Duration: 2h45m. The quiz will be collected in 30m. Answer the problems in the same sheet.

Quiz (2,5 points) Questions can be multiple choice. They score by half if an error, 0 if more.

1.- Which field in an IPv4 packet header will typically stay the same during its transmission? (ignoring NAT)
☐ Packet Length
☐ Destination Address
☐ Flag
☐ Time-to-Live

2.- What is the prefix length notation for the subnet mask 255.255.255.224?
☐ /25
☐ /26
☐ /27
☐ /28

3.- A DHCP server is used to assign IP addresses dynamically to the hosts on a network. The address pool is configured with 192.168.1.0/29. There are 2 servers (one is the DHCP server) and one router on this network that need to use reserved static IP addresses from the pool. How many IP addresses in the pool are left to be assigned to other hosts?
☐ 3
☐ 4
☐ 5
☐ 6

4.- What is a security feature of using NAT on a network?
☐ Denies all packets that originate from private IP addresses
☐ Allows internal IP addresses to be concealed from external users
☐ Denies all internal hosts from communicating outside their own network
☐ Allows external IP addresses to be concealed from internal users

5.- In a network with routers, switches and hubs a host sends an Ethernet broadcast frame (FF:FF:FF:FF:FF:FF). The message will reach:
☐ Only all hosts in the same VLAN than the source host
☐ Only all hosts connected to the same hub (there are several)
☐ Only all hosts connected to the same switch (there are several)
☐ Only all hosts connected to the same router (there are several)

6.- In a network with routers, switches and hubs:
☐ A hub does not segment the collision domain nor the broadcast domain
☐ A hub segments the collision domain but not the broadcast domain
☐ A switch segments the collision domain but not the broadcast domain
☐ A switch segments the collision domain and the broadcast domain

7.- An Internet link between Barcelona and Amsterdam has a data rate of 1Gbps and an RTT of 100ms. A TCP flow starts between hosts at both locations. The receiver's advertised window is never larger than 1MB. What is the maximum rate achievable by the sender?
☐ ~40Mbps
☐ ~80Mbps
☐ ~98Mbps
☐ ~0.83Gbps
☐ ~980Mbps

8.- In a recursive query for www.upc.edu directly to DNS root servers (you do not use a resolver):
☐ The response will include an A record for www.upc.edu
☐ The response will include an NS record for the .edu domain
☐ The response will include an A record for root name servers
☐ The response will include an NS record for the upc.edu domain

9.- The concept of "boundary" in MIME is always used in:
☐ HTTP to delimit each object
☐ SMTP to delimit each object
☐ Multipart objects to delimit each object in email
☐ Multipart objects to delimit each object in web

10. TCP connections used in HTTP are:
☐ Non-persistent by default in HTTP/1.1
☐ Non-persistent by default in HTTP/1.0
☐ With pipelining in HTTP/1.0
☐ With pipelining in HTTP/1.1

Duration: 2h45m. The quiz will be collected in 30m. Answer the problems in the same sheet.

Problem 1 (2'5 points)

The figure shows the sketch of the connection of a PC at home to the network of UPC. The figure includes the names of the interfaces, their IP addresses and the addressing scheme for each network. The PC connects to the server S located in the LAB sub-network of the UPC.
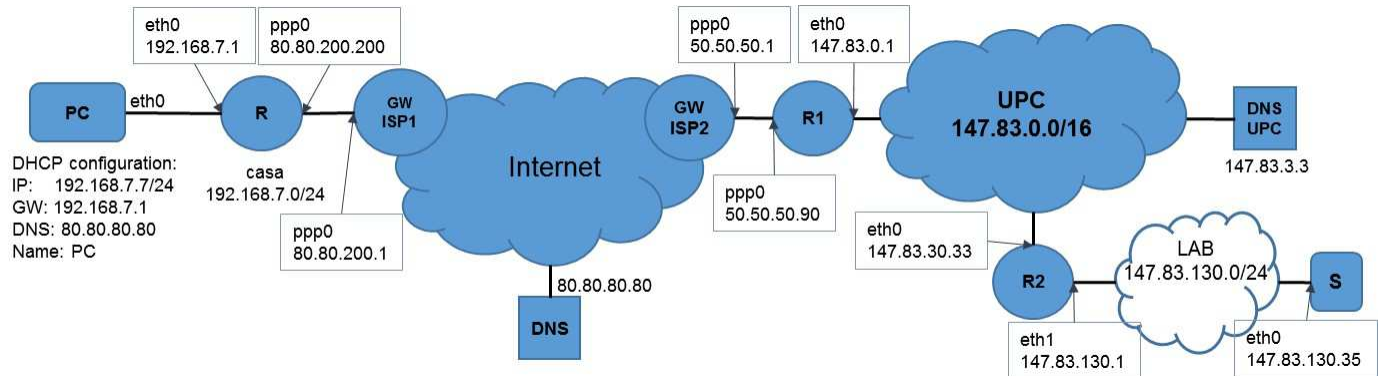
a) (0'25 points) With this information, complete the following routing tables (the rows you need).

PC			
Destination network	Mask	Gateway	Interface
192.168.7.0	/24		eth0
0.0.0.0	/0	192.168.7.1	eth0

R casa			
Destination network	Mask	Gateway	Interface
192.168.7.0	/24		eth0
0.0.0.0	/0	80.80.200.1	ppp0

R1			
Destination network	Mask	Gateway	Interface

R2			
Destination network	Mask	Gateway	Interface

b) (0'25 points) At the PC the command "*traceroute* S" is executed. Show the devices and IP addresses that will be displayed in the output list.

Consider now that the home network should be a sub-network of LAB. To do this a tunnel between the router at home (R interface ppp0) and the router at LAB (R2 interface eth0) is configured. The tunnel uses 10.10.10.0/30.

c) (0'25 points) Complete the routing tables of routers R and R2 with this new configuration.

R casa			
Destination network	Mask	Gateway	Interface
192.168.7.0	/24		eth0
10.10.10.0	/30		tun0
0.0.0.0	/0		ppp0

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R2			
Destination network	Mask	Gateway	Interface
147.83.130.0	/24		eth1

d) (0'25 points) At the PC "*traceroute* S" is executed. Show the devices and IP addresses that will be displayed in the output list.

e) (0'25 points) At the PC "*traceroute* DNS UPC" is executed. Show the devices and IP addresses that will be displayed in the output list.

This configuration is not adequate because all the devices at home reach the LAB network via the tunnel. The solution is to assign to the PC an IP address belonging to LAB (147.83.130.135). To do this, a **tunnel between PC and R2** is configured. The rest of devices at home maintain their private addresses.

f) (0'25 points) Complete the routing tables for PC and R2 with this new configuration.

PC			
Destination network	Mask	Gateway	Interface
192.168.7.0	/24		eth0
10.10.10.0	/30		tun0
0.0.0.0	/0		

R2			
Destination network	Mask	Gateway	Interface
147.83.130.0	/24		eth1

g) (0'25 points) At the PC "*traceroute* S" is executed. Show the devices and IP addresses that will be displayed in the output list.

h) (0'25 points) At the PC "*traceroute* DNS UPC" is executed. Show the devices and IP addresses that will be displayed in the output list.

The PC **should be allowed** to establish **ONLY** a SSH connection (port 22) with server S (any other type of connection must be denied). The rules at the firewall apply to all incoming and outgoing datagrams.

i) (0'25 points) Identify the interface where the rules must be defined and show the rules of the firewall.
Interface:

Source IP	Source port	Destination IP	Destination port	Protocol	Action

S must be allowed to send a PING command to PC.

j) (0'25 points) Show the rules that **must be added to the previous ones**.

| Source IP	Source port	Destination IP	Destination port	Protocol	Action

Duration: 2h45m. The quiz will be collected in 30m. Answer the problems in the same exam sheet.

Problem 2 (2,5 points)

In the network of the figure there are 10 PCs (C1...C10) connected to 10 servers (S1...S10) thorough the switches SW1 i SW2 and the router R1. All ports of SW1 are FastEthernet (100 Mbps) and all ports of SW2 are GigabitEthernet (1Gbps), all of them full duplex. All clients start simultaneously a download from the respective server (C1 from S1, C2 from S2, and so on) a file of 1GB (10^9 bytes) using a TCP connection each of them, to the maximum throughput allowed by the network. Assume the following: (1) R1 has a memory of 1 MB (10^6 bytes) that can store all datagrams pending to be transmitted (and discards those arriving when the memory is full); (2) all TCP sockets from the PCs and the server have a reception buffer of 60 kB; (3) assume, for the sake of simplicity, that TCP and IP header have 0 length and MSS is 1500 B; (4) all link delays are 0; (5) TCP acks are never lost and arrive immediately to the destination; TCP always send an ack upon receiving data, only implements SS/CA and is as efficient as possible (that is, ack are sent immediately, processing time is 0, etc.). Justify briefly your answers: results without justification will not be accepted. Give your results using the boxes and the given units.
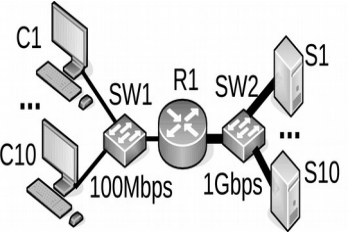
2.1 (0,25 points) Compute what will be the throughput, v_{ef}, that, approximately will get each PC.

$$v_{ef}= \qquad \text{Mbps}$$

2.2 (0,25 points) Compute the download time of the file (T) in minutes.

$$T= \qquad \text{min}$$

2.3 (0,25 points) Say what will approximately be the buffer occupation of R1. Say how many bytes there will approximately be. Will losses occur?

$$R1= \qquad \text{MB}$$

2.4 (0,25 points) Compute what will approximately be the RTT of each TCP connection.

$$RTT= \qquad \text{ms}$$

2.5 (0,5 points) Suppose now (and for the following items) that C1 is using an application like bittorrent to download the file. With this application it is possible to download the file simultaneously from more than 1 server, such that each server sends a different part of the file being downloaded. Suppose that the bittorrent application used by C1 establish 10 TCP connections, one with each server, while the other PCs download the file like in the previous items. Say what will be approximately the occupation of the buffer in R1. Say how many bytes there will be approximately in the buffer. Will losses occur?

$$R1= \qquad MB$$

2.6 (0,5 points) Say whether in steady state (a while after the download started) C1 will have the same throughput (v_{ef}^1) than the other PCs (v_{ef}^2). Compute approximately what will be the throughput (give both of them in case they are different).

$$v_{ef}^1= \qquad Mbps$$

$$v_{ef}^2= \qquad Mbps$$

2.7 (0,5 points) Compute what will approximately be the download time of the file for C1 (T_1) and for the other PCs (T_2). Give both of them in case they are different.

$$T_1= \qquad min$$

$$T_2= \qquad min$$

Duration: 2h45m. The quiz will be collected in 30m. Answer the problems in the same sheet.

Problem 3 (1,5 points)
You plug a new laptop into a wired Ethernet jack of a network switch for the first time. You have already told the network administrators your MAC address, and can join the network with no further configuration on your part.

Assume that:
1. your DHCP server is 147.83.10.2
2. your Ethernet address is 00:11:22:33:44:55
3. the IP address you'll be given is 147.83.10.22
4. the gateway IP address is 147.83.10.1
5. the gateway Ethernet address is 00:66:77:88:99:00
6. the netmask is 255.255.255.0

Let's consider the series of data exchanges that will occur on the link for your laptop to send a single UDP packet to 128.3.2.1. We assume that no frames are lost or discarded, and that no other traffic is exchanged.

a) Which of the following protocols are involved in the series of Ethernet frame exchanges?
☐ IP
☐ ARP
☐ UDP
☐ ICMP
☐ DHCP

b) How many broadcast Ethernet frames will traverse your link (sent or received)? (justify)

c) In which Ethernet frame (sent or received) will mention your IP address for the first time? (justify)
☐ 1st
☐ 2nd
☐ 3rd
☐ 4th
☐ 5th

d) How many Ethernet frames (sent or received) contain the Ethernet address of the gateway? (justify)

e) With the network interface of your laptop in promiscuous mode, which Ethernet addresses can be seen as other laptops get connected to the same switch and become configured?

Duration: 2h45m. The quiz will be collected in 30m. Answer the problems in the same exam sheet.

Problem 4 (1 point)

4.1 (0,5 points) Say which commands "HELO", "MAIL FROM:", "RCPT TO:", "DATA", "QUIT" from SMTP will be done by our email client and what headers of the email message there will be to send the message "ok" with subject "xc" from a@a.com with destinations b@b.com in the field "To", and c@c.com in the field "BCC" (blind destination). Invent the data not given and that you might need. It is not necessary to give the possible answers given by the server.

4.2 (0,5 points) Say how many RTTs (counting the connection establishment and termination) will last the connection, since the first segment is sent, until the last segment is received. Assume no losses and that it is sent the minimum number of segments. Draw a sketch of the transmission time diagram of the segments exchanged during the connection, showing clearly the RTTs that last the connection.