TÉCNICO LISBOA

INTEGRATED MASTER (MSC) IN ELECTRICAL AND COMPUTER ENGINEERING

NETWORKS AND INTERNET SERVICES

Laboratory Assignment

Multicast

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1. Objective

This laboratory assignment has the objective of studying Multicast using the GNS3 network simulator and familiarization with Cisco IOS.

A report should be filled in during the lesson with the answers to the questions and the results requested. It should be submitted into the Fenix system in PDF format until 23h59m of the Saturday following the last class scheduled for the work.

For this assignment, you are recommended to use the laboratory PC under the **Linux** operating system.

2. IGMP protocol

The architecture to be implemented for studying IGMP is shown in figure 1. All routers and PCs are implemented with c7200 routers, since VPCS does not support IGMP. You may change the PCs' icons to a computer icon to look like figure 1. This can be done by right-clicking the router and selecting the "Change Symbol" option. You may also change hostnames by right-clicking the device and selecting the "Change hostname" option.

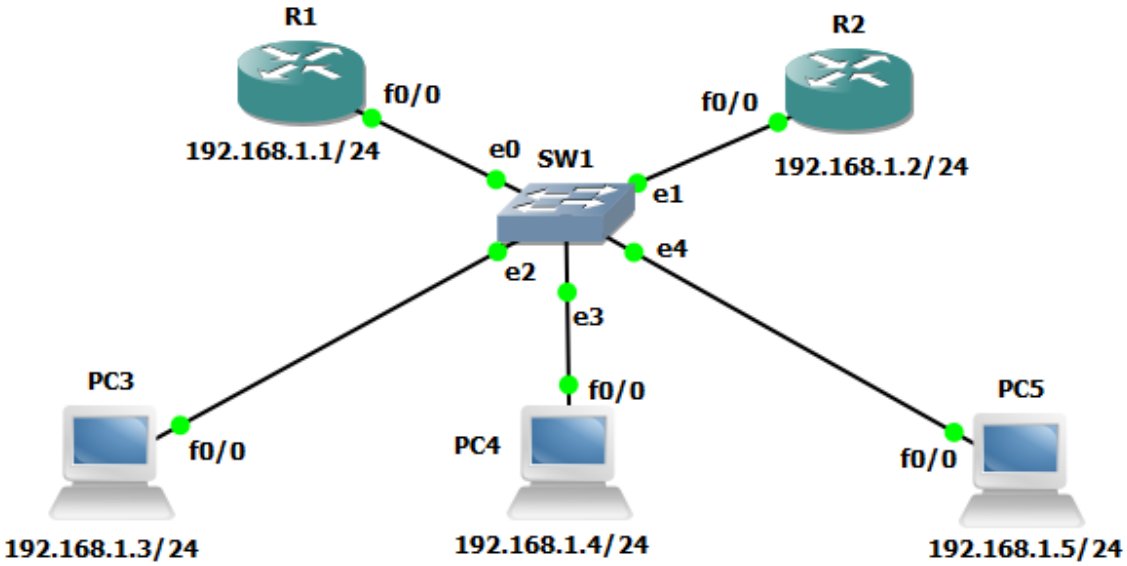

Figure 1: Network for IGMP experiments.

2.1 Initial configuration

a) Configure PC3 with the following commands:

```
PC3#configure terminal                                  enter configuration mode reading commands from terminal
PC3(config)#no ip routing                               disable routing functions for this device: it is a PC
PC3(config)#interface fastEthernet 0/0                  enter interface f0/0 configuration mode
PC3(config-if)#ip address 192.168.1.3 255.255.255.0     set IP address and subnet mask
PC3(config-if)#no shutdown                              activate the interface
PC3(config-if)#end                                      end configuration mode
PC3#write                                               save the configuration in the startup-config configuration
```

b) Configure the other PCs adapting these commands, according to figure 1. Register in the report the commands for PC4.

c) Configure R1 with the following commands:

```
R1#configure terminal                                  enter configuration mode reading commands from terminal
R1(config)#ip multicast-routing                        enable IP multicast routing
R1(config)#interface fastEthernet 0/0                  enter interface f0/0 configuration mode
R1(config-if)#ip address 192.168.1.1 255.255.255.0     set IP address and subnet mask
R1(config-if)#ip pim dense-mode                        set multicast mode for this interface
R1(config-if)#no shutdown                              activate the interface
R1(config-if)#end                                      end configuration mode
R1#write                                               save the configuration in the startup-config configuration
```

d) Configure the other router adapting these commands. Register in the report the commands for R2.

e) check connectivity from PC3 to all other devices (for instance with ping).

2.2 IGMP operation and group joining

a) Start a Wireshark capture at interface f0/0 of PC3. Use an IGMP filter. Observe the messages for a few minutes. What is the period of the query messages? Which router is sending them? To which multicast address are the queries sent? What is the meaning of this address? What is the value of the IP TTL header field? Why?

b) Notice that R1 and R2 are reporting that they belong to the 224.0.1.40 multicast group. This group is the Cisco-RP-discovery address and all Cisco routers, with PIM active, report belonging to this group. Now change the Wireshark filter to "`(igmp or icmp or arp) and !ip.addr==224.0.1.40`" to filter out the Cisco-RP-discovery group.

c) Make PC3 interface f0/0 join multicast group 239.0.1.2 with the "`ip igmp join-group 239.0.1.2`" configuration command. Enter this command a few seconds after observing an IGMP query in Wireshark. Note that you must enter interface configuration mode, so the following commands must be entered:

```
PC3#configure terminal                                 enter configuration mode reading commands from terminal
PC3(config)#interface fastEthernet 0/0                 enter interface f0/0 configuration mode
PC3(config-if)#ip igmp join-group 239.0.1.2            join multicast group 239.0.1.2
PC3(config-if)#end                                     end configuration mode
```

d) What message is observed as result of the join-group command? To which address is it sent? Is there an answer to this message?

e) Now make PC4 and PC5 also join the 239.0.1.2 multicast group. Register in the report the commands for PC5. Are there messages observed as result of the join-group commands?

f) Make PC3 ping the 239.0.1.2 multicast group twice. How many replies did PC3 get to the second ping? (Note that, due to the ARP resolution process, some answers to the first ping may not be received within the timeout). To which address (IP, MAC) were the pings sent? What is the relation between the destination MAC and IP addresses of the ping? Is ARP used to get the MAC address of 239.0.1.2? Are the replies to ping unicast or multicast to PC3?

g) Use the command "`show ip igmp groups`" on all routers to check the group membership information registered in each router. Register the results in the report. Do the routers know the addresses of all group members or the number of group members?

h) Observe the IGMP queries and reports for a few minutes. How many answers each query gets? Does the answer always come from the same device? Is the delay between the query and answer always the same? Why?

2.3 IGMP group leaving and querier election

a) Successively make PC3, PC4 and PC5 f0/0 interfaces leave the multicast group 239.0.1.2 with the "`no ip igmp join-group 239.0.1.2`" configuration command. Enter these commands a few seconds after an IGMP report message. Note that you must enter interface configuration mode to enter these commands, as in 2.2-c). Was there any message observed as response to these commands? Was there a difference when the last group member left the group? Why? To which IP address were the messages sent? What is the meaning of this address? Was the Query message different in this case?

b) Now, make R1 interface f0/0 stop participating in the multicast process with the "`no ip pim dense-mode`" command. Note that you must enter interface configuration mode, so the following commands must be entered:

`R1#configure terminal`	enter configuration mode reading commands from terminal
`R1(config)#interface fastEthernet 0/0`	enter interface f0/0 configuration mode
`R1(config-if)#no ip pim dense-mode`	exit multicast mode for the interface
`R1(config-if)#end`	end configuration mode

Wait a few minutes. Was there any message when R1 left the multicast process? Which router is now sending the IGMP queries?

c) Make R1 interface f0/0 participate again in the multicast process with the "`ip pim dense-mode`" configuration command. What can you conclude about the router's querier election mechanism?

d) Stop the Wireshark capture and stop all devices.

3. Multicast Routing

The architecture to be implemented for studying multicast routing is shown in figure 2. Again, all routers and PCs are implemented with c7200 routers. You can build this project by opening the previous project and saving as a new project name. For the routers, you should add PA-FE-TX network modules for each Ethernet port beyond the first. To insert these modules, right click the router symbol, choose "Configure", select the Slots tab and for each slot, choose in the pull-down menu the "PA-FE-TX" option. Finally, click Ok.

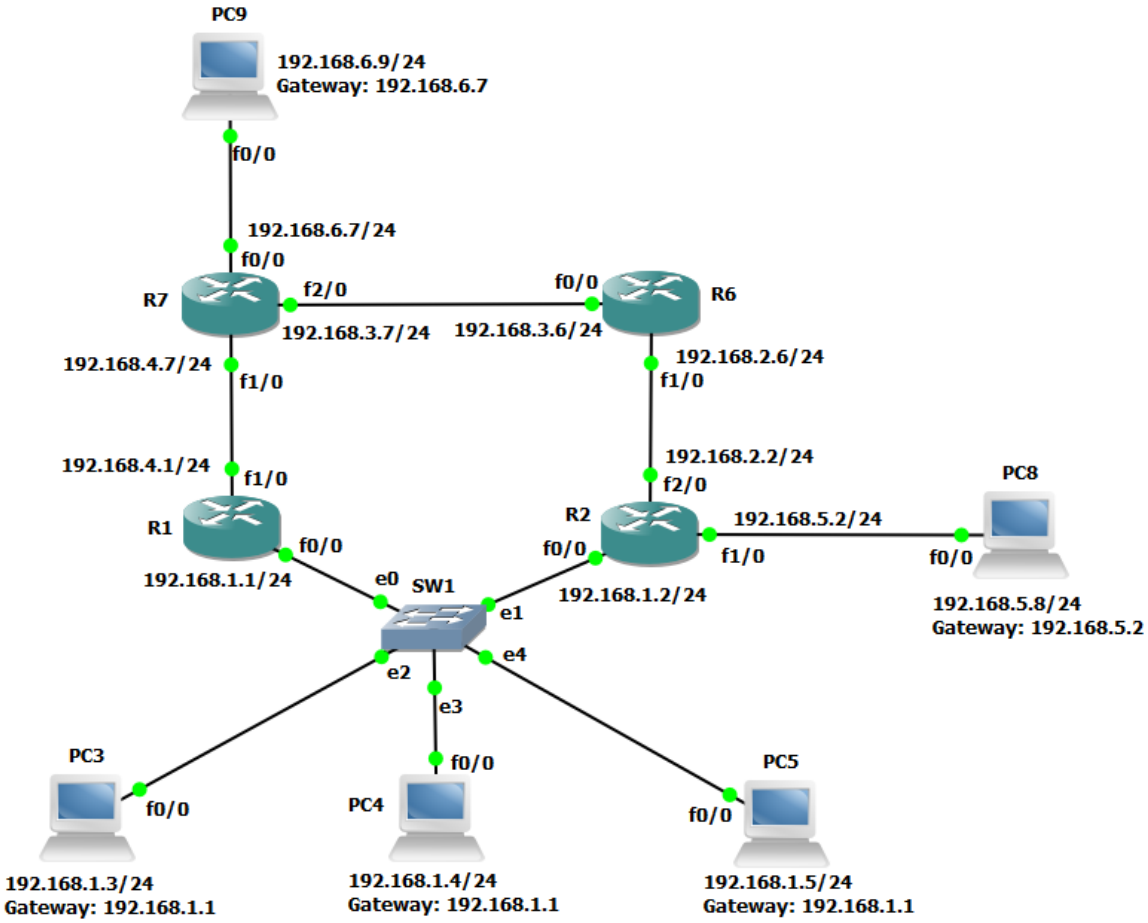

Figure 2: Network for Multicast Routing experiments.

3.1 Initial configuration

a) Configure OSPF routing in all routers. Add a default route to the PCs with the "`ip default-gateway 192.168.1.1`" (example for PC3) configuration command. Make all PCs join multicast group 239.0.1.2. A complete list of commands for PC3 and R1 is:

```
PC3#configure terminal                                  enter configuration mode reading commands from terminal
PC3(config)#no ip routing                               disable routing functions for this device: it is a PC
PC3(config)#ip default-gateway 192.168.1.1              set default route
PC3(config)#interface fastEthernet 0/0                  enter interface f0/0 configuration mode
PC3(config-if)#ip address 192.168.1.3 255.255.255.0     set IP address and subnet mask
PC3(config-if)#no shutdown                              activate the interface
PC3(config-if)#ip igmp join-group 239.0.1.2             join multicast group 239.0.1.2
PC3(config-if)#end                                      end configuration mode
PC3#write                                               save the configuration in the startup-config configuration

R1#configure terminal                                   enter configuration mode reading commands from terminal
R1(config)#ip multicast-routing                         enable IP multicast routing
R1(config)#interface fastEthernet 0/0                   enter interface f0/0 configuration mode
R1(config-if)#ip address 192.168.1.1 255.255.255.0      set IP address and subnet mask
R1(config-if)#ip pim dense-mode                         set multicast mode for this interface
R1(config-if)#no shutdown                               activate the interface
R1(config-if)#exit                                      exit interface configuration mode
R1(config)#interface fastEthernet 1/0                   enter interface f1/0 configuration mode
R1(config-if)#ip address 192.168.4.1 255.255.255.0      set IP address and subnet mask
R1(config-if)#ip pim dense-mode                         set multicast mode for this interface
R1(config-if)#no shutdown                               activate the interface
R1(config-if)#exit                                      exit interface configuration mode
R1(config)#router ospf 1                                configure OSPF routing for this router
R1(config-router)#network 192.168.1.0 0.0.0.255 area 0      list the networks to be advertised by OSPF
R1(config-router)#network 192.168.4.0 0.0.0.255 area 0
R1(config-router)#end                                   end configuration mode
R1#write                                                save the configuration in the startup-config configuration
```

b) Adapt these configuration commands for the other devices. From one PC ping all other PCs to check connectivity.

3.2 Multicast Routing Trees

a) From one PC, send an unicast ping to all other PCs to populate the ARP caches. From PC9, ping multicast group 239.0.1.2. Using the "`show ip mroute`" command in each router, check the state of each interface (Forward/Prune) for multicast group 239.0.1.2. Register the output of these commands in the report. Based on this, draw the multicast tree for multicast group 239.0.1.2.

b) From one PC, send an unicast ping to all other PCs to populate the ARP caches. From PC9 and PC3, ping the multicast group 239.0.1.2. Using the "`show ip mroute`" command in each router, check the state of each interface (Forward/Prune). How many multicast distribution trees are there? Draw the multicast tree for source PC3.

c) With the configuration of a), you should notice that after populating the ARP caches, the first ping from PC9 to multicast group 239.0.1.2 gets two answers from PC3, while the subsequent pings get a single answer from each PC. To observe this behaviour again, you will have to wait for the multicast routing entries in the routers to timeout, repopulate the ARP caches and send a multicast ping twice in succession. Why are there two replies to the first multicast ping and a single one to subsequent pings?

d) Knowing that reverse path forwarding based on unicast routing costs is used to build the multicast tree, modify the minimum number of OSPF routing costs by the minimum amount so that multicast traffic for group 239.0.1.2 from PC9 to PC3 goes through R6 and multicast traffic for group 239.0.1.2 from PC3 to PC9 goes through R1. Explain the modifications done and how you verified the intended operation. **Demonstrate the correct operation of your solution to the teacher during the class**.

4. References

[1] Cisco IOS IP Multicast Command Reference.
http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipmulti/command/imc-cr-book.html