COMPUTER NETWORKS

PROJECT

For this project we intend to build a computer network. We'll start by creating a webserver, then we will create a LAN for two PCs using a switch, and afterwards we will evolve to connect our LAN to others and create a typical corporate network.

During this project, we expect that you deliver 4 written reports that will summarize your efforts on reaching the objective. These reports are the following:

Phase	Due Date
Phase 1	Check dates on moodle
Phase 2	
Phase 3	
Phase 4	

PHASE 1 – WEB SERVER

On this first phase, you will install a Web Server on your PC and test the connection. A free web server is available on https://www.apachefriends.org/index.html. In order to test if it's working you can open a web browser and point it to your own PC using the address http://127.0.0.1/.

After testing the web server is running you can access it from another PC, tablet or mobile phone using your own IP address on the web browser.

Use Wireshark to capture the web access from another host and compare the HTTP headers sent by the client and the server. If you have trouble connecting to the server check if the firewall is disabled on the PC running the server.

Now, you will develop a Web client (that will replace your browser) using a programming language of your choice where you should establish a TCP connection to the server and request the base webpage from your previously installed webserver. You should also try using your client with a different webserver, from the Internet. The requirements are that:

- you MUST NOT use an HTTP library;
- you are supposed to establish the TCP connection by yourself, send the HTTP request and receive the HTTP reply;
- the HTTP reply should then be presented to the user;

- extra points will be given if you prepare your client to proactively act to the different HTTP replies;
- you do not need to develop a graphic application, a text-only application is enough.

Use Wireshark to capture the interaction from your application to the webserver and compare it to the one obtained previously when using the web browser.

WHAT TO INCLUDE ON THE REPORT?

- Screenshots of your application, browser and Wireshark captures;
- Source code of your application, with line-by-line explanation;
- List of headers sent by the client (browser and application) and server, and their meanings;
- Report on what was performed to achieve the objectives for this part (includes the installation and configuration process of web server).

INTRODUCTION TO PHASES 2, 3 AND 4

In this phase we start working on a virtual environment. Virtual environments allow us to build a much larger network without the needed access to the physical devices. To build our topology on a virtual environment you need to choose between a simulator or an emulator. Simulator are more convenient for small setups, however, are prone to bugs on the simulation process. Emulators provide a more authentic experience since they execute the binary image of the physical device while emulating the hardware. For this work, we will use EVE-NG an emulator.

Figure 1 shows what the network topology will look like in EVE-NG. It shows the already configured topology as provided to you. You can find it on \RCp\RCP-ProjFinal.unl inside EVE interface. **This means that you do not need to change the topology, you only need to start the devices and configure them.**

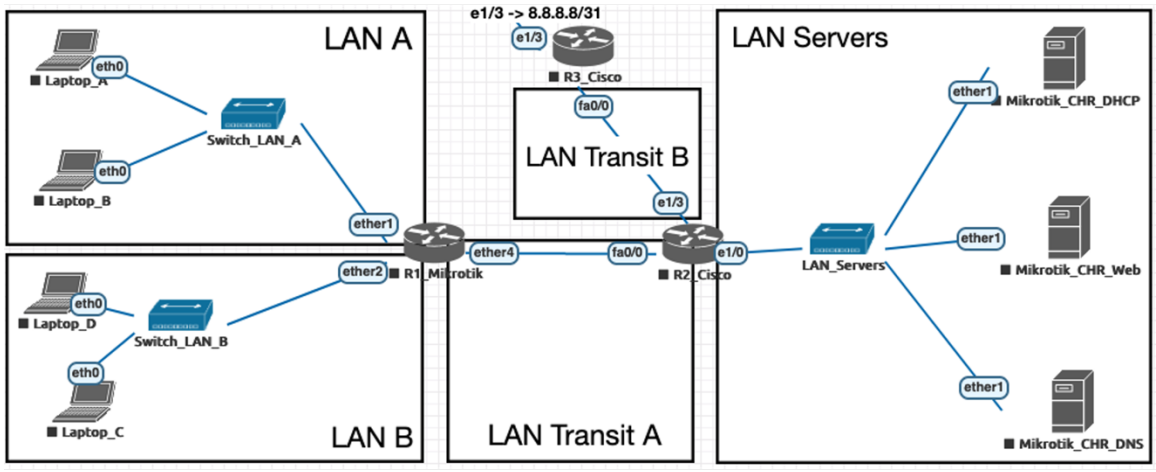

FIGURE 1: NETWORK DIAGRAM.

The emulator is a Web application running on powerful hardware to emulate all devices. You only need a web browser and a telnet client, Putty on windows, on Mac/Linux the built-in client is enough. Install the client pack from http://www.eve-ng.net/ if putty doesn't open automatically.

The emulator is available at http://eve.lrcd.e.ipl.pt – this URL is only available inside ISEL, or with the VPN IPL-Intra connected. Instructions for VPN access here: https://info.net.ipl.pt/vpn-vpnintra/ and VPN credentials (e-mail ending with @alunos.isel.ipl.pt) should be obtained here: https://info.net.ipl.pt/e-mail-crreact/ .

The EVE username is the initials of your teacher (jf, lp, lm, nco or nmal) followed by a dash "-" and the number of your group with two digits. For example, for group 1 or Prof. João Florêncio, you should use **`jf-01`** as username, and as password the one you received for Moodle on the beginning of the semester.

VERY VERY VERY Important notes:

The virtual environment is shared between all, so the system reinitializes frequently to remove devices that were left running unattended. Since the environment is shared, if everyone works only near the deadline the load on the server will be high and performance will be degraded. Make sure that you start working early to avoid issues and start only the devices you need.

In addition, you should only start the elements that will be used on each phase. For example, there's no need to start all the topology for the 2nd phase.

You must stop all the running devices before you close the Eve session. If you do not do it, your setup will be locked until the next system reset (performed 5 times per day).

PHASE 2 – CONNECTING DEVICES (USING LAN A AND B ONLY)

We will start by configuring LAN A. Since we are building our own LAN we should start by defining our own IP address range. The range attributed to your group is **`192.168.N.0/24`** where **N** is your group number.

To connect more than 2 PCs we need to use a switch as seen on Figure 2 (corresponding to the LAN A on the network diagram). Check the ARP Cache (use the **`show arp`** command) before and after pinging from one PC to the other. How can a PC know if it is connected to a switch? Is **`traceroute`** useful in this situation?

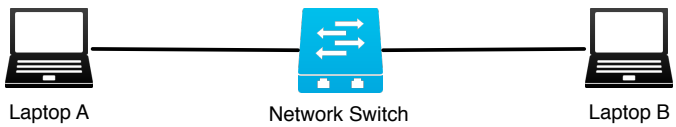

FIGURE 2: LAN A TOPOLOGY

Laptop A should have the IP address **`192.168.N.1`** and laptop B should have the IP address **`192.168.N.2`**. For now, no gateway is going to be defined.

After configuring the static IP address on each PC you should test the connectivity using the command **`ping`**.

WHAT TO INCLUDE ON THE REPORT?

- Screenshots of the VPCs configuration screens;
- Outputs of commands;
- Report on what was performed to achieve the objectives for this part, including answers to the questions.

CONNECT TWO LANS WITH A ROUTER

Let's continue by connecting multiple LANs (LAN A and LAN B) using a single Router. To do so we will connect two network interfaces on the router to the switch of each LAN. Figure 3 shows the expected topology. **Note that since you are using a new network you should have a difference address space for it. To do so you should subnet the address space given to your group.** Router interfaces should use the last available address of the subnet address range for each interface. Don't forget to also configure the default gateway on the different Laptops.

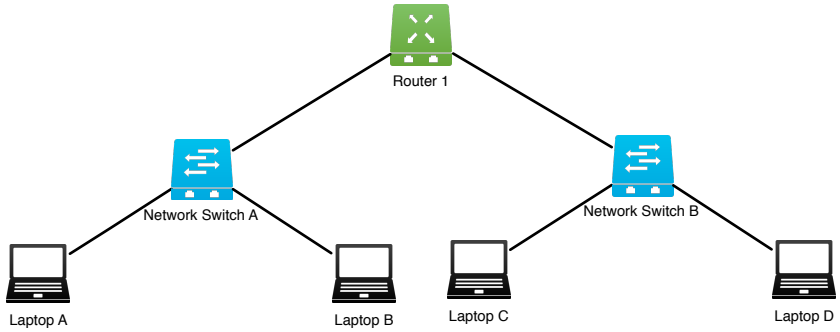

FIGURE 3: TWO LANS CONNECTED

The emulator is able to emulate both Cisco and Mikrotik devices. Router 1 is a Mikrotik device and Routers 2 and 3 are Cisco devices. For this phase, you will only need to configure Router 1 (add ip addresses to the interfaces and check that they are online)[1].

Test all configurations using the previous mentioned commands and observe that the MAC addresses from Laptops on the Left LAN do not appear on the ARP caches of PCs on the Right LAN. Also check the routing table on the router with the command **`ip route print`**.

[1] You can find information about the Mikrotik router at https://wiki.mikrotik.com/wiki/Manual:Console and https://wiki.mikrotik.com/wiki/Manual:IP/Address.

WHAT TO INCLUDE ON THE REPORT?

- Updated screenshots of the PCs configuration screens;
- Outputs of commands;
- Router configuration;
- What was performed to achieve the objectives for this phase, including answers to the questions.

PHASE 3 – CONNECTING MULTIPLE NETWORKS

Now that you understand subnetting, it's easier to expand our network. In this phase, we will connect our two LANs (A and B) to Server LAN using a Transit Network. LAN T will be considered a transit network between Router 1 and Router 2[2]. LAN A will be converted to our user network for department A and LAN B for the users of department B. LAN C will be our server network. Figure 4 shows a drawing of the network topology.

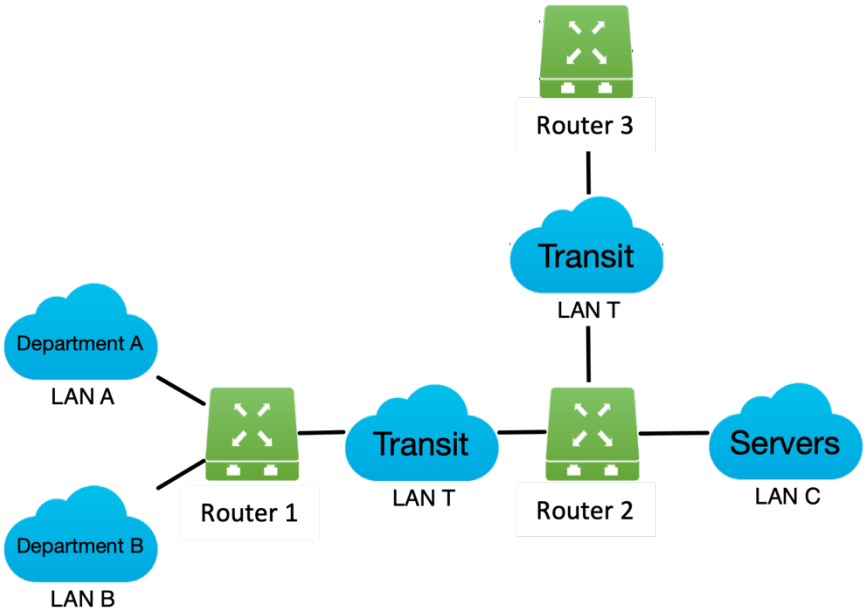

FIGURE 4: NETWORK TOPOLOGY WITH MULTIPLE ROUTERS

To obtain the number of clients connected to LAN A and B you should use the following formula:

$$\text{Clients}_{LAN_A} = \max\left(20, \left(\sum_{k=0}^{n} studentnumber_k\right) mod\ 100\right)$$

[2] Router 2 is a Cisco device and all the information required for its configuration can be found at Lab 04.00 - Routers).

$$\text{Clients}_{LAN_B} = \frac{\text{Clients}_{LAN_A}}{2}$$

which represents the sum of all group members (n represents the total number of students in your group) modulo 100 (select only the last two digits of the sum result), if this number is lower than 20, you should use the value 20.

The number of clients at LAN B should be half of the ones from LAN A.

LANs transit A and B should use a /30 address each.

LAN C should have the largest remaining contiguous block of your address space.

Additionally, to *simulate* the connectivity with the outside of our network, we will configure the IP address 8.8.8.8/31 on the e1/3 interface of Router 3.

Test the connectivity between networks and routers. If the configuration has been done properly, you should be able to *ping* all the network elements from one another, *i.e.* PC A should be able to ping Laptop B and Laptop C, Router 2, the servers in LAN C, and 8.8.8.8. The same for PC B, and so on…

Don't forget to adjust routing tables and default gateways on the PCs. Test if everything is working as expected, use the previous knowledge to test everything.

WHAT TO INCLUDE ON THE REPORT?

- IP Address distribution, including max number of devices and network and broadcast addresses per subnet;
- Command outputs in order to test connectivity and routing;
- Configuration of different devices and networks (including the address space used on each LAN);
- What was performed to achieve the objectives for this phase.

PHASE 4 – DEPLOY SERVICES

In this phase we will upgrade our network to a more realistic one by using DHCP and DNS to provide an easier experience to our users. Additionally, we will also add a webserver that will be available to the users. To achieve this, you must deploy 3 servers on LAN C. A server for DHCP, another one for DNS and the third one for HTTP.

Users of LAN A and B should be able to receive a network configuration automatically and also be able to access www.company.com server by the web server. Figure 5 shows the expected network diagram. You can test the DNS using **`nslookup`**, and DHCP on the clients using **`ipconfig /release`** or **`ipconfig /renew.`**

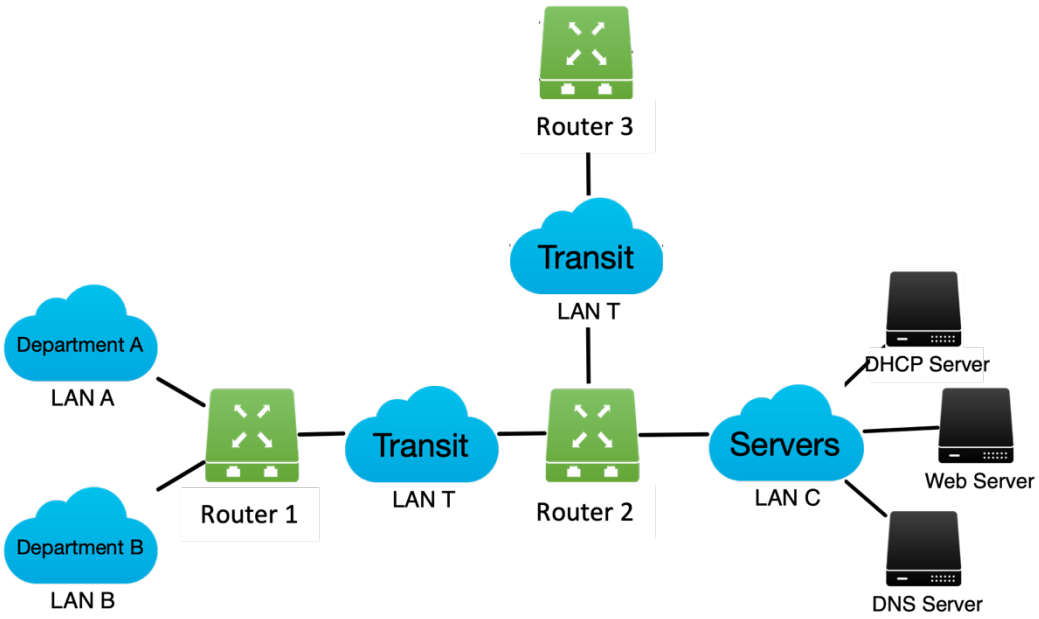

FIGURE 5: NETWORK WITH SERVICES.

Note that since we are using Mikrotik Routers to provide the services, some of the services do not require configurations, for example the Webserver, since it's already enabled on the router[3].

To test DNS perform a ping using the correct name, to test DHCP show the outputs of "ip" commands, and to test the Webserver use telnet to the correct port. Telnet is available on the Cisco router.

WHAT TO INCLUDE ON THE REPORT?

- Configuration of different devices and networks (including the address space used on each LAN);
- Command outputs in order to test connectivity, routing, DNS, DHCP and Web access;
- What was performed in order to achieve the objectives for this phase.

This is your last phase, by this time you should be able to understand all the concepts and protocols related with building a simple corporate network.

[3] More information about the DNS and DHCP configuration on MikroTik Routers can be found at https://wiki.mikrotik.com/wiki/Manual:IP/DNS , https://wiki.mikrotik.com/wiki/Manual:IP/DHCP_Server and https://wiki.mikrotik.com/wiki/Manual:IP/DHCP_Relay .