Department of Computer Science and Engineering

COSC 3213: Computer Networks I (Winter 2005)

Instructor: N. Vlajic
Date: February 23, 2005

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. Calculators 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	/ 15
4	/ 15
5	/ 10
6	/ 10
7	/ 10
Total	/ 100

1. Multiple Choice [30 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) The Internet model consists of _____ layers.

(a) three
(b) five
(c) seven
(d) eight

(1.2) As a data packet moves from the lower to the upper layers, headers are _____ .

(a) added
(b) subtracted
(c) rearranged
(d) modified

(1.3) When data are transmitted from device A to device B, the header from A's layer 4 is read by B's _____ layer.

(a) physical
(b) network
(c) transport
(d) application

(1.4) Which of the following can be determined from a frequency-domain graph of a signal?

(a) bandwidth
(b) phase
(c) power
(d) all of the above

(1.5) When one of the components of a signal has a frequency of zero, the average amplitude of the signal _____ .

(a) is greater than zero
(b) is less than zero
(c) is zero
(d) (a) or (b)

(1.6) What is the bandwidth of a signal that ranges from 40 KH to 4 MHz?

(a) 36 MHz
(b) 360 KHz
(c) 3.96 MHz
(d) 396 KHz

(1.7) A periodic signal can always be decomposed into _____ .

(a) exactly an odd number of sine waves
(b) a set of sine waves
(c) a set of sine waves, one of which must have a phase of 0^o
(d) non of the above

(1.8) A signal is measured at two different points. The power is P_1 at the first point and P_2 at the second point. The attenuation between the two points is 0 dB. This means _____ .

(a) P_2 is zero.
(b) P_2 equals P_1
(c) P_2 is larger than P_1
(d) P_2 is smaller than P_1

(1.9) _____ is a type of transmission impairment in which the signal loses strength due to the different propagation speeds of each frequency that makes up the signal

(a) attenuation
(b) distortion
(c) noise
(d) none of the above

(1.10) Which encoding type always has a nonzero average amplitude?

(a) unipolar
(b) polar
(c) bipolar
(d) all of the above

(1.11) The Nyquist (sampling) theorem specifies the minimum sampling rate to be _____ .

(a) equal to the lowest frequency of a signal
(b) equal to the highest frequency of a signal
(c) twice the bandwidth of a signal
(d) twice the highest frequency of a signal

(1.12) A modulated signal is formed by _____ .

(a) changing the modulating signal by the carrier wave
(b) changing the carrier wave by the modulating signal
(c) quantization of the source data
(d) sampling at the Nyquist frequency

(1.13) Which of the following is most affected by noise?

(a) PSK
(b) ASK
(c) FSK
(d) QAM

(1.14) Given an AM radio signal with a bandwidth of 10 KHz and the highest-frequency component at 705 KHz, what is the frequency of the carrier signal?

(a) 700 KHz
(b) 705 KHz
(c) 710 KHz
(d) cannot be determined from given information

(1.15) If the maximum value of a PCM signal is 31 and the minimum value is -31, how many bits were used for coding?

(a) 4
(b) 5
(c) 6
(d) 7

2. Circuit vs. Packet Switching [10 points]

time: 10 min

(a) [5 points] Which approach to switching, circuit or packet, can support more network users in theory? Explain your answer!

In theory, packet switching can support more network users. Circuit switching requires resources dedicated to each user, regardless of whether or not hey are actually using the network. Packet switching only uses resources when a user needs to use the network. Since the chances of all users needing the network at the same time are small, more users can be accommodated using packet switching.

(b) [5 points] Which approach to switching, circuit or packet, can be expected to provide better quality of service (QoS) to its users, under heavy congestion conditions? Explain your answer!

Under heavy congestion conditions, circuit switching will accommodate as many sessions as possible until the capacity of the network is reached. At this point no more circuit or sessions can be supported, and new attempts will be refused. Performance for existing sessions will be maintained.
In packet switching, heavy congestion will increase the amount of traffic in the network, resulting in increased delays and loss of packets. As congestion increases, overall performance decreases.

3. Amplitude Modulation **[15 points]**

time: 10 min

A 100 KHz carrier $cos(2\pi \cdot 100 \cdot 10^3 \cdot t)$ is amplitude-modulated by a signal s(t) given as:

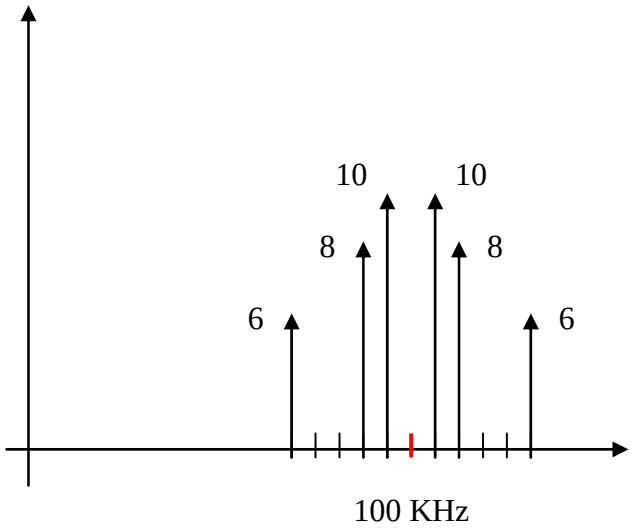
$$s(t) = 10 \cdot cos(2\pi \cdot 10^3 \cdot t) + 8 \cdot cos(4\pi \cdot 10^3 \cdot t) + 6 \cdot cos(10\pi \cdot 10^3 \cdot t)$$

- What frequencies are contained in the resultant modulated signal?
- Sketch the frequency spectrum of the resultant signal.

Carrier frequency: $f_c = 100$ KHz

Frequencies in modulating signal: $f_1 = 1$ KHz, $f_2 = 2$ KHz, $f_3 = 5$ KHz

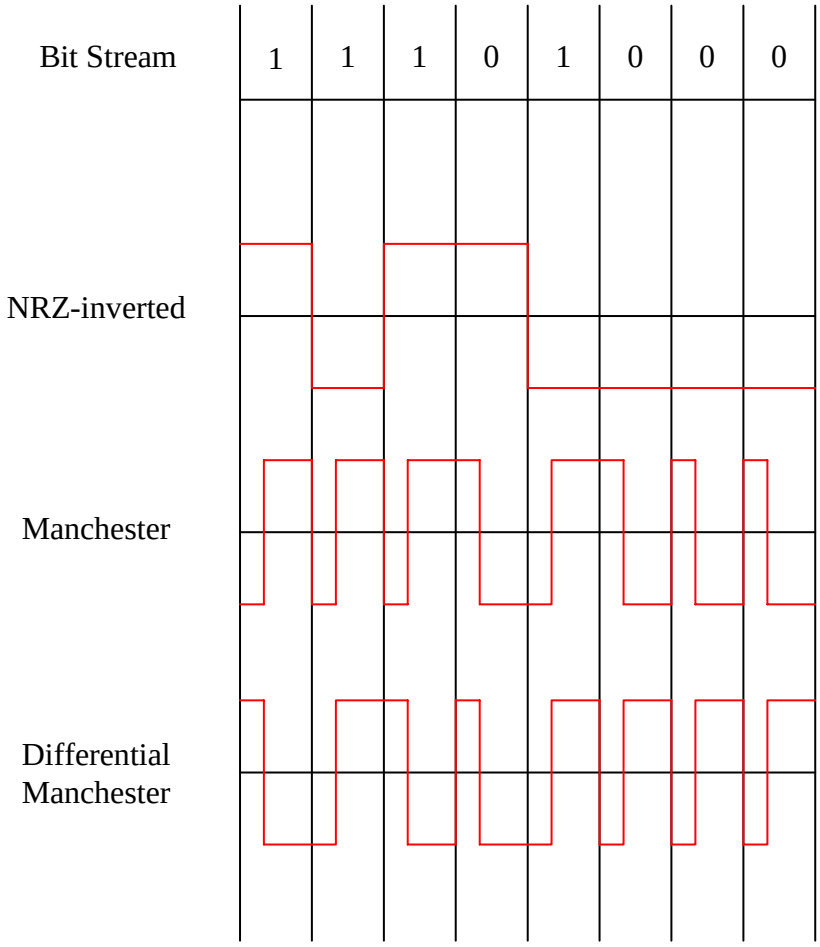
Frequencies in resultant modulated signal: $f_c \pm f_1$, $f_c \pm f_2$, $f_c \pm f_3$, or more precisely:
95, 98, 99, 101, 102, 105 [KHz]



4. Line Coding

[15 points]
time: 10 min

(a) [4 points] Encode the following bit stream.



(b) [4 points] What is the main advantage of Manchester over NRZ-inverted coding?

Manchester encoding provides perfect synchronization for any sequence of 0-s and 1-s.

(c) [3 points] What is the main advantage of NRZ-inverted over Manchester coding?

NRZ-inverted has lower pulse-rate, i.e. requires ½ of the bandwidth required by Manchester encoding.

(d) [4 points] Assume the following sequence: 10101010101010101. The sequence should be encoded using either Manchester or Differential Manchester scheme. Which of the two encoding techniques is more suitable for the given sequence? Justify your answer!

The given sequence encoded with Manchester scheme results in a signal that has ½ of the pulse rate compared to the signal that is obtained by encoding the same sequence using Differential Manchester scheme.

Hence, Manchester scheme is more appropriate in this case.

5. Channel Capacity **[10 points]**

time: 10 min

A link is to be operated at a bandwidth efficiency of B=9, i.e. at a rate of 9 bps for each Hz of bandwidth. Obtain the minimum SNR required at the receiver to allow, in theory, error-free transmission with this bandwidth efficiency. Express your answer in dB's.

Shannon formula for the ultimate capacity C of a communication link with W Hz bandwidth is $C=W\log_2(1+S/N)$ bps. Accordingly,

$$B = C/W = \log_2(1+S/N) = 9 \Rightarrow$$

$$2^9 = 1 + S/N \Rightarrow$$

$$S/N \approx 511 \Rightarrow$$

$$S/N = 10 \log 511 \text{ [dB]} \approx 27 \text{ [dB]}$$

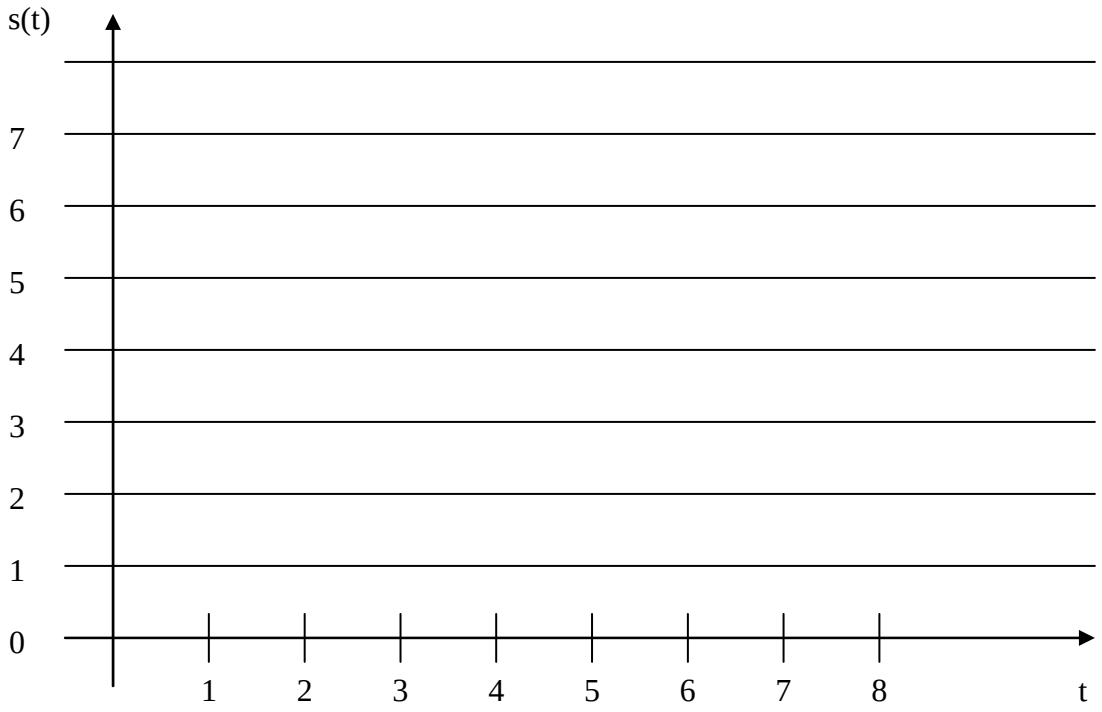
6. Analog-to-Digital Conversion [10 points]

time: 5 min

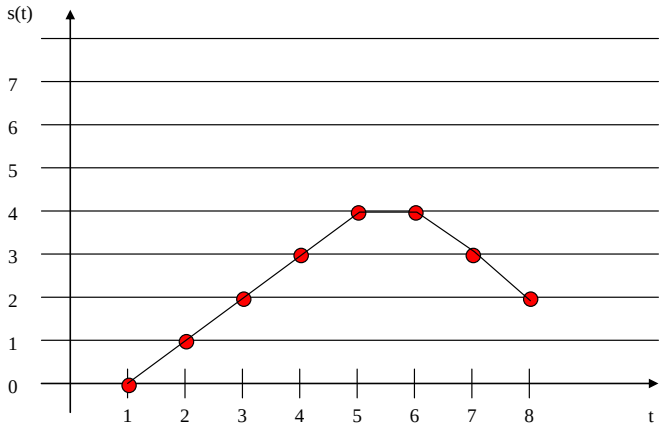
Assume a pulse code modulation (PCM) scheme that uses 3 bits to differentiate between 8 different levels of a PAM (i.e. analog) signal.
The following bit string, generated with the given PCM, has been received at time t=1:

000001010011100100011010

Sketch the analog signal that is represented by the string.



000 001 010 011 100 100 011 010

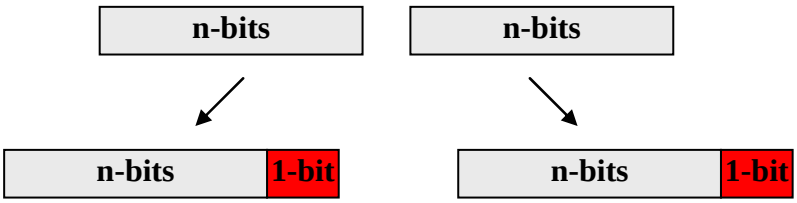


7. Error Control **[10 points]**

time: 10 min

Let $P_{detect}(n)$ annotate the probability of a successful error detection of the single parity check code on a sequence of n bits.

Now, suppose that two (single-parity) check bits are added to a group of 2n information bits. The first check bit is the parity check of the first n bits, and the second check bit is the parity check of the second n bits. (See figure below.)



(a) Find the error detection failure probability of this FEC scheme as a function of the error-detection probability of the single parity check code ($P_{detect}(n)$).

An error detection failure occurs if either the first subcodeword or the second subcodeword or both fail. Or, in other words, 'error detection failure' will not occur only in the case of successful error detection in both subcodewords. Hence,

P[detection failure in code of length 2n+n] =
= 1 – P[successful detection in both codes of length n+1] =
= 1 – $P_{detect}(n+1)P_{detect}(n+1)$

(b) Does it help to add a third parity check bit that is the sum of all the information bits?

2-bit technique will detect errors if
(a) (odd # of error bits in first sequence) & (odd # of error bits in first sequence)
(b) (even # of error bits in first sequence) & (odd # of error bits in first sequence)
(c) (odd # of error bits in first sequence) & (even # of error bits in first sequence)

2-bit technique will NOT detect errors if
(d) (even # of error bits in first sequence) & (even # of error bits in first sequence)

3-bit technique (i.e. an overall parity bit) cannot detect (d) either, as the number of errors in the overall codeword is still even and not detectable by a single parity bit.