DEPARTAMENTO DE ELETRÓNICA, TELECOMUNICAÇÕES
E INFORMÁTICA

LICENCIATURA EM ENGENHARIA DE COMPUTADORES E INFORMÁTICA

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REDES DE COMUNICAÇÕES II

LABORATORY GUIDE NO. 4:

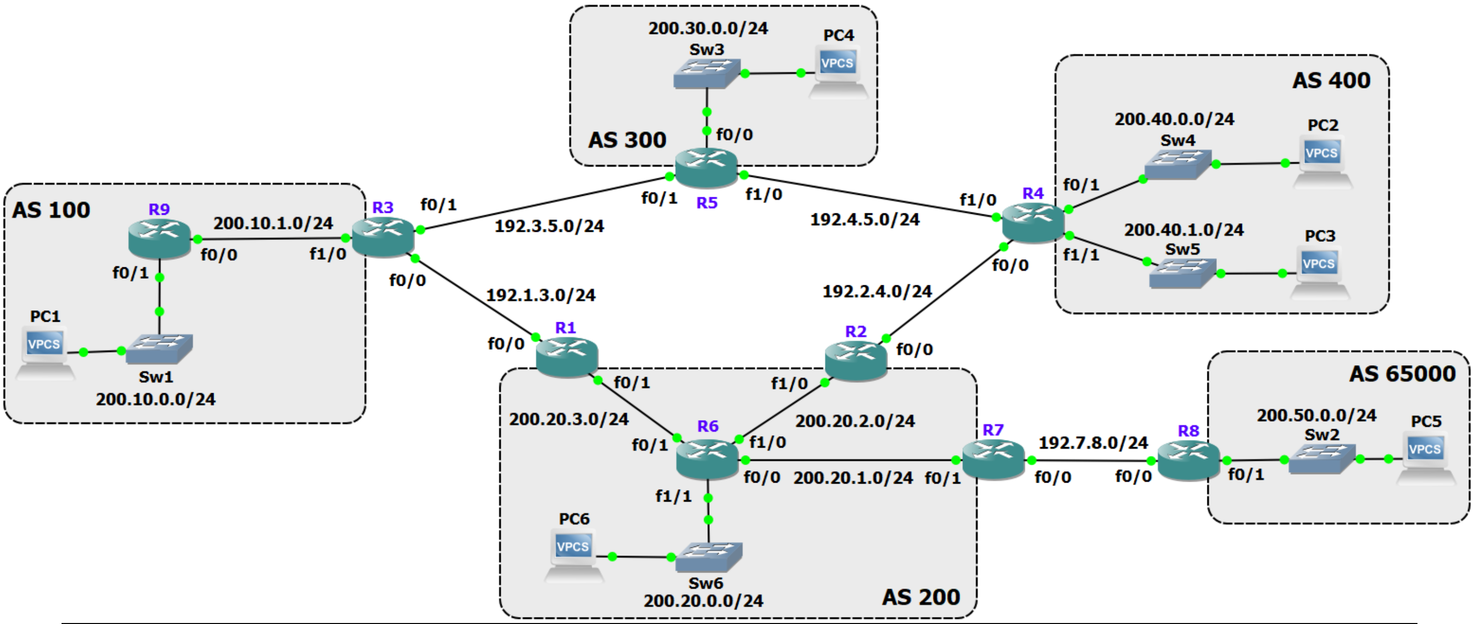
BGP & MP-BGP

In this Laboratory Guide:

- all routers should use the IOS image 15.1(4) of routers 7200 (provided in the elearning page of RC II) and with two network adapters:
  - C7200-IO-2FE in slot 0, providing 2 FastEthernet routing interfaces: `f0/0` and `f0/1`
  - PA-2FE-TX in slot 1, providing 2 FastEthernet routing interfaces: `f1/0` and `f1/1`
- all switches should use the basic Ethernet Switch available in GNS3

1. Initial IPv4 network setup

Create a GNS3 template with all equipment and links of the following network and run the template. On each interface of each router, configure an IPv4 address following the IP network address in the figure using the number of the router name as the host part of the address. On each PC, configure an IPv4 address following the IP network address in the figure (with the host part of the address equal to 100) and the IP address of its default gateway.



Configuration of IP addresses in router R6:

```
R6# configure terminal
R6(config)# interface f0/0
R6(config-if)# ip address 200.20.1.6 255.255.255.0
R6(config-if)# no shutdown
R6(config-if)# interface f0/1
R6(config-if)# ip address 200.20.3.6 255.255.255.0
R6(config-if)# no shutdown
R6(config-if)# interface f1/0
R6(config-if)# ip address 200.20.2.6 255.255.255.0
R6(config-if)# no shutdown
R6(config-if)# interface f1/1
R6(config-if)# ip address 200.20.0.6 255.255.255.0
R6(config-if)# no shutdown
R6(config-if)# end
R6# write
```

Configuration of IP address and default gateway in PC1:

```
PC1> ip 200.10.0.100/24 200.10.0.9
PC1> save
```

1.a. Check the IPv4 routing table of each router. Verify that the routing tables include all directly connected IP networks (if not, there are configuration errors that must be identified and corrected).

Check the IPv4 routing table in router R1, with or without the IP addresses of the (L)inks:

```
R1# show ip route
R1# show ip route | exclude L
```

1.b. Check (through ping) that each PC has connectivity with its default gateway (if not, there are configuration errors that must be identified and corrected).

In the Autonomous Systems (ASs) with more than one router (AS 100 and AS 200), activate the OSPFv2 routing protocol running the command `ip ospf 1 area 0` in all interfaces inside each AS.

1.c. Check the IPv4 routing tables of each router. Verify that the routers of each AS have connectivity to all IP networks of its AS but do not have connectivity to any of the networks of the other ASs.

1.d. Check (through ping) that PC1 has connectivity with the IP address of the AS 100 border router and PC6 has connectivity with the IP address of all AS 200 border routers (if not, there are configuration errors that must be identified and corrected).

2. BGP with one Border Router per Autonomous System

First, start a Wireshark capture in the link between routers R4 and R5. Then, configure an eBGP connection between routers R4 and R5 indicating in each peer the networks of its AS.

Configuration in router R4 of the eBGP connection between R4 and R5:

```
R4# configure terminal
R4(config)# router bgp 400
R4(config-router)# neighbor 192.4.5.5 remote-as 300
R4(config-router)# network 200.40.0.0
R4(config-router)# network 200.40.1.0
R4(config-router)# end
R4# write
```

2.a. Check (through ping) that PC4 has connectivity with PC2 and PC3 (if not, the eBGP connection configuration has errors that must be identified and corrected).

2.b. Analyze and justify the BGP messages of the Wireshark capture. In particular, check that:

- in the initial OPEN messages, each router selects its highest IP address as its Router ID, announces its Hold Time (by default, 180 seconds) and its AS number (for validation) and indicates whose capabilities are supported (identify which ones were indicated)
- in the UPDATE messages, each router announces the network prefixes belonging to its AS and each network prefix has the three well-known mandatory attributes (identify them and justify their values) and the optional non-transitive MED attribute [Footnote 1]
- KEEPALIVE messages are exchanged every 60 seconds (why?)

2.c. Analyze the IP routing tables of routers R4 and R5 and justify the new BGP entries. In particular, check that the administrative distance of network prefixes learned by eBGP is 20 and that the cost of the BGP routing paths is the value of the MED attribute received from the other AS.

2.d. Run the command `show ip bgp` in routers R4 and R5 (this command shows the information related with all network prefixes known by BGP on each router). Analize the information shown and check that it is in accordance with what you have observed in the previous **2.b** and **2.c**.

[Footnote 1] This behavior is not imposed by the BGP standard. In this CISCO implementation, when the network prefixes are explicitly indicated in the BGP process, the default behavior is that the router announces them with MED = 0.

Start now a Wireshark capture in the link between routers R3 and R5. Then, configure an eBGP connection between routers R3 and R5 in the following way:

- in router R5, you just need to add the new neighbor in the process `router bgp 300` (following the information in the figure),
- in router R3, instead of indicating the networks of its AS, redistribute the networks from the OSPF internal routing domain.

Configuration in router R3 of the eBGP connection between R3 and R5:

```
R3# configure terminal
R3(config)# router bgp 100
R3(config-router)# neighbor 192.3.5.5 remote-as 300
R3(config-router)# redistribute ospf 1
R3(config-router)# end
R3# write
```

2.e. Analyze the BGP messages of the Wireshark capture. First, check that the content of the OPEN and KEEPALIVE messages is consistent with what you have observed before. Then, justify the BGP UPDATE messages exchanged between R3 and R5. In particular, check that:

- the network prefixes announced by R5 to R3 include the prefixes learned by R5 from R4 (what is the AS_PATH attribute of these prefixes?) and, therefore, R5 assumes by default that its AS is a transit autonomous system
- the UPDATE messages sent by router R3 announce the network prefixes learned from OSPF (and, therefore, the ORIGIN attribute is INCOMPLETE) and are announced with the optional non-transitive MED attribute (which are the values?) [Footnote 2]

2.f. Analyze the IP routing tables of routers R3, R4 and R5 and justify the new BGP entries. In particular, justify the cost of the BGP routing entries in the different routers.

2.g. Run the command `show ip bgp` in routers R3, R4 and R5. Analize the information shown and check that it is in accordance with what you have observed so far.

2.h. Start a capture with Wireshark on the link between routers R3 and R5 to visualize ICMP packets. In router R3, test the connectivity with PC2 running in R3 each of the following two commands:

```
R3# ping 200.40.0.100
R3# ping 200.40.0.100 source f1/0
```

Justify the observed ICMP packets and explain why there is connectivity only when running the second command.

2.i. Test (through ping) the connectivity from PC1 (which belongs to AS 100) to any IP address belonging to AS 300 or AS 400. Check that the output is always the same. Justify why none of these connectivity tests is successful.

Configure R3 to announce itself to all other routers of its AS as the destination of a default OSPF route:

```
R3# configure terminal
R3(config)# router ospf 1
R3(config-router)# default-information originate always
R3(config-router)# end
R3# write
```

2.j. Verify that the routing table of router R9 changed accordingly. Then, repeat the connectivity tests conducted in **2.i** and explain why now all connectivity tests are successful.

[Footnote 2] This behavior is not imposed by the BGP standard. In this CISCO implementation, when the network prefixes are redistributed from an IGP routing protocol, the default behavior is that the router announces them with MED = 0 (for the directly connected networks) or MED = shortest path cost of the IGP protocol (for the not directly connected networks).

(TO BE COMPLETED)