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

Sirindhorn International Institute of Technology
Thammasat University

Midterm Examination: Semester 1/2010

Course Title : ITS323 Introduction to Data Communications

Instructor : Dr Steven Gordon

Date/Time : Friday 6 August 2010; 13:30 – 16:30

Instructions:

- This examination paper has 15 pages (including this page).
- Condition 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.
- Turn off all communication devices (mobile phone etc.) and leave them under your seat.
- Write your name, student ID, section, and seat number clearly on the answer sheet.
- The space on the back of each page can be used if necessary.
- Assume bits are ordered from left to right: 1st bit, 2nd bit, 3rd bit, …, nth bit
- Unless otherwise stated in the question, assume the speed of transmission is 3×10^8m/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 area A:

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

Questions [100 marks]

Question 1 [9 marks]

a) Draw the layered stack in the TCP/IP protocol architecture. [3 marks]

b) Which layer from the above TCP/IP protocol architecture does the following address belong to? [4 marks]

i. IPv4, e.g. 203.45.16.23 Layer: _____

ii. Email, e.g. steve@siit.tu.ac.th Layer: _____

iii. IEEE, e.g. 13:45:f5:e9:51:b9 Layer: _____

iv. Web server port, e.g. 80 Layer: _____

c) Protocols from which two layers are normally implemented in the operating system? [2 marks]

Question 2 [9 marks]

Consider the following communications signal:[NOTE: Missing “sin” n exam]

$$s_1(t) = 3.000\sin(2\times10^7\pi t) + 1.000\sin(6\times10^7\pi t) + 0.600\sin(1\times10^8\pi t) + 0.429\sin(1.4\times10^8\pi t)$$

a) Draw a plot of the signal in the frequency domain. [3 marks]

b) What is the period of $s_1(t)$? [1 mark]

c) Write an equation for a signal, $s_2(t)$, that uses the same absolute bandwidth as $s_1(t)$, has the same peak amplitude as $s_1(t)$, but only uses 3 sine components. [3 marks]

[Note: the question is not well written – I was supposed to say also a fundamental frequency]

d) Explain an advantage of $s_1(t)$ compared to $s_2(t)$ if both are used to transmit digital data. [1 mark]

e) Explain a disadvantage of $s_1(t)$ compared to $s_2(t)$ if both are used to transmit digital data. [1 mark]

Question 3 [10 marks]

The free space path loss model is:

$$P_r = \frac{P_t G_t G_r}{L}$$

where the absolute power loss is: $L = \frac{(4\pi d)^2}{\lambda^2}$

However this model is inaccurate in indoor environments, as it does not consider obstructions such as floors, ceilings, walls and office furniture. A more accurate model of indoor environments is the ITU Indoor Propagation model, where the path loss between two antenna's is calculated as:

$$L = 20\log_{10}(f) + N\log_{10}(d) + P_f(n) - 28$$

where:

- L is the path loss measured in dB
- f is the signal frequency in Megahertz (MHz)
- d is the distance in metres (m)
- N is the distance power loss coefficient, with values depending on frequency and environment
- $P_f(n)$ is floor penetration loss factor which depends on the number of floors (n) and frequency.

For an office environment using signals at frequency of 2.4GHz, N = 30. To cover 3 floors (n=2), $P_f(2)$ = 19.

Consider an IEEE 802.11 wireless LAN (Wi-Fi) device with the following characteristics:

- Transmit power: 12.5mW
- Receive threshold: -60dBm
- Frequency: 2.4GHz

Each device has the choice of three different types of antenna:

- Antenna 1: 5dBi gain; cost 500 Baht
- Antenna 2: 10dBi gain; cost 2000 Baht
- Antenna 3: 15dBi gain; cost 4000 Baht

a) What is the transmit power of the wireless device, measured in dBm? [2 marks]

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

c) Assuming two wireless devices (both with identical characteristics as above) are to communicate in the office environment over a maximum distance of 20m, which antenna type should be purchased? You must assume both devices will use the same antenna type and the ITU Indoor propagation model applies. You must show your calculations. [7 marks]

Question 4 [12 marks]

Figure 1 illustrates a portion of analog input data at a source computer. The analog data is to be transmitted to the destination computer using digital signalling. A 10KHz 3-bit PCM codec is used, as well as the NRZ-Invert encoding scheme. The minimum and maximum possible signal levels are marked on the figure.

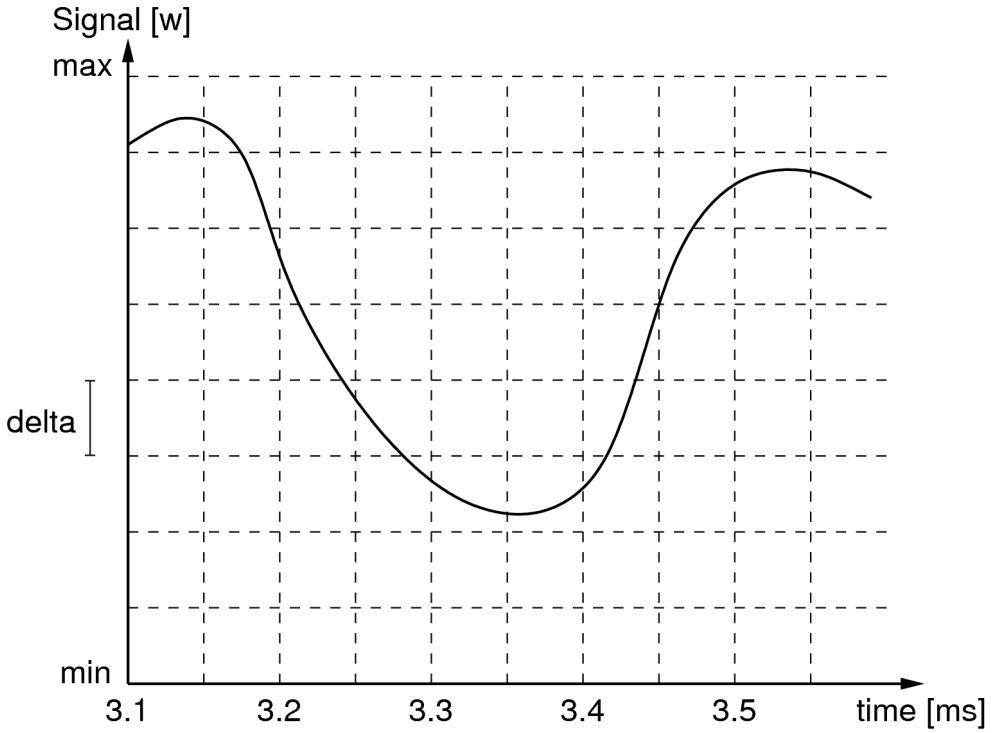
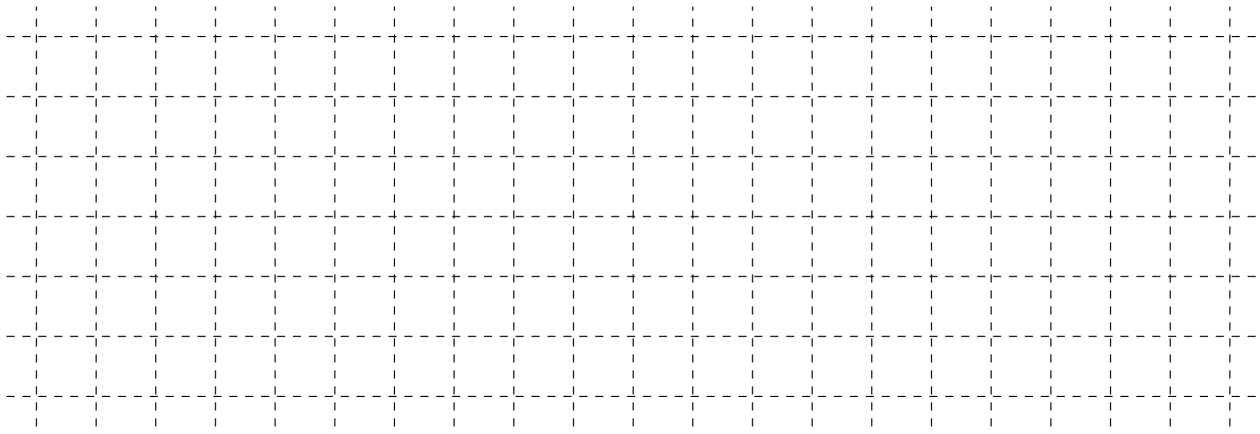


Figure 1

a) What is the digital data to be transmitted? [4 marks]

b) Draw the transmitted digital signal. [3 marks]



An alternative to PCM is Delta Modulation (DM). In DM, a "staircase" function is created based on the analog input data. When the analog input is sampled, if the analog input value is greater than the previous staircase value, then the staircase goes up one level; else, the staircase goes down one level. The digital output is derived directly from the staircase function: if the staircase level goes down, a bit 0 is output; if the staircase level goes up, a bit 1 is output. The step size of the staircase is called delta, δ. The figure below gives an example of Delta Modulation. Assume that the first staircase level is the level below the sampled analog input at time 3.1ms, and produces a bit 0 as output.

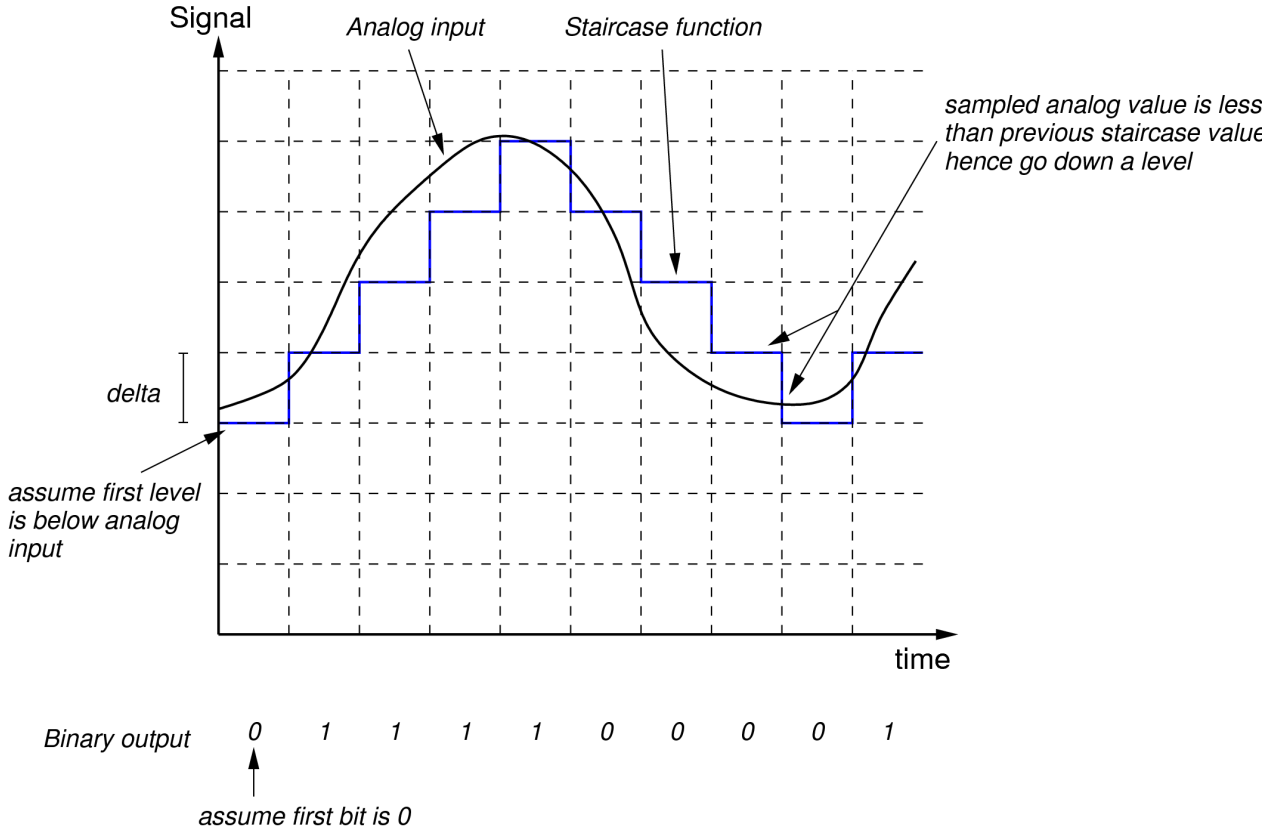


Figure 2

c) For the analog input data in Figure 1, what is the digital data to be transmitted if 20KHz DM is used with delta as shown on the figure? [3 marks]

d) Explain an advantage of using DM (compared to PCM). [2 marks]

Question 5 [8 marks]

Consider the network in Figure 3 where computer A is to send a single 1MB message to computer B.

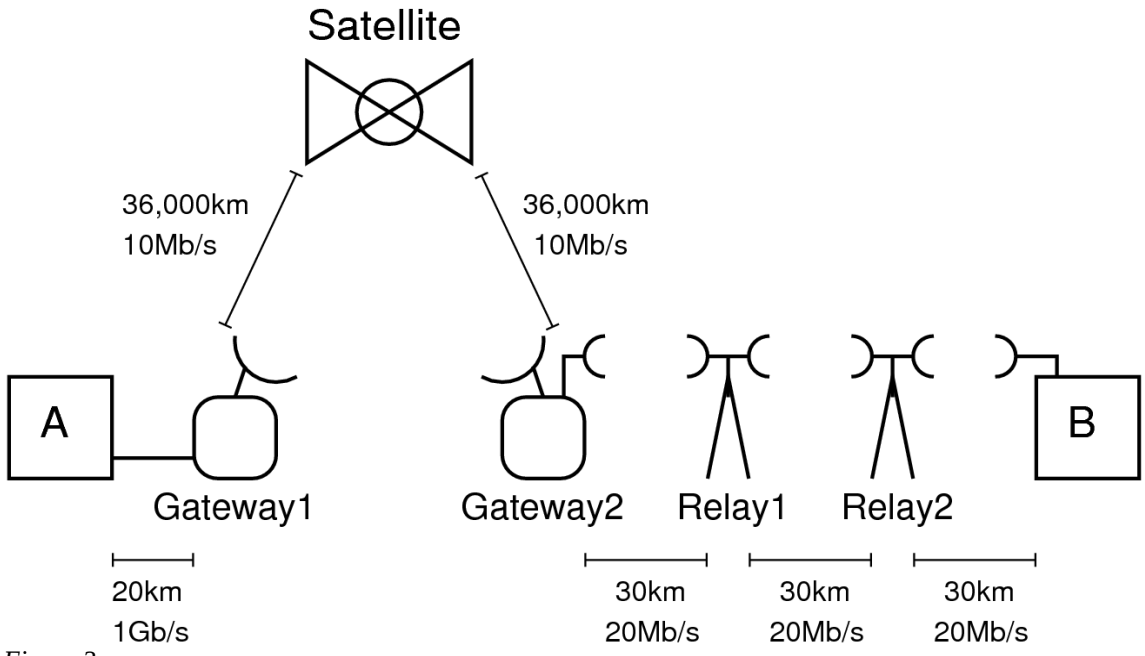


Figure 3

Assume the following:

- The geostationary satellite orbits the Earth at an altitude of 36,000km
- The transmission speed from Earth to satellite is $3x10^8$m/s
- The transmission speed over the wireless links (between Gateway2, relays and B) is $3x10^8$m/s
- The transmission speed over optical fibre (between A and Gateway1) is $2x10^8$m/s
- There is a processing delay of 3ms at each gateway, 0.8ms at each wireless relay, as well as a processing delay of 4ms at the satellite. There is no processing delay in the computers.
- There is a queuing delay of 20ms at each gateway. There is no queuing delay at the satellite, wireless relays or in the computers.
- Segmentation is not used.

a) What is the propagation delay from computer A to the first gateway? [1 mark]

b) What is the transmission delay from gateway to satellite? [1 mark]

c) What is the total delay for the message from computer A to computer B? [6 marks]

Question 6 [7 marks]

HDMI is a standard interface for sending uncompressed video from a video player or computer to a screen or monitor. The capacity of HDMIv1.3 is 10.2Gb/s.

A common HDTV format is a 1920x1080 pixel frame with 24-bit colour and 25Hz frame rate. A higher quality format used in cinemas is called “4K”, with the same colour depth, but 4096x2304 pixels with 50Hz frame rate.

a) Can a HDMIv1.3 connection support uncompressed 4K video? Show your calculations. [3 marks]

To transfer video over a network, compression is usually applied. Assume video (in either format) can be compressed to 1% of its original size.

b) How long would it take to download a 2 hour movie in 4K compressed video if the data rate from the server was 100Mb/s? (Ignore any overheads) [4 marks]

Question 7 [7 marks]

An encoding scheme maps 8 bits of digital data into 1 signal element.

a) In a noise-free environment with a bandwidth of 10MHz, what is the maximum theoretical data rate possible? [3 marks]

b) If the level of noise was measured to be -27dBm and the received signal strength of 2.041mw for a communications channel with bandwidth of 10MHz, what is the maximum theoretical data rate possible? [4 marks]

Question 8 [16 marks]

In this question you need to complete the sentence using only one of the following:

Amplitude Shift Keying	Bandwidth	Baud rate
Coaxial cable	Cyclic Redundancy Check	Delay
Errors	Flow control	Forward Error Correction
Frequency Modulation	Frequency Shift Keying	Full-duplex
Half-duplex	Hamming distance	IEEE
Jitter	Manchester encoding	Optical fibre
Parity check	Pulse Code Modulation	Signal rate
Simplex	Standard	TCP/IP
Throughput	Twisted pair	

Although there may be more then one correct answer, you must only give one answer (giving two or more will result in 0 marks). Each correct answer is worth 2 marks. You may use the above words/phrases more than once.

a) The _____ between 0101001 and 1101010 is 3.

b) _____ involves varying the frequency of the output signal as the amplitude of the input analog data changes.

c) With a _____ link, data can be sent in both directions, but not at the same time.

d) _____ is used to ensure the buffer at the receiver does not overflow.

e) _____ is used to transmit digital data as an analog signal.

f) _____ provides mechanisms for both detecting and correcting errors.

g) _____ is the most common wired technology for LANs and in-building communications.

h) File transfer applications cannot tolerate any_____.

Question 9 [13 marks]

Consider the sliding window flow control protocol being used over a single link from A to B. DATA frames carrying 900 Bytes of data (plus 100 Bytes of header) have a transmission delay of 10ms. ACK frames (100 Bytes of header) have a transmission delay of 1ms. The link propagation delay is 50ms. Assume the source A always has data ready to send, and B immediately sends an ACK frame after receiving a DATA frame (there is no processing delay and no errors).

First, consider a 3-bit sequence number is used. Assume A sends its 1st DATA frame at time 0s.

a) What is the maximum number of bytes of original data that A can send without having received an ACK frame? [2 marks]

b) At what time is the ACK of the 1st DATA frame received by A? [2 marks]

c) Does A spend any time at which it is not transmitting DATA frames? If yes, then how much time? If no, then explain why not. [2 marks]

d) What is the maximum throughput that can be achieved across the link from A to B? [2 marks]

Now consider the same scenario as above, but a 4-bit sequence number is used instead.

e) Does A spend any time at which it is not transmitting DATA frames? If yes, then how much time? If no, then explain why not. [3 marks]

f) What is the maximum throughput that can be achieved across the link from A to B? [2 marks]

Question 10 [9 marks]

Table 1 shows a set of frames received by the Data Link layer of a computer (including the time when it is received). Each frame contains a header plus data. The amount of data in each frame is shown in the Data column. The Data Link layer header contains five fields:

1. A 16-bit timestamp, which indicates the time when the frame was sent
2. Address of the source, in the format of a 48-bit IEEE address
3. Address of the destination, in the format of a 48-bit IEEE address
4. A 32-bit sequence number
5. A 2 byte field to indicate the type of protocol used.

Time received [ms]	*Sequence number*	*Timestamp [ms]*	*Data [Bytes]*
7	0	0	100
11	1	3	120
14	2	6	150
16	3	9	125
22	4	12	100
23	5	15	125

Table 1: Frames Received

Answer the following questions considering only the frames in the table.

a) What is the average delay from source to destination? [2 marks]

b) What is the jitter between source and destination? [2 marks]

c) What is the throughput for the received data? [2 marks]

d) Consider the source sending the frames. Assume the Physical layer at the source adds an additional 80 bits to each frame. What is the average rate at which bits are sent by the source Physical layer? [3 marks]