This mid-term has 5 questions worth a total of 45 points. Answer the questions in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page allotted to that question. Clearly indicate your derivations and circle your final answer.

Last Name: _____

First Name: _____

1. [7 points] Telegraph/Telephone/Internet

(a) [4 points] What is the data rate in bps of a telegraph computer capable of writing 100 wpm (words per min.) built from an alphabet consisting of 250 letters. Assume the average word length is 12 characters and that two characters are needed for framing.

$$R = \text{words per min} \times \frac{\text{chars}}{\text{word}} \times \frac{\text{bits}}{\text{char}} \times \frac{\text{min}}{\text{sec}}$$

$$= 100 \times (12+2) \times \lceil \log_2 250 \rceil \times \frac{1}{60}$$

(12+2): 12 + framing

$$= 100 \times 14 \times 8 \times \frac{1}{60}$$

$$= 186.7 \text{ bps}$$

(b) [3 points] A network must achieve errorless data rates of 350-kbps. The maximum channel bandwidth is only 15 kHz however. Your network allows a maximum of only 1.5 mW to reach your receivers. What is the maximum amount of noise that you can live with? Show units in the final answer.

$$C = W_c \log_2 (1 + SNR)$$

$$SNR = 2^{\frac{C}{W_c}} - 1$$

$$\frac{P_{sig}}{P_{noise}} = 2^{\frac{C}{W_c}} - 1$$

$$P_{noise} = \frac{P_{sig}}{2^{\frac{C}{W_c}} - 1} = \frac{1.5 \times 10^{-3}}{2^{\frac{350}{15}} - 1} = 1.42 \times 10^{-10} \text{ W}$$

2. [12 points] Network classification and topologies

(a) [1 point] Fill in the blanks: The traditional land line telephone provides a connection oriented service over a circuit switched network.

(b) [1 point] When we design a network to prevent routers from being clogged with too much data we call this functionality congestion control

(c) [1 point] What can Tier 1's do with each other at an IXP?

peer

(d) [2 points] Name two types of multiplexing schemes used when nodes need to share a medium.

FDMA, TDMA (CDMA, SDMA)

(e) [2 points] Packet switching networks like the Internet can be further classified into networks that either pre-select their route or that do not pre-select their route. Name both of these sub-classifications using the terms discussed in class.

datagram networks, virtual circuit networks

(f) [1 point] From the highest level of the classification hierarchy, what kind of network is Ethernet?

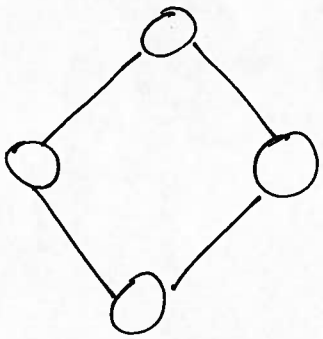
broadcast

(g) [1 point] Name one type of round robin network

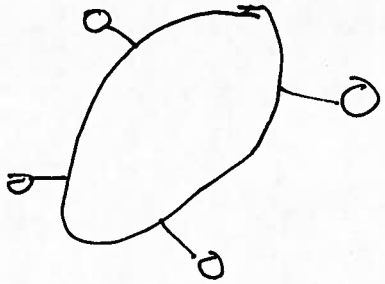
polling, slotted ring, token passing

(h) [3 points] Sketch an active ring network and a passive ring network. Clearly label which picture corresponds to which network.

ACTIVE



PASSIVE



3. [10 points] Basic network calculations. Question (b) (which is NOT related to (a)) is on the next page.

(a) [4 points] Packets with an average length of 1.5×10^3 bytes arrive at a router port. The average arrival rate of packets into the port corresponds to 35-Gbps. The port's average processing rate is 40-Gbps. The average distance a packet travels to the router is 5 km. If traffic to the port is such that occasionally the packet arrival rate is five times worse than average then how many bytes of buffer memory do you recommend be used in the port?

$\lambda_b = 35 \times 10^9 \qquad \mu_b = 40 \times 10^9$

# of packets in buffer & router

$$= \frac{\lambda_b}{\mu_b - \lambda_b} = \frac{35}{40-35} = 7$$

$\therefore$ on avg. $7 - 1 = 6$ packets in buffer

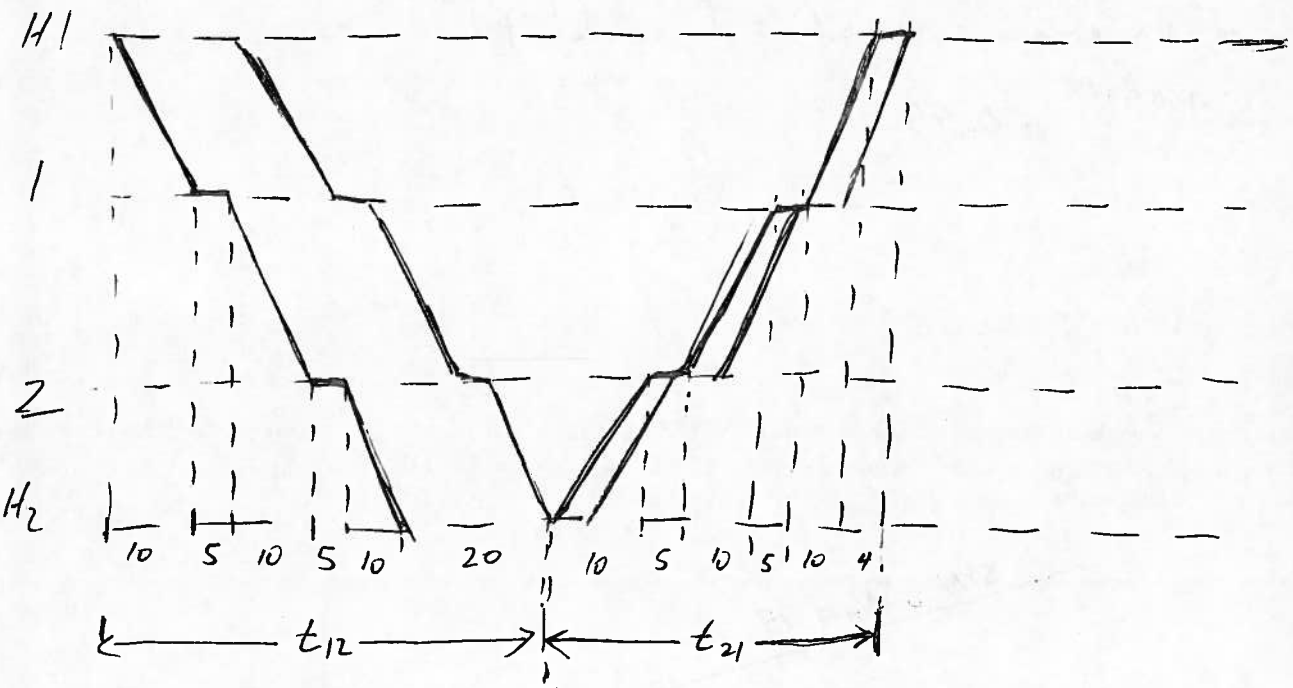
if packet arrival is 5x higher may need $7 \times 5 = 35$ packets in buffer & router $\therefore$ need buffer for 34 packet

$\therefore$ need memory of $34 \times 5 = 170$ packet

$= 170 \times 1.5 \times 10^3 = 2.55 \times 10^5$ bytes

(b) [6 points] Two hosts communicate through a network consisting of 2 cut-through routers (not store-and-forward) that can start processing a packet as soon as the first bit arrives. The hosts use a very simple communication scheme where each arriving packet must be acknowledged by the end-point host before the another packet can be sent. The hosts need to wait until they receive an entire packet before they understand what to do with it. **Find the throughput of this network** in bps.

The propagation time is 10 μs, the cut-through router processing time is 5 μs. 4000 byte message packets take 20 μs of transmission time and 800 byte acknowledgement packets take 4 μs of transmission time. The host processing time is zero.



$t_{12} = 3t_{prop} + 2t_{proc,route} + t_{tx,msg}$

$= 3\times10 + 2\times5 + 20$

$= 60\mu s$

$t_{21} = 3t_{prop} + 2t_{proc,route} + t_{tx,ack}$

$= 3\times10 + 2\times5 + 4$

$= 44\mu s$

$t_{total} = t_{12} + t_{21}$

$= 60 + 44 = 104\mu s$

$S = \frac{8\times4000}{t_{total}} = \frac{8\times4000}{104\mu s} = 308\ Mbps$

4. [10 points] More network calculations and protocols/services/layers

(a) [3 points] A 10^4 byte file is to be transmitted over a 2.5 Mbps communication line that has a bit error rate of 10^{-5}. What is the probability that the entire file is transmitted without errors?

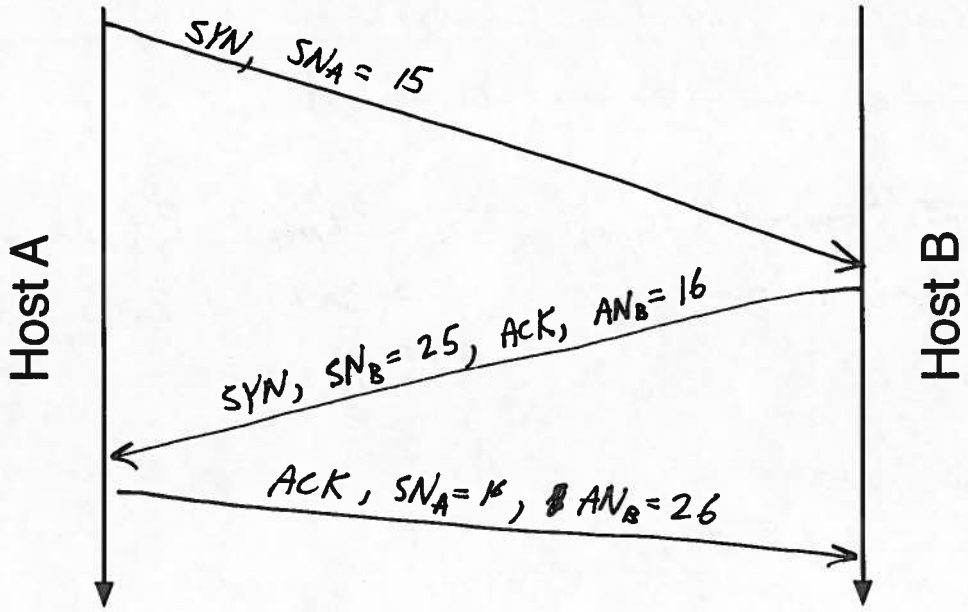
$p = 10^{-5}$

prob. of no error: $(1-p)$

prob of no error over whole file $(1-p)^{8\times10^4}$

$\approx e^{-p\times8\times10^4} = 0.45$

(b) [4 points] Host A seeks to connect to host B using TCP. Sketch how TCP uses segments to set upt this connection on the timeline plot provided. Assume A's initial sequence number is $SN_A = 15$ and B's is $SN_B = 25$. For full marks label the picture with all pertinent settings (as close to what we did in class as you can).



(c) [1 point] What application layer protocol is used to fetch an IP address?

DNS

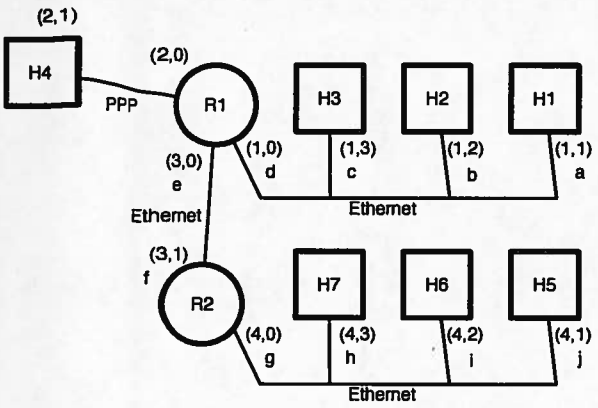
(d) [1 point] When a server is flooded it is waiting for a TCP segment with with a particular flag's bit set to 1. What is the name of that flag?

ACK

(e) [1 point] TCP uses the services of which protocol?

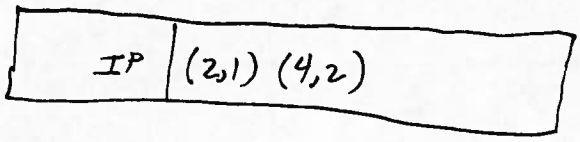
IP

5. [6 points] Consider the internetwork shown below. Internet protocol addresses are denoted by the numbers in brackets [i.e. (netID, hostID)] and physical addresses are denoted by letters. Hosts are denoted by squares and routers are denoted by circles. Assume that all hosts and routers already know the physical addresses of the units to whose subnetwork they are attached.

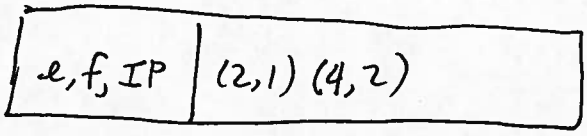


(a) [5 points] Sketch the frame or frames (and **just the frame or frames**, *sketching any more than asked will result in loss of marks*) that are transmitted over the course of a communication from the H4 to H6.
In your sketches *include not only the header of the frame, but also the header of the network layer packet encapsulated in the frame* (don't worry about frame trailers or the transport layer).

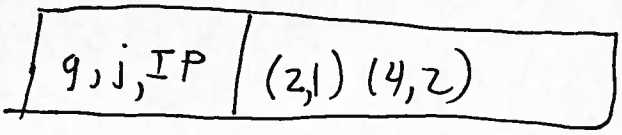
H4 to R1



R1 to R2



R2 to H6



Q1

Q2

Q3

Q4

Q5

Total