# THE UNIVERSITY OF AUCKLAND

**FIRST SEMESTER, 2006**
**Campus: City**

## COMPUTER SCIENCE

### Data Communications Fundamentals

**(Time allowed: TWO hours)**

**NOTE:**

- Attempt all questions. Calculators are NOT permitted.
- Marks for each question are as shown.
- Write your answers in the spaces provided (extra pages are provided at the end of this paper)
- 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 are not given enough information to answer a question, you should make a reasonable assumption as required to answer the question, 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 | 16 | |
| 2 | 12 | | 7 | 8 | |
| 3 | 6 | | 8 | 14 | |
| 4 | 12 | | 9 | 14 | |
| 5 | 14 | | 10 | 14 | |
| | | | Total | 120 | |

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1. **Transmission Media** [10 marks]

Briefly describe (with the help of simple diagrams) each of the following:

(a) Category 5 UTP cable [2 marks]

(b) Single-mode Optical Fibre [2 marks]

(c) Multimode Optical Fibre [2 marks]

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(d) In what kind of network situation would each of the above media be most suitable? Briefly explain your answer. [4 marks]

2. **Data Compression** [12 marks]

Construct a Huffman code for the following alphabet, using it in the remainder of this question:

| symbol | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| probability | 0.20 | 0.20 | 0.16 | 0.16 | 0.12 | 0.10 | 0.06 |

(a) Generate the code so that the shortest codeword starts with 1 and the longest with 0, with the leading bits corresponding to links near the root. [6 marks]

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(b) Encode the symbol string “ADFCBDA” , giving the resultant bit stream. Calculate its average codeword length (bits per symbol). *(You may show an answer like* $3\frac{1}{7}$*).* [2 marks]

(c) Decode the bit sequence “1001000000001001011,” giving its symbol sequence and average codeword length. [2 marks]

(d) Comment on and explain any differences between the codeword lengths from parts (b) and (c) above. [2 marks]

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3. **Ethernet LANs** This question refers to "classic" contention-bus Ethernet (10BASE5 or 10BASE2) and *not* to switch-based Ethernet (10BASE-T, etc). [6 marks]

   (a) A local-area network allows many stations to share one communication medium, but usually only one station can transmit at any one instant. For example, in some networks a station must wait for a "token" before being allowed to transmit. Explain how an Ethernet station first decides that it can try to transmit over the network and then confirms that it has sole access to the network. *(Ignore any actions after the first attempt).* [3 marks]

   (b) You hear that "Ethernet is inefficient because so much data is lost due to collisions." Comment upon this statement, explaining why it is true or false. [3 marks]

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4. **Error Detection** [12 marks]

The bit string **B**=011101101 is to be protected by a CRC checksum with generator polynomial $x^4 + x^2 + 1$, (i.e. the generator bit vector is 10101).

(a) Calculate the CRC checksum for **B** and hence the final transmitted codeword. Show your working. *(Hint: the division should give the quotient* 011010101*).* [6 marks]

(b) Now assume that **B** gets corrupted in transit so that the received codeword becomes 011001001*x*. . . *x* (two bit errors: on the 4th and 7th bits), where *x*. . . *x* is the checksum from part (a) and has no errors. Show by explanation and calculation how the receiver can detect that there is a problem. Show your working. *(Hint: the quotient should now be* 011111000*).* [6 marks]

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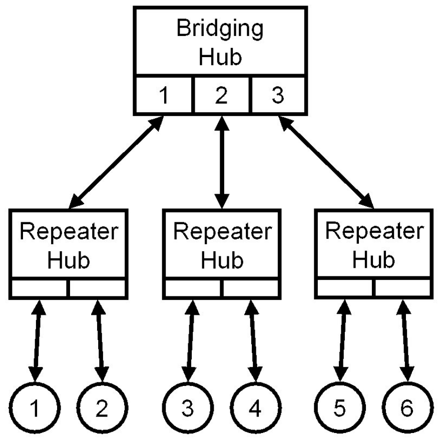
5. **Switches and Hubs** [14 marks]

The following questions refer to the network shown below. This network has one bridging hub, three repeating hubs, and six stations. You should assume the bridging hub uses the "transparent hub" routing procedure which was described in the lecture slides and explored in Assignment 3.




(a) Assume the forwarding database of the Bridging Hub is empty, immediately before any frames are sent. Then station 1 sends a frame to station 4, and station 5 sends a frame to station 6. What is the state of the forwarding database, immediately after these frames have been processed by the bridging hub? [6 marks]

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(b) Assume that all NICs are compliant with the 802.1Q VLAN standard, and that the forwarding database is currently empty. Also assume that these NICs are statically configured, so that stations 1, 2 and 4 are on VLAN ID = 1; and so that station 5 and 6 are on VLAN ID = 2. Station 3 is under the control of an attacker, Trudy, who is attempting to eavesdrop on communications in this system. Would Trudy be able to eavesdrop on a series of frames sent from station 1 to station 4, and also on a series of frames sent from station 5 to station 6? [4 marks]

- *Recall that 802.1Q frames have the following format: DA(6B), SA(6B), VPI(2B), PRI(3b), CFI(1b), VLAN ID(12b), LENGTH(2B), DATA(up to 1500B), PAD(if LENGTH < 64), FCS(4B). VPI is the "VLAN protocol ID" field, with hex value 0x8100; PRI is the priority field (currently unused); CFI is the canonical format identifier, used for compatibility with token rings; and VLAN ID is used to identify the VLAN to which the frame belongs.*
- *Frames in 802.3 have the following format: DA(6B), SA(6B), TYPE/LENGTH(2B), DATA(up to 1500B), PAD(if LENGTH < 64), FCS(4B). When the TYPE/LENGTH field has a decimal value greater than 1500, it is interpreted as a TYPE (and the length of the packet must be encoded elsewhere), otherwise this field is interpreted as a LENGTH.*

(c) Assume that the Bridging Hub and Repeating Hubs are replaced by a 6-port VLAN Bridge that is compliant with the 802.1Q standard. This bridge is transparent, that is, it populates its forwarding database in exactly the same way as a Bridging Hub, but with just one change: its flood frames are broadcast only within a single VLAN ID. Would this change increase the security of the system against eavesdropping by Trudy on Station 3, if the VLAN IDs are assigned as in the previous question? [4 marks]

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6. **Secure Communications** [16 marks]

The following questions refer to the protocol described below.

M1. Client to server: $S_p(U, C_p, t_c)$
M2. Server to client: $C_p(U, t_c, t_s)$
M3. Client to server: $S_p(U, t_s)$

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; $U$ is the client's username; $t_c$ and $t_s$ are the client and server's timestamps.

(a) Has the client identified itself 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 field(s) in the messages where Alice has identified herself. [3 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. [4 marks]

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(c) Has the server proved its identity to the client? [3 marks]

(d) Assume that an intruder “Trudy” can eavesdrop on all messages exchanged between a legitimate client computer “Alice” and a server “Bob.” Also assume that Trudy can inject messages into the communication channel. Propose a way in which Alice could send a request R for service to Bob, without allowing Trudy to request a similar service R’ fraudulently from Bob. (For example, R might be “move $100 from my bank account into Charles’ bank account”, and R’ might be “move $100 from my bank account into Trudy’s bank account”). [3 marks]

(e) Now assume that the computer named “Alice” is on a smart-card which is owned by a person named “Al.” Also assume that the server named “Bob” is an online portal for Al’s bank, the “BNZ.” Can Al prove his identity to the BNZ, and can the BNZ prove its identity to Al, by running this protocol? [3 marks]

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7. **Network Address Translation** [8 marks]

(a) What is meant by *Network Address Translation (NAT)?* [4 marks]

(b) Why might a network administrator decide to deploy a network address translator? [2 marks]

(c) What effect should the increasing use of IPv6 have on the demand for network address translators? [2 marks]

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8. **Network Routing** [14 marks]

(a) Explain briefly what is meant by the terms

i. *Distance Vector* routing [2 marks]

ii. *Link State* routing? [2 marks]

(b) What advantage(s) does *Link State routing* have over *Distance Vector routing?* [2 marks]

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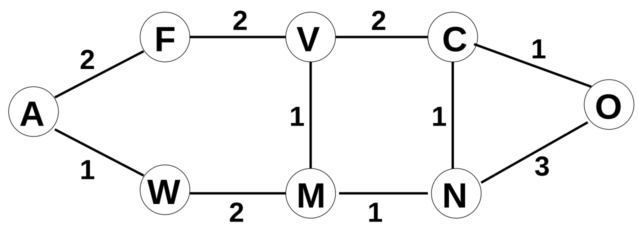
(c) Use Dijkstra's algorithm to calculate the shortest path from node A to node O in the following network, assuming that each link has the cost shown beside it.

You may present your answer in any appropriate manner, however it is enough to indicate the path added at each stage and its cost to the root. For example, if routing were from C, acceptable answers for the first stages might be

connect V to C, cost to C = 2,
connect M to V, cost to C = 3, and so on. [4 marks]




(d) Describe the sequence of events that would happen if the link between nodes W and M were to fail. Once the network had stabilised, what difference would users at node O observe? [4 marks]

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9. **Transport Protocols** [14 marks]

(a) UDP and TCP both use *ports.* Explain briefly what ports are, and how they are used by these protocols. Name one other protocol that does *not* use ports. [5 marks]

(b) TCP sends *segments* of data. How are those data segments identified? [2 marks]

(c) A TCP sender transmits five segments to a receiver, each containing 1000 bytes of data. Assuming that they all arrive at the TCP receiver correctly, how does the receiver respond to them? [3 marks]

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(d) Now assume that segment 2 (i.e. the second one sent) arrives after segment 5. How will the receiver respond to the incoming segments, so as to deliver their data bytes to the receiving application in their correct order? [4 marks]

10. **Domain Name System** [14 marks]

(a) What are Internet *domains*, and how are they organised within the Internet's *Domain Name Space?* [2 marks]

(b) What is meant by the term *Fully Qualified Domain Name (FQDN)?* [2 marks]

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(c) What information is carried in a type-A DNS Resource Record? [2 marks]

(d) Explain briefly how a domain name is looked up (i.e. *resolved*), so as to find its IP address? [5 marks]

(e) Is there any difference between resolving an IPv6 FQDN as compared with resolving an IPv4 FQDN? IF so, briefly explain that difference. [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.

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