Name ..... ID ..... Section ..... Seat No .....

Sirindhorn International Institute of Technology
Thammasat University

Midterm Exam: Semester 1, 2011

Course Title: ITS323 Introduction to Data Communications

Instructor: Steven Gordon

Date/Time: Monday 1 August 2011; 9:00–12:00

Instructions:

- This examination paper has 17 pages (including this page).
- Conditions of Examination: Closed book; No dictionary; Non-programmable calculator is allowed
- Students are not allowed to be out of the exam room during examination. Going to the restroom may result in score deduction.
- Students are not allowed to have communication devices (e.g. mobile phone) in their possession.
- Write your name, student ID, section, and seat number clearly on the front page of the exam, and on any separate sheets (if they exist).
- Assume bits are ordered from left to right. For example, for the data 00001111, the first (1st) bit is 0 and the last (8th) bit is 1.
- Assume the speed of transmission is 3×10^8 m/s
- Free space propagation path loss:

$$\frac{P_t}{P_r} = \frac{(4\pi d)^2}{G_t G_r \lambda^2}$$

- Antenna gain for parabolic antenna with effective area A_e:

$$G = \frac{4\pi A_e}{\lambda^2}$$

Question 1 [24 marks]

For each question fill in the blank space with the most appropriate term from Table 1. For each blank space you must give only one answer. However, there may be more than one correct answer. You may use a term from the table in more than one question. You must not use terms that are not in the table. Each correct answer is worth 1.5 marks.

No.	Term	No.	Term	No.	Term
1	accuracy	15	full-duplex	29	physical
2	amplitude modulation	16	guided	30	point-to-point
3	amplitude shift keying	17	half-duplex	31	port number
4	application	18	hardware address	32	pulse code modulation
5	coaxial cable	19	IP	33	simplex
6	codec	20	IP address	34	spectrum
7	CRC	21	LAN	35	TCP
8	data link	22	modem	36	time domain
9	data rate	23	multipoint	37	timeliness
10	delta modulation	24	network	38	transport
11	frequency	25	optical fibre	39	twisted pair
12	frequency domain	26	parity check	40	unguided
13	frequency modulation	27	phase modulation	41	WAN
14	frequency shift keying	28	phase shift keying	-	-

Table 1: Possible answers for Question 1

(a) Three important measures of effective data communications are: delivery, timeliness and _____.

(b) A _____ covers a large geographical area, whereas a LAN typically covers a campus, building or home.

(c) Two important protocols in the Internet, and from which the Internet stack gets its name, are _____ and IP.

(d) HTTP is a protocol for requesting and receiving web pages. It is part of the _____ layer.

(e) In a _____ configuration more than two devices share the transmission medium.

(f) A transmission medium that allows transmission in both directions, but only one direction at a time, is called _____.

(g) _____ can be described as varying the phase of the output carrier signal as the amplitude of the input data changes.

(h) Protocols in the _____ layer are normally implemented in hardware on network interface cards.

(i) _____ is the most common guided media used within home and building LANs.

(j) A _____ is used to identify application processes running on a computer.

(k) For multimedia or real-time applications, _____ is usually more important than accuracy.

(l) A _____ takes digital data as input and transmits an analog signal.

(m) _____ is a guided media that provides higher data rates and allows for transmission across larger distances than coaxial cable.

(n) _____ can be used to detect errors.

(o) The _____ layer includes the task of reliable deliver across a single link.

(p) Routing protocols, which are used to select the most appropriate path across the Internet, are most often part of the _____ layer.

Question 2 [12 marks]

Table 2 shows the list of codewords for a Hamming-distance based Forward Error Correction (FEC) scheme.

Data	Codeword
000	011011
001	100110
010	100111
011	010000
100	111100
101	001010
110	100101
111	001011

Table 2: Hamming-based FEC

(a) For the following cases, explain the steps taken by the receiver (showing any calculations where necessary), and summarise the outcome by answering the following questions. [6 marks]

i. The data 001 is to be sent from transmitter to receiver. The last bit transmitted is in error.

Steps taken by receiver:

Codeword received by receiver: _____ _____ _____ _____ _____ _____

Error detected by receiver? YES or NO

Data received: _____ _____ _____ (if applicable)

Is the correct data received? YES or NO

ii. The data 010 is to be sent from transmitter to receiver. The 1st bit transmitted is in error (that is, the 1st bit transmitted is different from the 1st bit received).
Steps taken by receiver:

Codeword received by receiver: _____ _____ _____ _____ _____ _____
Error detected by receiver? YES or NO (circle the correct answer)
Data received: _____ _____ _____ (if applicable)
Is the correct data received? YES or NO

iii. The data 100 is to be sent from transmitter to receiver. The 1st and 2nd bits transmitted are in error.
Steps taken by receiver:

Codeword received by receiver: _____ _____ _____ _____ _____ _____
Error detected by receiver? YES or NO
Data received: _____ _____ _____ (if applicable)
Is the correct data received? YES or NO

(b) Assuming you must use a FEC with 3 bits of data and 6-bit codeword, explain how the scheme in Table 2 could be changed to reduce the possibility of single-bit errors being undetected. [2 marks]

(c) If using a link with data rate of 20Mb/s, what is the maximum possible throughput using the encoding scheme in Table 2? [2 marks]

(d) Explain one advantage and one disadvantage of using an 5-bit codeword (instead of 6-bit codeword as in Table 2). [2 marks]

Advantage:

Disadvantage:

Question 3 [13 marks]

Consider a terrestrial microwave link between SIIT Bangkadi and SIIT Rangsit. The distance between the two campuses is 10km. Each campus uses the same equipment. The specification of the equipment is: antenna gain = 18.95dBi; receive power threshold (or sensitivity) = -70dBm; frequency = 3GHz.

(a) What is the minimum power at which the receiver at Bangkadi can successfully receive, measured in Watts? [2 marks]

(b) What is the wavelength of the transmitted signal? [1 mark]

(c) What is the absolute gain of one antenna? [2 marks]

(d) Assuming free-space path loss, what is the minimum transmit power required for the signal to be successfully received? [5 marks]

(e) Assuming both antennas are parabolic antennas where the effective area is $\frac{1}{\pi}$ of the physical area of the antenna, what is the diameter of the dish? [3 marks]

Question 4 [7 marks]

The frame rate of a web camera attached to your computer is 24 frames per second, where each frame is an image of 1600 x 1200 pixels. Each pixel uses a 24 bit value to represent a single colour.

(a) What is the data rate required to send the raw (uncompressed) video from camera to computer? [3 marks]

(b) Assuming the camera compresses the video before transmission, such that the compressed data is 1% of the original data size, what is the data rate required to send the compressed video from camera to computer? [1 mark]

(c) With the compressed video, what is the minimum bandwidth required on the cable (connecting web camera to computer) if there was a signal-to-noise ratio of 27.08dB? [3 marks]

Question 5 [12 marks]

Consider a network with two links: Link 1 is between devices A and B, while Link 2 is between devices B and C. The link and device characteristics are:

Device A: every packet transmitted incurs 100μs processing delay; every packet received incurs 100μs processing delay; no queuing delay

Device B: no processing delay; every packet received is put into a queue, which incurs queuing delay of 10ms and then is transmitted

Device C: every packet transmitted incurs 100μs processing delay; every packet received incurs 100μs processing delay; no queuing delay

Link 1: distance = 30km; data rate = 1Mb/s

Link 2: distance = 60km; data rate = 10Mb/s

(a) What is the transmission delay of a 1000B packet from A to B? [2 marks]

(b) What is the propagation delay from B to C? [2 marks]

(c) Consider a web browser on device A generates a 1000B request packet to be sent to C. Device C responds with a 10,000B web page (including headers) in a single packet. What is the response time for the web browser (i.e. the time between when the browser initiates the request until the page is received)? [5 marks]

(d) Consider an application on device A is transferring a 1GB file to device C. The protocol stack on device A splits the file into 10,000B segments, sending each segment as data in a packet. Every packet contains 200B of header. Assuming no errors in the network, what is the maximum throughput of the file transfer? [3 marks]

Question 6 [9 marks]

Consider the following communications signals:

$$s_1(t) = 30\sin\left(2\times10^3\pi t\right) + 10\sin\left(6\times10^3\pi t\right) + 6\sin\left(1\times10^4\pi t\right) + 4.37\sin\left(1.4\times10^4\pi t\right)$$

$$s_2(t) = 30\sin\left(2\times10^3\pi t\right) + 15\sin\left(4\times10^3\pi t\right) + 10\sin\left(6\times10^3\pi t\right) + 7.5\sin\left(8\times10^3\pi t\right)$$

$$s_3(t) = 15\sin\left(2\times10^3\pi t\right) + 5\sin\left(6\times10^3\pi t\right) + 3\sin\left(1\times10^4\pi t\right)$$

(a) What is the absolute bandwidth of $s_2(t)$? [2 marks]

(b) What is the period of $s_1(t)$? [2 marks]

(c) Draw a plot of $s_2(t)$ in the frequency domain. [2 marks]

(d) Comparing signals $s_1(t)$ and $s_3(t)$ for transmitting digital data, what is an advantage of $s_1(t)$? [1.5 marks]

(e) Comparing signals $s_1(t)$ and $s_3(t)$ for transmitting digital data, what is an advantage of $s_3(t)$? [1.5 marks]

Question 7 [8 marks]

(a) Consider the NRZI transmitted signal in Figure 1. What is the value of the data? [3 marks]

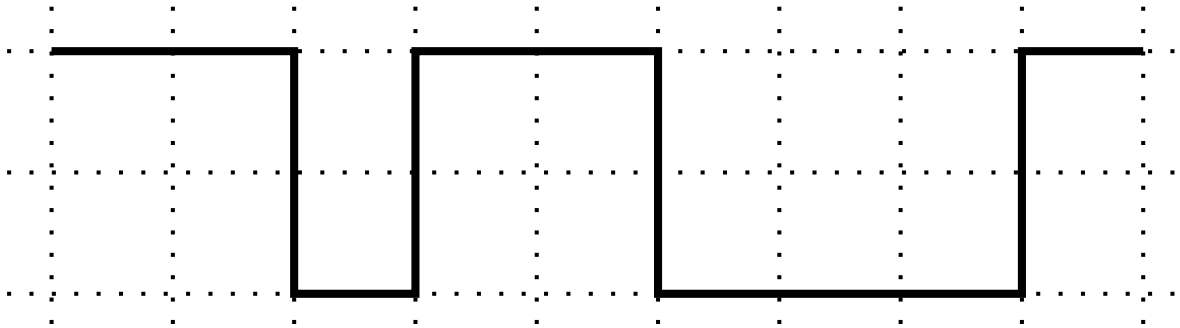

Figure 1: NRZI Signal

(b) Bipolar-AMI is described as: 0 = no line signal; 1 = positive or negative level, alternating for successive ones. Consider the data 010011100. Draw the Bipolar-AMI signal on Figure 2. [3 marks]

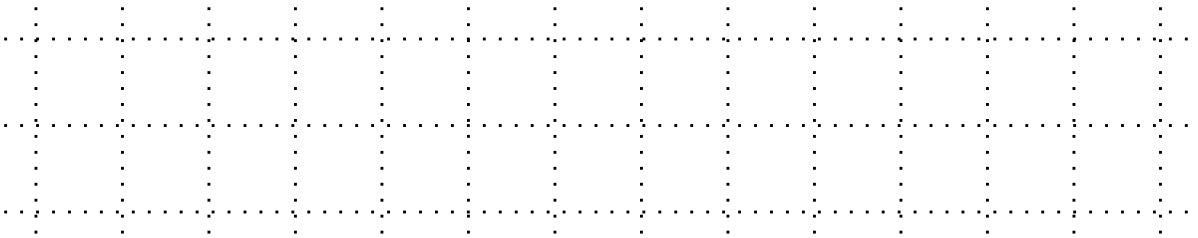

Figure 2: Draw the Bipolar-AMI signal

(c) Explain how Bipolar-AMI provides error-detection, whereas NRZI does not. [2 marks]

Question 8 [15 marks]

An audio recording application on Computer A used 4-bit PCM with a sampling rate of 10KHz to create the data: 101101100011010110011100. The data was sent to computer B.

(a) Draw the reproduced data at computer B on Figure 3. [5 marks]

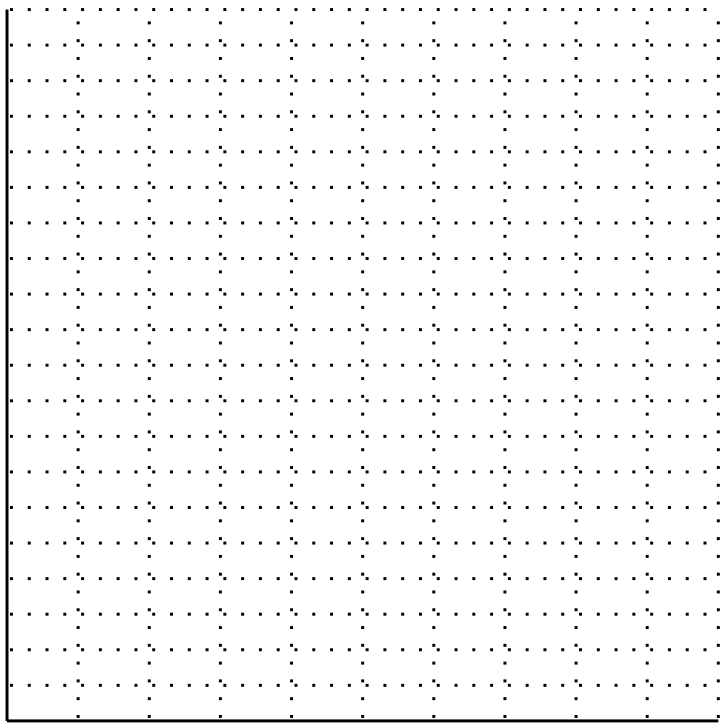

Figure 3: Draw the reproduced data

(b) To transmit the data from A to B, a combination of ASK (2 levels) and FSK (2 levels) are used. Design an appropriate shift keying scheme by selecting and drawing a possible combination of mapping signal elements to data. [3 marks]

(c) What is the ideal sampling rate if the original audio input signal is as shown shown in Figure 4? [2 marks]

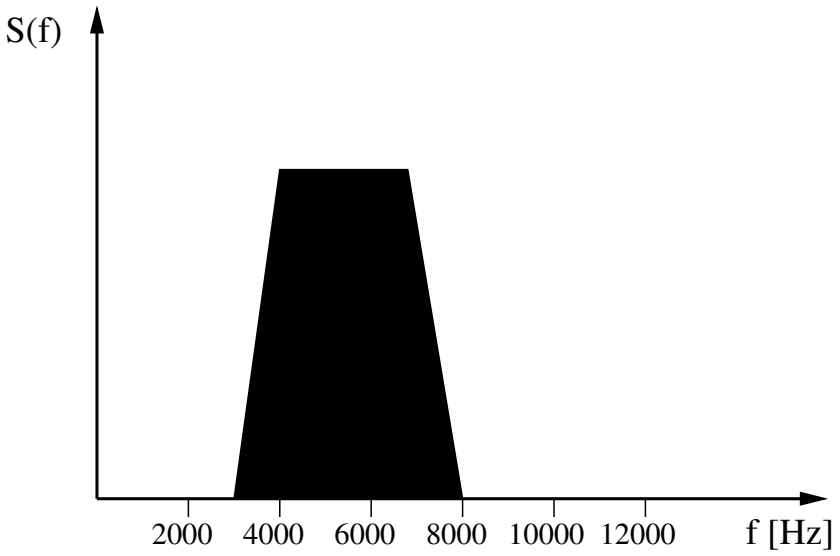

Figure 4: Frequency domain plot of original audio input

(d) If instead of sending to B, the application on computer A saved the data to a file, how large would the file be for a 10 minute recording? [3 marks]

(e) What are the two methods that the application on computer A use to increase the quality of the reproduced audio? [2 marks]