

Name 1: _____
Name 2: _____

Group number: _____

COMPUTER NETWORKING

LAB EXERCISES (TP) 1

TOOLS FOR EVERYBODY:

PING, TRACEROUTE, STATIC ROUTING

September 23, 2009

Abstract

In this TP you will familiarize yourself with the Internet Engineering Workshop (IEW) lab room and equipment. You will learn how to “statically” configure routers in order to achieve IP interconnection of a company network distributed over several sites, where each site has a Local Area Network (LAN). Statically means that you will define the routes manually (in the next TP you will use routing software in order to achieve the same goal). You will also learn how to configure a machine to access the Internet, and practice some networking commands that enable you to obtain information about Internet machines and about the connectivity and the paths between them.

1 ORGANIZATION OF THE TP

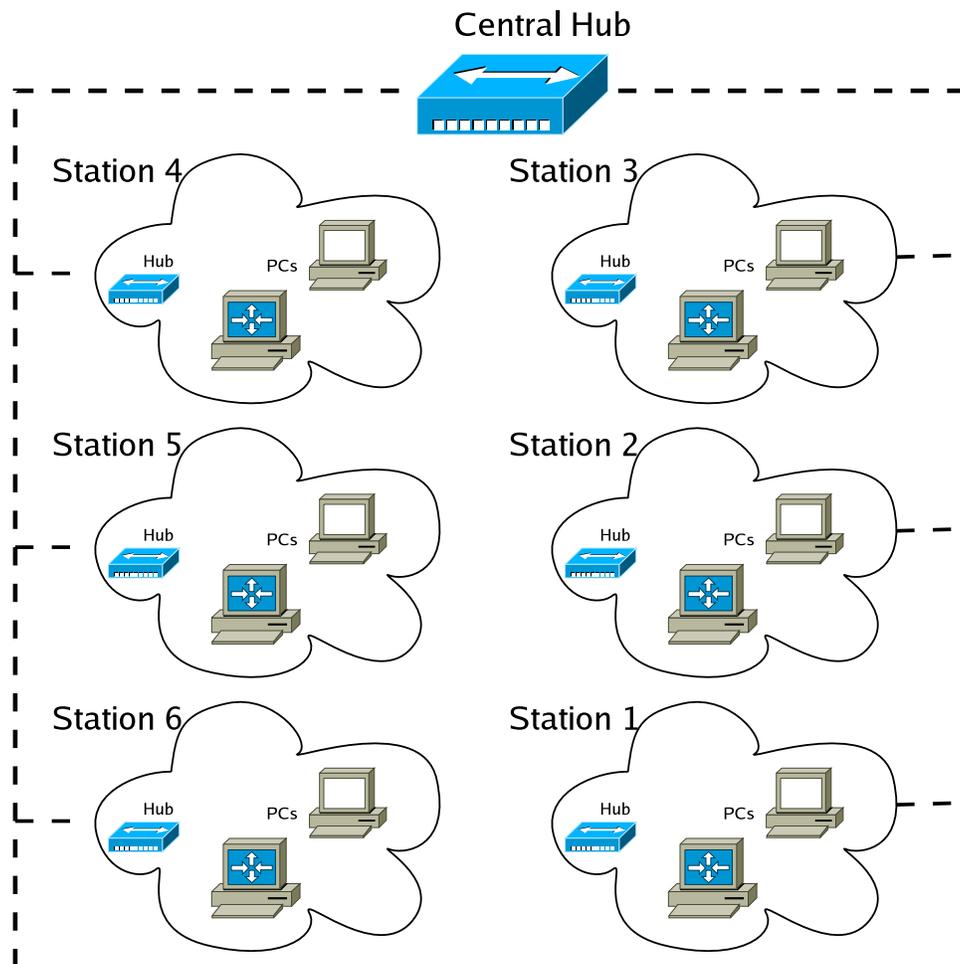
Each group of two students works on one work space. There are two computers per work space. The workspace number is written on the white stickers tagged to each computer. During the TP (part on building a company network, Section 4) you will have to collaborate with a group from another work space belonging to the same central hub (defined in Section 2). Before starting this part, you should choose the work space to collaborate with and synchronize the rest of the work with them (otherwise you might end up typing the same commands on two work spaces).

1.1 TP REPORT

Write your answers in this document during the TP. That will be your TP report (one per group). Don't forget to write your names and group number on the first page of the report.

2 IDENTIFY IEW ROOM EQUIPMENT AND YOUR WORKSPACE

The hardware equipment in the IEW room is shown in the figure below. Each work space consists of one “local” hub and two Linux PCs: one “workstation” PC and one “router” PC (the notation for PCs can be found on the stickers on each PC). Local hubs are placed next to the monitors and keyboards of your PCs. There is also one “central” hub, usually placed next to the windows, and used to connect multiple work spaces when required by an experiment. There are actually a few parallel configurations as the one shown on the figure below, each having its own central hub.



Existing networking hardware in the room

Though not shown in the figure above, there are also a few “EPFL” hubs that are connected to the EPFL’s network and used when the computers need to be connected to the Internet. These hubs are positioned on the upper part shelves and are shared by a few neighboring work spaces.

To interconnect the equipment you will use up to 3 short and 1 long 10BaseT cables at one work space.

Identify all the mentioned equipments and your workspace, before you start the actual work.

3 CONVENTION



The upper logo on the left means you should do the corresponding commands/actions on the workstation PC.



The second logo on the left is for the router PC.

4 STATIC ROUTING WITHIN A COMPANY NETWORK

In this section you will learn how to statically (manually) configure routing entries of the routers in order to achieve IP interconnection of a company network distributed over several sites, where each site has a Local Area Network (LAN). You will also use *wireshark* to observe which traffic is sent (or not) in some scenarios. This will help you to find what is configured correctly and what has to be configured additionally in order to achieve the connectivity.

A group will use the two PCs at their work space to form a LAN that corresponds to a company site LAN. The groups will interconnect the sites by having each group connect their router PC to the central hub and configure it manually, so that two workstation PCs at different LANs are able to communicate. The central hub implements an Ethernet network that simulates a Wide Area Network (WAN) of the company. In this section we do not use “EPFL” hubs.

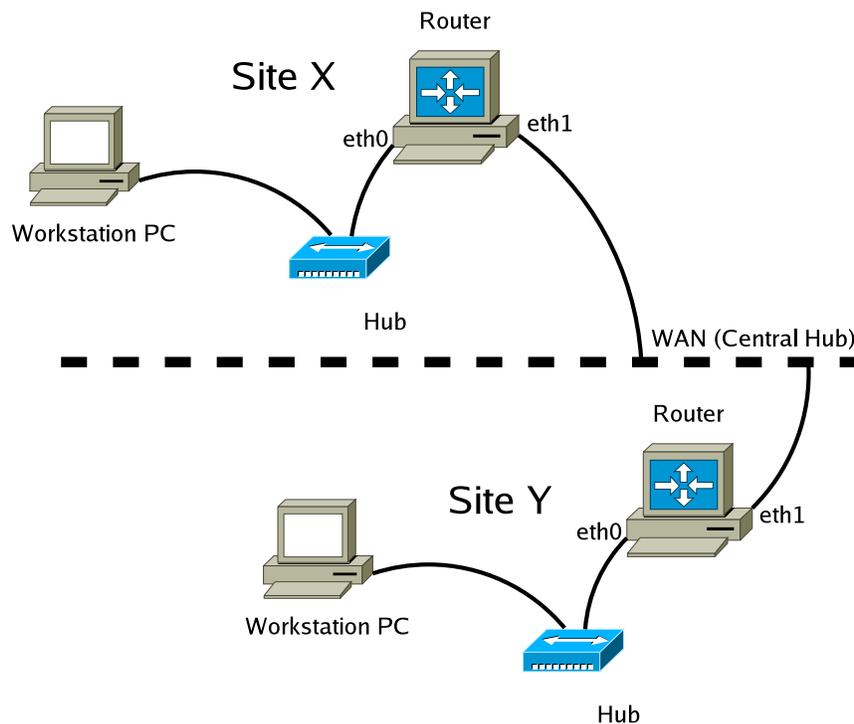
Organizational note: For some tests in this section you will have to cooperate and synchronize with another group connected to the same central hub (the backup solution is that you do the job of two groups).

4.1 PUT BOTH PCs INTO A PROPER INITIAL NON-CONFIGURED STATE

In order to put the machines into a clean initial non-configured state, click twice on the Network Workspace Manager icon that you can find on the desktop of each machine. From the menu that opens select “Load from Disk” and choose “lab-1-default: IEW default configuration for lab1”.

4.2 WIRING

Wire your PCs as shown in the following figure:



Wiring of the hardware equipment for the lab

4.3 ADDRESSING SCHEME

We use the following convention for writing IP addresses in the continuation of this document:

- X - the number of your work space
- Y - the number of the work space you collaborate to
- $_$ - you should find out which value should be used instead of $_$

Identify your workspace number (the workspace number is written on the white stickers tagged to the computers).

What is your workspace number? What is the number of the workspace you collaborate with?

We have at our disposal the private IP address space from 192.168.0.0 to 192.168.255.255.

- For the local network at your site, we will use the network address 192.168. X .0/24 (X is the number of your work space). The host identifier (the fourth byte) should be 1 to indicate the router PC and 2 for the workstation PC.
- The network address of the interconnection network is 192.168.100.0/24. On this network, the host identifier of the router's IP address corresponds to the number of the work space it belongs to.

How many networks does your router PC belong to? Name the type of the network(s).

Write down the IP addresses you will use for the interfaces according to this addressing scheme.

Workstation PC:

Router PC LAN (eth0):

Router PC WAN (eth1):

Which network masks should be used in our example?

4.4 ARE YOU CONNECTED? USE WIRESHARK TO SEE WHAT HAPPENS.

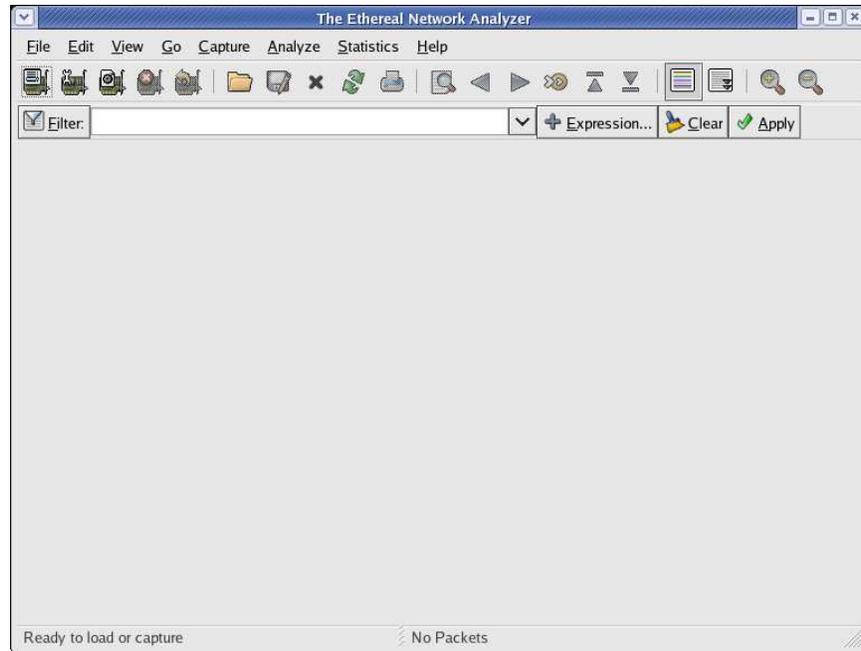
In order to have access to the commands that manipulate the network interfaces, you need to be logged in as superuser (root). You can do this by double click-ing on the Terminal icon on the Desktop of each machine (router PC and workstation PC)



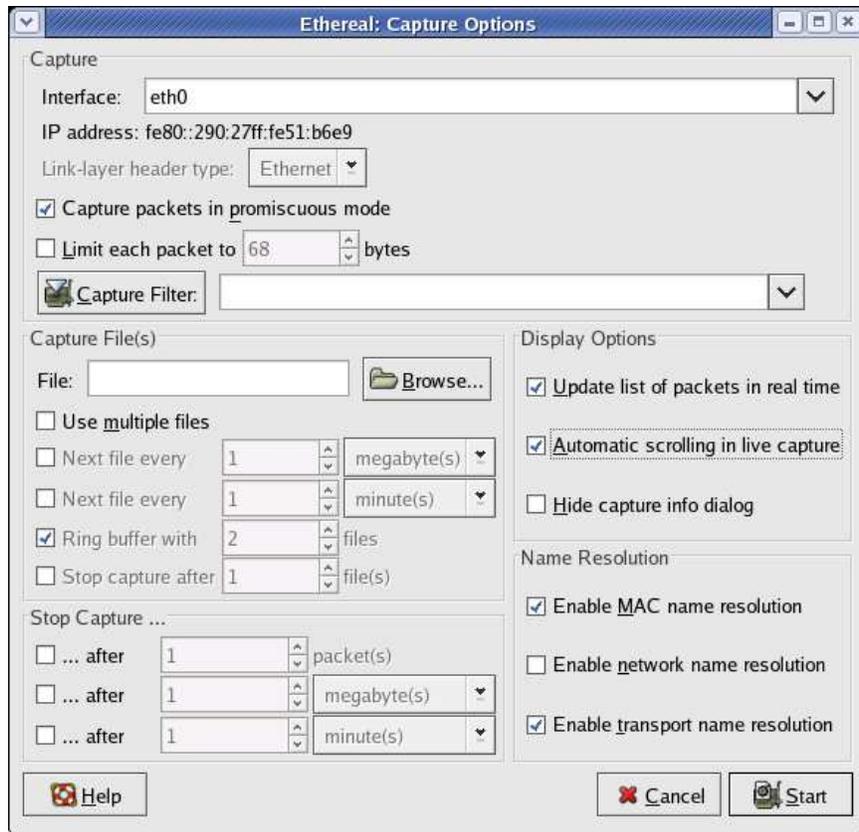
On the *router*, run *wireshark* to observe the traffic of the link 192.168.X.0/24. The *wireshark* program is used to capture the incoming and outgoing traffic on a network interface. In order to be able to run *wireshark*, you first have to put the interface up.

```
#ifconfig eth0 up  
#wireshark -i eth0 &
```

The following window will appear:



Start the frame sniffing process: open the *Capture/Options* menu and configure the options as indicated in the figure below. Then click *Start*.



From a terminal on the *workstation*, run a *ping* to the router.

```
#ping 192.168.X.1 (X is your workspace number)
```

What is the *ping* error message? Has the analyzer captured anything?

ping message:

Captured traffic:



To see the network interfaces of the workstation, type:

```
#ifconfig -a
```

What can we deduce from the above tests and displayed interface information?

4.5 CONFIGURING AND TESTING OF THE LAN

4.5.1 CONFIGURATION OF THE NETWORK INTERFACE OF THE WORKSTATION PC

The first step to do in order to achieve connectivity from your machine is to configure its network interface and to assign an IP address to the interface.



On the *workstation*, type:

```
#route -n
```

to visualize the routing table of the machine.

To configure your network interface and assign an IP address to it, type:

```
#ifconfig eth0 192.168.X.2 netmask 255.255.255.0
```

where eth0 is the name of the network interface, 192.168.X.2 is the IP address, **X** is your work space number and 255.255.255.0 is the netmask.

Which modifications were made to the routing table? [Notice there should be some modifications.] What are the new modifications used for?

Why do we need the netmask in the command above? Explain.

How can we compute the host part of an IP address? Give an example with the IP address of your computer and its associated netmask.



Look again at the interfaces of your machine:

```
#ifconfig -a
```

How many interfaces can you find? What are their names and what do they correspond to? What are the IP addresses and netmasks of these interfaces?

There is an MTU (Maximum Transfer Unit) field for each interface. What is its value for each of the interface? Why is it not the same for all interfaces?

Run another ping to the router's local interface:



```
# ping 192.168.X.1
```

What is the *ping* error message? Which traffic has been captured by the analyzer? (**NOTE:** Your analyzer should capture some traffic. If this is not the case, check if the cable connecting the router and workstation is plugged into the proper interface (eth0) of the router, by trying to plug it into another interface and repeating the ping command.)

ping message:

Captured traffic:

What can we deduce?

4.5.2 CONFIGURING OF THE ROUTER'S NETWORK INTERFACES



Take a look at the arp table of the workstation:

```
# arp -a
```



Configure the *router's* interface *eth0* according to the addressing scheme defined previously.

```
#ifconfig eth0 192.168.X.1 netmask 255.255.255.0
```

To verify the configuration, type:

```
#ifconfig eth0
```



Proceed in the same way to configure the *router's* interface *eth1*:

```
#ifconfig eth1 192.168.100.X netmask 255.255.255.0
```



Now, the router should be reachable from the workstation. Verify it by typing:

```
# ping 192.168.X.1
```

Which frames circulate on the network?



Take a look again at the ARP table of the workstation:

```
#arp -a
```

Explain what changed in the arp table of the workstation? What made these changes happen? Whose MAC address do you find there?

Now try to reach the router's outside interface from the workstation:



```
# ping 192.168.100.X
```

Can you reach the router's interface *eth1* from the workstation? Why?

What is the message you get when trying to ping a workstation that is not on the local network?

Why don't you see any frames on the network?

4.6 STATIC (MANUAL) CONFIGURATION OF ROUTING



Rerun *wireshark* to observe the traffic that circulates on network 192.168.100.0/24.

```
# wireshark -i eth1 &
```

Try a *ping* from your work space **router PC** to the 3 possible destinations of site Y (Y is the number the work space you collaborate to).



```
# ping 192.168.100.Y  
# ...
```

Fill Table 1 with the *ping* results (what you observe in the command window), **EXPLAINING ALSO EACH TIME THE REASONS AND OBSERVATIONS** for having such a result (i.e. what you observe using *wireshark* and what you conclude: which packets and by which machine are sent/not sent, forwarded/not forwarded, replied/not replied in each case, and why).

Table 1 Pings from your **router**:

Destination	Ping results and Explanations
192.168.100.Y (external interface of site Y's router)	
192.168.Y.1 (internal interface of site Y's router)	
192.168.Y.2 (workstation of site Y)	

Indeed, the router must be informed about other networks.

Do you think the use of a default gateway at the router is a good solution in this case, e.g., a company network distributed over several sites ? Why ?

4.6.1 SYNCHRONIZATION POINT: WAIT FOR THE GROUP AT WORK SPACE Y (THE GROUP YOU COLLABORATE TO) TO REACH THIS PART



Configure the routing table of the *router PC* so that the LAN at site *Y* can be reached:

```
# route add -net 192.168.Y.0/24 gw 192.168.100.Y
```

What do we need to add in order to be able to reach all the company sites?



Type the command:

```
# route -n
```

Try a *ping* from your work space **router PC** to the 3 destinations of the site *Y*:



```
# ping 192.168.100.Y  
# ...
```

Fill Table 2 with the *ping* results, **EXPLAINING ALSO EACH TIME THE REASONS AND OBSERVATIONS** for having such a result.

Table 2 Pings from your **router**:

Destination	Ping results and Explanations
192.168.100.Y (external interface of site Y's router)	
192.168.Y.1 (internal interface of site Y's router)	
192.168.Y.2 (workstation of site Y)	

In fact, a station with multiple interfaces is not a router. To turn it into a router, it is necessary to activate the forwarding process in the kernel. On the router, type:



```
#sysctl -w net.ipv4.ip_forward=1
```

4.6.2 SYNCHRONIZATION POINT: WAIT FOR THE GROUP AT WORK SPACE Y (THE GROUP YOU COLLABORATE TO) TO REACH THIS PART

Try a *ping* from your work space **router PC** towards the 3 destinations of the site Y:



```
# ping 192.168.100.Y
# ...
```

Fill Table 3 with the *ping* results, **EXPLAINING ALSO EACH TIME THE REASONS AND OBSERVATIONS** for having such a result.

Table 3 Pings from your **router**:

Destination	Ping results and Explanations
192.168.100.Y (external interface of site Y's router)	
192.168.Y.1 (internal interface of site Y's router)	
192.168.Y.2 (workstation of site Y)	

From your **workstation PC**, run a `ping` towards both interfaces of your router PC and towards the three addresses of the site Y:



```
# ping 192.168.X.1
# ...
```

Fill Table 4 with the *ping* results, **EXPLAINING ALSO EACH TIME THE REASONS AND OBSERVATIONS** for having such a result.

Table 4 Pings from your **workstation**:

Destination	Ping results and Explanations
192.168.X.1 (internal interface of the local router)	
192.168.100.X (external interface of the local router)	
192.168.100.Y (external interface of site Y's router)	
192.168.Y.1 (internal interface of site Y's router)	
192.168.Y.2 (workstation of site Y)	

What must be added to the workstation configuration so that the ping works? Explain.



Add a default route at the workstation (i.e. “configure default gateway”):

```
# route -n
...
# route add default gw 192.168.X.1
# route -n
....
```

What will occur if, at the time of the *ping* towards the workstation of site *Y*, the default gateway of the latter is not configured yet? Try this and observe what happens (which packets are sent/not sent). Write here your observations and conclusion.

Now, make sure that both workstations are given default gateways, and try a *ping* from your workstation to the workstation of the site *Y*.



```
# ping 192.168.Y.2
```

What should you do at your work space to reach other PCs in the room?

Is this sufficient to be able to ping the other PCs (and get reply from them)?

5 CONFIGURING A MACHINE TO ACCESS THE INTERNET AND TESTING YOUR CONNECTIVITY AND PATH TOWARD INTERNET HOSTS

In this section, you will learn how to configure your computer in order to be able to access the Internet and surf Web pages. To surf the Web, in addition to the configuration seen in the previous part of this TP, you will also have to configure your machine to use DNS (Domain Name System). You will practice some commands for getting information about Internet hosts, their connectivity and paths between them.

5.1 DO THE NECESSARY CABLING AND LOGIN

For accessing the Internet, you will use only the workstation PC at your work-space (the PC with one Ethernet interface). Use a short 10BaseT cable to connect this machine to an “EPFL” hub (“EPFL” hubs are normally connected to the Internet all the time, through the EPFL’s network).

What is your workspace number (for this section)?



Open a terminal by clicking on the “Terminal” icon on the Desktop.

5.2 MAKE YOURSELF AT HOME: KNOW YOUR COMMANDS ARSENAL

You should always have in mind what are the standard things you can do regarding connectivity of your PC to the Internet. Here is a list of the most often used commands with short descriptions of what they do:

ifconfig network interface configuration

route manually manipulate the routing tables

netstat display various network settings and informations

ping “from the submariners’ term for a sonar pulse”, the name should be explicit, no?

traceroute print the intermediate hops that packets take on their route to the destination

arp manipulate the system's ARP cache
host, nslookup DNS lookup and queries
whois the "who is who" directory of the Internet

5.2.1 OBTAINING INFORMATION ABOUT HOW TO USE A COMMAND: THE MAN COMMAND

How to obtain information on a command you don't know how to use? Using the command `man` you can query the reference manual of a command. For instance, to obtain the reference manual of the `ping` command, you would type

```
man ping
```

To navigate the document, use the up and down arrows, as well as the space bar. More useful is the possibility to search for a keyword when viewing a manual page. Type

```
/keyword
```

and press **return**. Then to navigate between the selections, use **n** (forward) or **N** (backward).

What is the purpose of the **-t** option of the `ping` command?

And of the **-c** option?

5.3 PUT YOUR MACHINE INTO A PROPER INITIAL NON-CONFIGURED STATE

In order to put the machines into a clean initial non-configured state, click twice on the Network Workspace Manager icon that you can find on the desktop of each machine. From the menu that opens select "Load from Disk" and choose "lab-1-default: IEW default configuration for lab1".

5.4 CONFIGURE THE NETWORK INTERFACE, THE DEFAULT ROUTER AND DNS



To check if you are connected to the Internet, you usually use the `ping` command:

```
#ping -c 1 www.google.com
```

Configure your network interface using `192.168.X.2` as IP address (`X` is your workspace number) and 16 bit netmask. Configure the default gateway to be `192.168.100.100`.

The DNS on your machine should be already configured correctly. To see if this is the case, open the file `/etc/resolv.conf` and verify that the following lines are present:

```
search iew.epfl.ch
nameserver 192.168.100.100
```

If they are not, use a text editor and put the correct entries listed above (do “man gedit” if you do not know any other linux text editor). Now you should be able to access the Internet. Try:



```
# ping -c 1 www.google.com
```

Check what happens if you replace the existing correct DNS entry by 128.178.15.8, then by 128.178.156.145. In each case try the next two commands:

```
# ping -c 1 www.google.com
# ping -c 1 209.85.135.103
```

What message do you get in each case? Explain what happens.

Before you proceed further, do not forget to put back 192.168.100.100 as your DNS entry.

5.5 NETWORK DEMYSTIFICATION

5.5.1 FROM DOMAIN NAMES TO IP ADDRESSES: HOST, NSLOOKUP AND WHOIS

As you might know from the lectures, the Domain Name System (DNS) allows to translate human friendly names of the machines (or sets of the machines) into their associated IP addresses.

What are the IP addresses of icwww.epfl.ch and www.google.ch? What names do you obtain with the reverse mapping?

Domain names can be bought by people or organization. For instance, the domain name epfl.ch is owned by the EPFL. All domain names are registered and it is possible to query the registry of domain names.

In what country are the machines `ocean.ueem.mz` and `www.ru.ac.za`? Who owns them?

Who owns the IP *network* 18.0.0.0?

5.5.2 MORE ABOUT PING, THE FIRST COMMAND YOU TRY WHEN SOMETHING GOES WRONG

The `ping` utility is likely one of the most important networking tools. And it is probably the one you will use the most during the lab exercise sessions. It is very simple; it sends an `ECHO_REQUEST` datagram to elicit an `ICMP ECHO_RESPONSE` from a destination. You can think of it as a kind of sonar.

Are the following machines reachable from your machine: `ic.epfl.ch`, `www.google.com`, `www.met.gov.fj`?

Furthermore, for each of the above mentioned machines, send out exactly ten `ICMP` packets. What is the average round trip time? Write down the commands you used.

Compare the round-trip time of the machines `www.nzherald.co.nz` and `www.newzealand.com`. Which one of the two hosts is actually located in New-Zealand? Explain.

Hint: compute the round-trip propagation time to the antipode of earth. (The round-trip distance is $40\,000\text{ km} = 4 \cdot 10^7\text{ m}$ and the propagation speed of light in glass – for trans-oceanic cables – is $2 \cdot 10^8\text{ m/s}$)

5.5.3 EXPLORING A PARTICULAR SOURCE-DESTINATION PATH: TRACEROUTE

Sometimes, you would like to know which route the packets are following from a given host to a particular destination. The `traceroute` utility is the tool of choice.

Find out the IP addresses and names of all interfaces between your workstation and planetlab01.ethz.ch. (Hint: you need to display the route that packets take from your workstation to planetlab01.ethz.ch). If you were at planetlab01.ethz.ch and you did a traceroute to your workstation, would you see the same IP addresses? Explain.

Can you determine the MAC addresses of these interfaces? Explain.

6 CLEAN-UP YOUR WORK SPACE

Reboot the PCs by typing:

```
# reboot
```

Unplug the 10BaseT cables and disconnect the power plug of your hub. Leave the long cable on the desk and connect the router and workstation PC to the hub located between the machines (i.e., leave the workplace in exactly the same condition you have found it).

7 CONCLUDING QUESTIONS

You can answer these questions without being in the lab, assuming you already did the above part of the TP.

Why do we need to the configure the network interface?

What do we configure?

Why do we have domain names?

Do we have a domain name server-like in the telephone network? Explain.

Why are routers used to interconnect LANs of a company network, i.e. why it is not always good enough to simply expand to a big LAN by using bridges and adding new Ethernet segments ? Explain the problems and how they are solved by using routers. Hint: think of arp, mac addresses, STP topology.