UNIVERSITÉ YORK UNIVERSITY

Department of Computer Science and Engineering

CSE 3213: Communication Networks (Fall 2009)

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Date: October 29, 2009

Midterm Examination

Instructions:

- Examination time: 75 min.
- Print your name and CS student number in the space provided below.
- This examination is closed book and closed notes. Calculator and one-sided cheat-sheet containing formulas only are allowed.
- There are 6 questions. The points for each question are given in square brackets, next to the question title. The overall maximum score is 100.
- Answer each question in the space provided. If you need to continue an answer onto the last page, clearly indicate that and label the continuation with the question number.

FIRST NAME: ______________________________

LAST NAME: ______________________________

STUDENT #: ______________________________

Question	Points
1	/ 30
2	/ 10
3	/ 12
4	/ 13
5	/ 15
6	/ 20
Total	/ 100

1. Multiple Choice [20 points] *time: 20 min*

Circle the letter beside the choice that is the best answer for each question. For each question choose only ONE answer.

(1.1) From the perspective of local area network (LAN) organization, the key advantages of bus (Ethernet) topology over ring topology are:

(a) equal access to the medium for all machines, i.e. fair sharing of capacity

(b) no packet collision

(c) fast / effective packet transmission under low traffic conditions, i.e. when there is only one machine sending at any given point in time

(d) none of the above

(1.2) Which of the following are considered to be advantage of circuit-switched over packet-switched networks?

(a) better line efficiency (i.e. capacity utilization)

(b) in-order packet delivery

(c) better network and/or connection survivability in case of individual switch/router failure

(d) smaller blocking probability (i.e. probability that a request for service gets rejected)

(1.3) Assume two web-browser applications on Computer A (applications A-1 and A-2) are communicating with the same web-server application on Computer B (application B-1). Which of the following must be true:

(a) A-1 and A-2 use the same port number, as they run on the same computer and exchange packets with the same server application

(b) all three applications (A-1, A-2, B-1) use the same port number

(c) the port numbers of A-1 and A-2 are different from each other, but one must be the same as the port number of B-2

(d) the port numbers of all three applications (A-1, A-2, B-1) are likely different from each other

(1.4) What is the phase shift (φ) of a sinewave with the maximum amplitude at time zero.

(a) $\varphi = 0$

(b) $\varphi = 45^\circ$

(c) $\varphi = 90^\circ$

(d) $\varphi = 180^\circ$

(1.5) A non-periodic digital signal will have ______________ number of amplitude values in the <u>time domain</u>.

(a) 0
(b) 3
(c) limited
(d) infinite

(1.6) A periodic digital signal will have ______________ frequency component(s) in the <u>frequency domain</u>.

(a) one
(b) limited number of discrete
(c) infinite number of discrete
(d) none of the above

(1.7) If the pulse rate of a digital signal is N [pulse/sec], then successful transmission of this signal over a noiseless channel (i.e. medium) will require that ______________ of the channel's bandwidth be allocated to the given signal.

(a) N [Hz]
(b) 2·N [Hz]
(c) N/2 [Hz]
(d) none of the above

(1.8) Assume a file is being transmitted between two computers over a single-hop link. The *propagation delay* component of the *overall delay* experienced during the transmission can be reduced by:

(a) compressing the file
(b) partitioning the file into packets
(c) increasing the transmission bit rate (i.e. reducing the duration of each bit)
(d) none of the above

(1.9) In Manchester and differential Manchester encoding, the transition at the middle of the bit is mainly used to ______________ .

(a) increase the signal's baud rate
(b) decrease the signal's baud rate
(c) decrease the noise levels
(d) none of the above

(1.10) In the case of NRZ-L coding, the signal's baud rate is generally expected to be ______________ the bit rate of the respective data sequence.

(a) equal to
(b) smaller than
(c) greater than
(d) (a) or (b)
(e) (a) or (c)

2. Potpourri [15 points]

2.1 [7 points] In a N-layer protocol hierarchy, a protocol data unit (PDU) in layer k (higher) is encapsulated in a PDU at layer k-1 (lower). Assuming the size of protocol header at each layer is M [bits], and the size of data in application layer is H [bits], what faction of bandwidth is used to send the data? And, what fraction is wasted on the transmission of headers?
(For simplicity, assume that an indefinite number of packets are generated at the application layer and sent back-to-back over the medium.)

The structure of the N-layer protocol hierarchy should look like the following:

Layer N PDU_N **:** **total bits = data = H**

Layer N-1 PDU_{N-1} **:** **total bits =** data +header **= H+M**

Layer N-2 PDU_{N-2} **:** **total bits =** PDU_{N-1} +header **= H+2M**

……

Layer 1 PDU_1 **:** **total bits =** PDU_2 +header **= H+(N-1)M**

So the size of frame being sent to the channel (which consumes bandwidth) is H+(N-1)M. Since the size of data is H, the fraction of bandwidth to send data is:

$\frac{H}{H+(N-1)M}$ **, while the fraction for the header is:** $\frac{(N-1)M}{H+(N-1)M}$

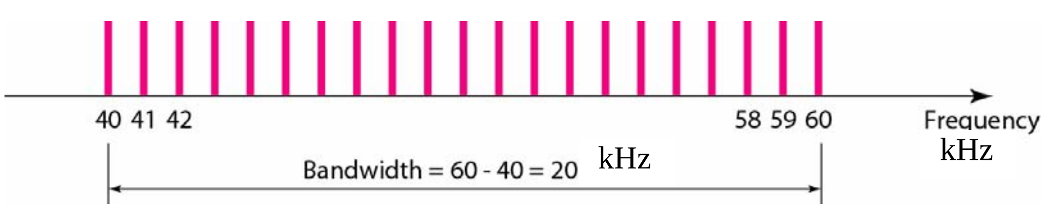
2.2 [8 points] A periodic signal (period T = 1 [msec]) has a bandwidth of 20 [kHz]. The highest frequency is 60 [kHz]. Sketch the spectrum of this signal, if all frequencies (i.e. sinewaves) contained in the signal are of the same amplitude.

The main harmonic of the given signal is: f = 1/T = 1 [kHz].

The higher harmonics are: k*f [kHz], where k= 1, 2, 3, …

Thus, based on the periodicity of the signal, its frequency characteristic is discrete, and comprises frequencies: 1, 2, 3, 4, … [kHz].

Given the other provided information, the actual shape/envelope of the signal's frequency characteristics turns out to be as follows:



3. Packet Transmission [15 points]

Suppose Alice (in Toronto) sends a 2000-bit frame to Bob (in Montreal) using a straight wire as shown in the figure below. The wire supports data rate of 100 [Mbps]. By the time the first bit of the frame arrives at Bob's computer, has the last bit of the frame left Alice's computer or not? The distance between Toronto and Montreal is 500 km.

Show your work to receive full credit.

Let us assume that the signal propagates at the speed of light through the wire. $3*10^8$ [m/sec].

The time required for <u>all but the last bit</u> to leave the computer (i.e. be placed on the wire) is:

Time_to_last_bit_transmission = 1999 [bits] / 100 000 [bps] = 0.19 [msec]

The time required for the first bit to arrive to Bob's computer is:

Propagation_time = $5*10^5$ [m] / $3*10^8$ [m/s] = 1.6 [msec]

Since Time_to_last_bit_transmission << Propagation_time, it means that the last bit DOES leave Alice's computer before the first bit arrives to Bob's computer.

4. Attenuation [15 points]

Assume the signal to noise ratio (SNR) at the input of an observed channel is 20 [dB]. We know that the signal attenuation of the channel is 10 [dB]. If the noise power at the output is twice as much as the noise power at the input, what is the signal to noise ratio in dB at the output?

Note: The channel does not attenuate the noise!

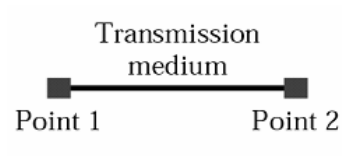


Figure ???

The basic idea behind this question is very simple: We are given $SNR_{in} = S_{in} / N_{in}$ (at the input). We are also given information about how much both S_{out} and N_{out} are with regard (i.e. when compared to) S_{in} and N_{in}. S_{out} is 10 dB smaller than S_{in}. N_{out} is 2 times larger than N_{in}. Accordingly, we can express the ratio $SNR_{out} = S_{out} / N_{out}$ as a function of respective S_{in} / N_{in}.

The ONLY challenging part of this question is to do proper conversion – either all parameters to non-dB or all parameters to dB values.

SNR_{in} [dB] = S_{in} [dB] – N_{in} [dB] = 20 [dB]

S_{out} [dB] = S_{in} [dB] – 10 [dB]

$N_{out} = 2*N_{in}$ => N_{out} [dB] = $10\log(2*N_{in})$ [dB] => **N_{out} [dB] = $10\log 2$ + N_{in} [dB] = N_{in} + 3 [dB]**

SNR_{out} [dB] = S_{out} [dB] – N_{out} [dB] =
= S_{in} [dB] – 10 [dB] – N_{in} [dB] – 3 [dB] =
= S_{in} [dB] – N_{in} [dB] – 13 [dB] =
= 7 [dB]

5. Channel Capacity [15 points]

5.1 [5 points] A communication channel has signal-to-noise ratio of 20 [dB]. If the bandwidth of this channel is 4 [kHz], what is the channel's maximum achievable data rate?

Based on the Shannon theorem: $R = C*\log_2(1 + SNR)$, **where** $SNR = 10^2 = 100$

Hence, $R = 4000*\log_2(1 + 100) = 4000 * 6.66 = 26.64$ **[kbps]**

5.2 [5 points] In order to achieve the above data rate in [bps], how many signal levels are needed?

Based on the Nyquist theorem: $R = 2*C \log(M)$, 26.64 **[kbps]** $= 8$ **[kHz]** $* \log_2(M)$

Hence, $M = 2^{3.33} \approx 10$

5.3 [5 points] If we are transmitting digital data at the rate 26.64 [kbps] by means of a digital signal that can assume 10 possible levels, what is the pulse rate of the resultant digital signal in [bauds]?

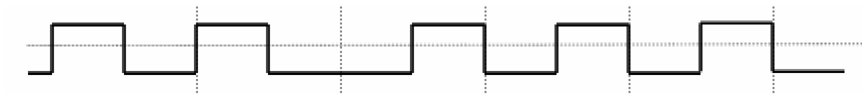
With 10 possible levels in the digital signal, we can transmit $\log(10) \approx 3.3$ bits per pulse. Hence, the pulse rate of the resultant signal is 3.3 times smaller than the rate at which digital data becomes available. That is:

Digital signal pulse rate = 26.64 / 3.3 = 8 [kbaud]

6. Line Coding [20 points]

6.1 The following figure shows a differential Manchester signal. What is the corresponding bit stream? [6 points]

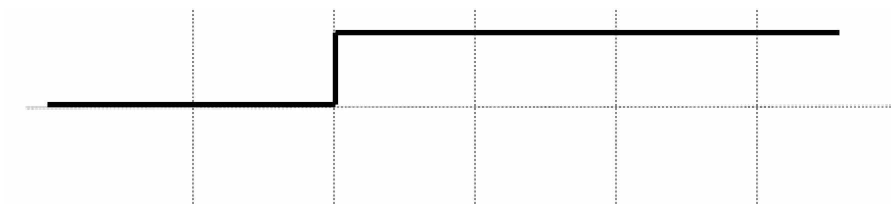
Differential Manchester signal:



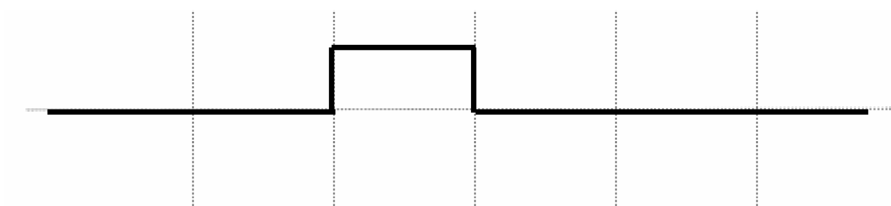
Corresponding bit stream ____**0**________**0**________**1**________**0**________**0**_______**0**

6.2 [8 points] For the bit stream identified in 6.1, draw the signals obtained by encoding the given stream using NRZ-I, Bipolar and Manchester coding?

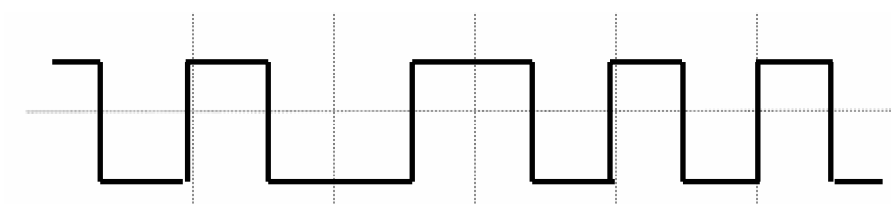
NRZ-I signal:



Bipolar signal:



Manchester signal:



6.3 [6 points] We need to send a stream of bits at the rate of 1 [Mbps] by means of 'digital signal' transmission. To accomplish this task, we have decided to encode the bits by employing block coding (4B/5B) followed by unipolar line coding.
In the worst case, how much of the channel/medium bandwidth is required for such transmission? Assume a noise free environment.

First, 4B/5B encoding increases the bit rate to 1.25 [Mbps].

In the worst case, the bit sequence (output) of 4B/5B coding would be an alternating sequence of 0-s and 1-s (01010101), resulting in the highest pulse rate of the resultant/final unipolar signal – 1.25 [M pulse / sec].

Based on the Nyquist theorem, successful transmission of 1.25 [M pulse / sec] requires B=1.25/2 [MHz] = 625 [kHz] bandwidth to be allocated to the given digital signal.