SEHH2238 Computer Networking

Assignment 1 (Individual)

Suggested Answer

Due Date: 11-March-2022 (Week 6, Friday) 18:00

Expected Learning Outcomes

- Grasp the key principles of data communications, the operation and protocols of computer networks.
- Analyze communication systems from the perspectives of communication architectures, transmission techniques, network organization, security, implementation techniques.
- Explore technical and practical issues of communicating data between computers over networks.

Instructions

a) This assignment should be completed individually and neatly.
b) Plagiarism will be penalized severely. Marks will be deducted for assignments that are plagiarized in whole or in part, regardless of the sources.
c) Submit soft copy of your assignment via Moodle before the due date.
d) **Late submission is NOT accepted.** You will get ZERO mark.
e) Answer ***ALL*** questions. Correct your answer to 4 decimal places.
f) You may assume 1K = 1000, 1M = 1000K and 1G = 1000M.
g) Please state clearly your source of references.
h) You can attach your reference materials.

Submission

- **Softcopy**

  Save your work, or scan your handwritten work, into a **PDF file**. Use the file name ***yourname_StudentID.pdf*** and submit it via Moodle.

Grading Aspects

- Marks are given to the accuracy of both steps and answer. **Detailed steps** should be provided.
- No mark would be given if your work is not readable (especially for handwritten work) and/or the steps cannot be followed.

<u>Question 1 (20%)</u>

(a) Describe the advantages and disadvantages of the TWO topologies used in the following hybrid network, and provide ONE real life example of using them: (12%)

The hybrid network contains bus and star topology.

i. Bus topology [L01S19]
   (a) Advantage:
      i. Easy installation, least cabling
   (b) Disadvantage:
      i. Due to power loss; no. of taps and distance between taps are limited
      ii. Difficult reconfiguration and fault isolation
   (c) Real life example: Traditional Ethernet using coaxial cable

ii. Star topology [L01S17]
   (a) Advantages:
      i. Less expensive for cabling and I/O ports
      ii. Robustness, easy fault identification and isolation
   (b) Disadvantage:
      i. Single point of failure
   (c) Real life example: Typical wired LAN

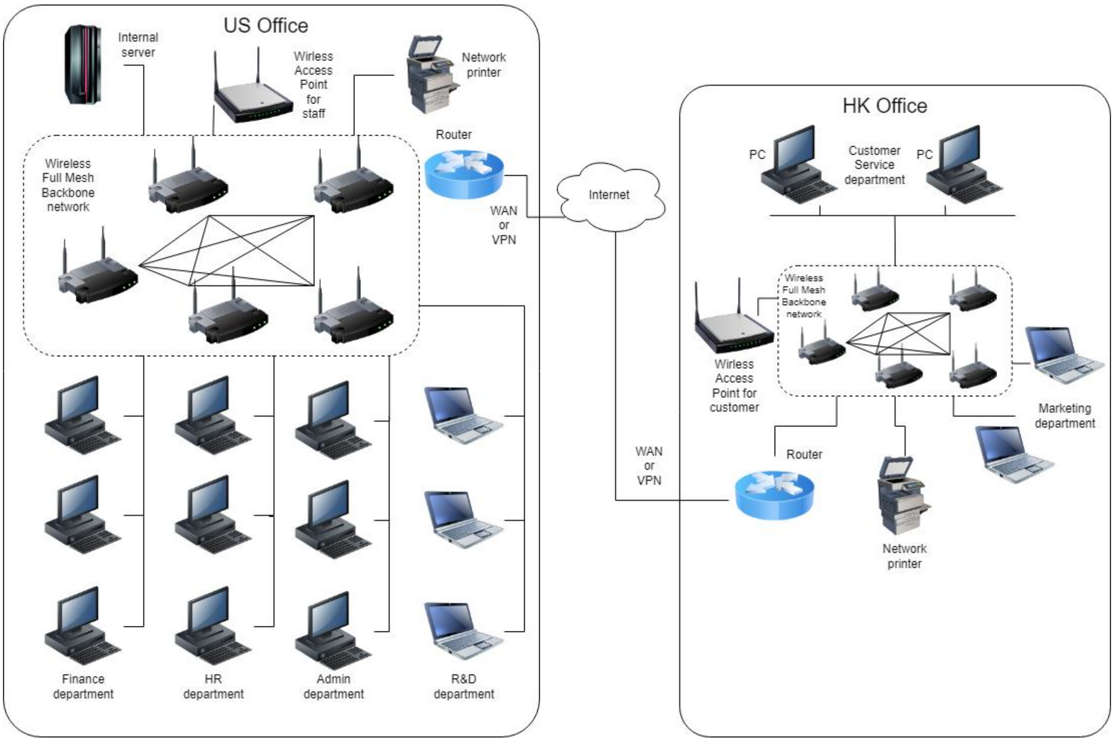
(b) Design a network of a company that consists of two offices in different physical locations: (8%)

- Hong Kong office
  - (a) Customer Service department (2 x PCs)
  - (b) Marketing department (2 x laptops)
  - (c) Network printer for staff x 1
  - (d) Wifi network for customers only
- US office
  - (a) Finance department (3 x PCs)
  - (b) Human Resource department (3 x PCs)
  - (c) Research and Development department (3 x laptops)
  - (d) Administration department (3 x PCs)
  - (e) Wifi network for staffs
  - (f) Internal server x 1
  - (g) Network printer for staff x 1

Indicate clearly the devices in the network (e.g. PC, server, router, switch, hub, etc.), and you should avoid single point of failure problem in your design. Justify your answer.

Hint: suggest using draw.io
Suggested network diagram:

- Network switch – star network topology
- LAN in US and HK offices
- WAN or VPN via Internet
- Router for DHCP, routing, firewall and WAN/VPN
- Wireless full mesh backbone network by wireless router to avoid single point of failure



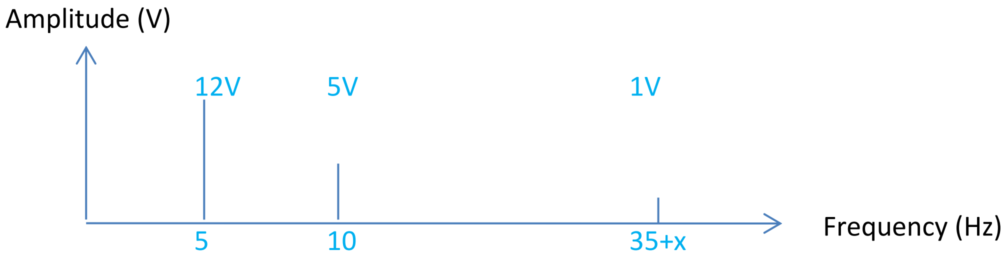
Question 2 (25%)

Consider a composite signal with initial power 65W and has the following three components:

- Amplitude: 12V, Frequency: 5 Hz, Phase: 0 degree
- Amplitude: 5V, Frequency: 10 Hz, Phase: 60 degrees
- Amplitude: 1V, Frequency: (35+x) Hz, Phase: 135 degrees

where x is the **3rd digit** of your student ID number.

(a) Plot the composite signal in frequency domain graph. (6%)



(b) Plot the composite signal in time domain graph for 1 second. (7%)
Hint: A sine wave can be represented as $f(t) = A\sin(2\pi ft + \theta)$.

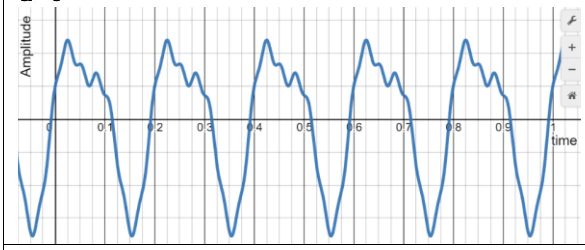
Suggested answer:

1. Use $f(t) = A\sin(2\pi ft + \theta)$ to plot three signal graphs

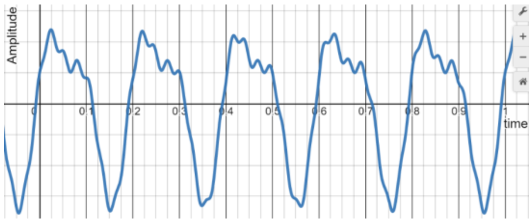
A	f	θ
12	5	0
5	10	60
1	35+0 (if 3rd digit is 0)	135

Q2b composite signal graphs by digit: frequency = (35+d) Hz

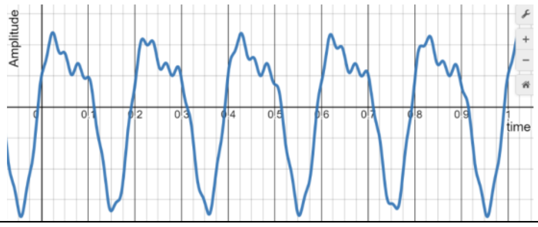
d=0



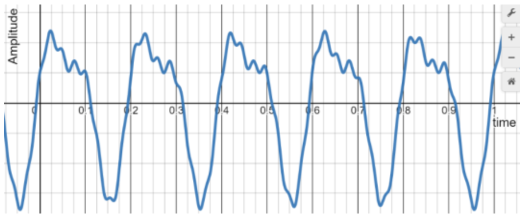
d=1



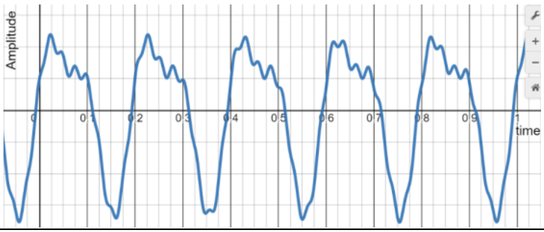
d=2



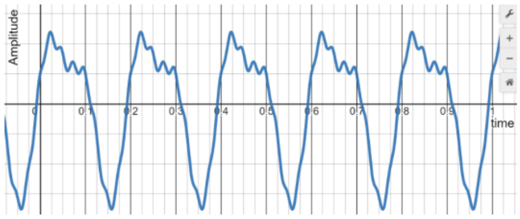
d=3



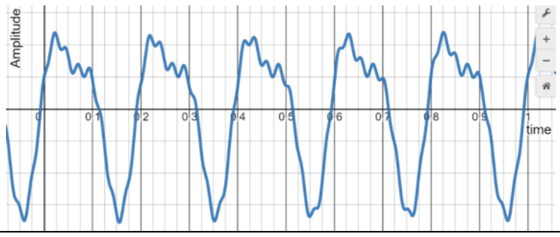
d=4



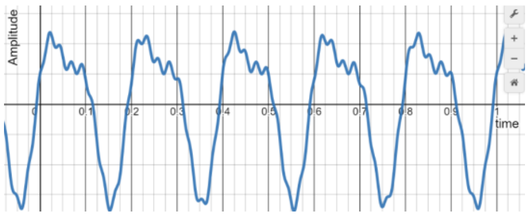
d=5



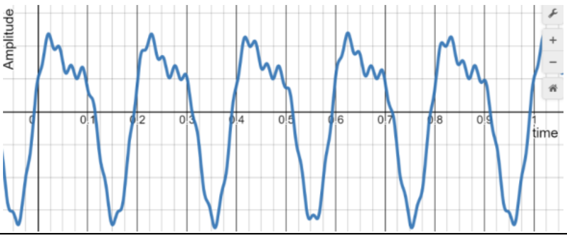
d=6



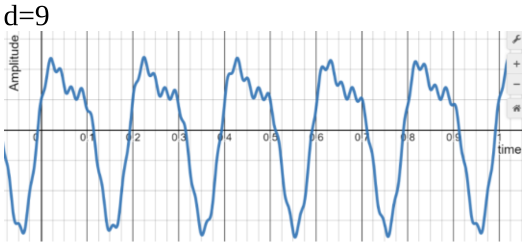
d=7



d=8



d=9



(c) If the signal travels through a medium with attenuation -3dB, what is the signal power at the receiver? (6%)

Let P be the signal power at the receiver [L02_S22]

$10 \log_{10}(P / 65W) = -3dB$
$P = 10^{-0.3} \times 65W$
$P = 32.5772$ (4 d.p.)

(d) Suppose the signal lasts for 20 seconds and is digitized by PCM using 127 levels. What is the minimum size of the resulted digital data? Express your answers in bits. (6%)

According to the Nyquist theorem, the sampling rate must be at least 2 times the highest frequency contained in the signal [L02S44]

As stated in question, high frequency component = $f_{max} = (35 + x)$
Minimum sampling rate = $2 \times f_{max} = 2 (35 + x)$
No. of bits per sample = ceiling ($\log_2 127$) = 7
Minimum size = 2 x (35 + x) (7) (20) = 280 (35 + x) **bits** where x is your digit

Therefore,

Digit	0	1	2	3	4	5	6	7	8
Size	9800	10080	10360	10640	10920	11200	11480	11760	12040

Question 3 (25%)

Consider that you are going to send the message "Hi!", where each character is encoded by 7-bit ASCII.

(a) What is the bit stream of your message? (3%)

Answer:

Decimal - Binary - Octal - Hex – ASCII
Conversion Chart

Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII
0	00000000	000	00	NUL	32	00100000	040	20	SP	64	01000000	100	40	@	96	01100000	140	60	`
1	00000001	001	01	SOH	33	00100001	041	21	!	65	01000001	101	41	A	97	01100001	141	61	a
2	00000010	002	02	STX	34	00100010	042	22	"	66	01000010	102	42	B	98	01100010	142	62	b
3	00000011	003	03	ETX	35	00100011	043	23	#	67	01000011	103	43	C	99	01100011	143	63	c
4	00000100	004	04	EOT	36	00100100	044	24	$	68	01000100	104	44	D	100	01100100	144	64	d
5	00000101	005	05	ENQ	37	00100101	045	25	%	69	01000101	105	45	E	101	01100101	145	65	e
6	00000110	006	06	ACK	38	00100110	046	26	&	70	01000110	106	46	F	102	01100110	146	66	f
7	00000111	007	07	BEL	39	00100111	047	27	'	71	01000111	107	47	G	103	01100111	147	67	g
8	00001000	010	08	BS	40	00101000	050	28	(	72	01001000	110	48	H	104	01101000	150	68	h
9	00001001	011	09	HT	41	00101001	051	29	)	73	01001001	111	49	I	105	01101001	151	69	i
10	00001010	012	0A	LF	42	00101010	052	2A	*	74	01001010	112	4A	J	106	01101010	152	6A	j

Therefore,

Bit stream of 'Hi!' = 1001000 1101001 0100001

(b) Suppose **two-dimensional odd-parity check** is used, with each character is considered as a block. Derive the bit stream to be transmitted. Show your steps. (8%)

Odd-parity check
0 is added if it contains odd number of 1's, and
1 is added if it contains even number of 1's

Two-dimensional odd-parity check

1001000	**1**
1101001	**1**
0100001	**1**
1111111	**0**

Bit stream to be transmitted: 1001000**1** 1101001**1** 0100001**1** 1111111**0**

Now, your friend replies a message "HA", where each character is encoded by **7-bit ASCII.** The message is protected by CRC using a polynomial below:

Check the **4th digit** of your student ID if it is odd or even, and use the corresponding CRC polynomial as divisor (see table 1).

Table 1

4th digit of your student ID number	CRC polynomial
Odd	$X^4 + X^3 + 1$
Even	$X^4 + X^2$

(c) Calculate the CRC. Show your steps. (8%)

Decimal - Binary - Octal - Hex – ASCII
Conversion Chart

Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII
0	00000000	000	00	NUL	32	00100000	040	20	SP	64	01000000	100	40	@	96	01100000	140	60	`
1	00000001	001	01	SOH	33	00100001	041	21	!	65	01000001	101	41	A	97	01100001	141	61	a
2	00000010	002	02	STX	34	00100010	042	22	“	66	01000010	102	42	B	98	01100010	142	62	b
3	00000011	003	03	ETX	35	00100011	043	23	#	67	01000011	103	43	C	99	01100011	143	63	c
4	00000100	004	04	EOT	36	00100100	044	24	$	68	01000100	104	44	D	100	01100100	144	64	d
5	00000101	005	05	ENQ	37	00100101	045	25	%	69	01000101	105	45	E	101	01100101	145	65	e
6	00000110	006	06	ACK	38	00100110	046	26	&	70	01000110	106	46	F	102	01100110	146	66	f
7	00000111	007	07	BEL	39	00100111	047	27	‘	71	01000111	107	47	G	103	01100111	147	67	g
8	00001000	010	08	BS	40	00101000	050	28	(	72	01001000	110	48	H	104	01101000	150	68	h
9	00001001	011	09	HT	41	00101001	051	29	)	73	01001001	111	49	I	105	01101001	151	69	i
10	00001010	012	0A	LF	42	00101010	052	2A	*	74	01001010	112	4A	J	106	01101010	152	6A	j
11	00001011	013	0B	VT	43	00101011	053	2B	+	75	01001011	113	4B	K	107	01101011	153	6B	k
12	00001100	014	0C	FF	44	00101100	054	2C	,	76	01001100	114	4C	L	108	01101100	154	6C	l
13	00001101	015	0D	CR	45	00101101	055	2D	-	77	01001101	115	4D	M	109	01101101	155	6D	m
14	00001110	016	0E	SO	46	00101110	056	2E	.	78	01001110	116	4E	N	110	01101110	156	6E	n
15	00001111	017	0F	SI	47	00101111	057	2F	/	79	01001111	117	4F	O	111	01101111	157	6F	o
16	00010000	020	10	DLE	48	00110000	060	30	0	80	01010000	120	50	P	112	01110000	160	70	p
17	00010001	021	11	DC1	49	00110001	061	31	1	81	01010001	121	51	Q	113	01110001	161	71	q
18	00010010	022	12	DC2	50	00110010	062	32	2	82	01010010	122	52	R	114	01110010	162	72	r

HA: 1001000 1000001

4th digit of your student ID number	**CRC polynomial**	**Divisor**	**Remainder CRC**
Odd	$X^4 + X^3 + 1$	11001	**1011**
Even	$X^4 + X^2$	10100	1100

Note: Divisor is degree 4; need to append 4 0s to data for division.

```
4th digit of SID = odd
=> divisor = 11001

           111 0101011 0010
       -------------------
11001 |1001000 1000001 0000
       11001
       -----
        10110
        11001
        -----
         11110
         11001
         -----
           111 10
           110 01
           --- --
             1 1100
             1 1001
             - ----
               10100
               11001
               -----
                11011
                11001
                -----
                   10 000
                   11 001
                   -- ---
                    1 0010
                    1 1001
                    - ----
                     1011 <= remainder
Ln 15, Col 18    100%    Windows (CRLF)    UTF-8
```

```
4th digit of SID = even and => divisor = 10100
           101 1111010 0011
       -------------------
10100 |1001000 1000001 0000
       10100
       -----
         11000
         10100
         -----
          1100 1
          1010 0
          ---- -
           110 10
           101 00
           --- --
            11 100
            10 100
            -- ---
             1 0000
             1 0100
             - ----
                10000
                10100
                  ---
                  1001 0
                  1010 0
                  ---- -
                    11 000
                    10 100
                    -- ---
                     1 1000
                     1 0100
                     ------
                     1100 <= remainder
Ln 1, Col 1    100%    Windows (CRLF)    UTF-8
```

(d) What is the bit stream to be transmitted? (2%)

Odd	1001000 1000001 **1011**
Even	1001000 1000001 1100

(e) Can CRC be used for error correction in data transmission? Justify your answer. (4%)

No. The number of redundant bits is only used for error detection, but not for error correction. Therefore, Forward Error Control, e.g. Hamming code should be used or error correction in data transmission.

Question 4 (30%)

Suppose you send a 180 Mb file to your friend at 8 km away. The channel data rate is 50 Mbps and the propagation speed is 4×10^8 ms^{-1}. Stop-and-Wait ARQ is used in the transmission. Each frame carries 1700 bits of data plus 32 bits of overhead (header + trailer). ACK frame has a fixed size of 60 bits. The queuing and processing delay along the path can be neglected.

Note: Use 1K = 1000, 1M = 1000K and 1G = 1000M.

(a) How many data frames will be sent? What are the sizes of data frames (fully filled with data) and last data frame (partly filled with data)? (5%)

180M / 1700 = 105882.35 ~ 105883 frames
Size of data frames (fully filled with data) = 1700 (data) + 32 (overhead) = 1732 bits
Size of last data frame = 180M – (1700 x 105882) + 32 = 632 bits

(b) What is the time to confirm the first frame is correctly received by the receiver? (8%)

Tx of first frame = 1732 / 50M = 34.64 µs
Tp of first frame = 8k / (4 x 10^8) = 20 µs
Tx of ACK = 60 / 50M = 1.2 µs
Tp of ACK = 20 µs
Total time for first frame = 34.64 + 20 + 1.2 + **20** = **75.84**µs

(c) Continued from (b), how long does it take to complete the file transmission? (5%)

Tx of last frame = 632 / 50M = 12.6 µs
Time for last frame = 12.6 + 20 + 1.2 + 20 = 53.8 µs
Total time = **75.84** x 105882 + 53.8
= 8030090.88+53.8
= 8030144.68 µs
= **8.030144**s

(d) If any ACK frame is delayed, how the transmission can be resumed? (4%)

Receiver has no action. Sender cannot receive ACK. It waits until timeout and retransmits the corrupted frame.

(e) Assume there are 3 frames lost in every 200 frames sent, no frame lost if less than 200 frames sent, and the last frame is not lost. By using a timeout value of (10 * x) millisecond (ms), where x is the **4th digit** of your student ID number, for example, set x = 7 if the 4th digit is 7, set x = 10 if the 4th digit is 0. Calculate the total time required for the process to complete. (8%)

Since 'the last frame is not lost', 105882 frames are used to devise the lost frames.
In 105882 frames, there are ⌊105882/200⌋ x 3 = 1587 lost, and 82 frames remaining
In 1587 + 82 = 1669 frames, there are ⌊1669 /200⌋ x 3 = 24 lost, and 69 frames remaining
In 24 + 69 = 93 frames < 200 frames, no lost happens.

No. of frame lost = 1587 + 24 = 1611

Extra time for each lost = Tx + timeout = 34.6 μs + 10x ms = (34.6 + $10^4 x$) μs

Total time = (8030144+ 1611 x (34.6 + $10^4 x$)) μs

4th digit of SID	x	Timeout (10x ms)	Total time T(x) ms
0	10	100	169.1887844
1	1	10	24.1987844
2	2	20	40.3087844
3	3	30	56.4187844
4	4	40	72.5287844
5	5	50	88.6387844
6	6	60	104.7487844
7	7	70	120.8587844
8	8	80	136.9687844
9	9	90	153.0787844

- End of Assignment -