UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2000

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

Friday 19 May 2000, 14:00
Duration: 90 minutes
(Reading time 5 minutes)

Answer THREE questions

Paper contains 4 questions

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 queueing theory with M/M/1 queues and Poisson distributions.

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

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

$$m = t\lambda$$

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

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

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

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

1a Name which layer in the OSI model would be most closely associated with the following:

i) Conversion between connectionless and connection oriented communication
ii) Bipolar encoding of information
iii) The Simple Mail Transport Protocol
iv) Continuous RQ protocols
v) Distance vector routing tables
vi) RSA encryption
vii) Synchronisation points

b You have been asked to install an IPv4 class B network, which has been assigned a network address 144.211.0.0. The network is spread over thirty offices, the largest having six hundred computers, and each office operating as a separate subnet.

i) Compute what would be a suitable subnet mask.
ii) State the maximum number of machines that would be allowed at each site.
iii) For your answer to (i), group the following machines by which are on the same subnet.

A. 144.211.201.209
B. 144.211.203.207
C. 144.211.205.205
D. 144.211.207.203
E. 144.211.209.201

c A symbol set comprising of $\{A, B, C, D, E\}$ has the symbol probabilities $\{0.3, 0.3, 0.2, 0.15, 0.05\}$.

i) Calculate the theoretical minimum number of bits per symbol necessary for encoding this symbol set.
ii) Derive a Huffman coding for the symbol set, and calculate the average number of bits used per symbol.
iii) Briefly explain why the answers to (i) and (ii) differ, yet Huffman coding is known to be the most efficient single symbol per codeword system.

The parts carry, respectively, 21%, 40%, and 39% of the marks

2a Encode the bit pattern 1000111_2 in each of the named schemes below:

i) Asynchronous transmission with one start bit and two stop bits

ii) Manchester synchronous transmission

iii) Binary amplitude modulation

Give a brief argument as to which you consider would make most efficient use of the available bandwidth in the channel.

b Distinguish the roles of *repeater*, *bridge* and *router* in the internetworking of LANs. What advantages does a *bridge* have over a *repeater*?

The table below shows average traffic rates on a single LAN between five hosts, where the LAN is currently running at its maximum capacity. Give a division of the LAN into two subnets separated by a bridge which minimises the total load on both subnets. Clearly state in your answer what are the two groups of hosts, and what is the load on each subset, as a percentage of the maximum load.

		To				
		H_1	H_2	H_3	H_4	H_5
From	H_1	–	18	398	47	737
	H_2	6	–	4	943	50
	H_3	690	1	–	12	50
	H_4	42	872	17	–	2
	H_5	500	72	644	0	–

c In a public key encryption system you have the following functions available:

$E(K, M)$ returns ciphertext version of M encrypted by key K

$D(K, M)$ returns a plaintext version of M decrypted by key K

$C(M)$ returns a CRC checksum for the message M

You are on host S_1, with secret key/public key combination K_1/K_1^{-1}, and wish to communicate with S_2, which has keys K_2/K_2^{-1}. Each host has the other's public key. Outline how the above functions are used at S_1 and S_2 to:

i) Send a confidential authenticated message M_x to S_2

ii) Send an authenticated message M_y to S_2, minimising the computation costs at each site.

The parts carry, respectively, 34%, 42% and 24% of the marks

3a You are to install a new leased line for the web site of a company, where the packets coming from the web server in response to Internet user requests are found at present to obey an exponential probability distribution, with a mean number of 75 packets per second, each 200 bytes long. The size of user requests is negligible. You may choose between 64k, 128k, 256k, and 512kbs^{-1} links for the web server, the cost of the link being proportional to its speed. The multiplexor you are using has a buffer which holds 8 packets. If you are told that it is necessary to provide a reliable service, but also not to waste money, determine which speed of link should be used.

b 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):

i) Why does the ping session to New York loose 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 loose any characters?

iii) What would you expect as a user of the telnet session to New York to notice about the network performance?

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

c 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, if the minimum packet size is kept to 64 bytes, and the network operates at:

A. $10 Mbs^{-1}$

B. $100 Mbs^{-1}$

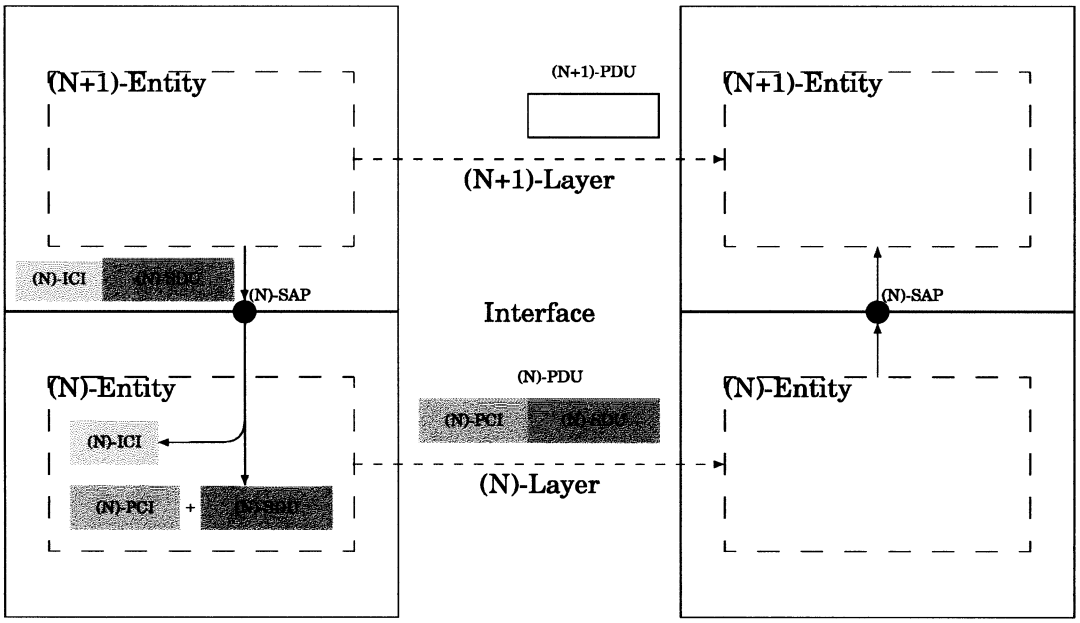
iii) In Gigabit Ethernet, briefly describe the option provided to use instead of CSMA/CD.

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

The three parts carry, respectively, 35%, 32%, and 33% of the marks

4a The following table contains information extracted from the data sheets of a certain communications system which conforms to the OSI model, the method by which the different fields are used in the OSI model being summarised in the figure below. 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) 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?

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 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 that the browser sends its requests to are formed 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 from the URL appear in log files as coming from fox.doc.ic.ac.uk?

The parts carry, respectively, 34%, 38%, and 28% of the marks