UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2001

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

Monday 14 May 2001, 14:00
Duration: 90 minutes
(Reading time 5 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 queuing 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 each of the following:

i) Conversion between connectionless and connection oriented communication
ii) Login and long term association of the communication
iii) Distance vector routing tables
iv) The HTTP protocol
v) Twisted pair cables
vi) ISO8825 transfer syntax
vii) Sliding windows

b You have been asked to install an IPv4 class B network, which has been assigned a network address 137.73.0.0. The network is spread over nine departments, the largest having two thousand computers, and each department operating as a separate subnet. You have to determine a number of settings for the network, all on which must be given in the standard decimal dotted notation for IPv4 addresses.

i) Compute what would be the possible subnet masks for the network.
ii) Briefly justify which of the subnet masks found in (i) is best to use, if you are to maximise scope for expansion.
iii) State the maximum number of machines that would be allowed at each site for your choice in (ii).
iv) Assuming your answer from (ii) is used, what address would you use to broadcast to all machines on the subnet containing 137.73.128.1
v) Briefly outline and justify what would be the most efficient method for twenty machines in three departments to broadcast to each other only. You answer should include a illustration of which IP addresses might be used.

c A set of hosts has keys distributed as shown below, with K_n^{-1} being the congruent key to K_n, such that $M = D(K_n^{-1}, E(K_n, M))$.

$H_1 : K_1, K_1^{-1}, K_2^{-1}, K_6$
$H_2 : K_1^{-1}, K_2, K_2^{-1}, K_6, K_7$
$H_3 : K_3, K_3^{-1}, K_1^{-1}, K_2^{-1}, K_6$
$H_4 : K_4, K_4^{-1}, K_1^{-1}, K_2^{-1}, K_7$
$H_5 : K_1^{-1}, K_2^{-1}, K_3^{-1}, K_4^{-1}, K_5, K_5^{-1}, K_6$

Explain how H_1 may directly send a message M to H_2 in a confidential and authenticated communication if:

i) No additional keys can be generated
ii) Additional keys can be generated, and efficiency is important

The parts carry, respectively, 21%, 47%, and 32% of the marks

2a You are to choose between two communication systems to operate over a 10,000km 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 Continuous RQ with Go-Back-N, and the other on Continuous RQ with Selective Repeat. The traffic over the line is found to consist of 1000 byte I-frames.

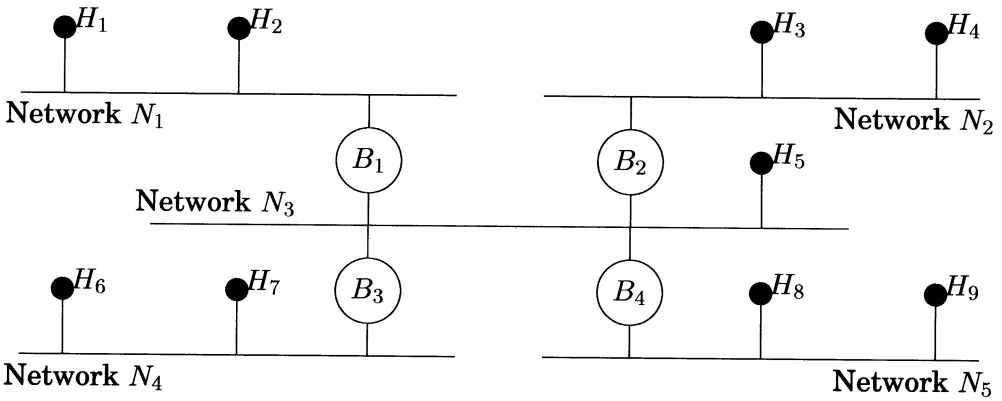
Determine the data transfer rate offered by the two systems if

i) no errors occur on the leased line.

ii) you are expecting a BER of 2×10^{-5}

iii) you are expecting a BER of 2×10^{-5}, *and* you have to use 100 bytes of each I-frame for control information.

b In the network below the routing tables of the various bridges B_1 to B_4 are initially empty.



Briefly explain your answers to each of the following, assuming that the bridges execute the *backwards learning algorithm* for routing packets:

i) When H_3 sends a packet to H_7, which networks will it be passed onto?

ii) If H_7 then sends a reply to H_3, which networks will it be passed onto?

iii) If after (ii), H_1 sends a packet to H_7, which networks will it be passed onto?

iv) What problem would arise if an extra network was introduced bridged onto N_1 and N_4?

v) How does a flood routing algorithm avoid the problem of (iv)?

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

The parts carry, respectively, 55% and 45% of the marks

3a An experiment is being conducted in contacting a host `oracle` from two subnets A and B in different offices of a company, where host `oracle` is located on subnet B. For each of the following questions briefly justify what you would infer from varying results found for using the ping command from host `subneta` on subnet A and from host `subnetb` on subnet B. (The `-s` option of ping allows you to change the size of the data field sent and returned).

```
subneta$ ping oracle
PING oracle (146.169.1.46) from 146.169.10.4 : 56(84) bytes of data.
64 bytes from oracle: icmp_seq=0 ttl=239 time=90.525 msec
64 bytes from oracle: icmp_seq=1 ttl=239 time=89.953 msec
subneta$ ping oracle -s 1000
PING oracle (146.169.1.46) from 146.169.10.4 : 1000(1028) bytes of data.
1008 bytes from oracle: icmp_seq=0 ttl=239 time=601.559 msec
1008 bytes from oracle: icmp_seq=1 ttl=239 time=599.908 msec

subnetb$ ping oracle
PING oracle (146.169.1.46) from 146.169.1.45 : 56(84) bytes of data.
64 bytes from oracle: icmp_seq=0 ttl=255 time=0.153 msec
64 bytes from oracle: icmp_seq=1 ttl=255 time=0.130 msec
subnetb$ ping oracle -s 1000
PING oracle (146.169.1.46) from 146.169.1.45 : 1000(1028) bytes of data.
1008 bytes from oracle: icmp_seq=0 ttl=255 time=0.458 msec
1008 bytes from oracle: icmp_seq=1 ttl=255 time=0.432 msec
```

i) How many routers are used for the IP traffic on the interconnecting network between subnet B and subnet A?

ii) If a telnet session to `oracle` from `subnetb` works, but a telnet from `subneta` gets no reply, what device may be present on the interconnecting network?

iii) If there is known to be only one slow link on the interconnecting network, what is the minimum speed that this operates at?

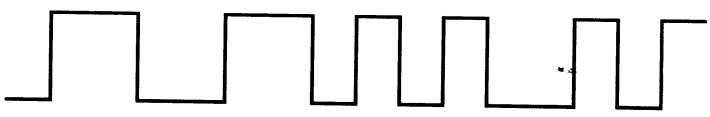
b Use your knowledge of communications theory to determine the theoretical limit possible for each of the claims below, and hence state if each of the systems is theoretically possible.

i) 22,000kbs^{-1} *data transfer* over a 4,000Hz telephone line with eight signalling levels and 15dB of noise.

ii) A *delay* averaging no more than 1ms for packets using a 16 input multiplexer over a 64kbs^{-1}line, where each terminal generates on average 48 packets per second of average length 10 bytes.

c Copy and annotate the following figure of a Manchester encoded signal with the bit boundaries and bit values represented by the signal.

Manchester Encoding



Write down as a binary number the information represented by the signal.

The three parts carry, respectively, 38%, 38%, and 24% of the marks

4a With respect to the use of *repeaters* and *bridges* in the internetworking of LANs:

i) In which layer of the OSI model does each sit?

ii) Which works on a store-and-forward basis?

iii) Which is also known as a *hub*?

b The following is a run-length encoding using three bit codewords. State what the original bit pattern is.

010111000101111001

c In a particular implementation of the OSI model, the system has been given what is purported to be a 'clean design' where all PDUs in all layers are of a fixed size, with an SDU of 50 bytes, and PCI of 4 bytes. (Reminder: in the OSI model, the PDUs exchanged in any layer are made up of a 'header' field called the PCI and a 'data' field called the SDU.)

i) How many physical layer PDUs are required to send one application layer PDU?

ii) How long will it take to transmit 1 byte of user data in this system, if the physical media operates at $1Mbs^{-1}$?

iii) Suggest how you might alter the design of the system to improve its efficiency in handling data.

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

http://www.bbc.co.uk/index.html
http://news.bbc.co.uk/index.html
http://www.bbc.co.uk:8080/index.html
ftp://www.bbc.co.uk/data/8000/prog.txt
mailto:today@bbc.co.uk

For each of the following questions, briefly explain how you obtained your answer:

i) How many DNS lookups must take place during the session?

ii) How many TCP/IP protocols will be used by the browser in the session?

iii) Choose one of the URLs and give the value of the port that will be contacted.

The parts carry, respectively, 14%, 22%, 36%, and 28% of the marks