Universidad Carlos III de Madrid

Department of Telematic Engineering

Computer Networks

Lab: Routing

Bachelor in Informatics Engineering

1. Objective

The main objectives of this lab is to become familiar with the work environment (GNU /Linux) and routers to be used in the course (Linksys WRT54GS). Once familiarized with them, you must configure an IP network whose connectivity is initially achieved by assigning static routes and then enabling the RIP routing protocol. For this second part we will start from a scenario whose address structure has already been studied and planned beforehand.

For this lab, students will work on setting up a simple scenario consisting of two terminal devices (PCs), two routers Linksys WRT54GS and then two additional router (forming a network with 4 routers Linksys).

In the sections corresponding to the IP network configuration, first you must have the addresses and static routes on both routers and the PCs that connect to the routers. Later, we employed a dynamic routing protocol (RIP) on routers.

Each PC has the TCP/IP stack available which enables the communication through the network interface. In order to get information about the TCP/IP stack implementation, we recommend to use the manual pages (e.g. `man 7 ip`).

2. Laboratory details

Carefully read the laboratory text completely before starting.

The laboratory is evaluated in person with the verification of the milestones that are conveniently indicated in the statement. In the case of not having been evaluated in person, the evaluation will be complemented with the **elaboration of a small report covering the milestones that remain to be evaluated. The document will be written from the template available in Aula Global and must be delivered at the latest one week after the fourth laboratory session using the Aula Global deliverer**. The evaluation is based on a series of milestones to be completed. Once you are confident that the milestone has been completed, take some screenshots that demonstrate this and explain it very briefly in the documentation (as indicated in the template). The screenshots should include:

- a ping between the computers.
- a traceroute between the hosts
- the configuration of the computers
    - in the case of a PC:
        - show ip route
        - show ip address
    - in the case of a router.
        - show running-configuration (sh run)
        - show ip route

If you have problems, ask the practice teacher.

It is mandatory to download and install the Virtual Machine BEFORE THE LAB SESSIONS (check the instructions in Aula Global).

Please consult the Linksys WRT54GS router manual available at http://www.it.uc3m.es/fvalera/ro/Linksys_routers_manual_uc3m_English.pdf (you may alternatively get it from the labs section in Aula Global). These routers use the Quagga program to implement the routing protocols. The complete documentation of this program is available at https://www.nongnu.org/quagga/docs/quagga.html

Milestone XX
The parts of the statement in this format show the milestones of the laboratory. Please fill a document section with each of these (brief section)

3. RySCA -2021 (Lightning) Virtual Machine Setup

1. Follow the installation instructions (available in Aula Global).

2. Open VirtualBox and launch the "RySCA - 2021" Virtual Machine.

3. Open a Terminal and introduce the following command **TWICE**:

   lightning update

4. Once the lightning has been correctly updated it is time to set up the laboratory scenario. To do so, write the following command in the Terminal window (depending on the Part you are doing you will have to load the first scenario or the second one):

   a. Part I (section 4) "lightning start RSC/S16_escenario_1"

   b. Part II (section 5) "lightning start RYSCA/p_encam_a"

5. Wait until the whole setup is done.

6. A figure with the experiment's topology will be opened. In addition to it, several terminals are opened, each of them corresponding to a particular router or host in the experiment.

7. Once all terminals are opened, you will be ready to work with the topology as if you had it set up in the laboratory with physical equipment (PCs and Linksys WRT54GS routers), using the same configuration commands that are used in them.

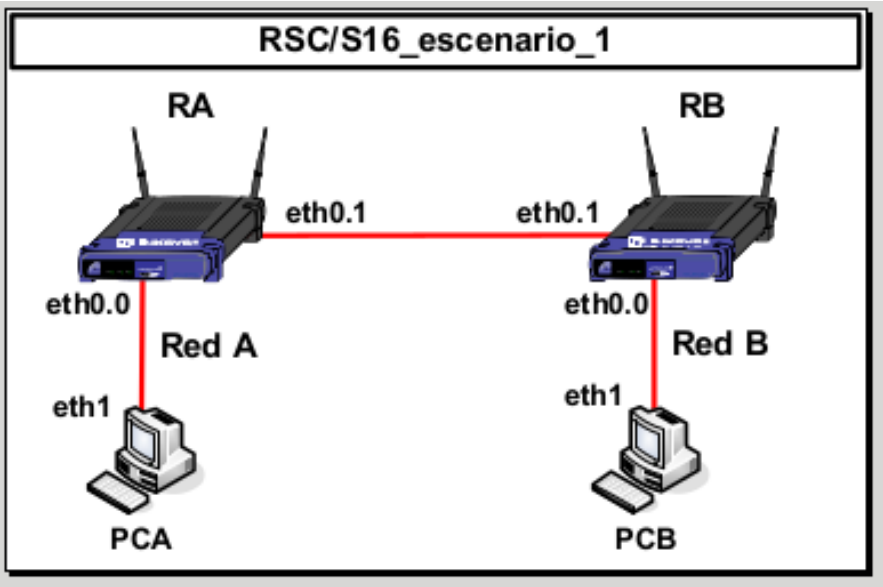
8. If you want to stop the created scenario just execute the following command:

   lightning stop

9. If you don't want to lose your work progress when you leave, please do not power off the virtual machine, just click on the "Save the machine state" button when closing the VM window.

4. Part I: Simple network interconnection

The proposed work includes the set up and the configuration of a simple network scenario depicted in figure 1. Once the required network is configured, the next step is to check that it is properly working using `ping` and `traceroute`).



4.1. Part I – Steps to follow

1. Start the VM and load the scenario by typing "**lightning start RSC/S16_escenario_1**".

    a. Remove the default IP addresses assigned to the eth0.0 through eth0.4 and wlan0 interfaces in the routers. **DO NOT** modify interface **lo under any cirumstance**.
    b. Assign an IP address to the Ethernet interface of computer PCA that is tagged as **eth1** and that is connected to Network A (the address must belong to the 10.0.A.0/24 prefix, A being any valid number that you arbitrarily select). There are several options to assign an IP address to a network interface in Linux. The most commonly used is the **ifconfig** command, but currently its usage is **NOT** recommended and the **ip** command is preferred instead because it is easier to use and more flexible. The **ip** command has a useful help manual, you are just required to type **'ip help'**, or: **'man ip'**).

    c. Assign an IP address to the interface of router A that is connected to the Network A (this IP address must belong to the prefix assigned to Network A, i.e. 10.0.A.0/24). Check the router's manual to see how to configure IP addresses in the router interface.

    d. Verify that the router and the host can reach each other using the **ping** command (either from the PC and/or the router).

2. "Connect" routers A and B through their Ethernet interfaces.

    a. Assign IP addresses to the interfaces that connect both routers. These IP addresses must belong to the 10.0.0.0/30 prefix.

    b. Verify that routers can reach each other using the **ping** command.

    c. Assign an IP address to the interface of router B connected to Network B (this address must belong to the prefix assigned to the Network B i.e. 10.0.B.0/24 for any valid value of B, different than A).

    d. Configure in both routers the routing table entries so that router A can reach network B and vice versa. Check the manual of the router to find out how to configure static routes in the router.

    e. Configure the routing tables in the host in network A (PCA) so it can reach network B. To configure the IP routing table of a Linux PC (and in general any UNIX machine), we have several options. The most classic is to use the **route** command, but - as with setting directions - now recommended not to use this command, in favor of the **ip** command.

    f. Perform the corresponding settings in PCB (IP address, routing table) so that it is included in the network configuration.

    g. Use the **ping** command from PCA to PCB.

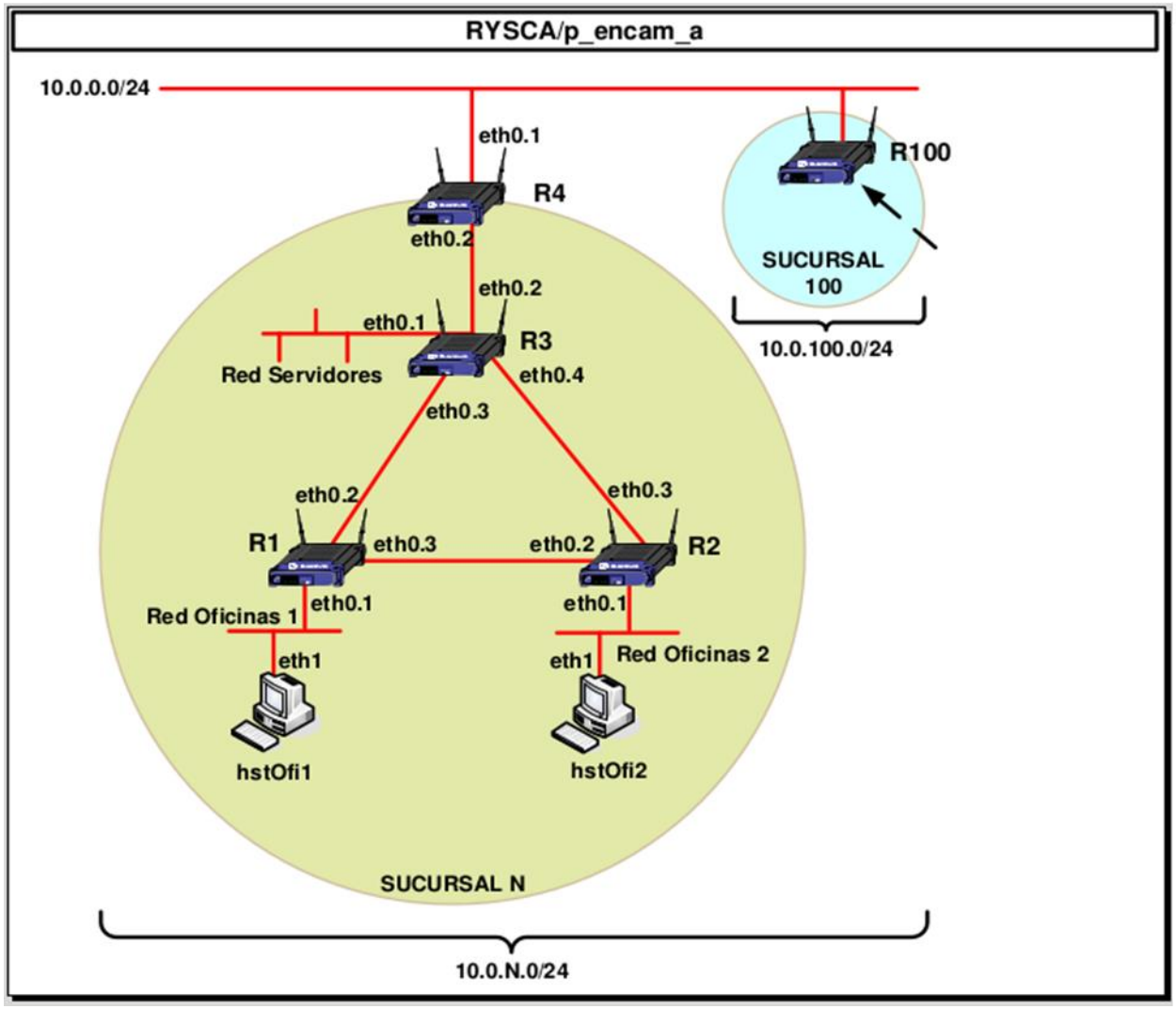
    h. Determine the route used by packets using the **traceroute** command (you can use the '-n' modifier to allow a faster execution of the command).

Milestone 1 (2 points)
Check the connectivity between the network A and B using the ping and traceroute commands from PCA to PCB. **Once the required configuration has been done, and the functionality checked, fill a section in your document with this milestone including screenshots of the ping and traceroute and a short explanation**

5. Part II: Network configuration

This section is intended to build and configure the IP network corresponding to the one specified in addressing exercise. The logical architecture of the scenario is shown in Figure 2.

This scenario corresponds to the network topology of a particular branch. Assign addresses to the network based on the results of addressing exercise.



The design requirements for Figure 2 scenario are as follows:

- The address range available for the branch is 10.0.X.0/24, where 'X' indicates the last two digit numbers of the NIA of any of the group
- The core network interconnecting all branches has the address range 10.0.0.0/24.
- Linksys WRT54GS routers will be used, each with 5 LAN (Ethernet) interfaces.
- Each branch has several areas, namely Office 1, Office 2 and a Server room. Because of the nature of the work performed in each area, independent networks are required, and are interconnected as shown in the diagram of Figure 2. This scheme provides a certain redundancy against link failures. Take this redundancy into consideration when designing the routing tables required in the routers.
- The network of Office 1 must have capacity to allow the connection of up to 100 hosts (PCs, printers, etc.).
- The network of Office 2 must have capacity allow the connection of up to 25 hosts (PCs, printers, etc.).
- The Servers network must have capacity to allow the connection of up to 10 hosts.
- Addresses must also be assigned to the different point-to-point networks used to interconnect the routers.

Regarding the RIP protocol, used for milestones 3 and 4, remember the following criteria:

- RIP should not be used on links where there are no neighbors that have the RIP protocol enabled.
- Identify the information available to the routers at the beginning of the times (from the point of view of RIP protocol operation). This information will be what is exchanged with RIP-speaking neighbors.
- You must be able to reach the router in office 100 from your office. To do this you will need to configure the eth0.1 interface of router R4.

5.1. Part II – Steps to follow

The steps to carry out the practice are the following:

1. Start the VM and load the scenario by typing "**lightning start RYSCA/p_encam_a**".
2. As in Part I, start by removing the default IP addresses assigned to the ethx.y and wlan0 interfaces in the routers.
3. Assign IP addresses to the router interfaces (R1, R2 and R3) and to the hosts (hstOfi1 and hstOfi2) and check that connectivity exists between PCs hstOfi1, hstOfi2 and the routers R1, R2, respectively, using, for example the **ping** command.
4. Assign IP addresses to each of the point-to-point network that interconnects the routers R1, R2 and R3 and check connectivity.
5. Configure the required static routes in R1, R2, R3 and in the PCs connected to the different networks to ensure total connectivity between all subnets. Check that connectivity exists between the different subnets using, for example, the ping command. Check also that the route taken by the packets is the right one, using the **traceroute** command (from the routers as well as from the PCs).

6. "Connect" R4 and configure the necessary routes in all pieces of equipment to ensure connectivity of the global scenario.
7. Configure in the routers the additionally required backup routes, in such a way that if a link is broken between R1, R2 y R3, global connectivity is not lost. To force a link failure, use the interface configuration command **shutdown** to disable the interfaces on both the routers connected to the link (if you have doubts about this point, consult with the lab teacher).

Milestone 2 (5 points)
Check that from any router and PC you have IP connectivity with any network interface of all pieces of equipment of the scenario (and that the route taken by the packets is the best possible). Check that global connectivity is maintained, even in the event of a link failure between R1, R2 y R3 (you may for instance traceroute from hstOfi1 to R4, shutdown one of the routers link used in this path and traceroute again to verify that the alternative route is taken). Once the required configuration has been done, and the functionality checked, fill a document section with this milestone.

8. Remove the static routes previously configured in the routers (maybe reloading the scenario is faster). Now the RIP routing protocol will be used.
9. Enable and configure the dynamic routing protocol RIP in the corresponding router interfaces. Verify, using the router's visualization commands, that the RIP protocol is working correctly.

Milestone 3 (1.5 points)
Check that from any router and PC you have IP connectivity with any network interface of all pieces of equipment of the scenario (and that the route taken by the packets is the best possible). Verify, using the router's visualization commands, that the RIP protocol is working correctly. Once the required configuration has been done, and the functionality checked, fill a section of the document to be delivered with this milestone (some screenshots with the pings and traceroutes and routing tables and some sentences of explanation).

10. Disconnect the wire interconnecting routers R1 and R2 (using **shutdown** command).

Milestone 4 (1.5 points)
Verify that after some time, the routing protocol restores a path between the two office subnets. Verify that with the link between R1-R2 down – and once the convergence time has elapsed (knowing that the routers used are not capable of detecting the failure/recovery of a link when it happens) – from any router and PC you have IP connectivity with any network interface of all pieces of equipment of the scenario (and that the route followed by the packets is the best possible). Verify, using the router's visualization commands, that the RIP protocol is working correctly. Once the required configuration has been done, and the functionality checked, fill a final section in your document with this milestone (some screenshots with the pings and traceroutes and some sentences of explanation).

6. References

[1] GNU/Linux manual (**man <command>**)
[2] Linksys WRT54GS router configuration manual, http://www.it.uc3m.es/linksys/english
[3] Linux Advanced Routing & Traffic Control HOWTO, http://www.lartc.org/howto
[4] Linux Networking HOWTO, http://www.tldp.org/HOWTO/Net-HOWTO/