THE UNIVERSITY OF AUCKLAND

SECOND SEMESTER, 2007
Campus: Tamaki

COMPUTER SCIENCE

Data Communications Fundamentals

(Time allowed: TWO hours)

NOTE:

- Attempt *all* questions. Calculators are NOT permitted.
- Write your answers in the space provided
  (extra space for answers is available on page **??**).
- No marks will be awarded if you merely state a correct answer. To obtain full credit, your script must clearly explain *why* your answer is correct.
- If you require additional information in order to answer a question, you should make a reasonable assumption as required for your answer, and you should explain your assumption on your script.

Surname: ..... Forenames: .....

Student ID: .....

Departmental Use Only					
Question	Marks allocated	Marks gained	Question	Marks allocated	Marks gained
1	10		6	10	
2	10		7	10	
3	8		8	10	
4	10		9	12	
5	10		10	10	
Total			Total	100	

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1. **Error Correction** [10 marks]

   (a) What is the minimum number of redundancy bits r required to correct n bits of data? [3 marks]

   (b) What is the minimum number of redundancy bits r required to correct $n = 10$ bits of data? [2 marks]

   (c) What is the maximum number n of bits of data that can be corrected with r redundancy bits? [3 marks]

   (d) What is the maximum number n of bits of data that can be corrected with $r = 4$ redundancy bits? [2 marks]

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2. **Prefix Codes** [10 marks]

(a) What is a prefix code? [3 marks]

b) State Kraft's theorem. [3 marks]

c) Can you construct a prefix binary code for which the codewords lengths are exactly 2, 1, 2, 133333 ? Justify your answer. [4 marks]

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3. **Signals and Noise** [8 marks]

(a) The following terms apply to a communications channel. Define each, and state its units:

i. Signal-to-Noise ratio, (S/N) [2 marks]

ii. Bit Rate [2 marks]

iii. Bandwidth [2 marks]

(b) What is the relation between bit rate and S/N in a noisy transmission? [2 marks]

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4. **Sliding Window protocols** [10 marks]

(a) Explain how a *sliding window* with n frames is used to transmit a stream of bytes using the simplest of the sliding window protocols, *go-back-n.* [3 marks]

(b) How does *go-back-n* handle frames that are lost in transit from sender to receiver? From receiver to sender? [3 marks]

(c) If we added the ability to ACK selected frames to 'go-back-n,' how would you expect the transmission performance to change? [4 marks]

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5. **Ethernet LANs** [10 marks]
This question refers to "classic" contention-bus Ethernet (10Base2) and *not* to switch-based Ethernet (10BaseT, etc.)

(a) Ethernet is a CSMA/CD protocol, in which hosts wait until the medium is idle before sending a frame. How can a collision between two packets occur? [3 marks]

(b) Briefly describe the algorithm that an Ethernet host uses to recover from a collision. [3 marks]

(c) What is the minimum size of an Ethernet packet? Explain how this minimum size is related to an Ethernet segment's collision behaviour. [4 marks]

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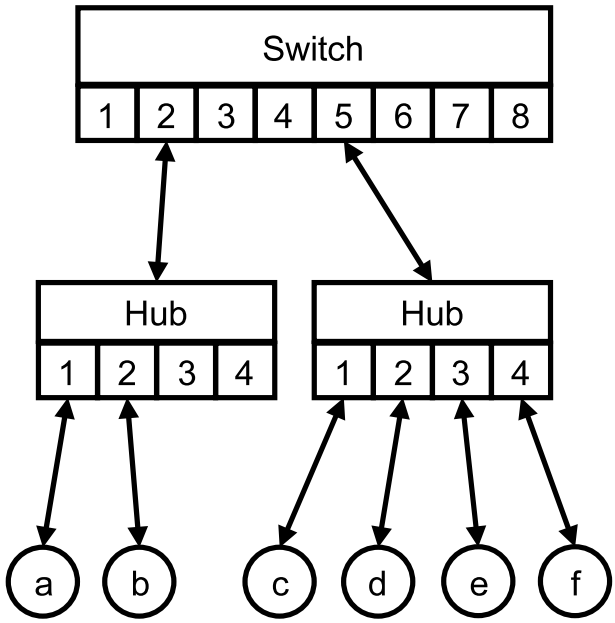
6. **Switches and Hubs** [10 marks]
The following questions refer to the network shown below. This network has one switch, two hubs, and six stations. You should assume the switch uses the "transparent" routing procedure which was described in the lecture slides.



(a) Assume the forwarding database of the Switch is empty, immediately before any frames are sent. Then station **a** sends a frame to station **b**, and station **c** sends a frame to station **d**. What is the state of the forwarding database, immediately after both of these frames have been delivered to their destination? [3 marks]

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(b) Assume that an attacker Trudy has gained control of station **c**. This station is in an area that is accessible to the general public, and is not carefully monitored. Would Trudy be able to get a complete copy of the payroll data being printed by workstation **a** to printer **b** (also in the Human Resources department). Explain your answer briefly, taking care to describe any important assumptions you make about network administration. [3 marks]

(c) Would your answer to the preceding question change if the switch (and all NICs) were compliant with the 802.1Q VLAN standard? You should assume that the network is properly administered so that it is secure against the threat of eavesdropping attacks (by attackers such as Trudy) from station **c**, and you should describe these administrative precautions. [4 marks]

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7. **Secure Communications** [10 marks]

The following questions refer to the (non-standard) protocol described below.

M1. Client to server: $S_p(U, C_p)$

M2. Server to client: $CA_s(S, S_p)$

M3. Client to server: $S_p(U)$

In this protocol, C_p and C_s are the client's public and secret keys; S_p and S_s are the server's public and secret keys; CA_p and CA_s are a certificate authority's public and secret keys; U is the client's username; S is the server's URL address. You should assume that both the client and the server know the value of CA_p before the protocol starts.

(a) Has the client identified themself to the server? For full credit, your answer should show how a computer named "Alice" would use this protocol to communicate with a server computer named "Bob". You should clearly indicate the step in the protocol where Alice first identified herself. [4 marks]

(b) Has the client authenticated itself to the server? For full credit, your answer should explain how a server "Bob" could determine whether or not some intruder (perhaps "Trudy") is impersonating a legitimate client computer "Alice" in step M1 or in step M3. You should assume that Trudy is able to attack the communication link (with interceptions, modifications, interruptions, and fabrications) but she doesn't know Alice's secret key. [3 marks]

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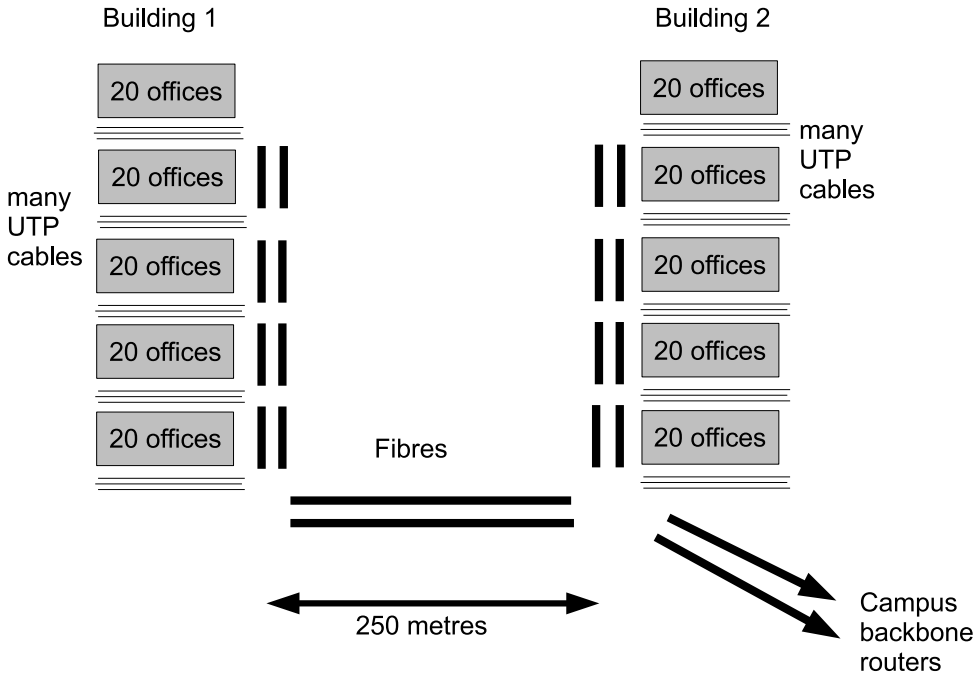
(c) Has the server proved its identity to the client? For full credit, your answer should explain how a client "Alice" could determine whether or not some intruded (perhaps "Trudy") is impersonating a legitimate server computer "Bob" in step M2. You should assume that Trudy is able to attack the link but doesn't know Bob's secret key. [3 marks]

8. **Switches and Routers** [10 marks]

Imagine you are designing a network for two separate departments. The people are mixed together in two office buildings 250 metres apart. Each building has 20 offices on each of 5 floors. It was decided to use Ethernet instead of wireless, and each office needs two Ethernet connections. Therefore 40 connections are needed on each floor of each building (400 connections in total).

There are plenty of UTP cables on each floor but only a few optical fibres running up and down and between the two buildings. One of the buildings has optical fibres connected to a large campus backbone.



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The devices available to you are

- Ethernet switches with 64 UTP 10/100 Mb/s Ethernet ports.
  Each switch also has two 1 Gb/s optical fibre ports.
  All ports can support VLANs.
- Routers with two UTP ports and two optical fibre ports.
  All ports can support VLANs.
  The router software can support RIP, OSPF, BGP4 and DHCP relaying if required.

(a) How many switches will you need on each floor? Why? [2 marks]

(b) The two departments insist on complete privacy from each other, but the staff are mixed up in both buildings. How will you solve that? Will you need more switches? [2 marks]

(c) Will you need routers on every floor, or in both buildings, or in only one building? Explain your answer. (It may help you if you mark the switches and router(s) on the diagram.) [2 marks]

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(d) The router or routers will need to connect to the campus backbone. For each of the following, will you switch it on or off? Give reasons for your choices. [2 marks]

i. RIP

ii. OSPF

iii. BGP4

iv. DHCP Relay

(e) Would you have to change anything to support IPv6 as well as IPv4? If so, give details. [2 marks]

9. **Transport Protocols** [12 marks]

(a) State three problems that are solved by TCP but not solved by UDP. [3 marks]

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(b) Give three examples of protocols that will work properly over UDP. [3 marks]

(c) Describe briefly how TCP implements flow control. [2 marks]

(d) What happens in a TCP session if the round trip time suddenly doubles? [2 marks]

(e) What happens in a TCP session if four or five consecutive packets are discarded in the middle of the network? [2 marks]

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10. **Internet sockets and applications** [10 marks]

(a) What is the purpose of the socket programming interface? [2 marks]

(b) Does a UDP socket allow the detection of packets with single bit errors? Explain your answer. [2 marks]

(c) Is it safe for an application to send and receive text passwords directly through a TCP socket? Explain your answer. If you think it is unsafe, briefly describe a safe solution. [3 marks]

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(d) What are the main differences between a peer-to-peer protocol such as Skype and a client-server protocol such as FTP or HTTP? Include simple diagrams in your answer. [3 marks]

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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.