THE UNIVERSITY OF AUCKLAND

FIRST SEMESTER, 2005
Campus: City

COMPUTER SCIENCE

Data Communications Fundamentals

(Time allowed: ONE hour)

NOTE:

- Attempt *all* questions in the space provided.
  Extra space for answers is available on pages 9 and 10
- This midterm test will contribute 50% to your coursework mark,
  and 15% to your overall course mark.
  Indicated marks are out of a total of 60 marks (one per minute).
- To obtain full credit, your script must clearly show how you obtained a correct answer.
- *If you require additional information in order to answer a problem, you should briefly explain why this information is necessary and why your assumptions about the 'missing values' or 'missing facts' are reasonable.*
- The speed of light is approximately $3 \times 10^8\ m/s$

SURNAME:

FORENAME(S):

STUDENT ID:

Question No.	*Possible marks*	*Awarded marks*
1. Physical Communication	6	
2. Communications Models	6	
3. Data Framing and Protocols	6	
4. Data Framing and Protocols	10	
5. Protocols	8	
6. Error Detection and Correction	12	
7. LANs and Ethernet	12	
Total	60	

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1. **Physical Communication** [6 marks]

   Compute the channel capacity of a 10 kHz channel with a signal/noise ratio of 0 dB.

   Formula is: $C = Blog(1 + \frac{S}{N_{power}})$ [2 marks]

   Convert $\frac{S}{N_{dB}}$ to $\frac{S}{N_{power}}$,
   $10^{\frac{0}{10}} = 1$ [2 marks]

   $C = 10kHz.log_2(1 + 1)$
   $= 10kb/s$ *(must get units correct)* [2 marks]

2. **Communications Models** [6 marks]

   A spacecraft is sending pictures to Earth from a distance of $1AU(= 1.5 \times 10^8 m)$. The raw bitrate is $8Mb/s$. How many megabytes of data buffers should be installed in this spacecraft, so that it can make efficient use of its data link to Earth? Show your reasoning.

   Time to send one bit $= 1.5 \times 10^8 / 3 \times 10^8 = 0.5s$
   Round trip time $= 2 \times 0.5 = 1s$ [2 marks]

   Bits in flight (bandwidth-delay product) $= 8Mb/s \times 1s = 8Mb$
   $= 1MB$ [2 marks]

   Need enough buffer space for at least the bits in flight, so 1 MB would be enough; say 1 to 4 MB to be safe. *Need to make a brief written argument here!* [2 marks]

   Yes, we know that really, $1AU = 1.5 \times 10^1 1m$ *!*

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3. **Data Framing and Protocols** [6 marks]

Is a sliding-window protocol necessary, or would an ARQ protocol be sufficient, for the efficient use of a link with the following characteristics: raw bitrate $1\ Gb/s$, distance $1.5\ m$, packet size $1.25\ kB$? Show your reasoning.

Assume that propagation speed is $2 \times 10^8 m/s$ *need to state what's assumed for this!*
Then EITHER:
Bits on wire $= 10^9 \times 1.5m/2 \times 10^8$
$= 7.5b$ $\times 2$ for round trip $\rightarrow 15b$ [2 marks]

'Bits in flight' $\ll$ packet size (given as $1.25kb$ [2 marks]

OR
Round-trip time $= 2 \times 1.5/2 \times 10^8 = 15 \times 10^-9 = 15ns$ *[2 marks]*

Time to send packet $= 1.25b \times 10^3/10^9 b/s$
$= 10\mu s$, i.e. $\gg$ round-trip time *[2 marks]*

Since the round-trip time is much shorter than the time to send a packet, we'll get Acks or Naks back very quickly, therefore ARQ is sufficient. [2 marks]

Of course we could use sliding windows, but here that would simply be adding unnecessary complexity.

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4. **Data Framing and Protocols** [10 marks]

Text messages on cellphones are limited to about 200 characters in length, so you can't send a 1 kB message, but you might send five 200-byte text messages in sequence and ask the recipient to assemble these in order.

Discuss this situation briefly, making accurate use of the following terms: *packet, protocol, header, connectionless service, connection-oriented service.*

Our five *(or more)* text messages will behave like *packets* sent over a fixed link.

If somehow we were to set up a fixed path for them through the cellphone network, that would give us a *connection-oriented service,* and all our packets would arrive in the order that they were sent.

However, we can't do that, we just send each packet separately, so we have no guarantee that our packets will arrive in order. In other words, we have to use a *connectionless service.*

At the receiving cellphone, we need to know the order the packets were actually sent. To do this we decide on a *protocol*, which specifies the structure of the packets we send, i.e. what information besides the original message.

The extra information, such as a sequence number (to give us the packet order) and a length field (to tell us how many data bytes are in the packet) we will put into a *header,* at the front of each packet.

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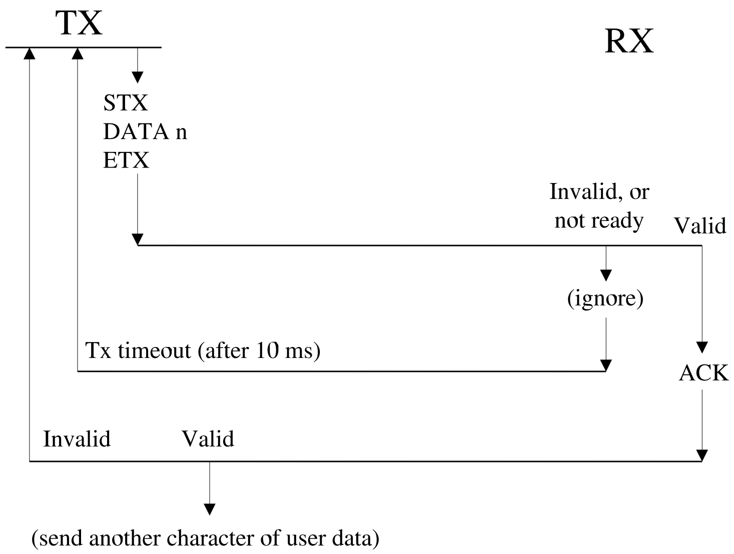
5. **Protocols** [8 marks]

Consider the following protocol for sending a stream of characters (user data) from a transmitter **Tx** to a receiver **Rx**. The stream of user data is broken up into a series of data packets. Each data packet carries one character of user data, framed by STX and ETX characters. The receiver's ACK packets are a single character.



In this protocol, when the transmitter Tx times out or receives an invalid packet, it will resend the previous packet.

Could this retransmission cause any problems for the user of this data link? Explain briefly.

Yes, it can cause (at least) two problems.

- An invalid packet received by TX may have been an ACK, but it will be (needlessly) resent.
- On high-latency links, TX can time out before a round trip – if that happens the packet will again be (needlessly) resent.

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6. **Error Detection and Correction** [12 marks]

(a) After a Cyclic Redundancy Check (CRC) is applied to a message and the message is transmitted, how does the receiver

i. Validate the message? [2 marks]

The receiver validates the message by using modulo 2 arithmetic to divide the message by the agreed upon generator polynomial (usually determined by the type of CRC used). If there is no remainder the message is correct. If there is a remainder an error occurred somewhere.

ii. Obtain the original message? [2 marks]

6b)If there is an error, (i.e. a remainder after performing the division from 6a) the original message cannot be obtained. Otherwise the original message is obtained by removing the last x bits from the message, where x typically is one less than the length of the generator polynomial
For example, if the generator polynomial was $x^3 + x^2 + x$ *(1110),*
we would remove the last 3 bits from the message.

(b) What information does the receiver require to validate and obtain the original message? [3 marks]

The generator polynomial, the received message and its attached CRC.

(c) In data communications, when a CRC algorithm is applied, what action does the receiver typically take if it determines the received message has an error somewhere? [2 marks]

The receiver discards the message and sends a request for a retransmission.

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(d) In data communications, give an example of a situation where you might use forward error correction. Give an example of a situation where you might use error detection. [3 marks]

> Forward error correction is used where it is difficult, or not possible to recover the original data, for example in data recording, deep space telemetry or reading off CDs. Error detection is typically used in all other situations, for example LANs.

7. **LANs and Ethernet** [12 marks]

(a) Explain the function of the following components. How do they differ from each other?

i. Hub [2 marks]

> A hub connects devices, or nodes on a network. It takes any incoming signals and repeats it to all other ports it is connected to. Essentially it is a multiport repeater. It typically does not perform any processing.

ii. Bridge [2 marks]

> A bridge connects network segments together and forwards packets between them. A bridge can filter traffic, i.e. if a node on segment A transmits a frame, the bridge can examine it and determine if is destined for segment B, and if so forward it, and if not drop the packet. Bridges are used to help reduce traffic congestion.

iii. Repeater [2 marks]

>)A repeater is used to extend the size of a LAN, by simply amplifying and regenerating the message. It does not analyse or process the message.

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(b) Explain how switched Ethernet works, and list three differences between switched Ethernet and a traditional Ethernet bus topology [6 marks]

Key differences between switched and traditional Ethernet (other differences may also be correct):

- Traditional Ethernet is half duplex, Switched Ethernet is full duplex
- Switched Ethernet is significantly faster than traditional Ethernet
- Switched Ethernet eliminates collision and CSMA/CD is no longer required unlike with traditional Ethernet
- The topology of switched Ethernet is more like a star

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SPARE PAGE FOR EXTRA ANSWERS

Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

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