UNIVERSITY OF ALBERTA

DEPT. OF ELECTRICAL AND COMPUTER ENGINEERING

ECE 487 B1 – Data Communications Networks

Midterm Examination

Instructor: Hai Jiang
Exam date: Wednesday Feb. 27, 2019
Exam duration: 50 minutes (1:00pm – 1:50pm)

Instructions:

1. Verify that this booklet contains 9 pages (including ARQ summary sheet).
2. Sign on Page 1
3. Place your I.D. card on your table.
4. Neatly enter your answers in the spaces provided.
5. Use the reverse sides of the pages for rough work. Answers written on the reverse sides of the pages will **NOT** be marked.

Last name: ____________________________________

First name: ____________________________________

Student I.D.: ____________________________________

Signature: ____________________________________

Question	Worth	Mark
1.	15	
2.	17	
3.	12	
4.	16	
Total	**60**	

GOOD LUCK!!!

1. Network Topology, Switching, and Network Model (**15 points**)

(1) Please make a comparison of circuit and packet switching in the following table. You only need to answer "Yes" or "No" in each field (**5 points**)

	Circuit Switching	Packet Switching
Dedicated path?		
Fixed bandwidth available?		
Potential waste?		
Call setup?		
Same route for all packets?		

(2) Please indicate in the following table the names of the seven layers in the Open Systems Interconnection (OSI) model. Please also indicate **one** responsibility of each layer. If you indicate multiple responsibilities for one layer, your mark will be based on the first responsibility. (**7 points**)

	Name of the layers	One responsibility
Layer 7		
Layer 6		
Layer 5		
Layer 4		
Layer 3		
Layer 2		
Layer 1		

(3) In the following table, please indicate the related layers (in the OSI model) of physical addresses, logical addresses, and port addresses. Also indicate whether or not the addresses are changed from hop to hop when a data message is transmitted from a source to its destination through multiple-hop communications. (**3 points**)

	Related layer(s) in OSI model	Changed from hop to hop? (Yes/No)
Physical addresses		
Logical addresses		
Port addresses		

2. Error Detection and Correction (**17 points**)

   (1) If you are given a block code, how can you tell whether or not it belongs to the class of cyclic codes? (**4 points**)

   (2) For the following data bits organized in two rows and three columns, please add two-dimensional parity-check bits, and give the corresponding codeword. Over the transmission medium, the second bit in the second row is changed from bit '0' to bit '1'. Please describe how the receiver will process the received codeword. (**3 points**)

$$\begin{matrix} 0 & 1 & 1 \\ 1 & 0 & 1 \end{matrix}$$

Question 2 (Continued)

(3) Consider the encoder and decoder for a Hamming code. Denote the 4-bit dataword at the sender as $a_3a_2a_1a_0$, and the 7-bit codeword at the sender as $a_3a_2a_1a_0r_2r_1r_0$. The three parity check bits are given as follows:

$r_2 = \quad a_2 + a_1 + a_0$ modulo-2 (so r_2 is parity check for a_2, a_1, and a_0)

$r_1 = a_3 \quad + a_1 + a_0$ modulo-2 (so r_1 is parity check for a_3, a_1, and a_0)

$r_0 = a_3 + a_2 + a_1$ modulo-2 (so r_0 is parity check for a_3, a_2, and a_1)

The received codeword at the receiver is denoted as $b_3b_2b_1b_0q_2q_1q_0$.

(a) How does the receiver calculate the three syndrome bits? (**2 points**)

$S_2 =$

$S_1 =$

$S_0 =$

(b) The receiver assumes there is at most one bit error in the received codeword. The three-bit syndrome creates eight different bit patterns ("000" to "111"). For each bit pattern, please indicate which bit (among the seven bits in the received codeword) the receiver considers corrupted. (**4 points**)

Syndrome $S_2S_1S_0$	000	001	010	011	100	101	110	111
Corrupted bit								

Question 2 (Continued)

(4) Consider the encoder for a Cyclic Redundancy Check (CRC) code. The divisor at the sender and receiver is $d_3d_2d_1d_0$=1011. Please give the codeword for dataword '1101'. Show your steps. (**4 points**)

3. Data Link Control (**12 points**)

(1) Recall that in High-level Data Link Control (HDLC) Protocol, we have Information-frame (I-frame), supervisory-frame (S-frame), and unnumbered-frame (U-frame). Please give an example when an S-frame should be used. (**3 points**)

(2) In Selective repeat ARQ, when an out-of-order frame is received, the receiver will NOT send an NAK for frame Rn (the next frame to be expected) if an NAK was sent for frame Rn before. Please explain the reason. (**3 points**)

Question 3 (Continued)

(3) The timer of a system using the selective repeat ARQ protocol has a time-out value of 3 ms. The round trip propagation delay is 4 ms. We ignore other delay (and therefore, the transmission time of any frame can be infinitely small). Draw a flow diagram for delivery of two data frames. We assume that from the upper layer, the request for the first and the second data frame arrive at time instant 0 ms and 1 ms, respectively. The first transmission attempt of the first data frame is corrupted. All other transmissions are successful. The number of bits in a sequence number is $m=2$. (**6 points**)

4. Multiple access and Ethernet (**16 points**)

   (1) In a pure ALOHA network, all transmissions have the same duration. Consider a target transmission that starts at moment t_1 and ends at moment t_2. Please indicate when the vulnerable time of the target transmission starts and when the vulnerable time ends. **Please repeat this question for a slotted ALOHA network.** (**6 points**)

   (2) A pure ALOHA network transmits 400-bit frames on a shared channel of 200 kbps (note that 1 kbps = 10^3 bits per second). What is the throughput (**in unit of frames per second**) if the system (all stations together) produces 1000 frames per second? Recall that the throughput for pure ALOHA is $S = G \times e^{-2G}$, in which G is average number of frames generated by the system during one frame transmission time, and S is average number of successful frames during one frame transmission time. (**4 points**)

Question 4 (Continued)

(3) Consider a standard Ethernet which implements carrier sense multiple access with collision detection (CSMA/CD). The standard Ethernet has only three stations in a line: the distance between Station A and Station B and between Station B and Station C are both 600 meters. The propagation speed is the speed of light (300,000,000 meters/second). The data rate is 10 Mbps. At time instant t_1=0 microsecond, Station B has a frame to send. So Station B senses the medium and finds that the medium is idle. Thus, Station B transits its frame. For this transmission, what is the duration of the vulnerable time? (**2 points**)

(4) Recall that a bridge can enhance the performance of the standard Ethernet. Please describe how a bridge works. (**4 points**)

The end

	S_n	Sequence #	Send Window Size	Receive Window size	Timer	ACK policy	Duplicate frames at receiver	Out-of-order frames at receiver
Stop-and-Wait ARQ	After a frame (say 0) is transmitted, S_n keeps 0 until ACK is back (which changes S_n to 1)	1 bit	1	1	Set up upon each data frame transmission or retransmission. Stopped upon ACK. Resend the outstanding frame upon a timeout.	ACK is issued when a frame (either expected or duplicate) is successfully received. If the expected frame (R_n) arrives, slide the receive window by one frame.	Discarded. But an ACK is issued.	No out-of-order frames
Go-back-N ARQ	The next frame to send (not sent yet)	m bits	2^m -1	1	When a frame is sent/re-sent, if timer is not running, then set up the timer. Timer is stopped when an ACK is received and there is no outstanding frame. (only one timer). Resend all outstanding frames upon a timeout.	ACK is issued only when the "expected" frame (R_n) arrives. Then slide the receive window by one frame.	Discarded. No ACK is issued.	Discarded. No ACK is issued.
Selective Repeat ARQ	The next frame to send (not sent yet)	m bits	2^{m-1}	2^{m-1}	Set up a timer upon each data frame transmission or retransmission, and stop a timer when the sender knows (by ACK reception) the corresponding data frame has been received. Resend the corresponding frame upon a timeout.	ACK is issued when frame R_n arrives. Then those consecutive received frames (starting from R_n) are delivered to the upper layer. Slide the receive window by one or more frames.	(here a duplicate frame is a frame that is NOT inside the receive window) Discarded. No ACK is issued.	(here an out-of-order frame is a frame that is inside the receive window but NOT R_n) Accepted. An NAK is issued for frame R_n if no NAK was sent for frame R_n before. Upon reception of the NAK, the sender resends frame R_n, and restarts the corresponding timer.