MIDDLE EAST TECHNICAL UNIVERSITY
Electrical and Electronics Engineering Department

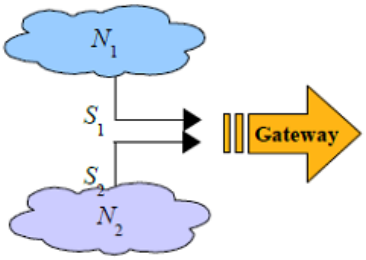
EE444 Introduction to Computer Networks
Practice Problems

Q1. Consider a local area network (LAN) which operates over 10Mbits/s CSMA/CD with 8 stations. Each station independently generates a traffic in which the elapsed time between two consecutive frame generation is exponentially distributed with mean 0.1 second, and the frames are 1250 Bytes including 250 Bytes of protocol and layered architecture overhead. The maximum value and mean of one-way propagation delay are 2 msec, and 1 msec, respectively.

(a) Assuming the channels in this network are error-free, what is the probability that any transmitted frame does not experience any collision?
(b) Find the average total delay a frame experiences from the time it is generated until it is successfully received by its specified destination?
(c) Find the actual data transmission rate observed by the Data Link Control sublayer?

Clearly state any reasonable assumption you make, and explain your reasoning.

Q2.



Consider the network architecture above. Two local networks, N_1 and N_2, composed of large number of stations operate with ALOHA protocol. Stations in N_1 may start transmission any time they have a frame ready. However, the network administrator in N_2 mandates that the stations may perform transmission only at the beginning of certain time slots with length equal to frame transmission time. Time elapsed between two frame generation instances follows an exponential distribution. Frame transmission time for both networks is 1 second. Measurements reveal that both networks N_1 and N_2 operate at their maximum efficient operating points yielding traffic flows of S_1 and S_2 frames per frame time, respectively.
Frames generated by both networks are destined to a gateway router, which connects these two networks to the Internet. The gateway router has a single outgoing link with a capacity to forward frames in an exponentially distributed frame forwarding time with an average of 1/F seconds.

(a) Find the minimum F such that frames are eventually out of the gateway
(b) Assume that the gateway follows time-division multiplexing to serve these flows such that the average time spent by each frame coming from N_1 and N_2 are equal to each other. Find the forwarding rates, in terms of F, provided by the gateway to the flows from N_1 and N_2 respectively

Q3. Given the following 6-bit data message, i.e. 101101, and the generator sequence 100 (i.e. coefficients of generator polynomial P(#)),

(a) Determine the CRC bits and the transmitted bit sequence.

(b) If only one of the least significant two bits in the received sequence is in error, find the probability that this error can be detected by the receiver.

Q4. Consider 2 stations A and B which are located at the two farthest locations in an experimental Ethernet network with infinite number of users. The line rate is 1 Mbps and the bit error rate is 10^{-4}. The flow and error control protocol used at the DLC Layer is Stop and Wait with ARQ. A is sending 4600 bit data frames and B is sending back 2600 bit acknowledgement frames. The time out interval (starting after the last bit of the frame is sent) is 20msec. One way propagation delay between A and B is 1 msec. Compute the highest efficiency that the network layer can achieve at station A. Ignore any headers. (HINT: For infinite number of stations, the optimal value for the probability that a station acquires the channel is 1/e.)

Q5. (a) Derive the throughput expression for a pure ALOHA network with infinite number of users which generate a total traffic (including the retransmitted frames) of G frames/frame time. Indicate all steps of your derivation. Explain your reasoning.

(b) Using your expression and the same assumptions in part (a) compute the throughput where the total generated traffic rate is 100 Kbits/sec with a frame size of 1 Kbits and channel capacity of 1Mbps. Leave the result in exponential form (no calculators are needed).

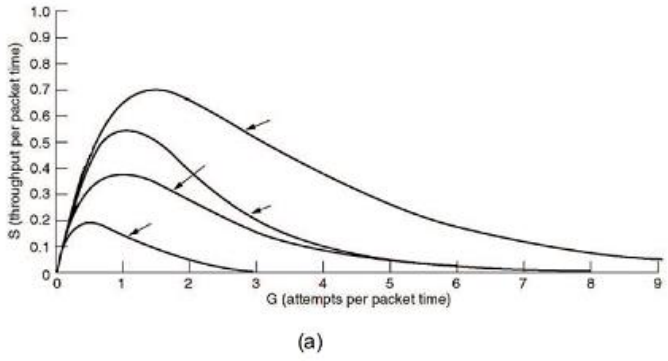
Q6. Consider a network with 100 stations. The capacity of the channel is 1 Kbits/sec. The medium access control is provided using the bit-map protocol. Each station generates frames with a Poisson distribution of 0.005 frames/sec average rate where the frame size is 400 bits. One way maximum propagation delay τ = 5ms.

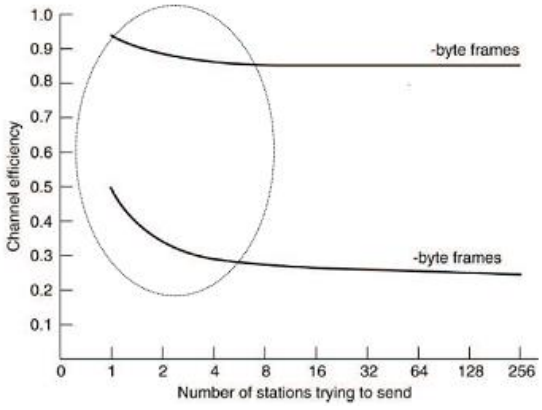
(a) What is the probability of collision for the frames transmitted by any station?

(b) What, is the average frame time observed in this network?

Clearly state any assumption that, you make.

Q7.





(a) Consider part (a) of the given figure which shows throughput as a function of load for 0.5 persistent CSMA, 1-persistent CSMA, ALOHA and slotted-ALOHA. Label the given arrows on the figure to indicate which protocol corresponds to which curve. Justify your reasoning.

(b) The two curves in part (b) of the given figure show the efficiency of Ethernet at 10 Mbps with 512-bit slot times for 64 Byte and 1024 Byte frames. Complete the labels on the curves with the corresponding frame sizes. Also explain the trend observed that is enclosed in the ellipse. Justify your reasoning.

Q8.

Algorithm Step #	Tentative Labels	Permanent Labels
1. Working node A:	B(2,A) C(1,A) D(4,A)	C(1,A)
2. Working node C:	D(3,C) F(5,C) B(2,A)	B(2,A)
3. Working node B:	E(3,B) D(3,C) F(5,C)	D(3,C)
4. Working node D:	E(3,B) F(5,C) (Nothing new)	E(3,B)
5. Working node H:	F(4,E)	F(4,E)

Assume that a router is using OSPF to compute the least cost path between A to F on the network given below. The above table shows the algorithm operation details by indicating each step and with the appropriate tentative (temporary) and permanent labels. Determine and write down (on the figure below) the link costs associated with each link so that the least cost path from A to F is A-B-E-F with the total cost of 4 could be obtained as a result of the steps given on the table above.