurations on other interfaces and Routers 2 and 3.

Analyze also the OSPFv3 information in routers:

```
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
```

>> Re-verify the routing tables and retest the connectivity between the equipment.

>> Compare the structure of OSPFv2 and OSPFv3 databases.

>> Why there no IPv6 references/addresses on the network and router databases?

4.2. 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.

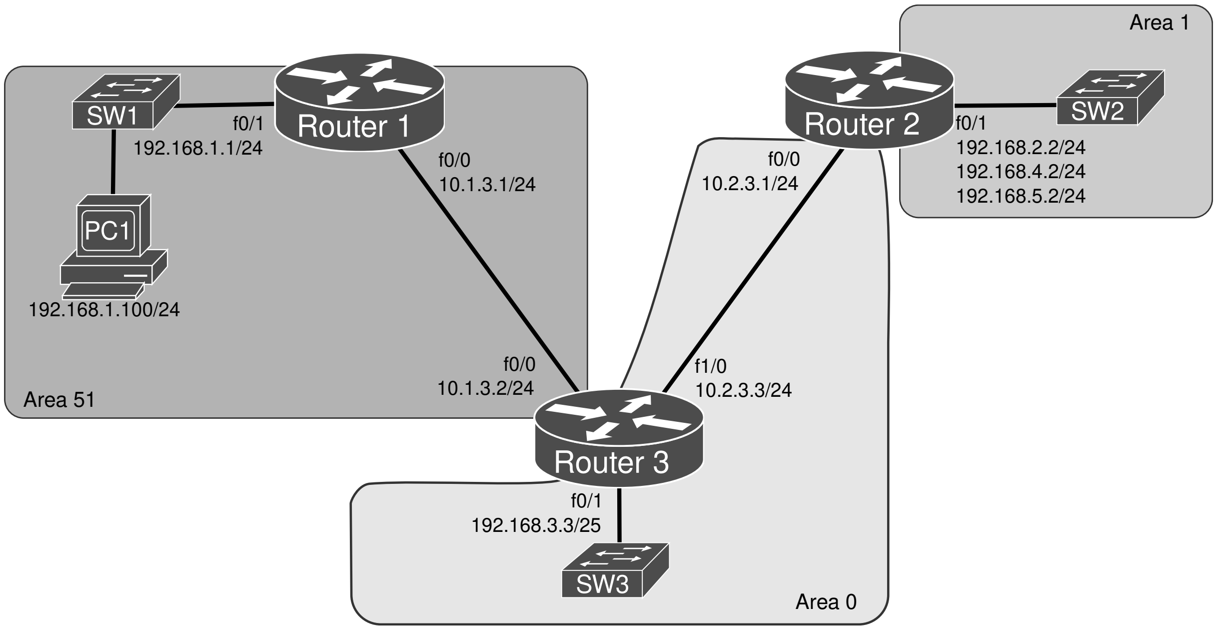
>> Explain how the network topology (routers and networks) is propagated, by identifying the LSA Type 1, Type 2 and the new LSA Type 8 and Type 9 within the OSPF Update packets.

4.3. Configure Router 1 to announce a default IPv6 route:

```
Router1(config)# ipv6 router ospf 1
Router1(config-router)# default-information originate always
```

>> Re-verify the routing tables and identify the default route being announced by Router1.

OSPFv2 with Multiple Areas



5.1. Configure the network according to the above figure:
- Configure networks 10.2.3.0/24 and 192.168.3.0/25 as <u>area 0</u>:
- Configure network 192.168.2.0/24 as <u>area 1</u>, and add two subnetworks in Router2 as <u>area 1</u>:

```
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 10.1.3.0/24 and 192.168.1.0/24 as <u>area 51</u>:

```
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
```

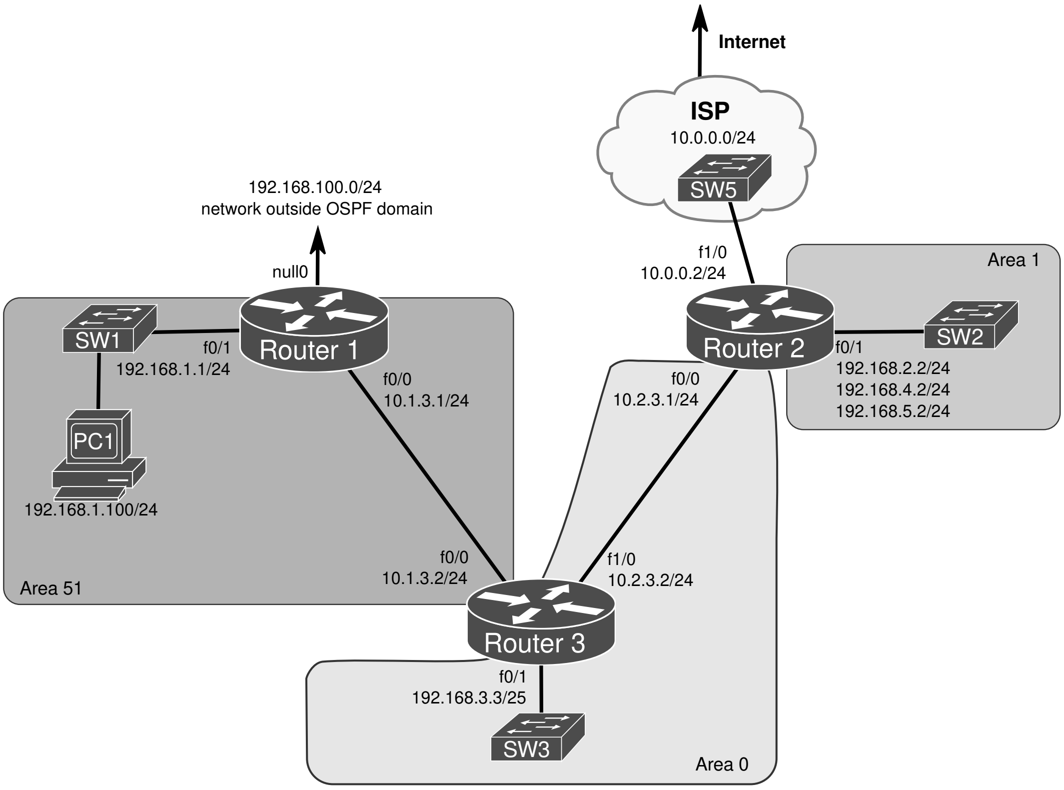
>> Re-verify the routing tables and re-analyze the OSPF database including the *Summary Net Link States* information with the command: `show ip ospf database summary` .
>> Explain how information from different areas is propagated, by identifying the LSA Type 3 within the OSPF Update packets.
>> Explain the contents of the database link states, and the advantages/disadvantages of using multiple OSPF areas.

5.2. 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



6.1. Configure a 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?

>> Explain how the external routes are propagated, by identifying the LSA Type 5 within the OSPF Update packets.

6.2. 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.

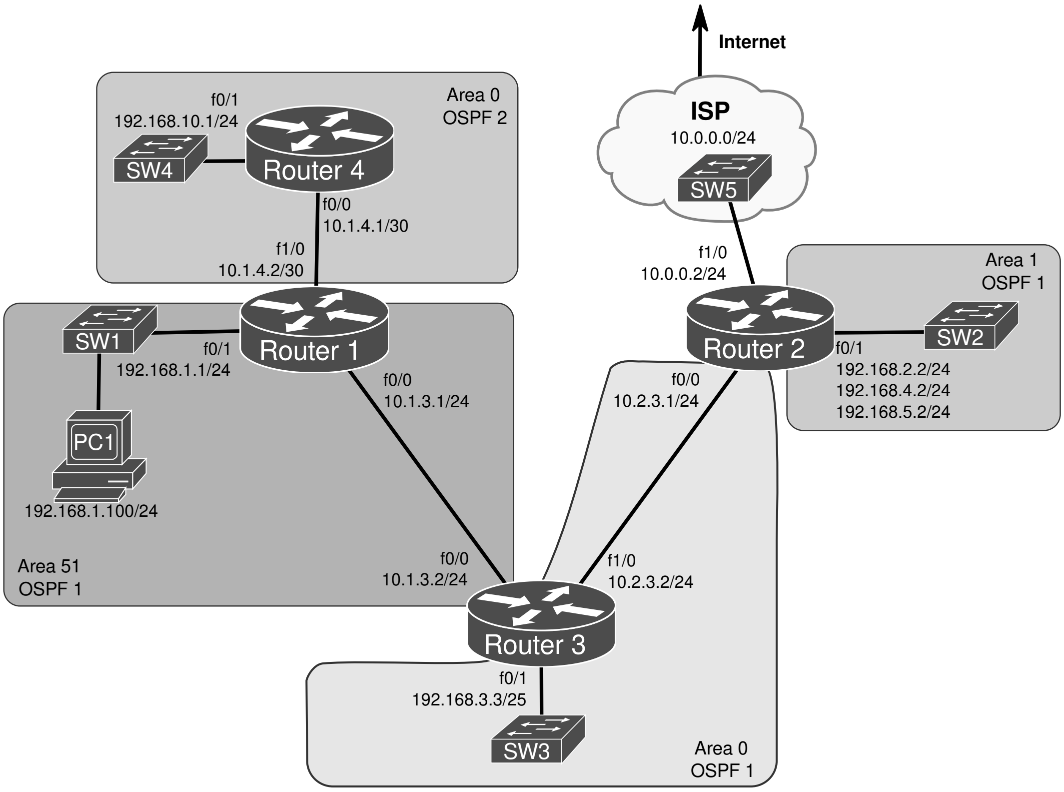
6.3. On Router2, configure another interface that simulate Internet connectivity via an ISP (previous figure). Create and advertise a default route using the following commands:

```
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
```

`At PC1, confirm that the default route is working properly by performing a ping to 10.0.0.2.`

>> Check the routing tables on Router1 and Router3 and explain what type of OSPF route has been added and what its metric is.

(Optional) External Routing Process Redistribution



7.1. 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
```

Analyze 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.

7.2. 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
```

Analize 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.

>> Explain how the external route is propagated, by identifying the LSA Type 5 within the OSPF Update packets.

7.3. <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
```

>> Analyze the routing tables of all routers. Test and explain how full connectivity was achieved.