Menoufia University. Faculty of Electronic Engineering. Dept. of Electronics and Electrical Communications. Fourth Year No. of pages: 3	جامعة المنوفية	Information Theory and Coding Final Exam 2019-2020 Time allowed: 3 Hr. Exam Date: 30-12-2019 Dr. Walid El-Shafai

Read the following questions carefully and answer as you much as you can.

Question (1) (9 degree) (4.5 degree/each question)

(a) Mention the discrete channel type of the following cases:

1- H(x, y)=H(x)

2- H(x, y)=H(x)=H(y)

3- H(x, y)=H(x)+H(y)

4- H(x/y)=H(x)

5- I(x,y)=H(x)=H(y)

6- H(x, y)<H(x)+H(y)

7- H(x/y)<H(x)

8- H(x, y)>H(x)+H(y)

9- H(x, y)>H(x)

(b) Compare between the following two discrete channels:

* The first channel has the input message such as "11111111111111100000" while the received message was "11111111000011100011".

* The second channel has the following matrix with the source probabilities of [0.17, 0.18, …., 0.25]:

$$\begin{bmatrix} 0.04 & ..... & 0.06 \\ ..... & 0.03 & 0.09 \\ 0.14 & 0.12 & .... \\ ..... & 0.08 & 0.13 \end{bmatrix}$$

Also, find the transition matrix and joint matrix of the opposite type of both two channels.

Question (2) (6 degree) (3 degree/each question)

(a) Discuss the variation of the mutual information on the channel with the error caused by the noise on the channel. Also, discuss the variation of the mutual information between two variables with the sum of their information values.

(b) Assuming a binary DMS Y with two symbols y_1 and y_2. Prove in more details that the average entropy has its maximum value when both y_1 and y_2 have equal probabilities, show your answer with drawing.

Question (3) (7 degree) (1 degree/each question)

- For the channel described by the following matrix:

$$\begin{bmatrix} 0.33 & .... & 0.4 \\ .... & 0.345 & 0.36 \\ 0.42 & 0.35 & .... \end{bmatrix}$$

Find:

1. The channel efficiency when its input probabilities [p(x)]=[0.3, 0.44, 0.26].

2. The joint matrix of its opposite channel type.
3. The correct information of this channel when its i/p and its o/p are independent.
4. The average lost information on transmitting only 10 symbol message length.
5. The capacity of this channel and the capacity of the channel of the opposite type, comment on your result.
6. The average lost information on receiving a message with 15 symbols.
7. The transition matrix of the opposite type.

Question (4) (16 degree) (1 degree/each question)

- **Try to complete all of the following sentences:**

1- For a lossless channel with ***n*** input symbols, the channel capacity is given by .....
2- For 4B3T code, the efficiency is ..... For 1B1T code, the redundancy is .....
3- For (7, 4) hamming code, if the message information bits are given by 1001. The encoded transmitted data is .....
4- For 3B4B code, the number of input and output words are ..... and ....., respectively. By similarity, for 5B6B code, the number of input and output bits are ..... and ....., respectively.
5- The value of hamming distance between the two transmitted words of 1101100 and 1100011 is ....., but their hamming weights are ..... and ....., respectively.
6- For the binary data 1110010001001101, the DMI encoded data is ..... But its CMI encoded data is .....
7- For (7, 4) hamming code, if the value of minimum hamming distance equals three, the number of the errors that can be corrected is ....., and consequently the number of errors that can be detected is .....
8- For the binary data 101000001100000011, the B6ZS encoded data is .....
9- For the received data given by (- - + + + + - - - - + - + - - + + - + + - - + - + - + +). By using 3B4B code, the decoded data is .....
10- For (7, 4) systematic hamming code, if the estimated syndrome at the decoder is given by a value of $(5)_{10}$. So, the error will be in .....
11- For cyclic code, if the generator polynomial is given by X^4+X^2+1, the number of bits that will be required for the CRC is ..... For that generator polynomial in a typical message, the percentage of all errors will not be detected is .....but the percentage of all errors will be detected is .....
12- The DSV value of the code sequence (- + + + - - - + - - + +) is ....., and that value of the code sequence (- - - 0 + - 0 + + + - +) is .....
13- If a repeating sequence of 101101101..., is applied to a scrambler circuit that is designed with a polynomial of X^5+X^3+1. The number of patterns which must be applied to the scrambler before latching occurred equals .....
14- If a scrambler circuit is designed by a polynomial of X^3+X^2+1, the number of required stages is ....., and the non-latched period for that design is ....., and the lock-up is happened at the value of .....
15- For the binary data 10000010111100001, the HDB3 encoded data is .....
16- If a convolutional coder with rate ½, and constraint length equals three. So, the maximum errors that can be corrected are ....., because .....

Question (5) (10 degree) (5 degree/each question)

(a) Sketch a block diagram of the scrambler and its associated descrambler which is described by a polynomial of $(13)_{10}$. Construct a table that derive the output from that scrambler when the repeating input pattern is given by $1+X^2$, with assuming all registers with the zero states at the first operation.

(b) Using X^3+X+1 for the generator polynomial.

1. Find the CRC for the following data **011010110** (most significant bit first).
2. What should the maximum size of the complete message be if single bit error correction is to be possible?
3. If the obtained data resulted in **(2)** is arrived erroneously at the receiver as **110110110CRC**, where CRC is your obtained CRC in **(1)**. Show that if the received errors are detected or not? Comment and explain why do you get this answer?

Question (6) (12 degree) (6 degree/each question)

(a) A convolutional coder with rate ½, constraint length equals three, and with generator polynomials (g_1, g_2) of $(5)_{10}$ and $(7)_{10}$, respectively, has been used to encode the data 10011 (assume the first input bit is the left most bit).

1. What is the encoder output with assuming the coder starts with zero in all stages?
2. If two errors occurred in the 2^{nd} and 8^{th} bits of the transmitted data, explain in-detail how to decode the received data using Viterbi algorithm, and write the decoded data.
3. Without explaining, answer only with Yes or No, if there is a further error occurred in the 5^{th} bit in the received data given in (b), do the Viterbi algorithm can correct these errors. Justify your answer with reasoning.

(b) Decode the following received words which have been encoded by the (7, 4) Hamming code (assume that they are either error free or contain one error):

(1) 0011100 (2) 1110100 (3) 0010110

* Assume that the received words take the form $(C_1C_2K_1C_3K_2K_3K_4)$, where C refers to parity check bit and K refers to the data bit.

Question (7) (10 degree) (5 degree/each question)

(a) In a piece of text only, the following letters are used with the number of times each letter appears is given in brackets; A (25), B (32), C (12), D (4), E (54), F (18), G (10), H (77), I (34).

1. Determine the average number of bits required to be allocated to each letter.
2. Obtain the bit representation for each letter with using the Huffman code.
3. Calculate the source efficiency and the code efficiency. Compare between them.

(b) The code sequences below are from a code with a DSV of 3. Which must contain an error?

(1) 0 + - - 0 + - - 0 + - - (2) - - - 0 + - 0 + + + - + (3) - + + + - - - + - - + +

Best Regards ***Dr. Walid El-Shafai***