Duration: 1h 30 minutes. El quiz will be collected in 20 minutes.

Test (3,5 punts). Questions count half if there is one error and zero if more than one error.

1. The transmission time of a packet of 1500 bytes at 10 Mbps is 1.2 ms. In one link, the end to end propagation time from a client to the server is 1 ms. Then, in this case, the total end to end delay when no intermediate nodes are present is 2.2 ms.
If three routers are added in the path between the client and the server:
☐ The minimum end to end delay will be 2.2 ms.
☐ The end to end delay will be at most 6.6 ms.
☐ The minimum end to end delay will be 5.8 ms.
☐ The minimum end to end delay will be 4.6 ms.

2. About the IP protocol.
☐ It is a connection-oriented protocol.
☐ It is an application protocol between a client and a server.
☐ It provides an unreliable communication.
☐ It is used between a client and a server and it includes error checking.

3. About ARP (*Address Resolution Protocol*).
☐ The protocol uses *broadcast* datagrams to identify the destination address.
☐ ARP uses *broadcast* Ethernet frames.
☐ It is used for discovering the MAC address (physical) associated with an IP address in the same network.
☐ The ARP table contains the association MAC address – IP address during a period of time and if the communication is active.

4. The command *ifconfig* provides the following information:
eno1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.1.68 netmask 255.255.255.0 broadcast 192.168.1.255
    ether 94:c6:91:1e:37:67 txqueuelen 1000 (Ethernet)
☐ The size of the data field (payload) of an IP datagram is 1500 bytes.
☐ The ARP table of the devices with which this PC has exchanged information will contain the association between 192.168.1.68 and 94:c6:91:1e:37:67.
☐ The IP address and the MAC address have been configured using DHCP.
☐ The size of the IP packet may be smaller than 1500 byes, including its header, but it cannot exceed it.

5. About IP and ICMP.
☐ ICMP generates error messages sending them to the IP source address of the datagram causing the error.
☐ ICMP messages go into the datagram data field and the protocol field of the header is ICMP.
☐ ICMP messages include a copy of the full datagram that caused the error.
☐ The ICMP echo reply message includes the amount of time since the ICMP *echo request* message and the reply.

6. About DHCP.
☐ The DHCP server is known since the start by its MAC address.
☐ The DHCP must be located in the same IP network because it is discovered using IP *broadcast*.
☐ DHCP configures the cache of the DNS server so that the device can communicate.
☐ DHCP configures, at least, IP address, the network mask, the IP address of the default router, and the IP address of a DNS server, even if the DNS server is located in a different IP network.

7. About an IP router.
☐ If the router performs NAT in one interface it cannot support a tunnel in the same physical interface.
☐ If the router performs PNAT (*Port and Address Translation*) it modifies one of the address field in the header and the checksum, but it does not modify the TTL field.
☐ If the checksum of the datagram fails it is discarded and an ICMP error message is sent.
☐ The TTL field is updated always, except when the destination address is a private one.

Duration: 1h 30 minutes. The quiz will be collected in 20 minutes. Answer in this same sheet.

Problem 1 (4 points)

A student of XC has Internet at home with a provider who allocates 1 public IP address (4.3.2.1). The student connects with a PC to the UPC VPN (UPCLink) according to the figure.
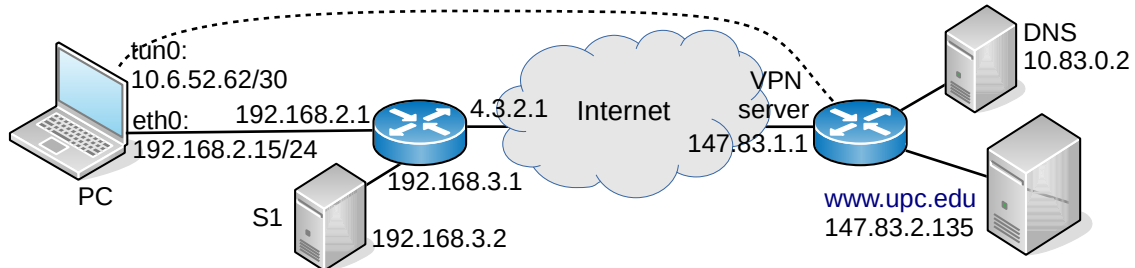
The home network has internal IP addresses 192.168.2.0/24 and the external IP address is 4.3.2.1.
The UPC network uses ranges 147.83.0.0/16 and 10.0.0.0/8.
When connecting the PC it gets from the home router by DHCP an address for eth0: 192.168.2.15/24.
When connecting to the UPC VPN it obtains tun0:10.6.52.62/30 with access to its DNS server 10.83.0.2.
There is also S1, a server at home with IP 192.168.3.2/24.

a) (0.25 points) If UPC assigns a /30 range to each external connection from network 10.6.0.0/18, how many users can connect simultaneously to UPCLink?

b) (0.25 points) If PC runs traceroute www.upc.edu, which IP addresses will appear in the list of hops to the destination that the traceroute dump will show?

c) (1 point) What will be the PC routing table, once connected to UPCLink, if we want PC to access hosts from the UPC network (private and public ranges) via the VPN and, directly without the VPN, to S1 and the Internet?

Destination	Mask	Gateway	Interface
0.0.0.0	0.0.0.0	192.168.2.1	eth0

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d) (0.5 points) Which source IP addresses will have the IP datagrams when they reach their destination if we run on the PC ping www.upc.edu and ping www.upv.es (another university)?
Indicate in each case whether or not the home router does NAT.

upc.edu:

upv.es:

e) (0.25 points) If we change the default route in PC:
```
sudo route delete default gw 192.168.2.1 dev eth0
sudo route add default gw 10.6.52.61 dev eth0
```
Which path will be followed and justify the answer:

ping www.upc.edu:

ping www.google.com:

f) (0.25 points) If we also run now:
```
route add –host 147.83.1.1 gw 192.168.2.1 dev eth0
```
Which path will be followed and justify the answer:

ping www.upc.edu:

ping www.google.com:

g) (0.5 points) We now connect S1 to the UPC VPN, which results in S1:tun0:10.6.53.62/30. Assuming the UPC VPN server does not apply any ACLs to limit traffic, which path of known addresses will show traceroute to 10.6.53.62 from:
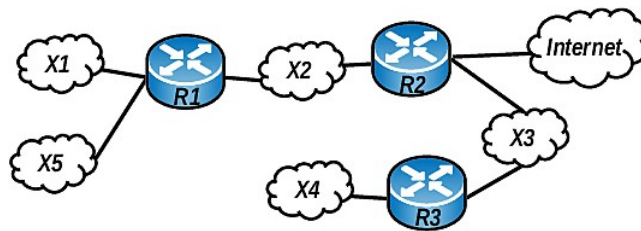
PC:

10.83.0.2 (DNS UPC):

Another Internet host:

h) (1 point) If the home router does PNAT on output and is configured to do DNAT on input with S1, configure the following <u>input ACL table (in) on the router's external interface</u> to ensure that:
from the internal network it is only allowed to connect to the VPN (IPinIP protocol) of UPC (147.83.1.1),
allow S1 to be a secure web server (TCP, port 443) for any Internet host, and
allow any internal client to connect to servers on the Internet (except IPinIP services).

Source IP/mask	Source Port	Destination IP/ mask	Destination Port	Protocol	Action
any	any	any	any	any	Deny

Duration: 1h30m. The quiz will be collected in 20 min. Answer in the same exam sheet.

Problem 2 (2.5 points)

2.1 (1 point) The network in the figure has been set up. The following table shows the address and mask assigned to each network. Fill in the columns with the broadcast address, number of bits of the hostid, and number of PCs that could be placed on each network.

Net.	@IP	mask	Broadcast (last address in the network)	Bits of hostid	Number of PCs
X1	172.16.254.0	255.255.255.0			
X2	172.16.255.0	255.255.255.128			
X3	172.16.255.128	255.255.255.192			
X4	172.16.255.192	255.255.255.224			
X5	172.16.255.224	255.255.255.224			

2.2 (0.5 points) Say which addresses in the base address 172.16.0.0/16 have not been assigned to any of the previous networks. Give your answer in the form: @IPstart ~ @IPfinal. Say how many IP addresses there are between @IPstart ~ @IPfinal (both included).

2.3 (0.5 points) Of the addresses in the base addess 172.16.0.0/16 that are left free, say which subnet having the largest number of IP addresses we could define, without overlapping with the previous networks. Give your answer in the form network address / number of bits in the mask. Say also which is the broadcast address of this subnet, and how many IP addresses this subnet has (network and broadcast addresses included).

2.4 (0.5 points) Assume that RIP version 2 is used with split horizon. All subnets X1, ... X5 are announced. The default route in R2 is also announced. Write in the table below the content of the update messages that R1 and R2 will send on network X2. Give the answer in the form (X, M), ..., where X is the network (X∈{X1, X2, ... X5, 0/0 (default path)}, and M is the metric.

R1's update on X2	
R2's update on X2	