TÉCNICO LISBOA

INTEGRATED MASTER (MSC) IN ELECTRICAL AND COMPUTER ENGINEERING

NETWORKS AND INTERNET SERVICES

Laboratory Assignment

Routing

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1. Objective

This laboratory assignment has the objective of studying Internet routing and using the GNS3 network simulator [1] for 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.

2. Network and OSPF configuration

The architecture to be implemented for routing testing is shown in figure 1. For this assignment, you are recommended to use the laboratory PC under the **Linux** operating system.

There are 3 steps for configuring the network in GNS3:

1. Build the network in GNS3;
2. Configure the routers;
3. Configure the virtual PCs.

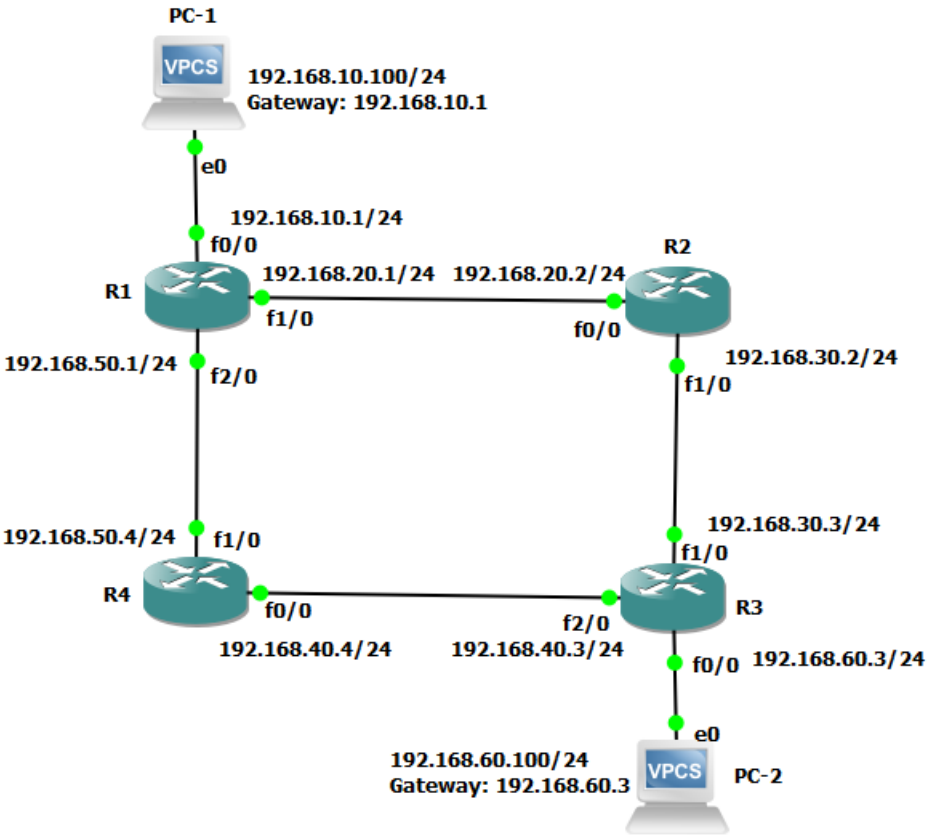

Figure 1: Network for OSPF experiments.

2.1 Building the Network in GNS3

a) Open GNS3 and start a new blank project.

b) From the left pane, select the "Browse Routers" icon, select "Router c7200" and drag-and-drop 4 routers to the central drawing window (R1-R4). From the left pane, select the "Browse End Devices" icon, select "VPCS" and drag-and-drop 2 virtual PCs to the central drawing window (PC-1 and PC-2). You can change the device names by right-clicking their icons and selecting "Change the hostname", if required.

c) For R1 and R3, you should have a C7200-IO-FE network module in slot 0 and PA-FE-TX network modules in slots 1 and 2 to have a total of 3 Ethernet ports. 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 correct option. Finally, click Ok. R2 and R4 only require 2 modules for 2 Ethernet ports, each one.

d) Click the "Show/Hide Interface Labels" button in the top buttons row to be active. Connect the routers, hubs and PCs by selecting from the left pane the icon "Add a link". Then click a router, select the appropriate interface name and click the destination equipment and again select its interface. Repeat for the other devices. In the end, click "Add a link" again to stop adding links. Note that if the different devices are too close to each other, the interface labels are not drawn. There is an option to "Reset the Interface Labels" in the "View" pull-down menu (hide the labels first) which may be handy if any of them is missing. You can also move the labels to another position with the mouse.

2.2 Router Configuration

a) Click the "Start/Resume all devices" button in the top buttons row. This will start the "dynamips" virtual machines, emulating Cisco routers running the Cisco's IOS image selected. All the routers will boot which takes some time. You may have to unlock the firewall. From the top buttons row, click "Console connect to all nodes" to start one PuTTY [2] window for each router and PC.

b) Now you can enter Cisco IOS commands into the routers' consoles. Cisco IOS accepts "?" to know the valid possible commands or parameters and "Tab" to auto-complete a keyword. Abbreviations are accepted, if there is no ambiguity. Type the command "`show interfaces`" in R1 console to know about the existing interfaces. The interfaces are named with the slot and port within that slot, e.g. FastEthernet 1/0 is port 0 of a FastEthernet card in the router slot 1. "`show ?`" will show the possible parameters of the show command. "`show in?`" will show all options starting with "`in`". "`sh<TAB> int<TAB>`" will autocomplete to the "`show interfaces`" command. You can also use the arrows in the keyboard to edit or go to the previous commands.

c) Now configure the IP addresses and subnet masks of each interface according to figure 1. The IP addresses shown in figure 1 are text notes added with the "Add a note" button: they do not show automatically when configured. The commands for R2 configuration are:

```
R2#configure terminal                                  enter configuration mode reading commands from terminal
R2(config)#interface fastEthernet 0/0                  enter interface f0/0 configuration mode
R2(config-if)#ip address 192.168.20.2 255.255.255.0    set IP address and subnet mask
R2(config-if)#no shutdown                              activate the interface
R2(config-if)#exit                                     exit interface configuration mode
R2(config)#interface fastEthernet 1/0                  configure the next interface
R2(config-if)#ip address 192.168.30.2 255.255.255.0    set IP address and subnet mask
R2(config-if)#no shutdown                              activate the interface
R2(config-if)#end                                      end configuration mode
R2#write                                               save the configuration in the startup-config configuration
R2#show ip interface brief                             show the IP configuration of the interfaces
```

d) The project is automatically saved to files whenever any modification is done. The project files are stored in folder "~/GNS3/projects/<project-name>" under Linux, where "~" is your home directory and in "C:\Users\<username>\GNS3\projects\<project-name>" under Windows. With a text editor, open the file "i2_startup-config.cfg" just saved in a subfolder of the project and try to find some of the commands you entered in the file. In a real router, this file is saved in the router's internal flash disk. Enter the command "`show startup-config`" on the router console and verify that the output is similar to the file. If you ever close the project and open it again, the topology and each router configuration will be there. You can zip the project folder and copy it to another PC or to continue working in the laboratory on the next class. Note that you should close GNS3 before zipping the project folder as GNS3 stores temporary file in the folder while it is working. Make sure in the end of the class you save and delete your project folder from the laboratory PC. Configure also the other routers, adapting these commands. Register in the report the commands entered in router R1.

e) Now configure OSPF routing in the network. The commands for R2 are:

```
R2#configure terminal                                   enter configuration mode
R2(config)#router ospf 1                                set OSPF routing with process ID 1
R2(config-router)#router-id 2.2.2.2                     set R2 router ID
                                                        list the networks to be advertised by OSPF
                                                        (area 0=backbone), mask is inverted
R2(config-router)#network 192.168.20.0 0.0.0.255 area 0
R2(config-router)#network 192.168.30.0 0.0.0.255 area 0
R2(config-router)#end                                   end configuration mode
R2#write                                                save the configuration in the startup-config configuration
R2#show ip protocols                                    check that OSPF is active
R2#show ip ospf interface fastEthernet 0/0              show OSPF default configuration
```

f) Now, configure the other routers adapting these commands. Use the same OSPF process ID 1 for all routers. Use router ID 1.1.1.1 for R1, router ID 3.3.3.3 for R3 and router ID 4.4.4.4 for R4. Observe the routing table of each router with "`show ip route`". Note that some routing table entries show two distances between brackets, the first is the administrative distance, which depends only on the protocol being used, and the second is the total path cost. For instance "[110/2]" means that the administrative distance is 110 (the value for OSPF) and the total path cost is 2. To forward packets, the router uses the routing table entry with the smallest cost for the routing protocol with smallest administrative distance. Note that the administrative distance for a directly connected network is 0 (not shown). Register in the report the commands entered in R3. Register and explain in the report, the routing table of R1. What is the default cost of sending over FastEthernet 0/0 interface for R2 (labelled "Cost:" in the last listed command output)?

2.3 Virtual PC Configuration

a) Change to window PC-1 for configuring the VPCS (Virtual PC Simulator for Dynamips/GNS3) application. Here, you can also use "?" to get help. Configure the PC with the following commands:

```
PC-1> ip 192.168.10.100/24 192.168.10.1     set IP address, subnet mask, gateway
PC-1> ping 192.168.10.1                     check connectivity to R1
PC-1> save                                  save the configuration to file
```

b) Now, configure PC-2 adapting these commands.

c) Check connectivity within the network with ping.

3. ARP Experiments

a) Start capturing traffic in the link PC-1↔R1. To do that, right-click the link attached to these interfaces, and select "Start capture" and "Ok". Wait a few seconds for Wireshark [3] to start.

b) Use an "icmp or arp" filter for Wireshark. At PC-1 VPCS, ping PC-2 for the following 3 different situations. Before each experiment, clear the ARP caches of the PCs with the VPCS command "`clear arp`". Register and explain the command results observed and the corresponding Wireshark traffic and why some commands failed.

1. With no gateway configured at PC-1;
2. With an incorrect gateway configured at PC-1, e.g. 192.168.10.20;
3. With the correct gateway configured at PC-1.

c) At PC-1, execute a traceroute to PC-2 using the ICMP protocol with the command "`trace 192.168.60.100 -P 1`". Register and explain the output. You may stop the Wireshark capture by clicking Wireshark's "Stop capturing packets" button, saving the capture to some file if you wish, closing Wireshark, then clicking the link where the capture was running and choosing "stop capture".

4. OSPF Experiments

a) At R1's console, execute a traceroute to PC-2 sending 10 probes per hop with the command "`traceroute 192.168.60.100 probe 10`". Register and explain the output, knowing that the ECMP routing rule is being used.

b) Now start a Wireshark capture at the link between R1-R2 and set the filter to "ospf" to observe the "Hello" packets sent in subnet 192.168.20.0/24. What is the periodicity of the "Hello" packets sent by a given router? What are the source and destination IP addresses? What type of destination address is being used? What is the meaning of this address?

c) Execute the command "`show ip ospf 1 database`" at R1 console. Register the output. How many nodes (routers) are there in the OSPF database? How many transit networks are there in the OSPF database?

d) Execute the same command on the other routers. Are the databases similar? Why?

e) Execute the command "`show ip ospf 1 database network`" at each router's console. Register the output from R1. Are the databases similar on every router? Why? Map the networks in the output of the command with those in figure 1: which routers are attached to each network?

f) Execute the command "`show ip ospf 1 database router`" at each router's console. Register the output from R1. Are the databases similar on every router? Why? Map the links attached to each router in the output of the command with those in figure 1.

g) Keeping the Wireshark capture running with an OSPF filter, simulate a failure in interface f1/0 of R2 with the following commands at its console. At PC-1, do a traceroute to 192.168.30.3. Register and explain the output. Register and explain R1's routing table. Execute again the command "`show ip ospf 1 database router`" and "`show ip ospf 1 database network`" at R1 console. Register the output. How many nodes (routers) are there in the OSPF database? How many networks are there in the OSPF database? Wait at least 2 minutes after disabling the link to enable it again (the commands are similar, except "`shutdown`" is replaced with "`no shutdown`"). Keep the capture running for at least 2 minutes more. Look at the OSPF Update packets and examine the LS Update Packet Body: Which links do R2 and R3 advertise to have, when the interface failed? (Note that a "stub" link is to a network with no other end, while a "transit" link has another end). Which links do R2 and R3 advertise to have, when the interface is enabled again? Of which type ("stub" or "transit")? Which routers are advertised as being connected to network 192.168.30.0/24, when the interface is enabled again?

```
R2#configure terminal                          enter configuration mode
R2(config)#interface fastEthernet 1/0          enter interface f1/0 configuration mode
R2(config-if)#shutdown                         de-activate the interface
R2(config-if)#end                              end configuration mode
R2#
```

h) You may stop the Wireshark capture.

i) Reconfigure the equipment such that the traffic between the PCs always goes counter-clockwise in the network, that is: PC1→R1→R4→R3→PC2, PC2→R3→R2→R1→PC1. Do the minimum number of modifications to the configuration and modify configuration by the minimum possible values. Search the necessary commands in [4]. Explain in detail, the required router/PC configuration commands, how you can check the configuration is ok, both by looking at command's output and by using Wireshark and why the modifications done are indeed minimum. **Show to the teacher during the class that your solution is working as requested.**

5. References

[1] GNS3 Graphical Network Simulator. http://www.gns3.com/
[2] PuTTY: A Free Telnet/SSH Client. http://www.chiark.greenend.org.uk/~sgtatham/putty/
[3] Wireshark Network Protocol Analyser. http://www.wireshark.org/
[4] Cisco IOS IP Routing: OSPF Command Reference
https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/iproute_ospf/command/iro-cr-book.html