Final Exam Xarxes de Computadors (XC), Grau en Enginyeria Informàtica		10/1/2020	Fall 2019
FIRST NAME (CAPITALS):	**NAME (CAPITALS):**	**GROUP:**	**DNI/ID:**

Duration: 2h45m total. The quiz will be collected in 20 minutes.

Quiz (2.5 points)

Multiple choice questions (any number of correct answers). Half when one error or 0 when more.

1. Regarding the IP addressing range 10.0.0.0/8:
- ☐ This is a private class A range.
- ☐ 10.0.0.1/32 is a valid IP address of that range.
- ☐ 10.0.255.1/32 is a valid IP address of that range.
- ☐ The last unicast IP address of the range is 10.255.255.254.

2. About IP: Fragmentation of IP packets
- ☐ Are only fragmented in the sender.
- ☐ Are fragmented along their path when size exceeds the MTU of the next hop.
- ☐ Get reassembled at the receiving end.
- ☐ Get reassembled along their path when the combined size fits the MTU of the next hop.

3. About UDP:
- ☐ UDP can send an ACK to confirm reception.
- ☐ The header of UDP datagrams has a checksum that protects the data payload from corruption.
- ☐ The UDP datagram header has an indication of the source and destination port.
- ☐ The UDP datagram header has a sequence number field.

4. About TCP:
- ☐ A connection has a common initial sequence number defined by the client.
- ☐ A connection has two initial sequence numbers, one defined by the client and another by the server.
- ☐ FIN and its ACK closes a connection in both directions of the communication.
- ☐ FIN and its ACK closes a connection in one direction.

5. About LANs:
- ☐ Ethernet switches can perform flow control.
- ☐ Ethernet hubs can perform flow control.
- ☐ Ethernet switches have no collisions across ports.
- ☐ Ethernet hubs have no collisions across ports.

6. About Wi-Fi:
- ☐ Uses RTS/CTS to handle the hidden node problem.
- ☐ Uses CSMA/CD (collision detection) to prevent collisions.
- ☐ Uses CSMA/CA (collision avoidance) to prevent collisions.
- ☐ The Service Set identifier (SSID) is a string text.

7. In a DNS resolution:
- ☐ A CNAME can return another CNAME record.
- ☐ An MX record contains the IP address of a mail server.
- ☐ The default DNS server of a network provides authoritative answers to its network.
- ☐ The DNS server of a domain provides authoritative answers for its domain.

8. About HTTP:
- ☐ The header of a GET reply is encoded as text (7bit).
- ☐ The body of a GET reply is encoded as text (7bit) objects delimited by boundaries.
- ☐ The body of a GET reply is encoded as a binary object delimited by a content-length.
- ☐ One HTTP connection can be used to send multiple messages in both directions.

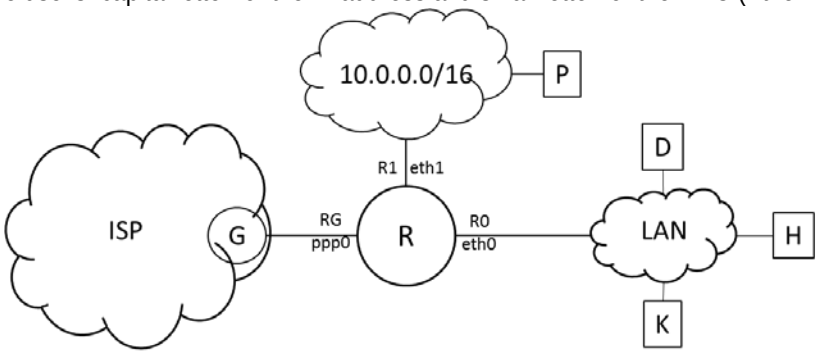
Final exam. Xarxes de Computadors (XC). Grau en Enginyeria Informàtica		10/01/2020	Fall 2019
NAME (in CAPITAL LETTERS):	FAMILY NAME (in CAPITAL LETTERS):	GRUP:	DNI/NIE:

Duration: 2h 45 minutes. The quiz will be collected in 20 minutes.

Problem 1 (3 points).

The local network (LAN) uses private addresses. D is the local DNS server, the router R is the DHCP server, H is a web server (HTTP) and K is the mail server. P is a workstation and G is the ISP's gateway (router). All the devices have been configured correctly and are on, except K that is off.

The notation we use is: capital letter for the IP address and small letter for the MAC (Ethernet) address.



a) (0.25 points) Complete the sequence of Ethernet frames and IP packets transmitted when K is turned on and obtains its configuration.

Ethernet		IP		
src	dst	src	dst	payload
k				

After the configuration K knows its IP address (K), the IP address of the DNS server (D), the IP address of the default router (R) and its name "mailserver.domini.org".

b) (0.5 points) Complete the sequence of Ethernet frames and IP packets when the command "*ping www.domini.org*" is issued from K, until the first response is back. Consider that www is an HTTP server in the same domain, that is, H.

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

c) (0.25 points) Determine the IP address seen by an external client when resolving the names:

www.domini.org

mailserver.domingi.org

d) (0.25 points) RIPv2 is running. Complete the routing table of router R with the metric:

Destination	Gateway	interface	metric
192.168.168.0/24 (LAN)	----	eth0	
10.0.0.0/16	----	eth1	
11.11.0.0/17	10.0.0.11	eth1	
11.11.128.0/17	10.0.0.11	eth1	
G/32 (ISP)	----	ppp0	
0.0.0.0/0	G	ppp0	

e) (0.5 points) Consider that the IP address of the router interface is the first IP address available in the subnetwork. That is, R0 is 192.168.168.1. From K (in the private network) the command "*traceroute 11.11.201.201"* is issued. Complete the sequence of routers and interfaces shown by the *traceroute*.

From the device with IP address 11.11.11.11 the command "*traceroute K*" is issued. Complete the sequence of routers and interfaces shown by the *traceroute*.

f) (0.25 points) Assign the smallest subnetwork for the LAN servers (D, K, H) and the minimum number of subnetworks within LAN (192.168.168.0/24).

g) (0.5 points) The command "*ping U*" is executed form device K. Consider that U is the address of an external server. Complete the sequence of IP datagrams that go through R. Identify the input and output interfaces. Note that the router performs PAT (PNAT port and address translation).

Interface	In/Out	Src IP address	Dst IP address	payload
eth0	in			

Which interface of the router R implements PAT?

h) (0.25 points) In order to connect with a remote LAN (192.168.200.0/24) a tunnel is setup from the remote router (RR) to router R (interface RG). Complete the new entries added in the routing table of R.

Destination	Gateway	interface	metric
192.168.0.0/30			
192.168.200.0/24			

i) (0.25 points) Complete the rules of the *Firewall* configured at interface RG needed for enforcing the following conditions: 1) Clients in LAN can access external servers; 2) web server (H) must be reachable form the Internet. The first column of the table shows which of the previous condition/s implement.

# RULE	IN/OUT	SRC IP	SRC port	DST IP	DST port	ACTION
1	IN	ANY	< 1024			
1	OUT	192.168.168.0/24				

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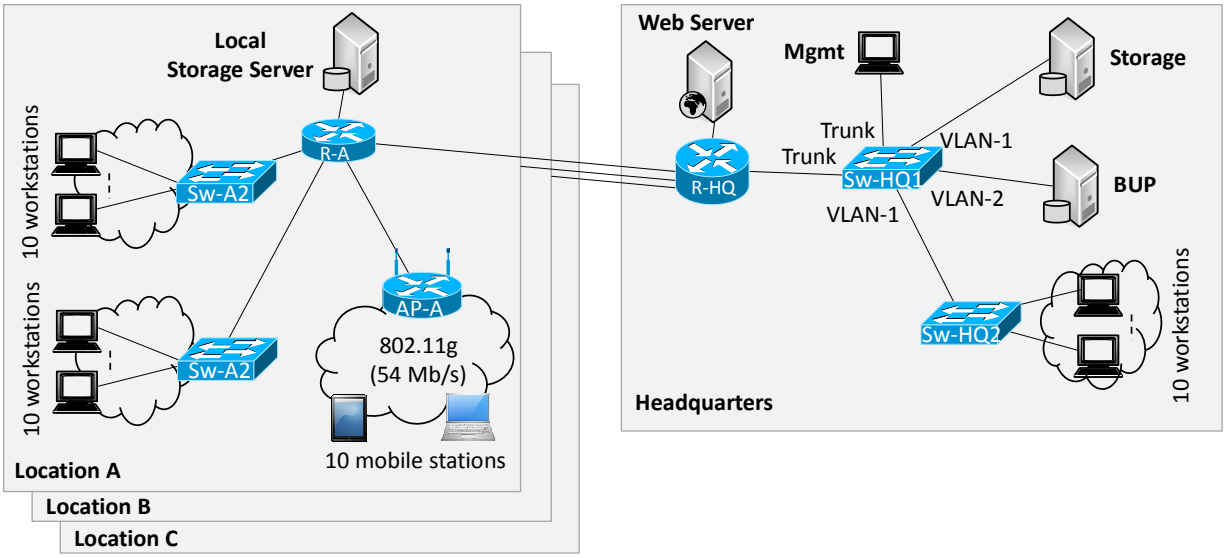
Duration: 2h45m.

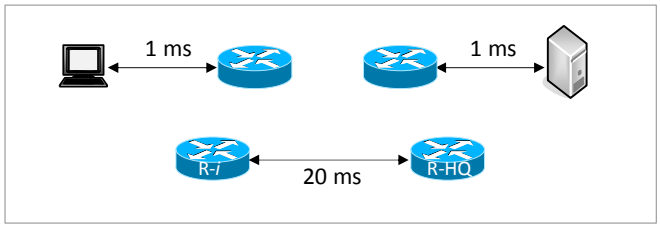
Problem 2 (3 points)

The figure represents the network topology of a company that consists of the headquarters (HQ) and 3 remote locations (A, B, and C) interconnected through lease lines. The network of each location includes 20 stations in two wired LANs, 10 mobile stations covered by one WiFi AP collocated with a router, and one local server. The network of the HQ consists of one storage and one back-up (BUP) server, and 10 workstations. Additionally, one station is reserved for managing the network in the HQ.

Different VLANs are configured in the HQs that are identified by the Ids in the interfaces of the Ethernet switches when applicable.

All the interfaces are 100baseTx (full duplex) except the WiFi that it is based on IEEE 802.11g. The efficiency of the switches is 100% and that of the access-point is 66.7% (two thirds). TCP is used to upload/download files.





The propagation delay between any host and its local router in a wired segment is 0.5 ms and 10 ms between any location and the HQs. Then, for instance, the minimum RTT (no time in the routers' queues) between a workstation and the local storage server in a remote location is approximately 2 ms and the minimum RTT between a local server in a remote location *i* and the storage server in the HQs is approximately 22 ms.

Answer the questions in the next page.

Note that there are two parts for LAN and TCP, respectively.

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Duration: 2h45m. Please answer the questions in the tables.

Problem 2 (3 points)

LAN (1 point)

a) (0.75 points) Assume that large files are uploaded/downloaded in the next scenarios. Answer the following questions in the next table for the scenarios that are given: (1) the bottlenecks that would be created, (2) which would be the mechanism(s) that would regulate the throughput of the stations, (3) the throughput that active stations would achieve.

(**Scenario A**) All the workstations in each remote location *i* upload a file to the local storage server.

(**Scenario B**) Local storage servers in the remote locations upload a file to the storage server in the HQ.

(**Scenario C**) All the mobile stations in each remote location *i* upload a file to the local server.

(**Scenario D**) The workstations in the HQ download a file from the company's web server in the HQ at the same time that the storage server uploads a file to the BUP server.

Scenario	Bottleneck	Flow Control Mechanism(s)	Throughput per host (Mb/s)
(A)			
(B)			
(C)			
(D)			

b) (0.25 points) Which are the contents of the MAC table in *Sw-HQ1* after the previous activity? Answer in the following table for the devices in the HQ, where:

- the *Y/N* field specifies whether at least one host in the entry would be in the MAC table,
- the *port* field specifies the name of the connected network device, e.g., *Sw-HQ2* specifies the interface that connects Sw-*HQ1* to switch *Sw-HQ2*.

MAC addresses learned in Sw-HQ1	Y/N	Port
Web server		
Management station		
Storage server		
BUP server		
Workstations		

TCP (2 points)

All the routers are configured with 1 MB ($1 \cdot 10^6$ bytes) queues. Hosts allocate 20 kB ($20 \cdot 10^3$ bytes) for reception buffer in TCP connections and do not use the window scale option. Assume MSS = 1 kB ($1 \cdot 10^3$ bytes)

Answer the following questions and explain your answers with an equation when possible or a short text.

c) (1 point):

What would be the time in the queues and the total estimated RTT?

Scenario	Time in queues (ms)	Estimated RTT (ms)
(A)		
(B)		

What would be the maximum throughput when TCP connections reach the steady state? What would be the optimal reception window in MSSs? (assume the RTT values estimated in the table above).

Scenario	Max. throughput per station (Mb/s)	Optimal Reception Window (MSS)
(A)		
(B)		

A different small file has now been loaded and took exactly 20 RTTs, measured from the time that each TCP connection was established.

d) (0.25 points): What was the size of the file? What was the last sequence number acknowledged by the server when the connections were closed? (assume that the first sequence number after each TCP connection was established was 1).

Size of the file (kB)	
Last Ack'ed sequence number	

e) (0.75 points): Let us now assume that a six-RTT outage interrupted the upload of the small file defined in the previous question after 6 RTTs (measured from the time that the TCP connections were established). Assume RTO = 4*RTT.

What would be the time to upload in RTTs?

Time to upload (#RTT)	Explanation

Let us assume that there is some background traffic and so, datagrams spend some time in each of the queues. Let us approximate total RTT values to those given in the table (time in each queue is 20 ms) for scenarios (A) and (B). What would be the time to upload in seconds and the average throughput achieved during the upload?

Scenario	Estimated RTT (ms)	Time to upload (s)	Average throughput per station (Mb/s)
(A)	2 + 20 = 22		
(B)	22 + 40 = 62		

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Problem 3 (1.5 points)

A user downloads a web page from HTTP 1.1 servers on his client device using a web browser. The page contains the following elements: http://w.x.org/x.html, http://i.y.com/i1.png, http://i.z.net/i2.png, http://i.z.net/i3.png.

Assume that:

Client RTTs: 5ms to local DNS server and 30ms to HTTP servers for x.org, y.com and z.net.
RTT between local DNS and any other DNS server: 20ms.
TTL of DNS records: 10000 for root-servers.net servers, 1000 for gtld-servers.net, 10 for HTTP and DNS servers for x.org, y.com and z.net.
The local DNS server does recursive resolution, the rest of DNS servers only iterative.
Each HTTP element fits in only one TCP segment.
Network traffic, server load or packet losses have negligible impact of delays.
The client browser will use the best strategy to minimize the response time and do concurrent connections.
All web and DNS caches are empty initially.
The web browser of the client keeps idle HTTP connections open for at least 10 seconds.

A) (0,5 punts) What would be the steps and resource records (A, NS) required to resolve w.x.org?

Source	Destination	Question	Type	Response (minimal useful resource r.)
Client	local server	w.x.org	A	--
Local server				

B) (0.5 punts) Compute the total time (ms) to download the page and each step that is part of the page load:

#	Delay	Total sum	App Prot	Operation	Destination	Details about the elements of delay
1			DNS	A w.x.org?	local DNS	
2	30		TCP	Open conn	w.x.org	SYN/ACK
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

C) (0.5 punts) 5 seconds after the previous page download, the client pushes the «reload» button. Asuming the client web browser has a cache, but the cache is unsure about the expiration of content.
Which of the lines in the previous table would disappear, change and how (delay, details)?

Protocol	Effect	Yes/No and reason	Delay contribution
DNS	NS records requested again?		
TCP	TCP/HTTP connections reopen?		
HTTP	Conditional GET requests done?		

What will be the total time to load the page?