UNIVERSITY OF ALBERTA

DEPT. OF ELECTRICAL AND COMPUTER ENGINEERING

ECE 487 B1 – Data Communications Networks

Midterm Examination

Instructor: Hai Jiang
Exam date: Friday Feb. 27, 2015
Exam duration: 50 minutes (1:00pm – 1:50pm)

Instructions:

1. Verify that this booklet contains 7 pages.
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.	30	
2.	10	
3.	10	
4.	10	
Total	**60**	

GOOD LUCK!!!

1. (1) For Open Systems Interconnection (OSI) model, in which layer is a trailer added? Which layer processes port addresses? Which layer processes physical addresses? Which layer processes logic addresses? Among the port addresses, physical addresses, and logic addresses, what addresses change from hop to hop? (**5 points**)

   In Layer 2 (data link layer), a trailer is added.

   Layer 4 (transport layer) processes port addresses.

   Layer 2 (data link layer) processes physical addresses.

   Layer 3 (network layer) processes logic addresses.

   Only physical addressed change from hop to hop

   (2) Please make a comparison of circuit and packet switching in the following table. You only need to answer "Yes" or "No" in each field (except for the last row). For the last row, please briefly describe when congestion happens. (**5 points**)

	Circuit Switching	Packet Switching
Store and Forward?	N	Y
Reservation?	Y	N
Call setup?	Y	N
Possible to have out-of-order packets at the destination?	N	Y
When does congestion happen?	Call setup	possible for each packet

   (3) We need to connect eight stations. How many links are needed in a mesh topology? How many links are needed in a star topology? How many drop lines are needed in a bus topology? How many links are needed in a ring topology (without counting the links that connect stations to repeaters)? Here a link means a wired connection that connects two points. (**4 points**)

   28; 8; 8; 8.

   (4) In High-level Data Link Control (HDLC) protocol, please describe what piggybacking is. And what is the major benefit of piggybacking? (**2 points**)

   Piggybacking is to combine data and ACK in a single I-frame.

   The benefit: reduce the total number of frames transmitted. Improve efficiency.

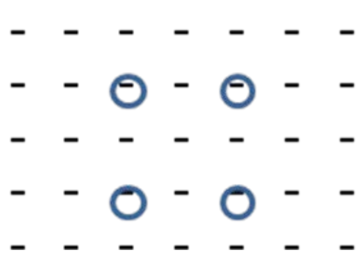
(5) A pure ALOHA network transmits 200-bit frames on a shared channel of 200 kbps (kilobits per second). How long is the vulnerable time? What is the throughput (in unit of frames per second) if the system (all stations together) produces 1000 frames per second? Recall that the throughput for pure ALOHA 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**)
Frame transmission time is 200 bits/200kbps = 1ms. So vulnerable time is 2ms.
G=1. $S= G \times e^{-2G} = 0.135$. So the throughput is 135 frames per second.

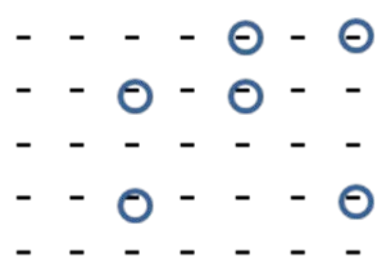
(6) For a block code to detect up to *k* bit errors (*k* is an integer), what should the minimum Hamming distance be? For a block code to correct up to *k* bit errors, what should the minimum Hamming distance be? (**2 points**)

To detect up to *k* bit errors, the minimum Hamming distance is k+1.
To correct up to *k* bit errors, the minimum Hamming distance is 2k+1.
(7) When can we call a block code as “linear block code”? When can we call a block code as “cyclic code”? (**2 points**)

Linear block code: exclusive OR of two valid codewords creates another valid codeword.
Cyclic code is a linear block code in which if a valid codeword is cyclically shifted (rotated), the result is another valid codeword.

(8) Please give an example for the case that a two-dimensional parity-check code cannot detect four bit errors; also give an example for the case that a two-dimensional parity-check code cannot detect six bit errors. (**4 points**)





(9) What is "bit stuffing" in framing in Layer 2 of OSI model? (**2 points**)

Adding one extra 0 whenever we have five consecutive 1s in the data, to avoid the bit pattern of the flag `01111110'.

2. 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:

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

$r_1 = a_3 + a_1 + a_0$ 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? (**3 points**)

$S_2 = b_2 + b_1 + b_0 + q_2$ modulo-2

$S_1 = b_3 + b_1 + b_0 + q_1$ modulo-2

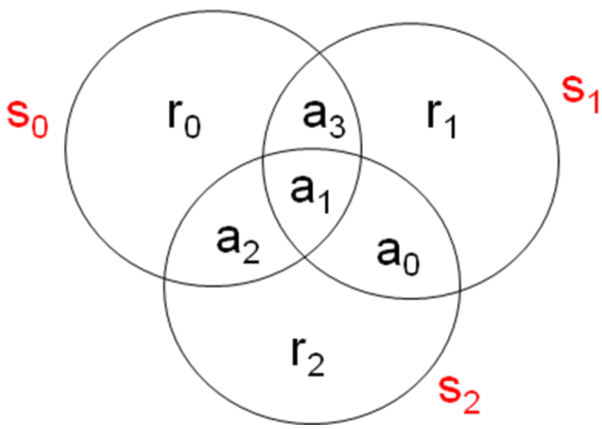
$S_0 = b_3 + b_2 + b_1 + q_0$ modulo-2

(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. (**7 points**)

(c)

Syndrome $S_2S_1S_0$	000	001	010	011	100	101	110	111
corrupted bit	none	q_0	q_1	b_3	q_2	b_2	b_0	b_1

(d)



(e)

3. Consider the encoder and decoder for a Cyclic Redundancy Check (CRC) 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 received codeword at the receiver is denoted as $b_3b_2b_1b_0q_2q_1q_0$. The divisor at the sender and receiver is $d_3d_2d_1d_0$=1011.

(a) Please give the codeword for dataword ‘1001’. Show your steps. (**4 points**)

(b) We know that codeword ‘1110100’ is a valid codeword. Assume that the codeword is sent from the sender side. Also assume that the channel from the sender to the receiver may have a burst error. Give example of a burst error that cannot be detected at the receiver side. Show your steps. (**6 points**)

(a)

```
         1 0 1 0
       ______________
1 0 1 1 / 1 0 0 1 0 0 0
          1 0 1 1
          -------
            0 1 0 0
            0 0 0 0
            -------
              1 0 0 0
              1 0 1 1
              -------
                0 1 1 0
                0 0 0 0
                -------
                  1 1 0
```

Codeword is 1001110

(b) If a burst error changes ‘1110100’ to any other valid codeword, then the burst error cannot be undetected. You can use any dataword different from ‘1110’ to generate the valid codeword, and determine the burst error accordingly. A simple way is to use the valid codeword you just derived in (a).

4. (a) Consider that a communication system uses Stop-and-Wait automatic repeat request (ARQ) protocol. The distance between the sender and receiver is 3,000,000 meters, and the signal propagation speed is 3×10^8 meters per second. The size of a data frame is 1000 bits. The size of an ACK frame is 100 bits. The transmission rate of the channel is 10 Mbps (megabits per second). We only consider signal propagation time and transmission time. All other processing time is ignored. The timeout value of a timer is 1 second. At the sender side, there are an infinite number of packets in Layer 3 to be sent. Assume all transmissions are successful. What is the system throughput? Here throughput means on average how many bits of information per second can be delivered successfully from the sender to the receiver. (**5 points**)
(b) Consider that a communication system uses Selective Repeat ARQ protocol. The signal propagation time from the sender to the receiver and from the receiver to the sender are both 10 milliseconds. We only consider signal propagation time. All other processing time is ignored. The timeout value of a timer is 1 second. The number of bits in a sequence number is *m*=3. At the sender side, Layer 3 has four requests at four moments: *t*=0 millisecond, *t*=1 millisecond, *t*=2 millisecond, and *t*=3 millisecond, respectively. The four requests are corresponding to 4 frames. The first transmission attempt of the second frame is corrupted. All other transmissions and retransmissions are successful. Please use a flow diagram to show what happens upon each event at the sender and receiver. In the flow diagram, you should show the frame transmissions between the sender and the receiver, the send window, the receive window, S_f, S_n, R_n, and when a timer is started/restarted/stopped. (**5 points**)

(a) one-way propagation time: (3×10^6 meters)/(3×10^8 meters/second) = 0.01 second.

Data frame transmission time: (1000 bits)/(10×10^6 bits/second) = 0.0001 second.

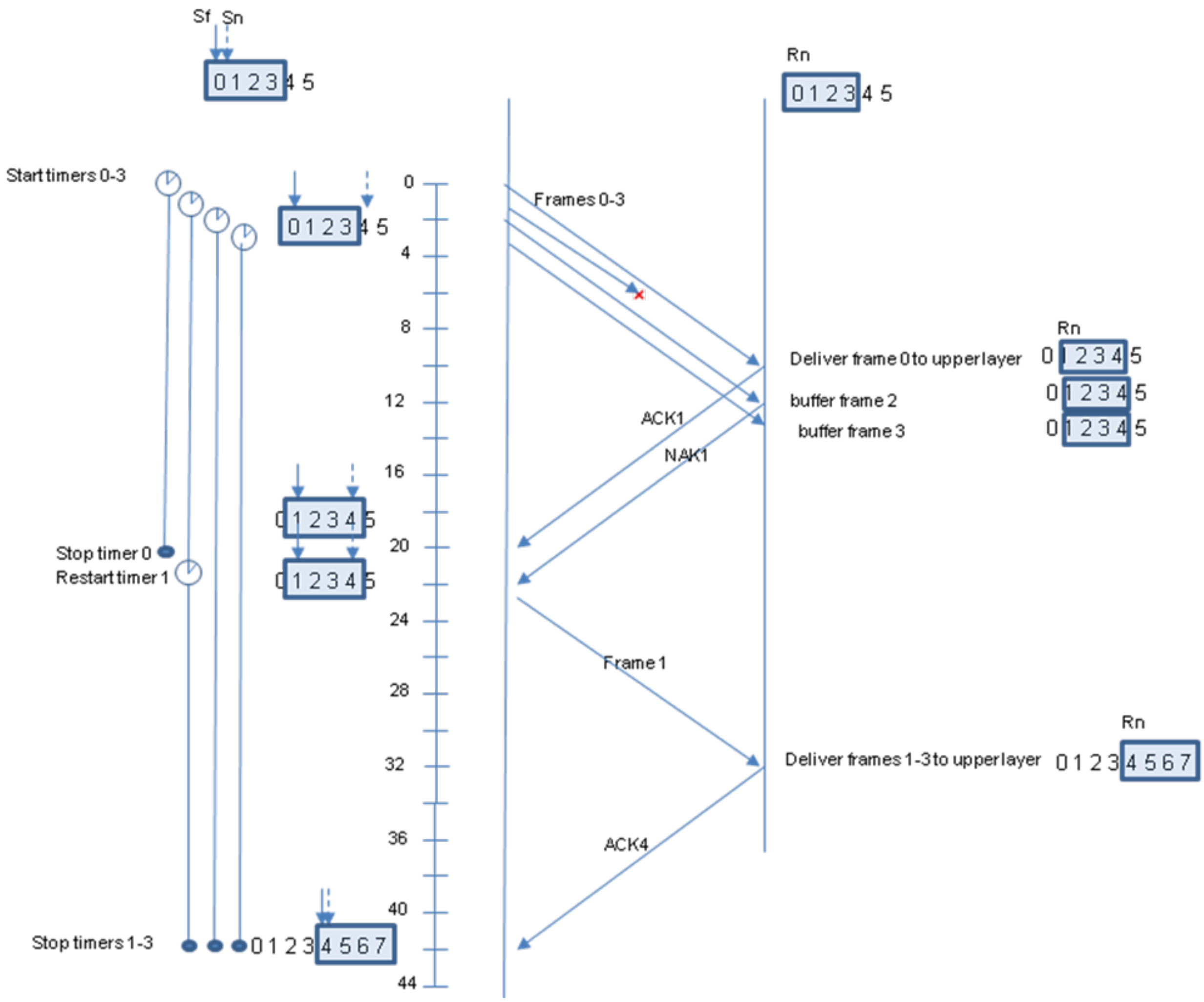
ACK frame transmission time: (100 bits)/(10×10^6 bits/second) = 0.00001 second.

So the system throughput is:

$$(1000 \text{ bits})/(2\times0.01+0.0001+0.00001)\text{second} = 49.7 \text{ kbps}.$$

 Name ______________________________ ID ___________

Question 4 (Continued)



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