UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2004

BEng Honours Degree in Computing Part II
MEng Honours Degrees in Computing Part II
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute

PAPER C212

NETWORKS AND COMMUNICATIONS

Wednesday 5 May 2004, 10:00
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators required

Equations that *might* be used in answering the questions

$$\log_2 x = \frac{\log_{10} x}{\log_{10} 2}$$

b Average number of bits of information each symbol represents
P_i Probability of symbol number i occurring
n Total number of symbols

$$b = -\sum_{i=1}^{n} P_i \log_2 P_i$$

C Bit rate
B Bandwidth in Hz
L Number of distinct signal levels
$\frac{S}{N}$ Signal to noise ratio

$$C = 2B \log_2 L$$

$$C = B \log_2 \left(1 + \frac{S}{N}\right)$$

The following are equations for M/M/1 queues.

m Number of arrivals expected in a period of time t
$P_{n,m}$ Probability of n arrivals if m are expected
λ Mean arrival rate at a queue
μ Mean serving rate of a queue
l Mean length of a queue
d Mean delay in the system
P_k Probability that a k size buffer blocks

$$P_{n,m} = \frac{m^n}{n!} e^{-m}$$

$$m = t\lambda$$

$$\rho = \frac{\lambda}{\mu}$$

$$l = \frac{\rho}{1-\rho}$$

$$d = \frac{1}{\mu - \lambda}$$

$$P_k = \frac{(1-\rho)\rho^k}{1-\rho^{k+1}}$$

1 a Which layer of the OSI model would you *most* associate with each of the following:

i) Coaxial cable

ii) IP fragmentation bit

iii) ICMP

iv) HTTP

v) Idle Request protocols

vi) Run length encoding

vii) Synchronisation points in CO communication

viii) TCP

b The following lists an XML file, and a table listing Abstract Syntax Notation 1 (ASN1) keywords and their ISO8825 tag encoding (in hex).

```
⟨binary_compound⟩
  ⟨atom⟩
    ⟨element⟩Na⟨/element⟩
    ⟨atomic_weight⟩2⟨/atomic_weight⟩
  ⟨/atom⟩
  ⟨atom⟩
    ⟨element⟩Cl⟨/element⟩
    ⟨atomic_weight⟩12⟨/atomic_weight⟩
  ⟨/atom⟩
⟨/binary_compound⟩
```

ISO8825 tag	ASN primitive	semantics
1	BOOLEAN	TRUE or FALSE
2	INTEGER	integer, big endian encoding
3	BITSTRING	list of bits
4	OCTETSTRING	list of bytes
16	IA5STRING	list of characters in ASCII
30	SEQUENCE	an ordered list of types

i) Suggest a suitable ASN1 definition for the XML data, making reasonable assumptions about the data types of the XML information.

ii) Give the ISO8825 transfer data of the XML data, as a sequence of hexadecimal bytes. (Note ASCII hex code for 'A' is 41, and for 'a' is 61).

c A Web browsing session visits the following URLs in order:

http://www.doc.ic.ac.uk/index.html
ftp://www.doc.ic.ac.uk/README
http://www.doc.ic.ac.uk:8080/index.html
http://www.doc.ic.ac.uk/courses/index.html
http://www.ic.ac.uk:8081/index.html

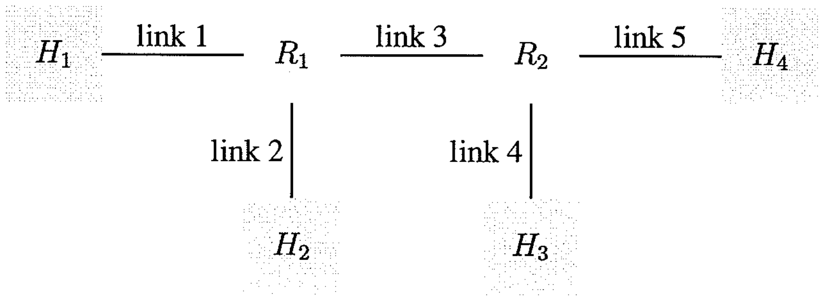
i) Briefly explain how the destination socket is formed by the browser for the first and third URL in the list.

ii) Briefly explain how many DNS requests are required during the session.

iii) Why might the web page returned for the first URL appear in log files as coming from linnet.doc.ic.ac.uk?

iv) Briefly explain which two of the listed URLs a firewall would not be able to differentiate between.

d Copy and complete the routing tables, to show their content after three channels are set up, first between H_1 and H_4, then H_1 and H_3, and finally H_4 and H_3. You must number VCIs starting from one.

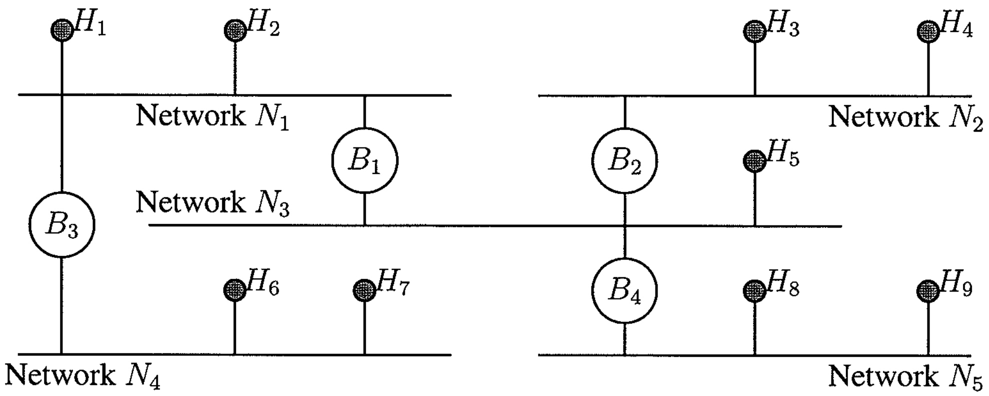


R_1			
channel		channel	
link	VCI	link	VCI

R_2			
channel		channel	
link	VCI	link	VCI

The four parts carry, respectively, 20%, 30%, 30%, and 20% of the marks.

2 a In the network below, the routing tables of bridges B_1 to B_4 are initially empty.



Assuming that the bridges execute the *backwards learning algorithm* for routing packets:

i) When H_5 sends a packet to H_3, which networks will it be passed onto?

ii) If H_3 then sends a packet to H_5, which networks will it be passed onto?

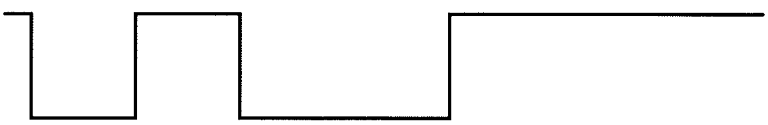
iii) If H_1 then sends a packet to H_3, which networks will it be passed onto?

iv) What problem would arise if a bridge between N_4 and N_5 was introduced, and how does a flood routing algorithm avoid the problem?

v) In practice, bridges periodically flush their learnt routing tables. Why is this so?

Briefly justify each of your answers.

b The following signal represents a seven bit codeword in NRZI.



i) Copy the diagram and annotate it with the bit borders using dash lines. Determine what the seven bit codeword is in binary.

ii) If one of the seven bits is to be used for parity, briefly explain which of even or odd parity would be the better choice.

iii) For your answers to (i) and (ii), does your codeword pass or fail the parity check?

c The following table contains information about a communications system which conforms to the OSI model. The PDUs used in the system are all of a fixed size in each layer.

	Size in Bytes		
Layer	ICI	PCI	SDU
Transport	4	32	32000
Network	12	12	1000
Data Link	16	60	5000

i) Briefly explain what information in the table does not directly affect the amount of data sent over the network.

ii) What process must be used to send a T-PDU over the network layer? How many N-PDUs are required to send one T-PDU?

iii) If we wish to minimise usage of bandwidth and the number of PDUs processed at the receiver, what process must be employed in the data link layer when sending an N-PDU? Using this process, how many D-PDUs are required to send one T-PDU?

d A multiplexer using STDM serves 16 input channels, and combines them on a 9,600bs^{-1} multiplexed channel. If each terminal generates on average 50 packets per minute, and each packet is on average 640 bits long, and both of these properties are exponentially distributed, what would be the average delay a packet suffers in the multiplexer?

The four parts carry, respectively, 30%, 25%, 25%, and 20% of the marks.

3 a Calculate the Hamming codeword for the data 11111111_2, using even parity for the calculation of the parity bits.

b If 16 level signaling is being used over a 9kHz bandwidth channel, what is the maximum bit rate that can be obtained over the channel? Briefly explain why the use of more signalling levels to increase the bit rate is limited in its effectiveness by the presence of noise in the channel. What is the maximum signal to noise ratio in dB that could be present on the 9kHz bandwidth channel before the bit rate you have already calculated would be reduced?

c The following gives the results of using the ping command, from a host connected to the Internet via an ISP in London. The host 194.159.254.213 is a server at the same site as where the dial-up connection is served, host 199.222.69.151 is in New York.

```
dialuphost$ ping 194.159.254.213
PING 194.159.254.213 (194.159.254.213) from 194.222.1.1
64 bytes from 194.159.254.213: icmp_seq=0 ttl=252 time=74.5 ms
64 bytes from 194.159.254.213: icmp_seq=1 ttl=252 time=70.6 ms
64 bytes from 194.159.254.213: icmp_seq=2 ttl=252 time=70.6 ms
64 bytes from 194.159.254.213: icmp_seq=3 ttl=252 time=90.6 ms
64 bytes from 194.159.254.213: icmp_seq=4 ttl=252 time=70.6 ms

dialuphost$ ping 199.222.69.151
PING 199.222.69.151 (199.222.69.151) from 194.222.1.1
64 bytes from 199.222.69.151: icmp_seq=0 ttl=242 time=168.0 ms
64 bytes from 199.222.69.151: icmp_seq=1 ttl=242 time=150.2 ms
64 bytes from 199.222.69.151: icmp_seq=4 ttl=242 time=150.2 ms
```

Briefly explain (giving the most likely reason if alternatives exist) the following:

i) Why does the ping session to New York lose packets, but the ping to the London host does not?

ii) Why does a telnet session to New York, running at the same time as the ping to New York, appear not to lose any characters?

iii) What would you expect as a user of the telnet session to New York to notice about the network performance, when compared to that of a telnet session in a LAN?

iv) What does the TTL figure indicate, and why does it differ for the two ping command invocations?

d i) What is the consequence of 802.3 Ethernet's usage of CSMA/CD for MAC on the relationship between minimum packet size and maximum network length?

ii) In an Ethernet system based on CSMA/CD, where the signal propagation speed is $200 \times 10^6 ms^{-1}$, and no allowance is made for having repeaters in the network, calculate the maximum network length, assuming the minimum packet size is 64 bytes, and that the network operates at $10Mbs^{-1}$.

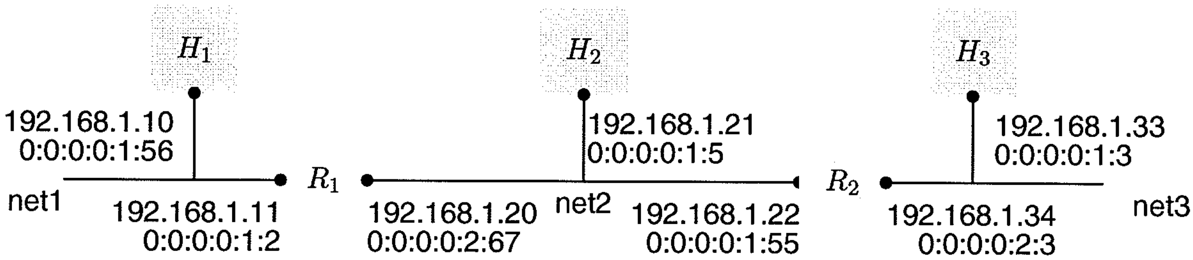
iii) What would the speed in (ii) be if the speed were instead $100Mbs^{-1}$?

iv) In Gigabit Ethernet, briefly describe the optional alternative provided to use instead of CSMA/CD.

v) Briefly describe one option used in Gigabit Ethernet that improves the maximum length of the network allowed whilst *maintaining* the use of CSMA/CD.

The four parts carry, respectively, 20%, 20%, 30%, and 30% of the marks.

4 a The diagram below illustrates an IP Class C network operating over Ethernet hardware, where each network interface is labelled with its IP address and IEEE MAC address. The network divided into subnets with a netmask of 255.255.255.240.



i) Explain how many additional hosts can be put on net2.

ii) Compute the broadcast address for net2.

iii) Compute which network IP address 192.168.1.18 belongs to.

iv) If H_1 sends a ping packet to H_2, copy and complete the table below to show all Ethernet frames that are sent by all hosts and routers in the process of transmitting the ping packet from H_1 to H_2 (you do not need to show the frames involved in the reply ping packet).

From	Message Sent	Source IP	Source MAC	Destination IP	Destination MAC
⋮					

v) If the netmask on H_1 were set to 255.255.255.224, will a ping from H_1 to H_2 still work? Briefly justify your answer.

vi) If the netmask on H_1 were set to 255.255.255.224, will a ping from H_1 to H_3 still work? Briefly justify your answer.

vii) Suppose R_1 and R_2 were to act as a firewalls, such that H_1 was to be able to access host H_2 as a proxy web server, and where H_2 forwards requests onto actual web server H_3. Outline how you would configure R_1 and R_2 to make H_3 secure against direct interference from H_1 and to make H_2 as secure as is possible.

b You are to choose between two communication systems to operate over a 50km 1Mbs^{-1} leased line between two offices, with signal propagation speeds of $200 \times 10^6 ms^{-1}$. One of the systems is based on Idle RQ, and the other on Continuous RQ with Go-Back-N. The system based on Idle RQ is cheaper. The traffic over the line is found to consist of 250-byte I-frames.

i) Determine the data transfer rate offered by Idle RQ if no errors occur on the leased line.

ii) Determine the data transfer rate offered by Go-Back-N if no errors occur on the leased line.

iii) Determine which (if either) of the two systems you would choose if you are to maintain an application data transfer rate of at least 750kbs^{-1}, and you are expecting a BER of 2×10^{-5}

c A symbol set comprising of $\{A, B, C, D, E\}$ has the symbol probabilities $\{0.3, 0.3, 0.2, 0.15, 0.05\}$. Derive a Huffman coding for the symbol set, and calculate the average number of bits used per symbol.

The three parts carry, respectively, 50%, 30%, and 20% of the marks.