ITS323 – Assignment 1

Guidelines

- Deadline: Wednesday 22 July 2009, 1pm. We will discuss the assignment answers in class after submission – late assignments will receive 0 marks.

- Total marks: 100 (10% of final grade)

- Bonus marks (up to 20 marks) may be given to groups that produce exceptional reports/answers.

- Group assignment: work in groups of 3 – each students must contribute to the assignment.

- You must submit evidence of calculations. For example, if you use Scilab (or other mathematics software) you must submit your source code and in your assignment answers explain how/where the code was used. If you use Excel (or other spreadsheet software) you must submit the spreadsheet and in your assignment answers explain how/where the spreadsheet was used. If you calculate by hand (not recommended, but allowed), you must include all calculations in the assignment answers.

- Report: use the supplied Word/OpenOffice template for your reports. Submit the report via email (to steve@siit.tu.ac.th) in PDF format only. The report must be named:

    `groupX-report.pdf`   where X is your group number.

- Attachments: any source code/spreadsheets etc. must be submitted as attachments in the same email as the PDF. Do not use zip/tar/rar etc. Give meaningful names, e.g.:

    `groupX-q1answers.sci`

    `groupX-q3answers.xls`

- Updates, hints and questions about the assignment will be announced via the its323 mailing list.

Question 1 [15 marks]

Your company has two office buildings, one in Bangkok and the other in London. Currently you have two available options for connecting the two offices:

1. Satellite: each office building uses a parabolic satellite antenna on the roof, communicating with a geostationary satellite (which is located approximately 36000km above the ground). The the satellite links provide 20Mb/s full duplex. The processing/queuing delay at the transmitter/receiver stations is negligible (assume 0), however the processing delay at the satellite is measured to be *SatProc* ms. The protocol architecture for the satellite transmission system introduces an overhead of 100 Bytes for every message sent.

2. Optical Fibre: each office has optical fibre connections, and your Internet Service Provider can offer a dedicated 10Mb/s full duplex connection between the two cities. The total propagation delay across the ISP's network is *FibreProp* ms, and the ISP guarantees a maximum queuing/processing delay across their network of 10µs. There are no other significant processing/queuing delays. The protocol architecture for the optical fibre transmission system introduces an overhead of 80 Bytes for every message sent.

In evaluating the two options your determine that you want to minimize both delay (for a single packet) and throughput for all applications. For throughput, it is assumed message sizes are *MsgSize* Bytes, and no segmentation is performed. From previous measurements you determine the best option will be the one that minimise the function *F*:

$$F(throughput, delay) = \frac{weight_t}{throughput} + \frac{delay}{weight_d}$$

where *throughput* is measured in Mb/s, *delay* in ms, and $weight_t$ and $weight_d$ are the values defined for your group (along with *MsgSize, FibreProp* and *SatProc*).

a) Which option do you choose? Explain your answer, showing any calculations used. [15 marks]

Question 2 [35 marks]

Consider the signal encoding scheme that may be used over the first link from a company office (data rate of 10Mb/s).

a) Assuming text *M1* is to be transmitted, produce a plot of the transmitted signal for the NRZ encoding scheme for your group. [5 marks]

b) For your NRZ encoding scheme, analyse the impact of noise on the accuracy of the received data. The transmitted data is string *M2*.

   i. With uniform random noise, compare the bit error rate for: different amplitudes of noise (0 and above); different link data rates.

   ii. With impulse noise, compare the bit error rate for: different durations of the impulse; different link data rates. In all cases, you may fix the impulse amplitude to 2 (that is, twice as large as the transmitted signal). [25 marks]

c) Discuss the conclusions that can be made from your analysis in part (b). [5 marks]

For part (b) when using Scilab to determine the bit error rate, because of the randomness in the noise, you should repeat the calculations at least 5 times and then take the average bit error rate. For example, generate the transmitted signal, add the noise, determine the received data, and calculate the bit error rate. Then repeat these 4 steps at least 5 times, and take the average of the 5 (or more) bit error rates recorded.

To illustrate the impact of noise, you may use plots of bit error rate versus noise or data rate.

Question 3 [30 marks]

One of the applications used by your company involves sending analog data from measurements between the offices in Bangkok and London. You are developing your own in-house application to convert that analog data to digital data using Pulse Code Modulation.

For simplicity, you can assume the input analog data is the summation of n sinusoid signals with fundamental frequency f, peak amplitude A, and phase p.

a) Plot the input analog signal. In your plots, consider the data from time 0 to time t. The values of f, A, p and t are defined for your group. [5 marks]

b) Compare PCM for different sampling rates and bits per sample, and explain the trade-offs that must be considered when using PCM. To compare you must: [25 marks]

i. Produce different plots of the output analog signal under different conditions.

ii. Calculate the percentage of the link throughput that would be used by this application under the different conditions.

iii. Discuss the trade-offs, referring to the plots and percentages in the above two points.

Question 4 [20 marks]

Consider the Bangkok office building, where you want to deploy a wireless network for communications within the building. You would like to use a single wireless access point to provide coverage across multiple floors of the building. The ITU Indoor Propagation model is suitable for calculating the path loss between two antenna's in your office environment.

You have the choice of 3 different wireless devices (the same type of device is used for the wireless access point and the client devices).

a) If coverage area is the most important factor, which device would you choose for your wireless network? [15 marks]

b) Explain what factors (other than coverage area) your should consider when selecting between the 3 devices. [5 marks]

Wireless Devices

Device #	Freq. [MHz]	Data Rate [Mb/s]	Tx Power [mW]	Receive Threshold [dBm]	Antenna Gain [dBi]
1	900	11	30	-80	3
2	900	11	15	-80	6
3	900	11	30	-85	3
4	900	11	15	-85	6
5	2400	54	30	-85	3
6	2400	54	15	-80	9
7	2400	54	30	-80	6
8	2400	54	15	-85	9
9	5200	54	50	-85	6
10	5200	54	30	-90	9
11	5200	54	50	-90	6
12	5200	54	30	-90	12

ITU Indoor Propagation Model

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

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.

Selected values for N and $P_f(n)$ can be found from the following tables (these are based on real measured values, although have been changed slightly for the Assignment):

Distance Power Loss Coefficient, N			
Frequency	Residential	Office	Commercial
900 MHz	-	33	20
2.4 GHz	28	30	22
5.2 GHz	-	31	-

Floor Penetration Loss Factor, P_f(n) (*n* floors)			
Frequency	Residential	Office	Commercial
900 MHz	-	9 (1 floor)	-
900 MHz	-	19 (2 floors)	-
900 MHz	-	24 (3 floors)	-
2.4 GHz	4n	15 + 4(n-1)	6 + 3(n-1)
5.2 GHz	-	16	-

If your network must cover 2 floors, then the value of n is 1 (the signal must pass through 1 floor). If the signal does not have to pass through floors (n=0), then Pf(n) = 0 for all cases.

Scilab

Scilab (www.scilab.org) is free mathematical processing software. It is similar to Matlab, and uses a similar syntax. For this assignment you will perform some basic calculations in Scilab, in some cases producing plots of data. A file of functions useful for this assignment is provided (see website). You may use any of the provided functions, as well as create your own.

To get started (after installing and starting Scilab):

1. Open the provided Scilab file (`assignment1.sci`):
   a) From the Scilab Console, go to Applications → Editor menu
   b) From the Scilab Editor, open `assignment1.sci`
2. Load the functions in `assignment1.sci` into Scilab:
   a) From the Scilab Editor, go to Execute → Load into Scilab
3. Run the example:
   a) From the Scilab Console, type:
        `[signal_rate, num_bits] = assignment_example()`

Now you can try the other provided functions.

Question 1

No provided functions. You may create your own if you wish.

Question 2

Provided functions:

- `as_create()`: create an analog signal/data composed of multiple sinusoids.
- `as_plot()`: plot an analog signal/data (can also be used to plot digital signal/data)
- `pcm_encode()`: encode analog data using PCM to produce digital data as output
- `pcm_decode()`: decode digital data using PCM to produce analog data as output

Other Scilab in-built functions that may be useful are: `xs2png()`, `xs2jpg()` and others for saving a Scilab figure as a png/jpg or other format.

Question 3

Provided functions:

- `text2bin()`: convert ASCII string to binary array
- `bin2text()`: convert binary array to ASCII string
- `ds_nrzl_encode()`: encode digital data to digital signal using NRZ-Level
- `ds_nrzl_decode()`: decode digital signal to digital data using NRZ-Level
- `add_uniform_noise()`: add random noise to a signal
- `add_impulse_noise()`: add an impulse of noise (plus random background noise) to a signal
- `bit_error_rate()`: counts the number of bit errors between a transmitted and received signal

Question 4

No provided functions. You may create your own if you wish.

Question 1 Data

Group	MsgSize	FibreProp	SatProc	weight$_t$	weight$_d$
1	1500	50	20	53	60
2	1000	75	15	5	43
3	500	100	10	78	35
4	1500	125	5	86	39
5	1000	150	20	36	76
6	500	50	15	46	21
7	1500	75	10	54	12
8	1000	100	5	25	68
9	500	125	20	76	77
10	1500	150	15	15	67
11	1000	50	10	96	55
12	500	75	5	52	12
13	1500	100	20	93	95
14	1000	125	15	85	78
15	500	150	10	78	81
16	1500	50	5	26	60
17	1000	75	20	37	58
18	500	100	15	71	30
19	1500	125	10	5	59
20	1000	150	5	93	32
21	500	50	20	88	38
22	1500	75	15	75	85
23	1000	100	10	94	59
24	500	125	5	59	10
25	1500	150	20	43	86
26	1000	50	15	48	33
27	500	75	10	99	56
28	1500	100	5	79	36
29	1000	125	20	63	98
30	500	150	15	20	96
31	1500	50	10	55	62
32	1000	75	5	11	21
33	500	100	20	52	73
34	1500	125	15	42	13
35	1000	150	10	1	77
36	500	50	5	43	64
37	1500	75	20	41	19
38	1000	100	15	77	10
39	500	125	10	14	49
40	1500	150	5	32	73
41	1000	50	20	76	13
42	500	75	15	8	25
43	1500	100	10	53	91
44	1000	125	5	32	97

Question 2 Data

M1: The first letter of the first names of each group member. E.g. if Steven Gordon is working with Bill Gates and Linus Torvalds, then M1 = SBL

M2: The first name and last name of each group member. E.g. M2 = StevenGordonBillGatesLinusTorvalds

Groups 1 to 20 must use NRZ-Level.

Groups 21 and above must use NRZ-Invert-on-ones.

Question 3 Data

Group	A	f	p	n	t
1	1	1	0	2	2
2	1	1	0	3	2
3	1	1	0	4	2
4	1	1	0	5	2
5	1	2	0	2	2
6	1	2	0	3	2
7	1	2	0	4	2
8	1	2	0	5	2
9	1	3	0	2	2
10	1	3	0	3	2
11	1	3	0	4	2
12	1	3	0	5	2
13	1	4	0	2	2
14	1	4	0	3	2
15	1	4	0	4	2
16	1	4	0	5	2
17	1	1	$\pi/2$	2	2
18	1	1	$\pi/2$	3	2
19	1	1	$\pi/2$	4	2
20	1	1	$\pi/2$	5	2
21	1	2	$\pi/2$	2	2
22	1	2	$\pi/2$	3	2
23	1	2	$\pi/2$	4	2
24	1	2	$\pi/2$	5	2
25	1	3	$\pi/2$	2	2
26	1	3	$\pi/2$	3	2
27	1	3	$\pi/2$	4	2
28	1	3	$\pi/2$	5	2
29	1	4	$\pi/2$	2	2
30	1	4	$\pi/2$	3	2
31	1	4	$\pi/2$	4	2
32	1	4	$\pi/2$	5	2
33	1	1	π	2	2
34	1	1	π	3	2
35	1	1	π	4	2
36	1	1	π	5	2
37	1	2	π	2	2
38	1	2	π	3	2
39	1	2	π	4	2
40	1	2	π	5	2
41	1	3	π	2	2
42	1	3	π	3	2
43	1	3	π	4	2
44	1	3	π	5	2

Question 4 Data

Group	Device 1	Device 2	Device 3	Floors
1	1	5	9	2
2	2	8	10	2
3	3	8	12	2
4	4	8	12	2
5	1	6	11	2
6	2	6	10	2
7	3	7	10	2
8	4	8	10	2
9	3	8	10	2
10	1	7	11	2
11	2	7	9	2
12	1	5	9	3
13	2	6	9	3
14	3	6	10	3
15	4	6	9	3
16	2	7	9	3
17	3	8	11	3
18	4	6	10	3
19	3	8	11	3
20	4	5	9	3
21	1	6	10	3
22	4	6	12	3
23	1	5	9	4
24	2	5	11	4
25	4	8	9	4
26	3	7	10	4
27	1	3	6	4
28	2	5	7	4
29	1	4	6	4
30	3	7	11	4
31	4	8	12	4
32	1	8	9	4
33	1	5	9	2
34	2	8	10	2
35	3	8	12	2
36	4	8	12	2
37	1	6	11	2
38	2	6	10	2
39	3	7	10	2
40	4	8	10	2
41	3	8	10	2
42	1	7	11	2
43	2	7	9	2
44	1	5	9	3