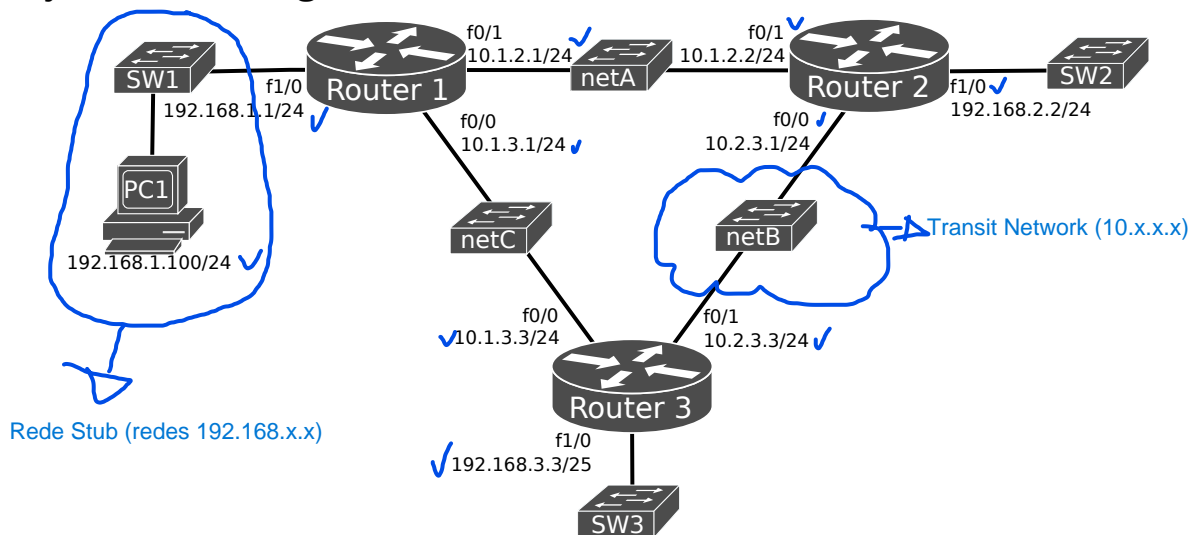




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REDES DE COMUNICAÇÕES 2

IPv4 Dynamic Routing with RIP



1.1 Assemble the above depicted network **using GNS3** and configure all IPv4 addresses. **Note that network 192.168.3.0 has mask /25 (255.255.255.128) and the other 192.168.*.0 networks have mask /24.**

Verify the interfaces' configurations and IPv4 routing tables in all routers:

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

```
Router1# show ip route
```

>> Analyze the routing tables.

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. Pq a version 1 não suporta sub-redes, não trabalha bem se houver redes diferentes

>> Explain how routers define the network masks of the networks announced with RIPv1.

1.3. **Start a packet capture in networks A, B and C** 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 RIPv1. Port: 520

>> Explain the contents of RIPv1 packets, namely network prefixes and costs.

(*)

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 networks A, B and C** 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 not present in RIPv1.

>> Explain the contents of RIPv2 packets, namely network prefixes and costs.

(**)

(*) Por causa do Split Horizon, este protocolo só anuncia as redes "úteis", otimiza os custos dos caminhos. Ex: o R3 não anuncia a netA pq este tem 2 possíveis caminhos para essa rede (Em R3: "sh ip route"), então haverá outro Router que chega com menos "esforço" a essa rede.

(**) Para perceber (exemplo): Se fizer uma captura na rede 10.2.3.1 (um porto do R2), este Router não anuncia para a rede do porto (10.2.3.0), senão para as outras duas interfaces 192.168.2.0 e 10.1.2.0, dps como R1 ainda tem mais rede, anuncia também 192.168.1.0

1.6. **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.

Re-enable (with command no shutdown) the interface of Router 1 with network C (10.1.3.0/24).

Administrative Distance

1.7. 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.

1.8. Re-configure at Router1 the static route to network B via Router2 to have an administrative 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.

Dynamic Default Routes (with RIPv2)

1.9. **Start a packet capture in networks A, B and C** and capture 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).

1.10. **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. "sh ip route" -> tem 3 Os do OSPF e os custos são diferentes dos RIP, a distância admin. é 110 enquanto que nos RIP era 120

>> Retest the connectivity between the equipment.

No RIP o custo era sobre o nº de Routers intermédios (no caminho), R1 para netB tinha custo 1, mas no OSPF o custo é de cada interface, no exemplo anterior seria custo 2 pois passa por 2 interfaces

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
```

Os Routers têm a sua interface Designated quando só há um caminho por essa interface, por exemplo para as redes 192.168.x.x a interface que as liga à rede são Designated.

Vemos que o R1 é o DR, pois as suas 3 interfaces são DR, a interfaces do R2 e do R3 que vão dar ao R1 têm de ser Backup (BDR) e as ramificações (192.168) são DR nos R2 e R3, pois essas redes só têm essas "entradas"/interfaces para a rede

>> 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
```

O R3 ficou como DR, pois tem o maior ID

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.

filters to Wireshark: "ospf and ip"

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
```

Para além dos "Hello", aparecem outros pacotes (Description, Request, Update). No Update, a info que este diz é praticamente igual à info da database

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
```

(Só estão as Transit Networks)

>> 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
```

No R2, int f0/0, o custo passa a ser 50, ent o R2 para chegar ao R3, é melhor passar pelo R1, passando a ter um custo [110/3] via 10.1.2.1 (show ip route)

>> 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:

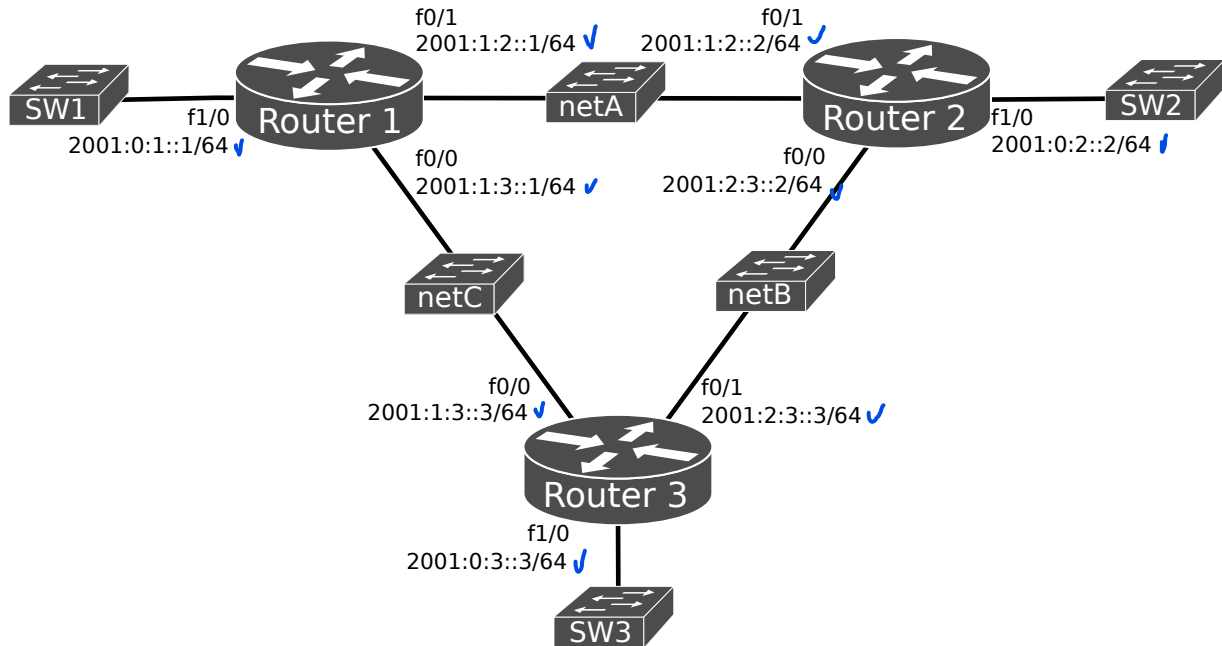
```
Router1(config)# router ospf 1
Router1(config-router)# default-information originate always
```

>> 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.

Ir ao Router fronteira do nosso sist. autónomo, este protocolo faz com que este Router meta uma rota por defeito (0.0.0.0). Basicamente está a ser configurado este Router como Router fronteira para, caso os pacotes tenham de sair do sistema (external routing domain), fazem-no através deste, e através da rota 0.0.0.0.

IPv6 Dynamic Routing



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 networks A, B and C 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.

(Optional) RIPng

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 proc1 metric-offset 10
```

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

3.4. **Start a packet capture in networks A, B and C** and capture 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. **Start a packet capture in networks A, B and C** and capture 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 procl 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

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.
If no IPv4 address is configured in the router, it is mandatory to define the OSPFv3 router ID manually in all routers:

```
Router1(config)# ipv6 router ospf 1
Router1(config-router)# router-id 1.1.1.1
...
```

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
```

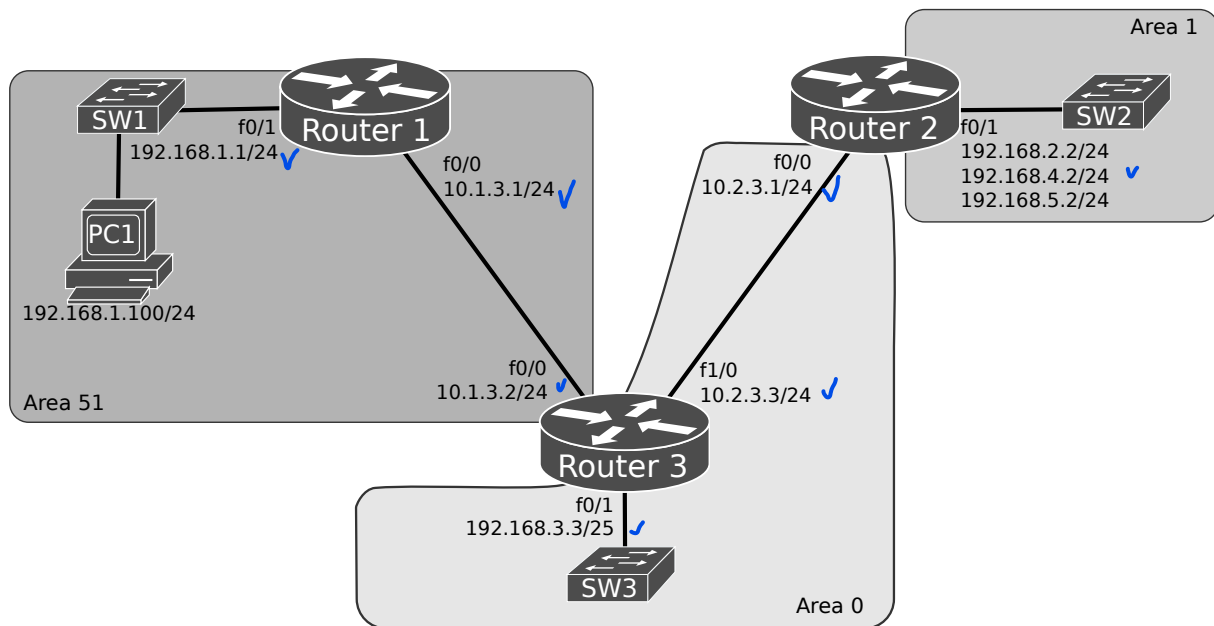
>> Re-verify the routing tables and identify the default route being announced by Router1.

"show ipv6 ospf 1 database":

Agora no fim do comando aparece:

ADV Router	Age	Seq#	Prefix
192.168.1.1	85	0x80000001	::/0

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 area 0:
- Configure network 192.168.2.0/24 as area 1, and add two subnetworks in Router2 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 10.1.3.0/24 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 how information from different areas is propagated, by identifying the LSA Type 3 within the OSPF Update packets.

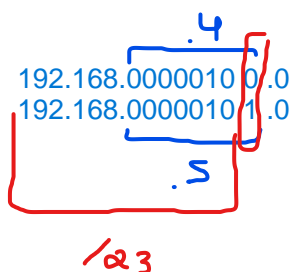
>> Explain the contents of the database link states, and the advantages/disadvantages of using multiple OSPF areas.

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

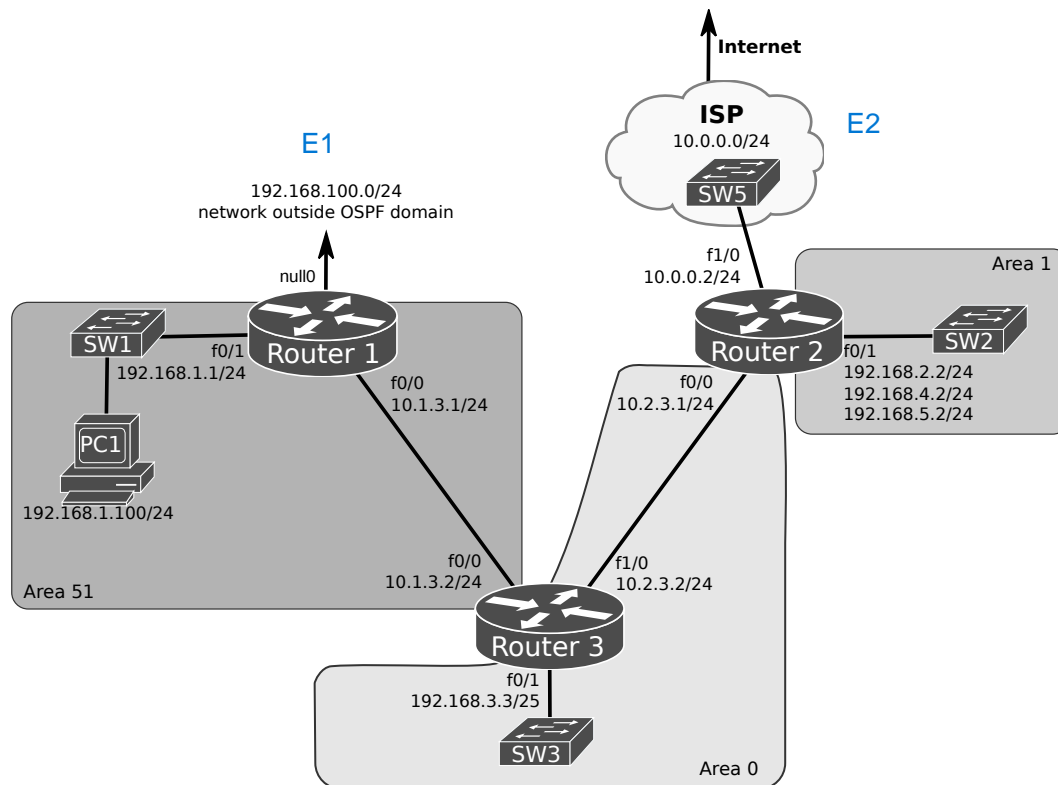
```
Router2(config)# router ospf 1
Router2(config-router)# area 1 range 192.168.4.0 255.255.254.0
```

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

No R2 poderia haver mts pequenas redes como 192.168.4.0, .5, .6 e assim. Pode-se pedir ao R2 para, em vez de anunciar cada uma destas redes por linha, anunciar para a area 0 o agregado de redes, o conjunto de redes, pois todas "cabem" na máscara /23.



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
```

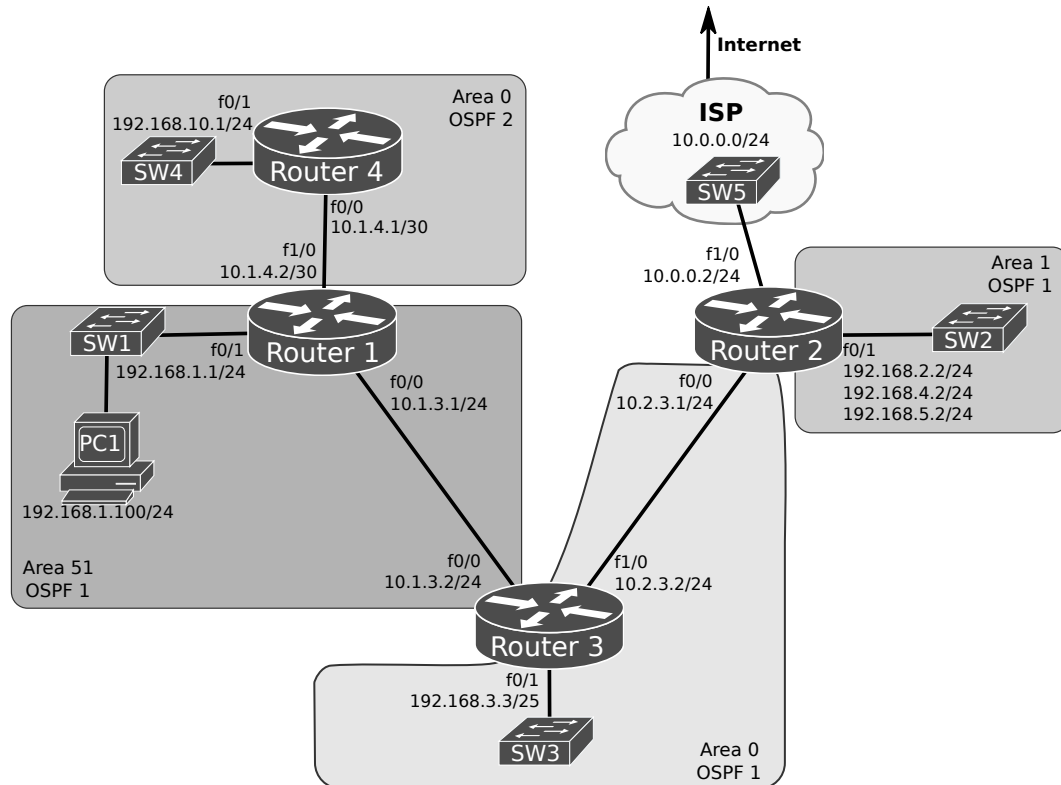
At PC1, confirm that the default route is working properly by performing a ping to 10.0.0.2.

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

E1-> Está a ser adicionada uma rede conhecida, se se pingar para essa rede em específico, vai para ai.

E2 -> Está a ser declarada essa rede/rota como default, i.e., se algum dos routers/PCs fizer um ping para um endereço não conhecido, manda-se ao E2 tratar dele, é a "saída default" caso o endereço do ping não corresponder a nenhuma das outras rotas/redes.

External Routing Process Redistribution



Só meti os address e no shutdown

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
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
```

!ID must be different from process 1

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
```

Analyze 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. Bi-directional redistributions should be avoided, 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.