Department of Computer Science
University College London

Cover Sheet for Examination Paper to be sat in May 2001

COMPC329/D15: Communications and Networks

Answer THREE questions

Calculators are permitted

Checked by First Examiner: Date:

Approved by External Examiner: Date:

Answer THREE questions

1. a) Statistical analysis of football results shows that results occur with the following relative frequencies:

   Home win (H) 25%

   Away win (A) 12.5%

   No-score draw (i.e. neither side scores) (N) 25%

   Score draw (i.e. 1-1, 2-2, etc.) (S) 37.5%

   Given that we want to transmit the results of 1000 football matches as H, A, N or S, how many bits would we need to transmit using an ideal coding scheme?

[6 marks]

b) Explain why digital rather than analogue transmission is favoured in modern communications systems.

[5 marks]

c) “Pulse Code Modulation (PCM), as used in telephony, samples a signal at 8KHz using 256 quantisation levels”. Briefly outline how this scheme works and, by reference to Nyquist’s theorem, explain how the sampling rate was chosen.

[6 marks]

d) There is much interest today in sending voice traffic across IP networks. Give reasons why this approach might make more efficient use of transmission capacity than the circuit-switched PCM scheme that has traditionally held sway.

[6 marks]

e) One of the challenges of implementing interactive “voice over IP” is management of delay and jitter. Outline the sources of delay and jitter in the Internet and describe a technique for reducing the effect of jitter. Explain how the problem of jitter affects the choice of transport protocol for carrying voice over IP.

[10 marks]

2. a) Given a signal *s(t)* the Fourier transform $\Im\{s(t)\} = \int_{-\infty}^{\infty} s(t)e^{-2\pi ift}dt$

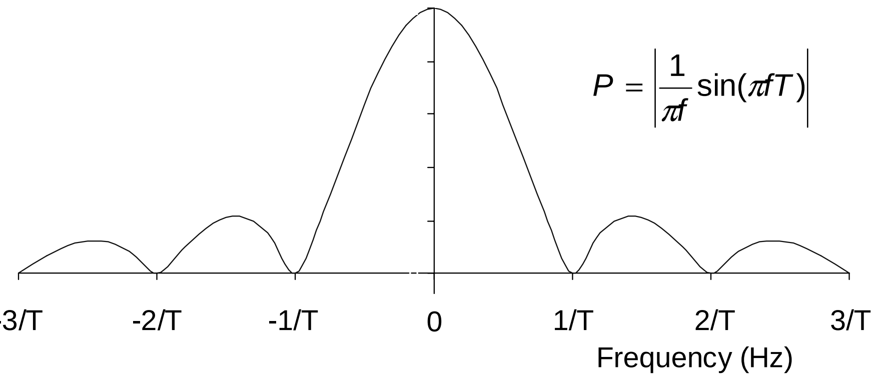
i) A square pulse of length T sec is given by:

$$s(t) = 1 \quad \frac{-T}{2} \le t \le \frac{T}{2}$$
$$= 0 \quad \text{otherwise}$$

Show that the Fourier transform of *s(t)* is given by $\Im\{s(t)\} = \frac{1}{\pi f}\sin(\pi fT)$

[6 marks]

ii) The sketch below shows the spectrum of the square pulse in i). Explain how this sketch should be interpreted in relation to the *effective bandwidth* of the pulse.



[3 marks]

iii) Suppose we have two signals *u(t)* and *v(t)* with Fourier transforms *U(f)* = $\Im\{u(t)\}$ *and* *V(f)* = $\Im\{v(t)\}$ respectively. Show that:

$$\left|\Im\{u(t)+v(t)\}\right| \le \left|\Im\{u(t)\}\right| + \left|\Im\{v(t)\}\right|$$

[4 marks]

iv) Briefly discuss implications of the result proved in iii). Under what circumstances would we find $\left|\Im\{u(t)+v(t)\}\right| = \left|\Im\{u(t)\}\right| + \left|\Im\{v(t)\}\right|$?

[4 marks]

[Question 2 continued on next page]

[Question 2 continued]

b) A router has two interfaces; one to a 10Mbps Ethernet and the other to a basic-rate ISDN interface (2x64Kbps B-Channels).

Packets of mean size 5,000-bits arrive from the Ethernet at a mean rate of 16 packets per second. The arrival process and the distribution of packet sizes can be assumed to be negative exponential. The queuing discipline ensures that packets are distributed evenly between the two B-Channels. Demonstrate that the buffering requirements in this system are likely to be greater than would be the case if the ISDN interface were to be replaced by a single 128 Kbps channel. [N.B. for an M/M/1 system the mean number in the system is given by $\lambda / (\mu - \lambda)$ where μ is the service rate and λ is the arrival rate.]

[4 marks]

c) i) 1000-bit packets are transmitted over a channel with a *bit-error rate* (BER) of 10^{-5}. Assuming bit-errors are independent, calculate the probability that a packet will be affected by an error.

[3 marks]

ii) The packets in i) are transmitted over a link which operates at 100,000 bits/sec with a propagation delay of 10ms. A *stop and wait ARQ* protocol is in use; acknowledgement packets are 100 bits and the transmit timeout is 100ms. What would be the throughput in packets per second on an error-free channel? What would be the throughput if the channel had the packet error rate calculated in i)? [You may ignore processing delays at the transmitter and receiver. State any further assumptions you make]

[6 marks]

iii) The *stop and wait* ARQ protocol in ii) is replaced by a *continuous request go-back-n* protocol. Discuss what window size and timeout should be chosen for maximum throughput.

[3 marks]

3. a) i) Briefly explain why a coding scheme must possess redundancy if it is to support the detection of errors.

[3 marks]

ii) A communications system sends packets of up to 1500 bytes over a relatively error-free channel. A mechanism is needed which will detect transmission errors in these packets; addition of a single *parity bit* is proposed. Explain why this mechanism will detect all single-bit errors and discuss whether such a scheme would be effective in practice.

[2 marks]

iii) Explain how a *cyclic redundancy check* (CRC) is calculated. Show that such a check will detect all errors which affect an odd number of bits provided the generator polynomial has $(x + 1)$ as a factor.

[12 marks]

b) i) Describe the token bucket mechanism for policing packet traffic.

[10 marks]

ii) Given a token bucket of size b bytes with replenishment rate r bytes/sec and a peak arrival rate of p bytes/sec it can be shown that the maximum time for which the peak rate can be maintained is $b/(p-r)$ *sec*.

A source generates packets on a 10 Mbps link on a regular 1 second cycle. At the start of each cycle 10 10,000-bit packets are transmitted back-to-back at the full line speed. For the remainder of each cycle no data is transmitted. What should be the parameters b, p and r of a token bucket which **just** accommodates this source?

[6 marks]

4. a) A channel on a wireless network is shared by stations which transmit packets at 100,000 bits/sec with a mean packet size of 1000 bits. The maximum propagation delay between any two stations is limited to 4ms. Discuss the feasibility and advisability of employing the CSMA-CD (Carrier-Sense Multiple Access – Collision Detection) strategy on this network.

[8 marks]

b) i) In the context of an Ethernet LAN, distinguish between *broadcast transmission*, *multicast transmission* and *promiscuous mode*.

[3 Marks]

ii) Describe the backward-learning algorithm employed in *transparent MAC bridges*. Explain why this algorithm cannot be used in configurations which include loops.

[5 marks]

iii) Given that the *transparent MAC bridge* provides efficient network interconnection with zero configuration overhead, why is it not considered suitable as a global solution to the problem of network interconnection?

[6 Marks]

c) i) Briefly explain the operation of a *distance vector* routing protocol.

[5 marks]

ii) Some distance vector protocols introduce a rule called *split horizon*. Illustrate, by means of an example, the problem that the split horizon rule is intended to tackle and explain how the rule operates.

[6 Marks]

5. a) A web server runs on a computer with domain name haig.cs.ucl.ac.uk. A browser accesses a page with URL http://haig.cs.ucl.ac.uk/foo.html. Both the browser host, the web server host and the DNS host are connected to the same Ethernet LAN. Give an account of the steps that take place as the browser requests the page. [Assume no useful cached information is available at the start of the exchange. You do not need to account for **every** packet sent!]

[8 marks]

b) Explain what is meant by a *user-level session*.

[2 marks]

i) Explain one method whereby a user-level session spanning several *HyperText Transfer Protocol* (HTTP) requests may be implemented.

[3 marks]

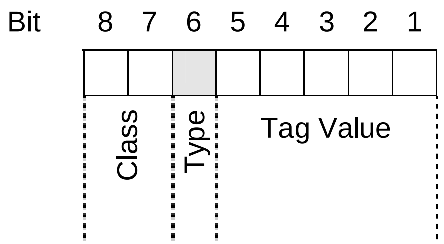
ii) How is the concept of a user-level session realised in the Internet *File Transfer Protocol* (FTP)? Outline the principal events that occur at the transport layer and above as a file is transferred from the server.

[4 marks]

c) Discuss the role played by *cacheing* and *proxies* in the world-wide web. What impact, if any, do proxies have on user-level session maintenance?

[9 marks]

d) Tag bytes in the ISO *Basic Encoding Rules* (BER) are constructed as follows:



Where:

```
Class: 00 = UNIVERSAL, 01 = APPLICATION
Type:  0 = Primitive, 1 = Constructed
Tag Value: 00010 = INTEGER
           10000 = SEQUENCE
           00100 = OCTET STRING
```

Given the following ASN.1 syntax definition:

```
IpAddress ::= [APPLICATION 0] IMPLICIT OCTET STRING (SIZE (4))
SocketAddress ::= SEQUENCE {
    ipAddr IpAddress,
    port INTEGER (0..65535)
}
```

Illustrate how an instance of `SocketAddress` would be encoded for transmission.

[7 marks]

[END OF PAPER]