Examen final de Xarxes de Computadors (XC)		Grau en Ingeniería Informàtica	14/1/2021	Tardor 2020
Name	Surname		Group	DNI

Duration: 2h45m. The quiz will be collected in 25 minutes. Answer the problems in the same sheet.

Quiz (2.5 points) All the questions are multi-answer: They score half if there is an error, 0 if more.

1. Say which of the following statements are true with respect to HTTP
   - ☐ In a non-persistent HTTP connection each HTTP request message is sent over a different TCP connection
   - ☐ A client can send a file to the server with a GET with MIME
   - ☐ A customer can submit data from an HTML form in the query-string of a GET
   - ☐ On an HTTP 1.1 connection it is possible to request multiple objects in a single GET

2. Suppose a TCP congestion window of cwnd=15.000 bytes, MSS = 1.500 bytes and *slow start threshold* ssth=10.000 bytes. Then you receive 1 ack that confirms new data. Say which of the following values of the cwnd in bytes are possible when the ack is processed.

   ☐ 10.000 ☐ 3.000 ☐ 15.150 ☐ 15.000 ☐ 16.500

3. In an iterative query from www.xc.com to a root-server it is plausible that the answer has:
   - ☐ No resource record if the name www.xc.com does not exist
   - ☐ A CNAME type resource record of the name www.xc.com, if the name exists
   - ☐ A type A resource record for the .com domain
   - ☐ An NS type resource record for the domain .com

4. Say which statements are true regarding IP:
   - ☐ In case of fragmentation, the field "identification" of the IP header of all fragments of the same datagram will be the same
   - ☐ Each time an IP datagram crosses a router it is decreased the TTL field of the header
   - ☐ If a datagram carrying a UDP message goes through a router that does NAT, the router will have to change the checksum of the IP header
   - ☐ If a datagram carrying a UDP message is sent through an IPIP tunnel, the protocol field of the external IP header will be different from the protocol field of the internal IP header

5. Say which of the following protocols are connection oriented

   ☐ TCP ☐ UDP ☐ Ethernet ☐ DHCP ☐ IP

6. The TCP protocol...
   - ☐ It can be used for unicast transmissions
   - ☐ Application data can only be transmitted when the socket is in the ESTABLISHED state
   - ☐ It has mechanisms to adjust the value of the MSS in order to avoid fragmentation
   - ☐ It can used for broadcast transmissions

7. In which cases it is possible a full duplex link?
   - ☐ Between a PC and an Ethernet hub
   - ☐ Between two Ethernet switches
   - ☐ Between a laptop and a wifi AP
   - ☐ Between a router and an Ethernet switch

8. Which statements are true about an Ethernet switch?
   - ☐ If a frame is received and the destination address is not in the MAC table, it is sent over all ports on the same VLAN, except the port through which it was received
   - ☐ If a frame is received and the destination address is not in the MAC table, it is sent to all ports of all VLANs, except for the port through which it was received
   - ☐ The MAC table contains MAC addresses, port, VLAN and IP addresses
   - ☐ The information in the MAC table is constructed using the destination address of the frames it receives

9. Say which of the following statements about RIP are true
   - ☐ Update messages are sent periodically
   - ☐ When RIP has converged the metric of the RIP entries in the routing tables will be as small as possible
   - ☐ The convergence time depends on the number of hops between the two most distant routers
   - ☐ Split-Horizon reduces the size of the update messages

10. Say which of the following statements about charsets are true
    - ☐ A character that is encoded with UTF-8 with a single byte has the same binary code as the encoded character with ASCII
    - ☐ To send an email with UTF-8 encoded text it will be needed MIME with `Content-transfer-encoding: base64`
    - ☐ To download a web page with coded text with UTF-8 it will be needed MIME with `Content-transfer-encoding: base64`
    - ☐ To encode U+122AB with UTF-8 will be required more than 1 byte

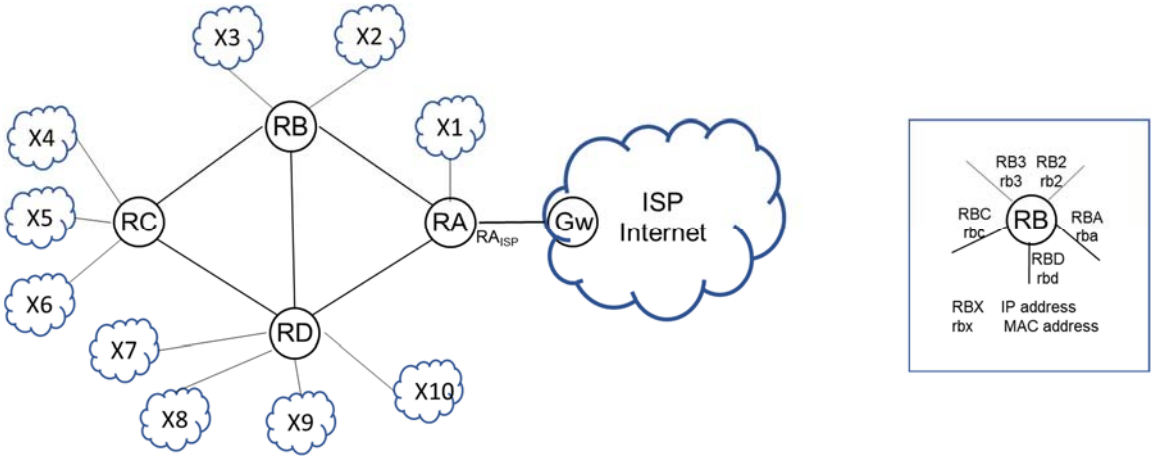
Final exam. Xarxes de Computadors (XC), Grau en Enginyeria Informàtica		14/01/2021	Fall Semester 2020
NAME (in UPPERCASE):	FAMILY NAME (in UPPERCASE):	GROUP:	ID/DNI/NIE:

Duration: 2 hours and 45 minutes. The quiz will be collected in 25 minutes.

Problem 1 (3 points)

The figure shows the configuration of the subnetworks within an organisation and the connection to its ISP and the Internet. The right of the figure shows the notation for the IP and MAC addresses for router B.

.



a) (0.5 points) The block of IP addresses available is 200.200.192.0/20. Assign a /24 block to each subnetwork in such a way that they may be aggregated to minimize the number of routs in the routing tables.

X1	200.200.192.0/24
X2	
X3	
X4	
X5	

X6	
X7	
X8	
X9	
X10	

Which block remains unassigned?

b) (0.5 points) Complete the routing tables of the four routers with the aggregated address for the Destination, the MAC address for the interface and the RIP metric. (RB/RD means that both routes may be).

Destination	RA			RB			RC			RD		
	GW	if	met	GW	if	met	GW	if	met	GW	if	met
(X1) 200.200.192.0/24	---	ra1	1	RA	rba		RB/RD	rcb/d		RA		
(X2+X3)	RB	rab		---	*							
(X4+X5+X6)	RB/RD	rab/d		RC	rbc		---	*	1			
(X7+..+X10)	RD	rad		RD	rbd					---	*	1
0.0.0.0/0	GW	eth0	1	RA	rba		RB/RD	rcb/d		RA		

* indicates that there is a route for each subnetwork with its corresponding interface.

c) (0.25 points) Use the block of private addresses 10.0.0.0 and assign the addresses of the point-to-point links between the routers using the minimum number of addresses.

RA-RB	
RB-RC	
RB-RD	

RC-RD	
RD-RA	

d) (0.25 points) If the link RD-RA fails, indicate ONLY the routes that will be modified.

Destination	RA			RB			RC			RD		
	GW	if	met	GW	if	met	GW	if	met	GW	if	met
X1												
X2+X3												
X4+X5+X6												
X7+X8+X9+X10												
0.0.0.0/0												

e) (0.5 points) Suppose that the ARP tables of the routers contain the MAC addresses of the link interfaces between the routers only and that the ARP tables of the devices are empty.
A device H3 (located in subnetwork X3) issues that command "*ping H1*" (H1 is located in X1).
Complete the sequence of Ethernet frames and IP packets in subnetwork X3.

Ethernet		ARP		IP		
src	dst	Q/R	message	src	dst	Payload
h3						

f) (0.25 points) The same as in the previous case in the link RB-RA.

Ethernet		ARP		IP		
src	dst	Q/R	message	src	dst	Payload

g) (0.25 points) Subnetwork X are not enough and private networks are added (P1 .. P10) with addresses in the block 10.2.0.0/15. Each network Pi is connected next to Xi (the routers have enough ports to do it).
Will it be necessary to run PAT (*Port and Address Translation*)? If so, in which interface?
A client in a private network (10.2.11.21:17000) starts a TCP connection with 147.83.83.147:80.
Complete the values of the fields in the datagram headers going through RA and to the Internet.

Internal interface of RA

src IP	src #	dst IP	dst #
10.2.11.21	17000		

External interface of RA

src IP	src #	dst IP	dst #

h) (0.25 points) A remote private network is added P11 (10.111.0.0/16) and a tunnel between RA and a remote router (RR) is configured. P11 and RR are not in the figure.
The client 10.2.11.21:17000 starts a TCP connection with the remote server 10.111.4.5:80, located in P11.
Complete the values of the fields in the datagram headers going through RA and to the Internet.

Internal interface of RA

src IP	src #	dst IP	dst #
10.2.11.21	17000		

External interface of RA

src IP	src #	dst IP	dst #

i) (0.25 points) A *Firewall* is configured at the external interface of router RA (RA_{ISP}).

#RULE	IN/OUT	SRC IP	SRC port	DST IP	DST port	PROT	ACTION
1	IN	ANY	< 1024	ANY	> 1024	TCP/UDP	ACCEPT
1	OUT	ANY	> 1024	ANY	< 1024	TCP/UDP	ACCEPT
2	IN	ANY		200.200.192.0/20		ICMP	ACCEPT
2	OUT	200.200.192.0/20		ANY		ICMP	ACCEPT
3							
3							
	ANY	ANY	ANY	ANY	ANY	ANY	DENY

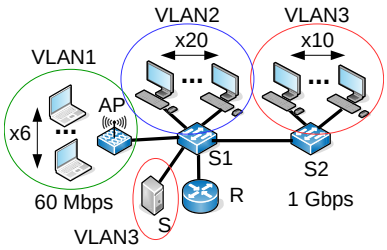
What is the effect of rule 1?
What is the effect of rule 2?
Add rule 3 so that TCP servers in X1 may be accessed from external clients.

Examen final de Xarxes de Computadors (XC)	Grau en Ingeniería Informàtica	14/1/2021	Tardor 2020
Name	Surname	Group	DNI

Duration: 2h45m. The quiz will be collected in 25 minutes. Answer the problems in the same sheet.

Problem 2 (2.5 points. The score of all questions is the same.)

The network in the figure has been configured with 3 VLANs, 36 PCs and 1 server S. All ethernet links are 1 Gbps full duplex. The AP (access point) is configured in bridge mode, and has a capacity of 60 Mbps. That is, the sum of the throughput of VLAN1's wifi PCs can be as high as 60 Mbps. Assume that all PCs establish a TCP connection with the server and send at the maximum speed allowed by the network. All TCP connections advertise a window (awnd) of 60 kbyte (k=10^3). The router can store up to 1 Mbyte (M=10^6).



2.1 Justify why the PC connections from VLANs 1 and 2 will pass through the router, and those from VLAN 3 will not.

2.2 Say what will be the throughput, v_1, v_2, v_3, which will get a PC of each of VLAN1, VLAN2, and VLAN3, respectively. Justify the answer, indicating where the bottleneck (CA) will be. Give the results in Mbps.

2.3 Justify why there will be losses on the router.

To answer the following questions assume the following: (i) The connections have been started for some time and the window has achieved a steady state regime. (ii) The window of all connections that pass through the router follow a periodic shape, of period T, as shown in Figure 1. (iii) Do the approximation that each time the router queue fills up all connections reach their maximum window (W in Figure 1).

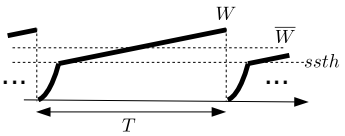


Figure 1

2.4 With the help of the sketch in Figure 1, calculate approximately the relationship between the maximum window, W, and the mean window, $\overline{W}$, of a connection that pass through the router.

2.5 Justify why the maximum RTT of all TCP connections that pass through the router will be the same.

Continue on the back of the page.

2.6 Compute approximately the maximum round trip time, RTT, of one of the TCP connections passing through the router. Give the result in ms.

2.7 Justify whay the mean RTT, $\overline{RTT}$, of the connections passing through the router will be approx $\overline{RTT} \approx 3/4\ RTT$, where RTT is the maximum RTT, and calculate $\overline{RTT}$ of the connections passing through the router. Give the result in ms.

2.8 Compute approximately what the mean window will be, $\overline{W}_1$, $\overline{W}_2$, of a VLAN1 and 2 connection respectively. Give the results in kbytes.

2.9 Justify whether or not VLAN3 connections will have losses, and say what the maximum and mean window, W_3 and $\overline{W}_3$, respectively, will be. Give the results in kbytes.

2.10 Make a sketch like the one in Figure 1 showing the evolution of the window for one of the connections passing through the router, indicating the phases where the window is in *slow start*, SS, and *congestion avoidance*, CA.

2.11 Suppose that the TCP connections use a MSS= 1460 bytes. Compute approximately the duration of the *congestion avoidance* phase, T_{CA}, for each period T shown in Figure 1, for a connection of the VLAN1. Give the result in ms.

Final exam Xarxes de Computadors (XC), Grau en Enginyeria Informàtica		14/1/2021	Fall 2020
FIRST NAME (CAPITALS):	LAST NAME (CAPITALS):	GROUP:	DNI/ID:

Duration: 2h45m total. The quiz will be collected in 25 minutes. Please answer here.

Problem 3 (2 points)

A user at UPC downloads a web page from HTTP 1.1 servers on his client.upc.edu PC using a web browser. Each domain has a web and DNS server in the same location, and the latency (one way) across each of them is 5 ms. Therefore the latency from client.upc.edu to each server (the time to reach each server one way) is:

DNS	ns.upc.edu	ns.d1.eu	ns.d2.eu	ns.eu	a.root-servers.net
Web	w.upc.edu	w.d1.eu	w.d2.eu	w.eu	w.root-servers.net
Latency (ms) from client	5	10	15	20	25

Assume that:

All web and DNS caches are empty initially. All resource records have TTL longer than the observation period.
The local DNS server does recursive resolution, the rest of DNS servers only iterative.
The client browser keeps the connections open for several seconds, and will use the best strategy to minimize the response time and do concurrent connections.
Every DNS request or response, HTTP request and HTML response fits in only one TCP segment and takes no extra time over RTT. Every JPG file takes 10 ms to download (from first to last byte of the response).
Network traffic, server load or packet losses have negligible impact on delays.
Values for IP addresses can be expressed as @name: for instance @w.eu represents the IP address of host w.eu.

Notation for diagrams: (from an example for downloading from client.upc.edu the home page at w.upc.edu)

client.upc.edu ns.upc.edu/w.upc.edu

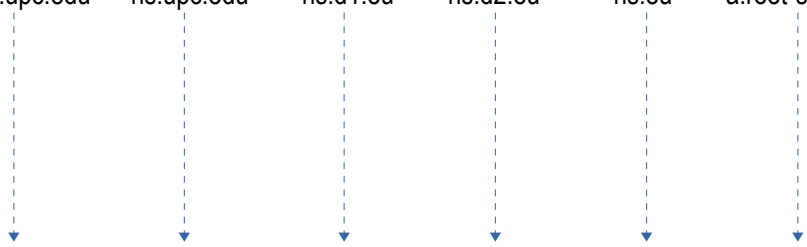
1) → +5ms

2) ← *(repeated for TCP and HTTP, omitted for brevity)*

Prot	Source IP	Dest IP	Operation	Resource	Value/comment	Latency
DNS	@client	@ns.upc.edu	A?	w.upc.edu	*1)*	5 (one way)
DNS	@ns.upc.edu	@client	A	w.upc.edu	w.upc.edu CNAME w.upc.es; w.upc.es A @w.upc.es *2)*	5
TCP	@client	@w.upc.edu	SYN		All consecutive after previous	5
TCP	@w.upc.edu	@client	SYN, ACK			5
HTTP	@client	@w.upc.edu	GET?	«/»		5
HTTP	@w.upc.edu	@client	GET	«index.html»	CONTENT, 1 segment, no extra time as html	5

A) (0,75 points) What would be the steps and resource records (A, NS) required to resolve the DNS name in the command “ping w.d1.eu” on the client? Draw the diagram of network interactions and then complete the table.

client.upc.edu ns.upc.edu ns.d1.eu ns.d2.eu ns.eu a.root-servers.net

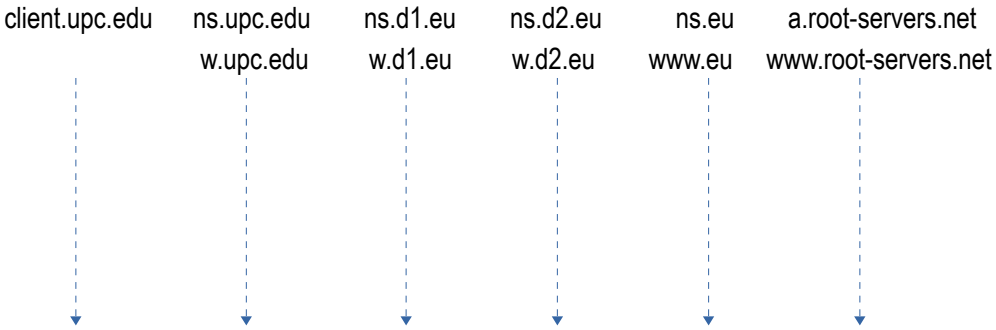


Prot	Source IP	Dest IP	Operation	Resource	Value/comment	Latency

B) (0,25 points) What would be the total response time observed by client.upc.edu for the previous resolution? Show the contribution of latency for each step and the total amount.

C) (0,75 points) Just after that, the web browser visits page http://w.d1.eu. The page contains two embedded images as: "<html><img src="http://w.d1.eu/i.jpg"> <img src="http://w.d2.eu/i.jpg"></html>"

Draw the diagram of network interactions (considering DNS, TCP, HTTP) and then complete the table.



Prot	Source IP	Dest IP	Operation	Resource	Value/comment	Latency

D) (0,25 points) What would be the total download time for the last byte of the page observed by client.upc.edu? Show the latency contribution for each element and the total. Remember that some interactions can be concurrent, and JPG downloads take extra 10 ms.