UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2002

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 1 May 2002, 16:00
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

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

$$m = t\lambda$$

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

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

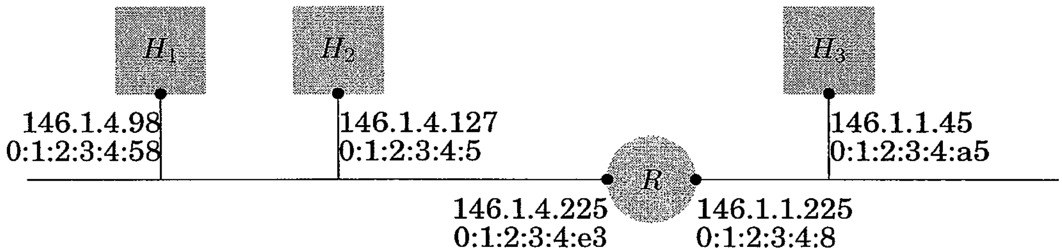
$$d = \frac{1}{\mu - \lambda}$$

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

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

i) RJ45 plugs and sockets
ii) Remote login
iii) Abstract syntax notation 1 (ASN1)
iv) LAN bridges and switches
v) TCP
vi) FTP
vii) Internetworking and IP

b The following illustrates a fragment of an Ethernet IP network, where the netmask on all hosts is set to 255.255.255.0. All hosts and routers have no cached information about each other's hardware (MAC) addresses, but do know each other's IP addresses.



In answering the following questions, note that the `-c 1` option of the `ping` command causes just one ICMP Echo Request frame to be sent, `-n` means the *no* use of DNS is made, and `-s 64000` makes the ping IP packet 64008 bytes long, as opposed to the default 64 bytes.

i) Copy and complete the following table, listing all the Ethernet frames that are sent by any host or router, when H_2 issues the command `ping -n -c 1 146.1.4.98`.

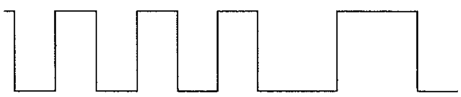
From	Type	Source MAC	Source IP	Destination MAC	Destination IP
H_2	ARP Request	146.1.4.127	0:1:2:3:4:5		

ii) Complete a similiar table as in (i) listing all the frames sent by any host or router, when H_3 issues the command `ping -n -c 1 146.1.4.98`

iii) If all hosts use a TTL of 255, what TTL would you expect to be reported by the ping command of (ii)?

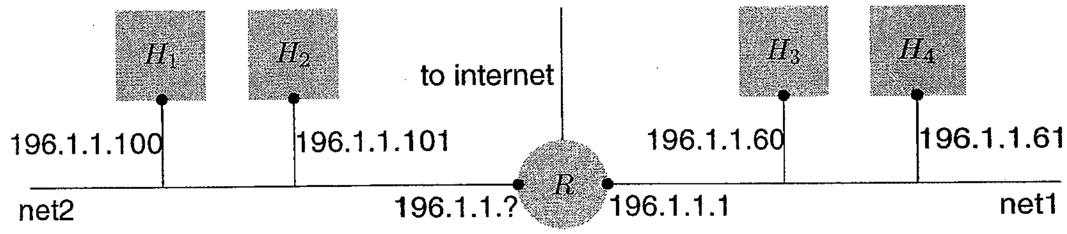
iv) If the Ethernet operates at 10Mbs^{-1}, and the times reported for (i) and (ii) were both about 2ms, estimate what would be the time reported when H_3 issues the command `ping -s 64000 -n -c 1 146.1.4.98`.

c The following signal shows binary data in differential encoding. Copy the diagram clearly mark position of the bit borders and the binary value (0 or 1) of the bit.



The parts carry, respectively, 21%, 57%, and 22% of the marks

2a The diagram below illustrates an IP Class C network with two subnets connected to the Internet via a single router R, where the subnets net1 and net2 have netmask 255.255.255.192.



i) Compute to which network a new H_5 with IP 196.1.1.66 belongs.

ii) Suggest what might be the value of ? for the IP address of R on net2

iii) What value of netmask and what network address would you choose for a new net3 added to R, if you wanted to have around 100 hosts on that subnet?

b Use your knowledge of communication theory and its equations to compute if the following statements being made about three new communication systems could be true:

i) A 250kbs^{-1} data transfer rate on 100kHz bandwidth UTP cabling with four level analogue signalling, and 20dB of noise.

ii) A mean delay of less than 0.1s for a STDM relay handling 16 hosts, each generating on average 7 packets per second of 250 bytes, and multiplexing onto a 250kbs^{-1} line.

iii) A mean delay of less than 0.1s for a TDM relay handling 16 hosts, each generating on average 7 packets per second of 250 bytes, and multiplexing onto a 250kbs^{-1} line.

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
$D(K^{-1}, M)$ returns a plaintext version of M decrypted by key K^{-1}
Keys are currently distributed as follows:
$H_1 : K_1, K_1^{-1}, K_s^{-1}$
$H_2 : K_2, K_2^{-1}, K_s^{-1}$
$H_s : K_s, K_s^{-1}, K_1^{-1}, K_2^{-1}$

i) List the messages exchanged by the three hosts, when H_1 and H_2 use H_s as a trusted secure host to obtain each other's public keys via the Needham and Schroeder protocol (you may omit the final exchange of nonces in your answer).

ii) Once the public keys have been obtained in (i), how would H_1 send H_2 a confidential and authenticated message M.

The parts carry, respectively, 40%, 32% and 28% of the marks

3a The message 011001110101 has been received, coded using Hamming code, with b_1 on the right, and even parity having been used.

i) If at most one bit of the message is in error, extract what the original data bits sent by the transmitter were.

ii) How many extra data bits could have been added to the message without any requirement for additional redundancy bits?

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

```
⟨? xml version="1.0" encoding="ASCII" standalone="no"?⟩

⟨part⟩
  ⟨part_number⟩IC123⟨/part_number⟩
  ⟨quantity⟩512⟨/quantity⟩
⟨/part⟩
```

ISO8825 tag	ASN primitive	semantics
1	BOOLEAN	TRUE or FALSE
2	INTEGER	integer, little endian encoding
3	BITSTRING	list of bits
4	OCTETSTRING	list of bytes
16	IA5STRING	list of character in IA5
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 '1' is 31).

c In Gigabit Ethernet (1000Mbs^{-1} Ethernet) there is the option to use CSMA/CD. Ethernet has a long established minimum frame length of 64 bytes. For this system:

i) Calculate the maximum end-to-end length of a cable with $200 \times 10^6 ms^{-1}$ propagation speeds, if no special techniques are used (*i.e.* the CSMA/CD system operates in exactly the same way as 10Mbs^{-1}Ethernet).

ii) Briefly describe what special techniques are employed by Gigabit Ethernet to allow CSMA/CD to operate over longer distances.

The three parts carry, respectively, 35%, 35%, and 30% of the marks

4a You are to evaluate the effectiveness of ARQ protocols for a communications system that operates between two hosts 3,600km apart, on a channel operating at 2.5Mbs^{-1}, with signal propagation speeds of $200 \times 10^6 ms^{-1}$, and BER of 10^{-6}. Data by default is sent in 1250 byte I-frames. For the system:

i) calculate the efficiency of Idle RQ

ii) calculate the efficiency of Continuous RQ based on Go-Back-N

iii) calculate the efficiency of Continuous RQ based on Selective Repeat

iv) determine which of (i), (ii), and (iii) can support 600kbs^{-1}data transfer rates, and for those that do not support the data rate, suggest how you might change the system to support the data rate.

b A Web browsing session visits the following URLs in order, where the browser starts with all its caches empty.

http://moa.doc.ic.ac.uk/index.html
http://moa.doc.ic.ac.uk/ftp-archive/prog.tgz
http://moa.doc.ic.ac.uk/image.jpeg
http://moa.doc.ic.ac.uk:8080/index.html
ftp://pjm:secret@moa.doc.ic.ac.uk/index.html

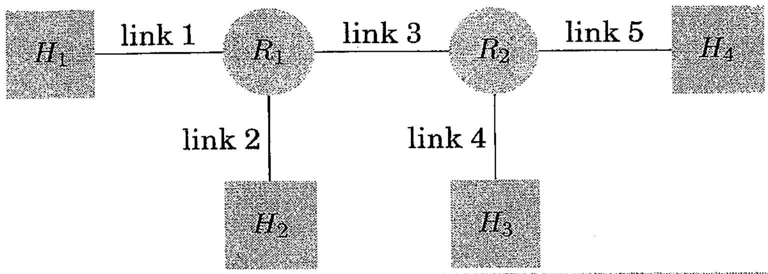
Briefly explain your answer to each of the following:

i) How many DNS lookups are required for the browsing session?

ii) How many server sockets must the browser contact in the session?

iii) Which one of the services might represent a security hole, if the doc.ic.ac.uk domain were protected by a basic firewall setup based around restricting access to well known services?

c The following diagram shows four hosts linked by virtual circuits over two routers, with the routing table for each router shown below.



R_1

in/out link	in/out VCI	out/in link	out/in VCI
1	1	2	3
1	2	3	1
2	2	3	2

R_2

in/out link	in/out VCI	out/in link	out/in VCI
3	1	5	2
3	2	4	1

i) List the pairs of communicating hosts

ii) Describe what would need to be added to each routing table to create a *new* connection between H_1 and H_4, assuming that the lowest free VCI is allocated on each link.

The parts carry, respectively, 46%, 30%, and 24% of the marks

