Data Communications Midterm 2023

Oct. 24th, 13:30-14:30

Student ID _____ Name _____

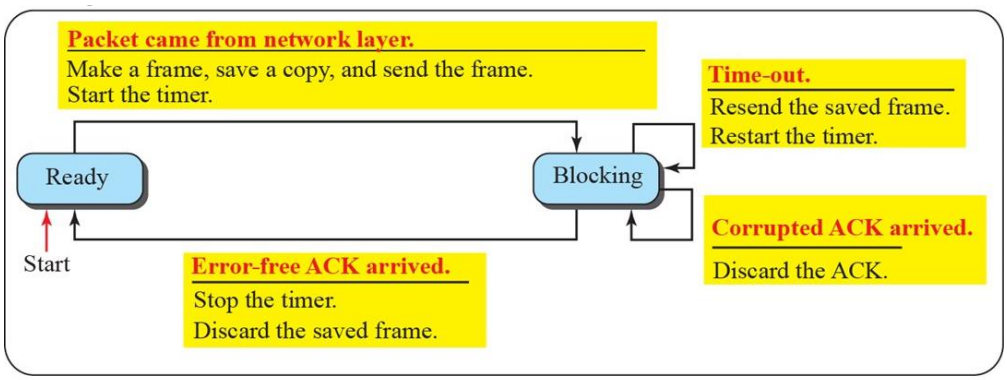
- ☞ **You can answer either in English or in 한글.**
- ☞ **Specify correct units (e.g. bps, Hz, bits, baud, dB) for full credits**
- ☞ **Use of <electronic devices, cheat sheets, open books> will be considered cheating**

1. In a bit-oriented protocol, a frame is enclosed between two Flag fields. Each flag has the bit pattern 01111110.
   A. In case the original data is 01111101111110111110111, what will the receiver see when the bit-stuffed frame arrives at it? _____ **(2pts)**
   B. If the bitrate of the original data is 10 Mbps, what is the resulting data rate due to bit stuffing in the worst case? _____ **(2pts)**

2. We want to use 4-bit checksum. The data that we want to send is 7, 11, 12, 0, 6, 6, in decimal notation.
   A. What is the checksum value computed by the sender? [in decimal notation] _____ **(3pts)**
   B. What would you get if you add the data and the checksum? [in decimal] _____ **(2pts)**
   C. Would the checksum be the same for 6, 11, 7, 0, 12, 6? (Y/N) ____ **(1pt)**

3. A communication channel has 10 MHz for bandwidth. The transmitted signal power was 19 dBm, and the signal power was attenuated to half the original value. If the noise power at the receiver is 1 dBm,
   A. What is the SNR in dB scale? _____ **(2pts)**
   B. What is the Shannon limit in this situation? _____ **(2pts)**
   C. If an engineer aims at 80% of the Shannon lmit for practical reasons, what is the number of signal levels that she should use? _____**(2pts)**
   D. Can the engineer use AMI? (Y/N) _____ **(1pt)** Why (Why not)? _____ **(2pts)**

4. The following FSM depicts the sender in the in the Stop-and-Wait protocol that uses positive ACK. Suppose you want to modify it to use the sequence number in the frames so that sequence number in the ACK frame (≡ SQN_{ack}) is one larger than the sequence number of the correctly received data frame (≡ SQN_{data}).
   A. In addition to saving a copy of the transmitted frame, what value should be stored by the sender? _____ **(2pts)**
   B. To transition from "Blocking" to "Ready," what additional check should be performed in relation to the answer of (A)? _____ **(2pts)**



5. We want to send a data string 0011 by using Bluetooth.

   A. Blutooth uses $g(x) = x^8+x^7+x^5+x^2+x+1$ as generator. What is the CRC? [Hint: an 8-bit string] **(5pts)** _____

   B. $g(x)$ can always detect odd-numbered errors in the data. This is because it has $x+1$ as a factor. Namely, $g(x) = (x+1)f(x)$. Here, $f(x) =$ _____ **(3pts)**

   C. When transmitted, the CRC in (A) is attached at the end of the data to form a 12-bit string. Use the 4B/5B mapping codes in the following table to obtain the block coder output for the given data string followed by the CRC-4 obtained in (A). _____ **(2pts)**

Data Sequence	*Encoded Sequence*
0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
0111	01111

1000	10010
1001	10011
1010	10110
1011	10111
1100	11010
1101	11011
1110	11100
1111	11101

   D. If the line coder is MLT-3 (assume that the last signal level was negative), depict the signal movement for the answer in (C) by drawing the thick lines along the signal edges (horizontal and vertical). **(3pts)**



   E. After line decoding and block decoding, the receiver recovers the data and the CRC. If the first bit in the data is flipped to 1 so that the data part becomes 1011 instead of 0011, what will be the syndrome computed at the receiver? **(4pts)** _____

   F. Can we also use the above table as a linear block code? (Y/N) _____**(1pt)** Why/why not? _____ **(2pts)**

Use this space for your calculations
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6. Starting from the codeword 1001, you want to make a "cyclic" code book.

   A. How many codeword do you have in the complete codebook? _____ **(4pts)**
   B. What is the minimum hamming distance of the code? _____ **(2pts)**
   C. Based on (B), up to how many error bits can you detect in a codeword with a guarantee? _____**(1pt)**

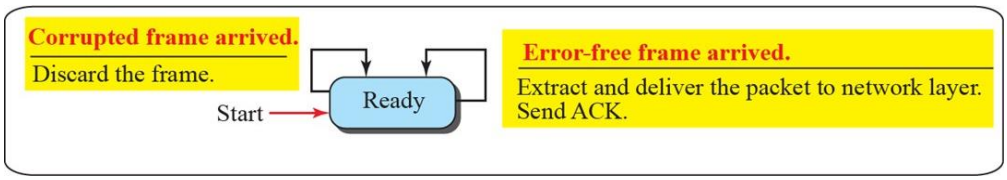
7. What are the three functionalities that datalink layer has to perform except medium access control? _____**(1pt)**, _____**(1pt)**, _____**(1pt)**

8. Compact Disc uses 44.1 KHz sampling rate, and each sample is quantized to one of 65,536 levels.
   A. What is the maximum human hearing frequency? _____ **(1pt)**
   B. Justify the CD sampling rate based on the answer of (A). _____ **(2pts)**
   C. What is the number of bits we should use to encode a quantized value? _____ **(1pts)**

9. In QPSK, the in-phase component is $3\pi/2$ (radian) and the quadrature component is π (radian). What is the phase of the final transmitted signal? _____ **(2pts)**

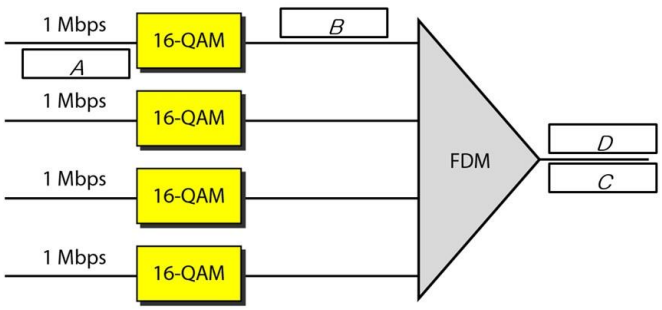
10. What are three numbers associated with a simple sine wave? _____ **(1pt)**, _____ **(1pt)**, _____ **(1pt)** [Hint: they are used for modulation].

11. The following FSM depicts the operation of the receiver in the Stop-and-Wait protocol that uses positive ACK. Suppose you want to modify it to use NACK instead of positive ACK.
   A. What additional action should the "Ready" state perform upon "Corrupted frame arrived" event? Briefly explain. _____**(2pts)**
   B. What action(s) upon "Error-free frame arrived" event should be removed? _____ **(2pts)**



12. If each bit in the frame is randomly corrupted while transit with a uniform probability p, the probability that the received frame is errorless is $(1-p)^n$.
   A. What is the probability that an n-bit frame contains at least one corrupt bit? _____ **(1pt)**
   B. If p is very small, we can approximate $(1-p)^n \approx 1-np$. If $p = 10^{-3}$, what is the maximum frame size that we can use if we want to limit the average packet corruption probability to 10%? _____ [bits] **(3pts)**
   C. What is the maximum frame size to maintain the target frame corruption probabilty of 10% if $p = 2 \times 10^{-3}$? _____ [bits] **(1pts)**

13. In the following figure, "*A*" and "*C*" are information types (i.e., digital or analog) and "*B*" and "*D*" are bandwidths. Fill the blanks: A = _____**(1pt)** B = _____ **(2pts)** C = _____ **(1pt)** D = _____ **(2pts)** You must use correct units for B and D to get full credits.



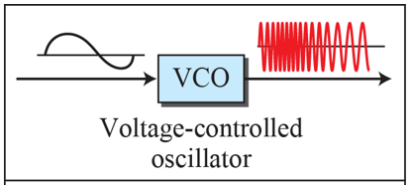
14. Suppose 8B6T produced signals ++0-0- and -00-+0, respectively, for first and the second 8-bit units. For the next 8-bit unit, the original line coding is +--0-+. How should the last 6-element signal be changed to, to keep DC balance? _____ **(2pts)**

15. Four channels are multiplexed through TDM.If each channel sends 100 bytes/s and we multiplex 1 byte per channel,
    A. What is the frame rate? _____ **(1pt)**
    B. What is the frame size? _____ **(1pt)**
    C. What is the bit rate on the multiplexed line? _____ **(1pt)**

16. A communication medium provides the frequency band between 917 and 918 MHz. The SNR on this band is 3 (not 3 dB).
    A. Can you use Manchester encoding to put the data onto this band? (Y/N) ____ **(1pt)** Why (or why not)? Answer in less than four words. _____ [Hint: property of the given band] **(2pts)**
    B. In case we aim at 80% of the Shannon capacity on the channel, what would be the symbol rate if we employ 16QAM? _____ **(3pts)**

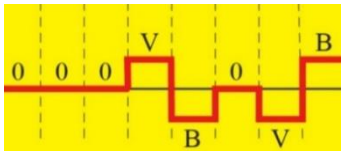
17. For the following statements, answer true (T) or false (F). **(0.5pts each, 12 pts total)**
    A. ASK is more efficient than FSK in terms of bandwidth use for the given bit rate. _____
    B. AM is used in some type of coaster pager (a.k.a. guest buzzer or "진동벨") _____
    C. FDM and WDM are used for multiplexing analog input signals but TDM is for digital signals. _____
    D. Nyquist sampling theorem requires sampling at twice the highest frequency of a given signal as a necessary condition for full reconstruction of the signal. ____
    E. dB_m is not equivalent to dB. ____
    F. If a signal power becomes one half of the original, the attenuation is 2 dB. _____
    G. Our general goal in communication is to increase the data rate while decreasing the signal rate. _____
    H. DC components are especially problematic in low-pass channels. _____
    I. QAM is used for lower speed transmission, and QPSK is used for higher speed transmission. ____
    J. If SNR is 0 (not 0 dB), communication is not possible. ____
    K. AMI is immune to DC component problem. _____
    L. Apple Pay and Samsung Pay uses FSK as an underlying technology. _____

18. Answer the questions about the following figure.
    A. What is being performed here? Answer in less than three words. _____**(1pt)**



    B. What is the standard bandwidth of the answer of problem (A), when used in radio broadcasting? _____**(2pts)**

19. For the depicted scrambling scheme that encodes bits 100000000 (but only showing the last 8 bits portion in the figure), answer the questions below.



    A. What was the previous signal level (among +, -, 0)? _____ **(1pt)**
    B. This technique complements AMI. What problematic aspect of AMI does the above figure cope with? Answer in one word. _____ **(1pt)**
    C. Compared with block coding, what is the advantage of using scrambling instead? _____ **(1pt)**

1.
   A. 01111100111110101111101011 1
   B. 7/6*10Mbps
2.
   A. 3
   B. 15
   C. Y
3.
   A. 15 dBm
   B. 50 Mbps
   C. 4
   D. Y, 4 levels > 3 levels required by AMI
4.
   A. Sequence number
   B. SQN_ack == SQN_data +1 ?
5.
   A. 01001110
   B. $x^7 + x^4 + x^3 + x^2 + 1$
   C. 10101 01010 11100
   D. 00++0 0—00 +0---
   E. 11101010
   F. N, not closed under XOR (or does not have 0)
6.
   A. 8
   B. 2
   C. 1
7.
   A. Framing
   B. Error control
   C. Flow control
8.
   A. 22,000 Hz
   B. 2 * Maximum human hearing frequency = 2*22KHz ~ 44.1 KHz
   C. 16
9. 5/4 pi
10.
   A. Amplitude
   B. Frequency
   C. Phase
11.
   A. Send NACK
   B. Send ACK
12.
   A. 1-(1-p)^n
   B. 100 bits
   C. 50 bits
13.
   A. Digital
   B. 250 kHz
   C. Analog
   D. 1 MHz
14. -++0+-
15.
   A. 100 frames/s
   B. 4 bytes
   C. 3200 bps
16.
   A. N, band-limited channel
   B. 400 Kbaud
17.
   A. T
   B. F
   C. T

D. T
E. T
F. F
G. T
H. T
I. F
J. T
K. T
L. F

18.
A. FM
B. 200 kHz

19.
A. +
B. Synchronization
C. Doesn’t increase bit rate