University of Southern California
"EE450: Introduction to Computer Networks"
Midterm Exam, **2:10 hour**
March 1, 2019

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Undergraduate (Graduate)

Part 1: True/False	27%	22
Part 2: Quickies	42%	36
Part 3: Error Detection	12%	12
Part 4: Name Resolution	11%	8
Part 5: Sockets	8%	8
Total	**100%**	

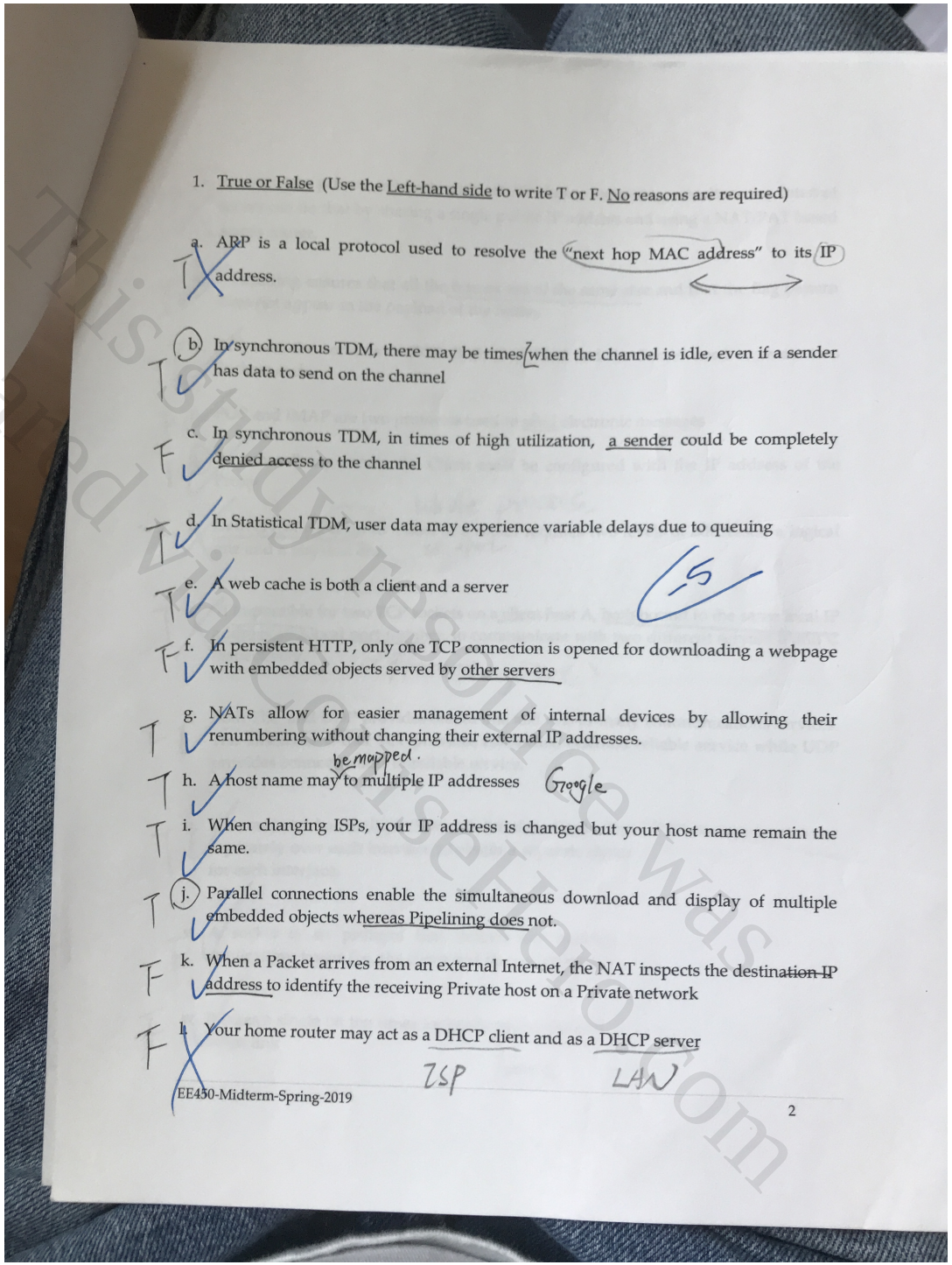
86

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 are 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. No other electronic gadget is allowed
- 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 (Use the Left-hand side to write T or F. No reasons are required)

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

T b. In synchronous TDM, there may be times when the channel is idle, even if a sender has data to send on the channel

F c. In synchronous TDM, in times of high utilization, a sender could be completely denied access to the channel

T d. In Statistical TDM, user data may experience variable delays due to queuing

T e. A web cache is both a client and a server

F f. In persistent HTTP, only one TCP connection is opened for downloading a webpage with embedded objects served by other servers

T g. NATs allow for easier management of internal devices by allowing their renumbering without changing their external IP addresses.

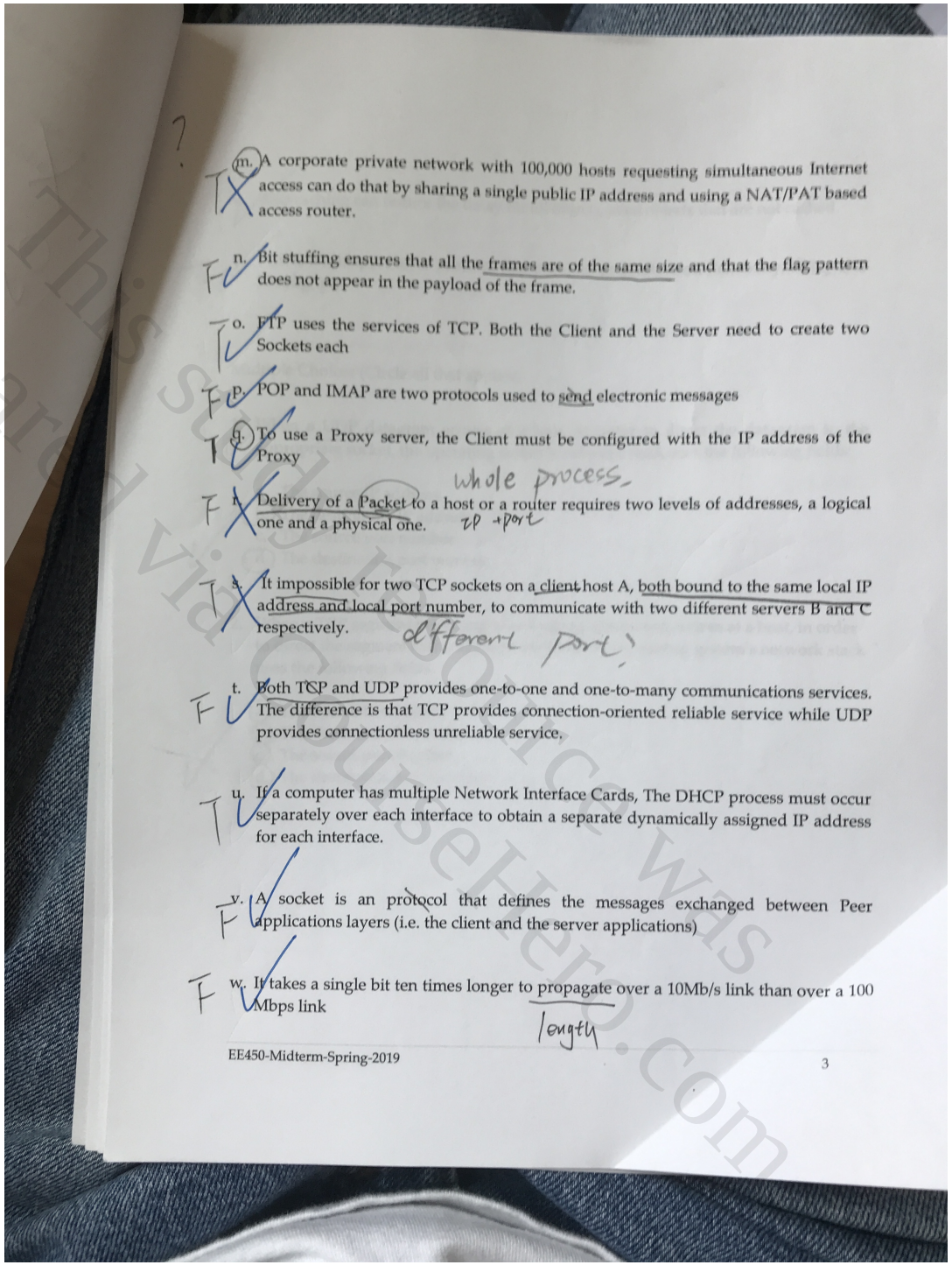
T h. A host name may be mapped to multiple IP addresses

T i. When changing ISPs, your IP address is changed but your host name remain the same.

T j. Parallel connections enable the simultaneous download and display of multiple embedded objects whereas Pipelining does not.

F k. When a Packet arrives from an external Internet, the NAT inspects the destination IP address to identify the receiving Private host on a Private network

F l. Your home router may act as a DHCP client and as a DHCP server



m. A corporate private network with 100,000 hosts requesting simultaneous Internet access can do that by sharing a single public IP address and using a NAT/PAT based access router.

n. Bit stuffing ensures that all the frames are of the same size and that the flag pattern does not appear in the payload of the frame.

o. FTP uses the services of TCP. Both the Client and the Server need to create two Sockets each

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

q. To use a Proxy server, the Client must be configured with the IP address of the Proxy

r. Delivery of a Packet to a host or a router requires two levels of addresses, a logical one and a physical one.

s. It 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.

t. Both TCP and UDP provides one-to-one and one-to-many communications services. The difference is that TCP provides connection-oriented reliable service while UDP provides connectionless unreliable service.

u. 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.

v. A socket is an protocol that defines the messages exchanged between Peer applications layers (i.e. the client and the server applications)

w. It takes a single bit ten times longer to propagate over a 10Mb/s link than over a 100 Mbps link

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

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

Multiple Choices (Circle all that applies)

1. When a UDP datagram arrives at a host, in order to direct the datagram to the appropriate socket, the operating system's network stack uses the following fields:

   a. The source IP address.
   b. The destination IP address
   c. The source port number
   d. The destination port number

2. When a TCP segment belonging to an existing connection arrives at a host, in order to direct the segment to the appropriate socket the operating system's network stack uses the following fields

   a. The source IP address.
   b. The destination IP address
   c. The source port number
   d. The destination port number

$10\times10^{6}\times20\times10^{-3}=$

a. BW · RTT

200×10^{3}

200 kbps = 20%

you don't know that RTT is 2Tp otherwise I would have stated that.

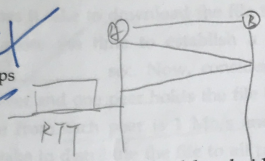
Part 2: Quickies (every blank is worth 2 point)

1. Consider a 10 Mbps link with a 20 msec RTT. Assume that the sender can transmit one frame at a time. The frame size is 5 Kbyte.

R = 10Mb

RTT = 4x10^-3 s

Tp = 10ms



$\frac{4\times10^{-3}}{10^{-7}}$ $\frac{40\times10^{3}}{10\times10^{6}}$ 4×10^{-3}

a. The maximum throughput is 1.67M bps

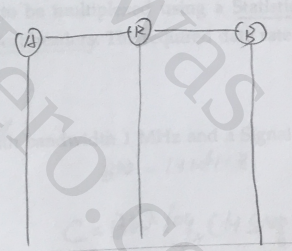
b. The maximum link utilization is 16.7 %

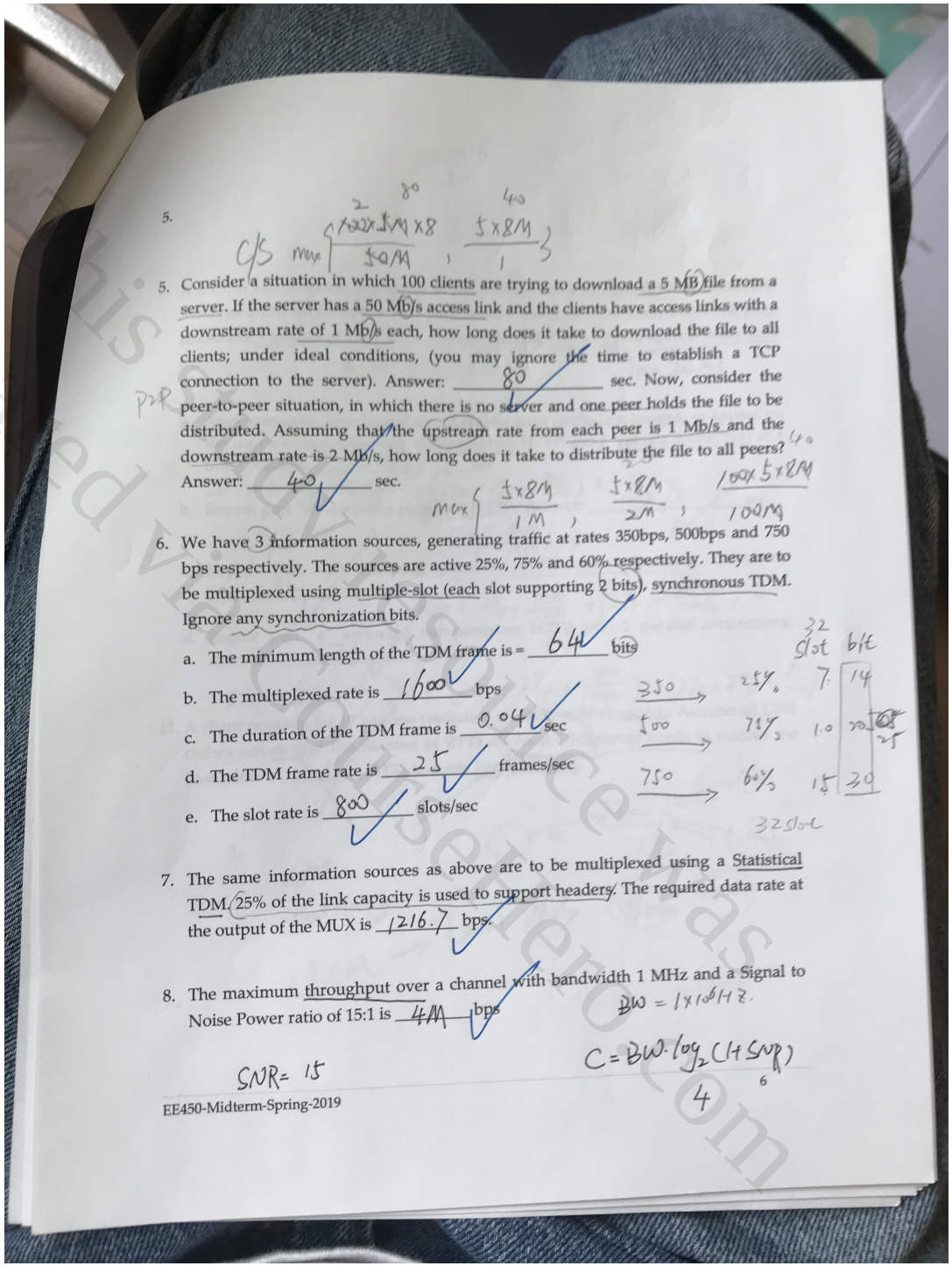
2. Ten sources are multiplexed using FDM on a link that has a total bandwidth of 10KHz. The maximum bandwidth for each source if there must be a 200 Hz guard band between the channels is 820 Hz

$9\times200+10\times=10K$

3. In a certain DLC protocol, the Flag used to indicate the start and end of the frame is 0111. Assume that Zero stuffing is used (To prevent the occurrence of the flag sequence anywhere in the frame). The data sequence is 011011101101. The sender will transmit the sequence 01100110101001 (Do NOT include the Flags)

4. Consider transmitting a packet from host A to host B via a router (i.e. hosts A and B are located on different networks). All ARP tables (in hosts and router) are empty. Let x denote the time (in seconds) to transmit the packet. Let y denotes the time (in seconds) elapsed from the beginning of transmitting an ARP query until receiving an ARP response, Ignoring propagation delay, the total time it takes to forward the packet from A to B is (2x+2y) sec.





5. Consider a situation in which 100 clients are trying to download a 5 MB file from a server. If the server has a 50 Mb/s access link and the clients have access links with a downstream rate of 1 Mb/s each, how long does it take to download the file to all clients; under ideal conditions, (you may ignore the time to establish a TCP connection to the server). Answer: 80 sec. Now, consider the peer-to-peer situation, in which there is no server and one peer holds the file to be distributed. Assuming that the upstream rate from each peer is 1 Mb/s and the downstream rate is 2 Mb/s, how long does it take to distribute the file to all peers? Answer: 40 sec.

6. We have 3 information sources, generating traffic at rates 350bps, 500bps and 750 bps respectively. The sources are active 25%, 75% and 60% respectively. They are to be multiplexed using multiple-slot (each slot supporting 2 bits), synchronous TDM. Ignore any synchronization bits.

   a. The minimum length of the TDM frame is = 64 bits
   b. The multiplexed rate is 1600 bps
   c. The duration of the TDM frame is 0.04 sec
   d. The TDM frame rate is 25 frames/sec
   e. The slot rate is 800 slots/sec

7. The same information sources as above are to be multiplexed using a Statistical TDM. 25% of the link capacity is used to support headers. The required data rate at the output of the MUX is 1216.7 bps.

8. The maximum throughput over a channel with bandwidth 1 MHz and a Signal to Noise Power ratio of 15:1 is 4M bps

9. A user in Los Angeles, connected to the internet via a 10 Mb/s (b=bits) connection retrieves a 150 KB (B=bytes) web page from a server in New York, where the page references 3 images of 1 MB each. Assume that the one way propagation delay is 20 ms.

$T_p = 20\,ms$.

a. Approximately, how long does it take the page (including images) to appear on the user's screen, assuming non-persistent HTTP using a single connection at a time? Answer: 2.84 sec

$2 \cdot T_p + 2T_p + \frac{1200k}{10M} + (2T_p + 2T_p + \frac{8M}{10M}) \times 3$

b. Repeat part "a" assuming persistent HTTP. Answer: 2.72 sec

$2T_p + 2T_p + \frac{1200k}{10M} + (2T_p + \frac{8M}{10M}) \times 3$

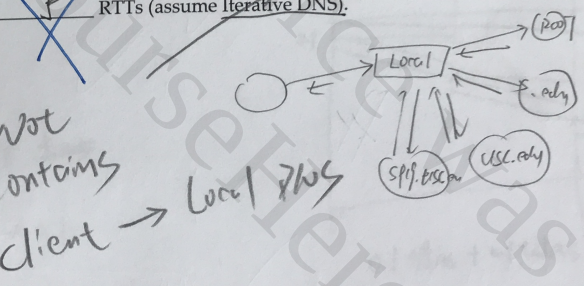
c. Repeat part "a" assuming persistent HTTP with pipelining. Answer: 2.64 sec

$2T_p + 2T_p + \frac{1.2M}{10M} + (2T_p + \frac{8M}{10M/3}) =$

d. Repeat part "a" assuming non-persistent HTTP with 2 parallel connections. Answer: 2.76 sec

$2T_p + (2T_p + \frac{1.2M}{10M}) + (2T_p + 2T_p + \frac{8M}{10M/2}) + (2T_p + 2T_p + \frac{8M}{10M})$

11. A client requests the IP address resolution of ee450-ee.SP19.usc.edu Assume all DNS caches are empty. The number of RTTs the local DNS server needs to resolve the host name is 5 RTTs (assume Iterative DNS).



2

Not contains

client → Local DNS

One way delay

12. The number of hops separating two end hosts A and B is 3 with the middle hop twice as long as the other two. A message of 10 Kbits long is to be transmitted. The data rate on each link is 10 Kbps. The propagation delay over a short hop is 10 msec. It is desired to compare the end-to-end delay for two different switching technologies.

TTL.

a. Circuit Switching: Assume the call set-up delay is 0.2 sec.

0.2s + (10ms + 20ms + 10ms) × L

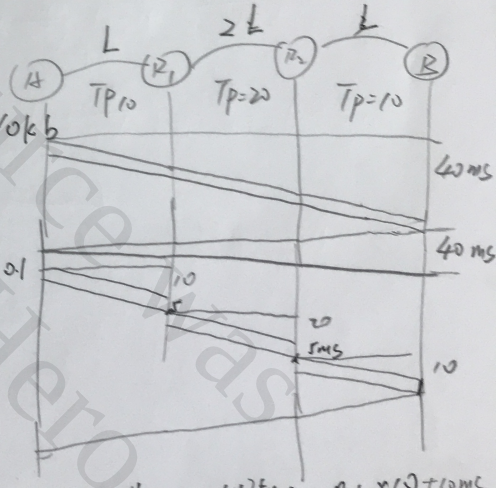
80ms

Answer: ~~1.28~~ sec

b. Packet Switching: Assume each Packet length is 1Kbits and a Queuing delay at each intermediate node of 5 msec

10packets 0.1s 10kb

Answer: 1.29 sec



-6

10.1 x 10 + ~~1~~

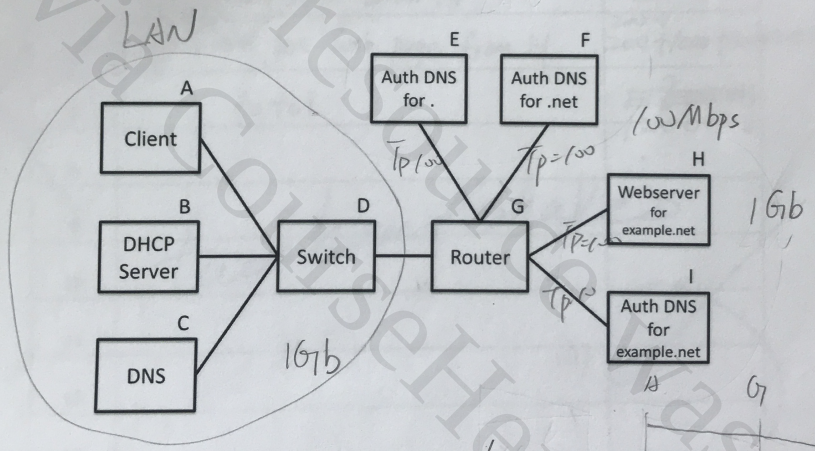
+ 0.1 + 0.2 + 0.1

10 x 0.1 + 0.04 + 0.04

Part 4: Name Resolution (2 + 9)

Client A wants to download a webpage http://example.net/index.html from the web server H. The web page is 1G-bit long. Client A does NOT know the IP address of Server H. Client A already got his IP address and the IP address of the local DNS (Server C) from the DHCP server (Server B). Assume:

- DNS commands and http commands are so small compared to the file such that you can ignore their transmission times (ONLY)
- The propagation delay within the LAN is negligible. The propagation delay between servers E, F, H and I to the Router is 100 msec.
- The LAN operates at 1 Gbps. Each Link between servers E, F, H and I to the Router operate at 100 Mbps.
- The DNS is iterative
- DNS runs over UDP whereas HTTP runs over TCP.



Answer the following questions:

a. How many total Networks are there in the diagram (2 points)

5 Networks

b. Calculate the time elapsed from the moment user A enters the URL until the time the file is completely downloaded. Create a table that identifies the steps taken (in

order) along with the time required to accomplish each step (do NOT accumulate time in each step), After you are done with the steps you MUST add to find out the total time (9 points)

(You may add more rows if needed)

Step	Action	Delay (msec)
1	Send DNS Query to Local DNS (c)	0ms
2	Local DNS ask for Server E	200ms
3	Local DNS asks for Server F	200ms
4	Local DNS return DNS answer to client	0ms
5	Hand Shaking with server H	200ms
6	handshake request and get web page from H	200+200+1000+10000 ms
7	total	~~11800 ms~~ 12000 ms
8		
9	two handshakes	
10		
11		
12		
13		
14		
15		

$\frac{1\times10^3}{10^8\times10^6} = 10s$ (handshake get data. & store and forward)

-3