UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION, APRIL 17, 2001 (TUESDAY)

Third Year – Electrical and Computer Engineering

ECE361S – COMPUTER NETWORKS

Exam Type: A

Examiners – E. Law/D. Etiemble

Student Name: ____________________

Student Number: ____________________

Rules:

1. This is a Type A examination. You are not allowed to use aid-sheets, textbooks or any other materials.
2. You may only use non-programmable calculator.
3. Write your answer on the ruled side of the examination book provided with this examination. You may use the un-ruled side for calculations or drafts.

Question	Score
1	/17
2	/15
3	/8
4	/12
5	/7 (3)
Total	**/59**

1. [17 points in total] (a) (4 points) Given the following codes, can you find all the orthogonal codes? If there are more than one set of orthogonal code, please indicate all of them:

(0101, 1110, 1100, 0001, 1011, 1111)

(b) (5 points) In an CDMA system, there are 3 users. In part (a) of this question, there is a set of three orthogonal codes. We assign these orthogonal codes to these users. For the above indicated orthogonal codes, they are assigned to bit logic 1; their inverses are assigned to bit logic 0. If now all three users are sending the following same information in the air CDMA channel. Can you give the summed signal of the aggregated transformed value?

10011

(c) (6 points) If you are given the following summed signal sent by these three users again, please decode it into the three original binary signals sent by the three different codes.

(-1,+1,-3,-1) (-3,-1,-1,+1) (+3,+1,+1,-1)

(d) (2 points) If you are given the primitive equation, $g(x) = x^3+x^2+1$, to generate random codes for CDMA, can you explain with a simple reason why it cannot give you a set of orthogonal codes?

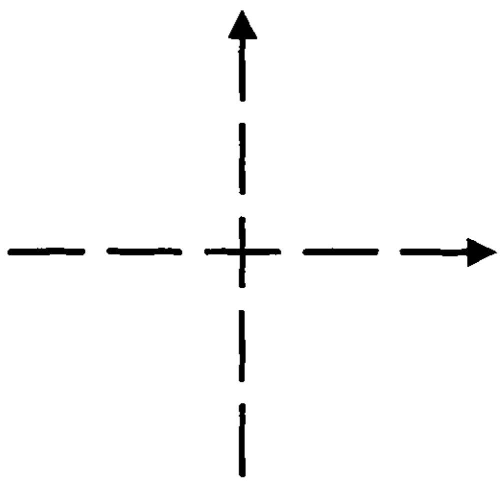
2. [15 points in total] In a Stop-and-Wait Automatic Repeat Request (ARQ) data link point-to-point system, host A is sender and host B is the receiver. The information for the system is as follows:
   - The size of a data frame: f bits;
   - The size of an acknowledgement frame: a bits;
   - All frames including data and acknowledgement frames have error correcting capability of 1 single bit error;
   - The bit error probability for the system: p;
   - The transmission rate of the system: R bits/second;
   - Timeout timer starts after the last bit of a data frame is sent, and the timeout time is set to: T sec;
   - System one-way propagation delay: t_p sec;
   - Processing time required for both data and ack frames at the hosts: t_k sec;

   (a) (4 points) Assume that no frame will get lost in the system; however, there are chances to have bit errors in transmission. Calculate the retransmission probability for this system, P_r. Please give the exact expression without making any approximation. [Hint: Either data or acknowledgement frame cannot be received correctly or cannot be corrected properly will initiate retransmission.] (b) (2 point) Please give an approximation of the P_r if $p<<1$? [Hint: Use $(1-p)^n = 1-np$ if p is very small.] (c) (2 point) Please denote the time required for a completed one frame transaction between host A and host B as t_o sec using the variables indicated above. (d) (3 points) Please give the average number of retransmission, n, required for each frame transmission in terms of the retransmission probability, P_r. [Hint: This is a geometric distribution.] (e) (4 points) Now please express the average value of the total time required for one frame transmission, and put it in terms of P_r, and the other variables indicated above. Please do not use the variable t_o in your final answer.

3. [8 points in total] (a) (1.5 points) In signal transmission, can you explain the three terms: attenuation, distortion, and noise? (b) (1 point) There are typically coding techniques are used before the source signal is sent to the noisy communication channel. What are they? (c) (3 points) For the (7,4) Hamming codeword, we have

Information	Codeword	Information	Codeword
0000	0000 000	1000	1000 110
0001	0001 111	1001	1001 001
0010	0010 101	1010	1010 011
0011	0011 010	1011	1011 100
0100	0100 011	1100	1100 101
0101	0101 100	1101	1101 010
0110	0110 110	1110	1110 000
0111	0111 001	1111	1111 111

What is the Hamming distance of this code? When we send the signal encoded with this Hamming code, if the bit error probability is 0.01, what is the approximated probability that there is undetectable error at the receiver? This code is t-bit error correcting code. What is the value of t? (d) (2.5 points) The following diagram shows the signal constellation of the V.32 standard. How many bits can be represented by each baud signal? This standard was used in modem with a baud rate of 2,400. Among all the bits information, one bit is used for synchronization, the rest of the bits in each baud signal are used for passing data. What is the data transmission bit rate for this standard?



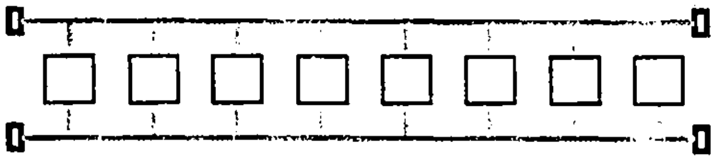
4. [12 points in total] (a) (4 points) A large enterprise is trying to accommodate a large number of computing stations (say, more than 200 stations), and trying to use only one shared medium network. The IT department is picking either the Ethernet network or the token ring network. Which shared medium technology should be the correct selection in this scenario, and why?

(The following system setup is for parts (b) and onwards.) There is a shared medium network, which works similar to the Ethernet network, that has two parallel buses, and each station is connecting to both buses. All stations are operating on

CSMA/CD. The system is depicted as shown in the figure below with following parameters:

- Number of stations: M, and M>>1;
- Expected frame transmission time: X secs;
- Probability that a station may send a frame: p, and p<<1;
- Given a frame is going to send, the probability to send to bus 1: f_1;
- Given a frame is going to send, the probability to send to bus 2: $1-f_1$;
- One-way end-to-end propagation delay for bus 1: t_1 sec;
- One-way end-to-end propagation delay for bus 2: t_2 sec.

Whenever each station has a frame to send, it shall arbitrarily picks one bus on uniform distribution to pass a frame. (b) (3 point) What is the probability that a frame can be sent successfully, P_s? Please do not do any approximation on this part. (c) (1 point) Please approximate the result in part (b) by ignoring any p terms with orders larger than or equal to 2; and show that it can be approximated with the expression Ge^{-G}. (d) (4 points) Please estimate and comment on the maximum system utilization of this system. Can you discuss the positive effects of this dual-bus system? Please indicate the maximum number of stations you can set for this system. (Recall that the maximum system utilization of a CSMA/CD system with one single bus is $\rho_{max} = \dfrac{1}{1+a(1+2e)}$, where $a = \dfrac{t_{prop}}{X}$, t_{prop} is the one-way propagation delay from one end of a bus to the other end, X is expected frame transmission time, and e=2.714. For this maximum utility calculation, we should set the approximation in part (c) with G equals to 1.)



5. [7 points in total (3 points are for extra bonus)] (a) (5 points) Similar to the OSI seven-layer architecture, the SONET transport system can also further partitioned into three different layers. What are they? Can you explain their roles in operations? (b) (2 points) Please discuss the differences between message switching and packet switching networks, please ignore the cut-through switching concept. (c) (Bonus part: 3 points) The Erlang-B formula is used to calculate the blocking probability of a circuit-switched networks with Poisson arrival process, it is $P_b = \dfrac{\frac{a^c}{c!}}{\sum_{j=0}^{c} \frac{a^j}{j!}}$, where a is the offered load, and c is the trunk size. Please try to explain how you can get this equation. Furthermore, please elaborate the term, the average call holding time, and how does it link to the Erlang-B formula.