University of Southern California
"EE450: Introduction to Computer Networks"
Midterm Exam, **2:10 hour**
March 5, 2021

Name: _____

Undergraduate Graduate

Part 1: True/False	25%	
Part 2: Quickies	40%	
Part 3: Error Detection	10%	
Part 4: Error/Flow Control	15%	
Part 5: DNS, HTTP & Web Caching	10%	
Total	**100%**	

Notes:

- You can work the problems in any order you wish (the goal is to try to accumulate as many points as you can). If you get stuck in one problem, go to another.
- All your answers must be on the exam paper.

Rules:

- This is a closed book, closed notes exam. You are only allowed one post card 5"x7" of formulas ONLY and a Calculator.

- Adherence to the University's Code of Ethics will be strictly monitored and enforced. Academic Integrity violations, such as cheating, will result in a series of actions and penalties including the student failing the class.

1. True or False

   a. The BW x Delay product is the maximum # of bits/sec that can be transmitted in one RTT.

   b. A Traffic that is transmitted from a host in the US to a host in Europe MUST traverse a Tier-1 Network.

   c. In sliding window flow control, there can never be more outstanding frames than the receive window size.

   d. It is impossible for two TCP sockets on a client host A, both bound to the same local IP address and local port number, to communicate with two different servers B and C, respectively.

   e. A root name server can return an authoritative response for any domain name.

   f. The number of name servers that must be contacted to resolve ee.usc.edu from a client located outside of usc.edu. (Presume no entries are cached anywhere) is 3.

   g. ARP is a protocol used to resolve the "next hop IP address" to its MAC address.

   h. The data being read from a UDP server-side socket could have been sent by more than one client.

   i. In Statistical TDM, the number of time slots in each frame is less than the number of input lines to the MUX.

   j. If a computer has multiple Network Interface Cards, The DHCP process must occur separately over each interface to obtain a separate dynamically assigned IP address for each interface.

k. A socket is an interface that defines the messages exchanged between Peer applications layers.

l. An Ethernet adapter (NIC) passes every non-corrupt frame that it receives up to the network layer.

m. Flow control ensures the receiver never receives frames out-of-order.

n. An application calling recv on a TCP socket will never get data out of order from the network.

o. It takes a single bit ten times longer to propagate over a 1Mb/s link than over a 10 Mbps link.

p. Routers only process frames that are specifically addressed to them or frames that are broadcasted.

q. An internet router connecting N networks need to have N IP addresses.

r. TCP is a transport layer protocol that provides guarantees on Reliability, Delay and Throughput

s. POP and IMAP are two protocols used to send electronic messages.

t. Web caching can reduce the delay for all objects, even objects that are not cached,

u. Suppose Client A initiates a Telnet session with Server S. At about the same time, Client B also initiates a Telnet session with Server S. If A and B are different hosts, is it permissible that the source port number in the segments from A to S is the same as that from B to S.

v. Each node, including hosts and routers, must have one and only one ARP cache, the purpose of which is to minimize the number of broadcast ARP request frames.

For the following parts, you MUST supply a reason for your Yes/No (No credit will be given otherwise). In all these parts, there is a single client and a single server communicating using TCP sockets with the client having some data to send to server (not the other way around). Each of the following scenarios shows a different order in which the socket calls are called on both the client and the server. Assume all system calls are blocking, and there is some latency between the client and server. We write the system call when it is initiated by the client and/or server; it returns sometime between then and when the next local system call is executed. For each scenario, answer the following: Can the server ever get the data sent by the client? (Yes or No). If No, Why NOT? Reason?

w.

Client	Server
	socket()
socket()	
	bind()
connect()	
	listen()
send()	
	accept()
close()	
	recv()
	close()

Answer:

---

x.

Client	Server
socket()	
connect()	
send()	
	socket()
	bind()
	listen()
	accept()
	recv()
close()	
	close()

Answer:

---

y.

Client	Server
	socket()
socket()	
	bind()
	listen()
	accept()
connect()	
send()	
	recv()
close()	
	close()

Answer:

Part 2: Quickies (every blank is worth 2 point)

1. Consider a transmission link that uses the stop and wait protocol. The ratio of the transmission delay to the propagation delay is 1/2. Frames are transmitted at a rate of 10 Mbps and each frame is 1k bits long. Bits propagate 2.5×10^8 m/sec.

   - The length of the link is _____ meter.
   - The link utilization is _____ %

2. Five sources are multiplexed using FDM on a link that has a total bandwidth of 4800 Hz. The maximum bandwidth for each source if there must be a 200 Hz guard band between the channels is _____ Hz.

3. Suppose a DLC sender (Layer 2) wants to send 0011111010100000. The sequence of the bits that results after zero stuffing is _____.

4. It is desired to distribute a 1Gbit file to 100 clients. The server has a 50 Mb/s access link, and the clients have access links with a downstream rate of 5 Mb/s each, how long it takes to download the file to all clients; under ideal conditions (you may ignore the time to establish a TCP connection to the server). Answer: _____ sec. Now, consider a peer-to-peer configuration (i.e., No server), with one peer holds the file to be distributed. Assuming that the upstream rate from each peer is 2 Mb/s, how long does it take to distribute the file to all peers? Answer: _____ sec.

5. We have 3 information sources, generating traffic at rates 35Kbps, 50Kbps and 70Kbps, respectively. The sources are active 25%, 75% and 50% respectively. They are to be multiplexed using multiple slot (each slot supporting 1 bit), synchronous TDM. Ignore any synchronization bits.

   a. The minimumlength of the TDM frame is = _____ bits.

   b. The multiplexed rate is _____ bps.

   c. The TDM frame rate is _____ frames/sec.

   d. The duration of the TDM frame is _____ sec.

6. The same information sources as above are to be multiplexed using a Statistical TDM.10% of the link capacity is used to support headers. The required MUX rate at the is _____ bps.

7. Two packets are transmitted back-to-back over a two-hop error-free network. The length of each packet is 1K bits. The data rate on the first hop is 1Mbps. Each hop is 500 meters long and the propagation speed is 2.0×10^8 m/sec. The second packet experience queuing delay at the router of 2 msec. The data rate of the second hop is _____ bps. The overall throughput is _____bits/sec.

8. A channel has a bandwidth of 12MHz. The minimum SNR (in dB) required for this channel to support a data stream at a rate of 100 Mbps is _____ dBs.

9. The link between the client browser and the web server can support 100 Mbps with a round trip time RTT = 250msec. Suppose that the browser wants to download a base HTML page of 500 Kbits long. The HTML file contains 3 imbedded images each of 100 Kbits long. All images are located on the same web server. The time needed to set up a TCP connection is 1RTT. Ignore the transmission time of the HTTP commands (GET).

   a. Approximately how long does it take for the page (including images) to appear on the user's screen, assuming non-persistent HTTP using a single connection at a time? Answer: _____ sec

   b. Repeat part "a" assuming persistent HTTP. Answer: _____ sec

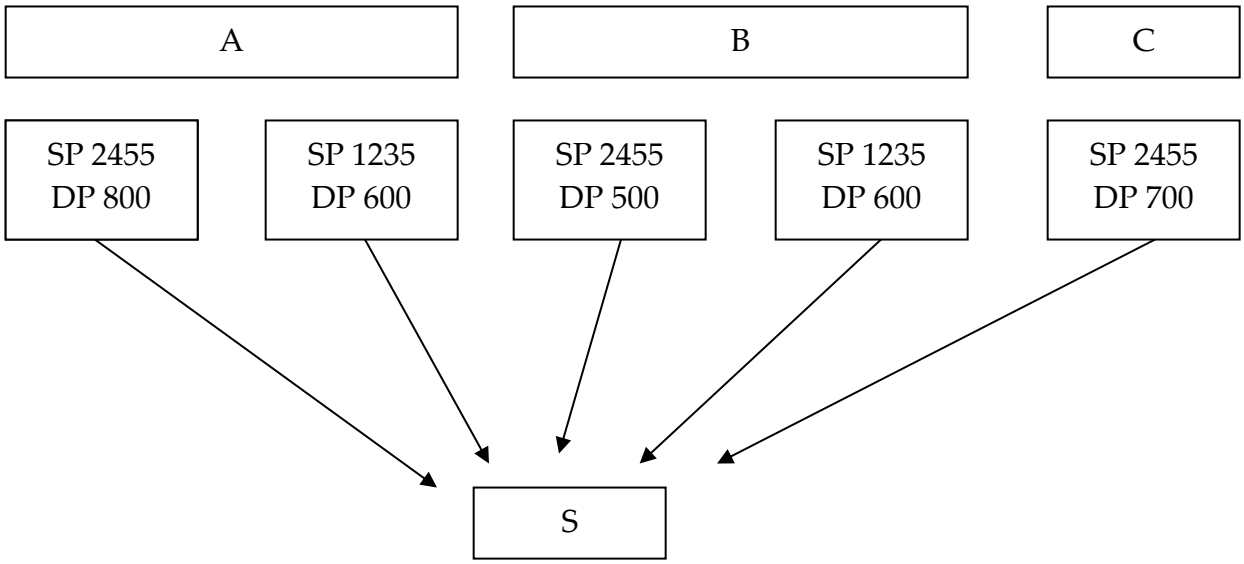
   c. Repeat part "a" assuming persistent HTTP with pipelining. Answer: _____ sec

   d. Repeat part "a" assuming non-persistent HTTP with 2 parallel connections. Answer: _____ sec

10. Three nodes A, B, C are communicating with a server node S. with the indicated Source and Destination Port numbers. From this diagram determine, what is the "total" number of sockets does "S" have to open assuming:

    a. UDP Sockets: _____

    b. TCP Sockets: _____



Work Sheet 1

Work Sheet 2

Work Sheet 3

Part 3: Error Detection

3. It is desired to send the following Data sequence "10001010" over a communications link. An FCS generator $x^4 + x^2 + 1$ is used to generate the FCS sequence.

   a) How many FCS bits are generated? What are they? What is the transmitted bit sequence? Identify the FCS bits in that sequence. Show details of your work.
   b) Now suppose the received sequence is 010010101101. Was it received correctly? If so, what was the data sequence according to the receiver? If not, can you tell how many bit errors occurred? Show your work.
   c) Now suppose the channel introduces the following error sequence100010000101. Will the receiver be able to detect the error? Prove your answer analytically.

   Note: Parts "b" and "c" is a continuation of part "a"

Work Sheet 4

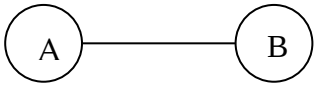
Part 4: Sliding Window ARQ (5+10 points)

4. Consider a Data link that uses Selective Repeat request ARQ with a sending window size of 4. Suppose the transmission time of a frame is 1 second. Assume the one-way propagation delay is 0.5 seconds. Assume the acknowledgement frame transmission time is 1 second. Neglect processing delay. Assume station A begins with frame F_0. A time-out mechanism of 3 seconds (**The timer starts when you transmit the last bit of a frame**). Acknowledgements are sequenced as follows: ACK_n means receiver is acknowledging frame F_n (i.e., not accumulative acknowledgements). Frames received out of order are acknowledged. When receiver receives a frame in error, it drops it and does nothing. Frames are 1000 bits long. The sender has only 6 frames to send F_0 through F_5.

   Draw the frame-exchange-timing diagram for the following sequence of events. Be sure to label each data frame (and ACK frames) with a sequence number.

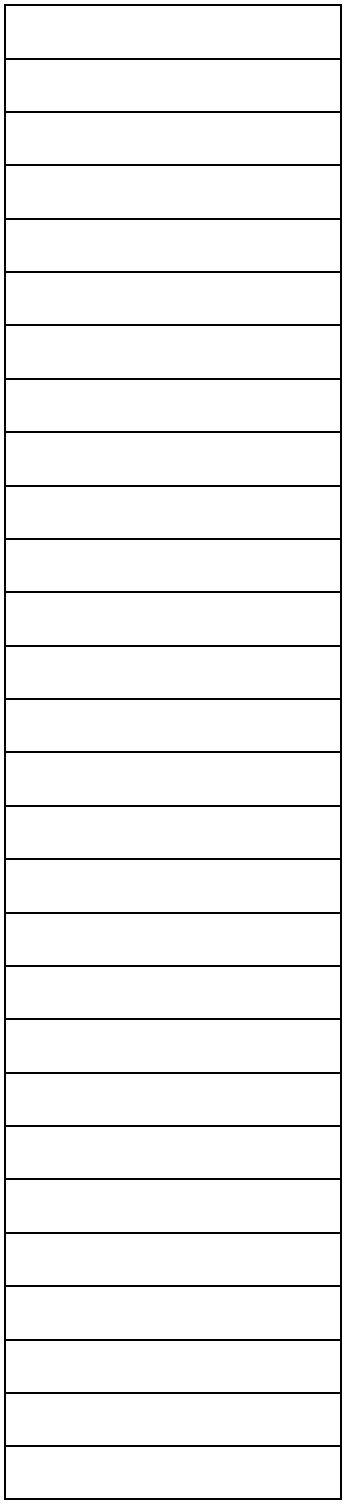
a) Station A sends 6 frames in a row, starting at t=0. Assume all frames are received with no errors. Calculate the throughput of the link if station A has only those 6 frames to transmit. How can the sender send 6 frames continuously if his window is only 4?

b) Frame F_1 is received in error and frame F_3 is lost in the channel. Calculate the throughput and the link utilization.



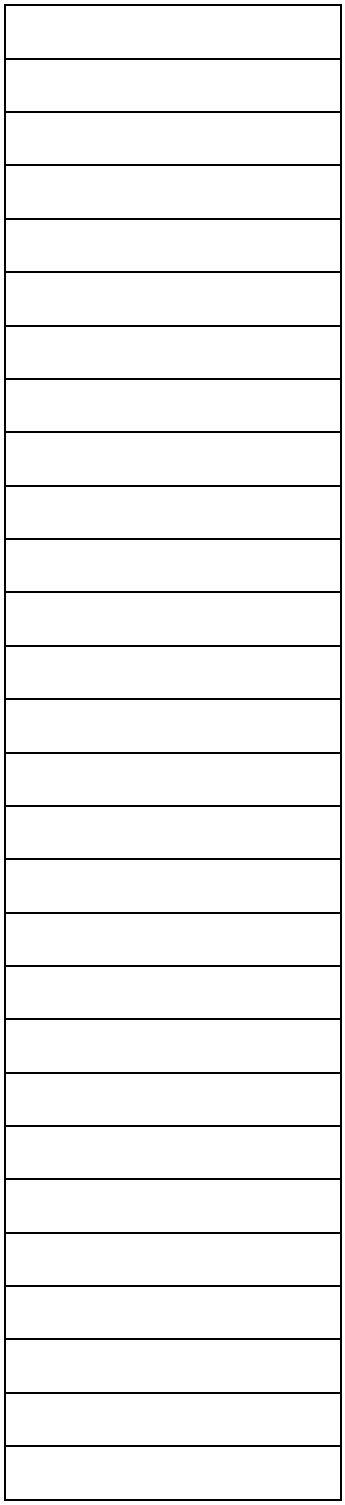
Work Sheet #5

Start from t = 0 and assume every division is 0.5 sec



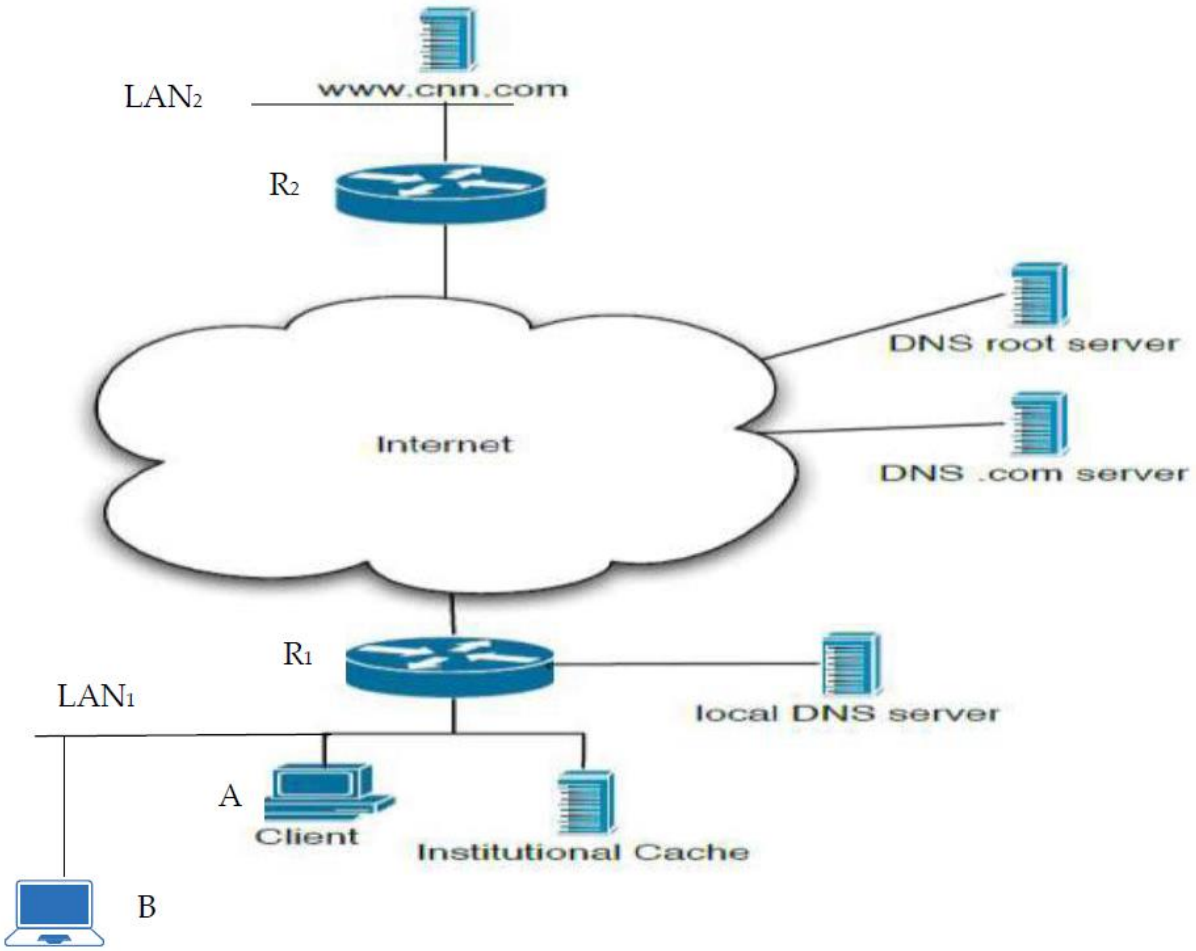
Work Sheet #6

Start from t = 0 and assume every division is 0.5 sec



Part 5: Name Resolution and Web Browsing

Consider the following configuration. Host A is located on LAN_1. A web Server X (www.cnn.com) is located on LAN_2. Suppose that the user at host "A" types the URL of server X to download a given 1G-bit HTML file. Host A does **NOT** know the IP address of Server X (and neither does the local DNS server). Host A is configured with the IP address of the local DNS server. Assume the following:



- DNS commands and HTTP commands are tooshort compared to the file such that you can ignore their transmission times (**ONLY**). Do NOT ignore the Propagation delays.
- The propagation delay within either LAN is negligible. The propagation delay from R_1 to R_2 is 100 msec. The propagation delay from the local DNS server and the root name server is 200 msec. The propagation delay from the local DNS server and the

TLD server is 150 msec. The propagation delay from client A to the local DNS server is 50 msec.

- The TLD server has the IP address of the web server.
- Each LAN operates at 1 Gbps. The link between R_1 and R_2 is 10 Mbps (in each direction)
- The local DNS server is configured with the IP address of the root name server.
- Local DNS server is recursive (which means that the local DNS server will be contacting other name servers NOT the client). All other DNS servers are iterative.
- DNS runs over UDP whereasHTTP runs over TCP.
- Ignore any other delay component such as processing and Queuing.

a. Calculate the time elapsed from the moment Client A enters the URL till the time the file is completely downloaded. You need to list the steps involved clearly in the table provided. The order is IMPORTANT.

b. Now assume that LAN_1 has a web cache (The institutional cache). Assume client A is the only active client and assume that 60% of his requests can be satisfied by the local cache. What is the average rate at which the client can receive data in this case?

Work Sheet #7

Table maybe longer or shorter what you need. **Make sure to add the total delay in the third column** (Do not accumulate delays). Make sure your "actions are clear".

Step	Action	Delay (msec)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Work Sheet 8

Step	Action	Delay (msec)
16		
17		
18		
19		
20