Department of Computer Science
University College London

Cover Sheet for Examination Paper to be sat in May 2001

COMP3C32: Network Architecture

Answer THREE questions

Calculators are permitted

Checked by First Examiner: Date:

Approved by External Examiner: Date:

1. a) Outline the principle of operation and characteristics of the three principal types of optical fibre.

[9 marks]

b) Suppose we have a signal *s(t)* and $S(f) = \Im\{s(t)\}$ is the Fourier transform of *s(t)* given by:

$$S(f) = \int_{-\infty}^{\infty} s(t) e^{-2\pi i f t} dt$$

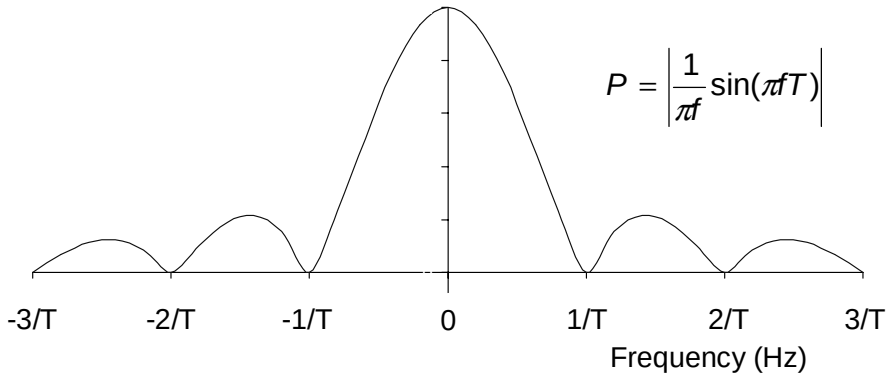
i) *c(t)* is a sinusoidal carrier of frequency f_0. Thus we may write $c(t) = \cos(2\pi f_0 t)$. We generate a new signal $m(t) = s(t).c(t)$. Show that the Fourier transform of *m(t)* is given by:

$$\Im\{m(t)\} = \tfrac{1}{2}[S(f - f_0) + S(f + f_0)]$$

[7 marks]

ii) The graph shows the spectrum of a square pulse of length *T* sec given by:

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



By reference to the result in i) or otherwise, sketch a graph of the spectrum of the signal generated by the transmission of a square pulse of light of duration 5×10^{-15} sec at a frequency of 6×10^{14}Hz. Estimate the channel bandwidth needed to transmit such a pulse giving reasons for your estimate.

[9 marks]

[Question 1 continued on next page]

[Question 1 continued]

c) Some transmission systems make use of techniques classified as "*spread-spectrum*".

i) Under what circumstances are these techniques useful?

[1 mark]

ii) A transmission system is intended to have a capacity of 64 Kbps. The signal-to-noise ratio is known to be –30 dB. What bandwidth is needed? [You may need Shannon's theorem $C = W \log_2(1+S/N)$ where C is the capacity, W is the bandwidth and S/N is the signal-to-noise ratio]

[5 marks]

iii) Explain why direct modulation techniques such as Phase-Shift Keying cannot be used to achieve spread-spectrum transmission.

[2 marks]

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

i) Packets of mean size 10,000-bits arrive from the Ethernet at a mean rate of 6 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 delay imposed by this system is 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 time in the system is given by $1/(\mu - \lambda)$ where μ is the service rate and λ is the arrival rate.]

[4 marks]

ii) Are there any circumstances in which a queue can form in the router for traffic flowing in the other direction (from ISDN to Ethernet)? (Explain your answer).

[4 marks]

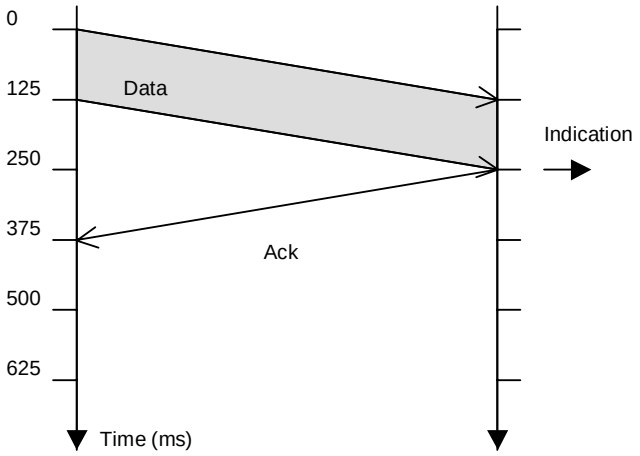
b) A TCP connection is transmitting data from an Ethernet host to an ISDN host via the router in a). The ISDN host offers an initial window of 16 Kbytes. Discuss the likely history of such a transmission if the "*slow start*" algorithm is **not** used. What would you estimate the resulting *round-trip time* (RTT) on the connection to be?

[8 marks]

[Question 2 continued on next page]

[Question 2 continued]

c) The diagram shows the transmission and acknowledgement of a single Internet *Transmission Control Protocol* (TCP) segment across a 64Kbps link. **Note that all protocol header, CRC and framing overheads have been ignored.**



Assuming that the round trip delay remains roughly constant, that the transmitter operates a timeout of 500ms from the transmission of the first bit of a segment, that the segment size remains constant and that the receiver keeps the window size fixed at 4K bytes.

i) Draw a clear time-sequence diagram, based on the one above, which illustrates how the protocol recovers from the loss of a single TCP segment. [N.B. you do not need to account for TCP congestion control mechanisms.]

[6 marks]

ii) Discuss whether the window size used is optimal.

[3 marks]

d) Outline the *fragmentation* mechanism used in IP version 4. Fragmentation is now "considered harmful". Why is this?

[8 marks]

3. a) Presented below are extracts from the augmented *Backus-Naur Form* (BNF) specification of the *HyperText Transfer Protocol* (HTTP).

```
generic-message = start-line
                  *(message-header CRLF)
                  CRLF
                  [ message-body ]
…
start-line      = Request-Line | Status-Line
…
Request-Line    = Method SP Request-URI SP HTTP-Version CRLF
…
Method          =   "OPTIONS"
                | "GET"
                | "HEAD"
                | "POST"
                | "PUT"
                | "DELETE"
                | "TRACE"
                | "CONNECT"
                | extension-method
…
message-header  = field-name ":" [ field-value ]
field-name      = token
field-value     = *( field-content | LWS )
field-content   = <the OCTETs making up the field-value
                  and consisting of either *TEXT or combinations
                  of token, separators, and quoted-string>
```

Give an example of a simple HTTP “GET” request than conforms to this grammar.

[5 marks]

b) Explain what is meant by a *user-level session*. Explain one method whereby a user-level session spanning several HTTP requests may be implemented.

[6 marks]

c) What is the role of a *concrete transfer syntax*? The concrete transfer syntax used within CORBA (*Common Object Request Broker Architecture*) includes no typing information whilst that used within Java RMI (*Remote Method Invocation*) is fully typed. Explain this statement and discuss reasons for these contrasting approaches.

[8 marks]

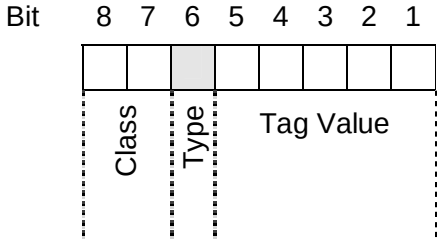
d) A distributed system is to be built using CORBA (*Common Object Request Broker Architecture*). The server is to be written in C++ whilst the client is to be written in Java. Describe the software tools that are likely to be used in the production of client and server software starting from a common interface definition.

[7 marks]

[Question 3 continued on next page]

[Question 3 continued]

e) 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:

```
GetRequest-PDU ::= [APPLICATION 0] IMPLICIT PDU
SetRequest-PDU ::= [APPLICATION 1] IMPLICIT PDU
PDU ::= SEQUENCE {
      request-id ::= INTEGER (0..65535),
      data ::= OCTET STRING
}
```

Illustrate how an instance of `GetRequest-PDU` would be encoded for transmission.

[7 marks]

4. a) Briefly contrast the end-to-end delay characteristics of a packet-switching network compared with those of a circuit-switched network.

[5 marks]

b) A router is receiving packets with a mean size 1000 bits at a mean rate of 1000 packets per second from one link and is outputting them on another link. It is required that 99% of the packets suffer delays of less than 20 ms.

i) Given the normal M/M/1 queue assumptions it can be shown that the probability of a packet remaining in the system for a time less than t is given by $P[T < t] = 1 - e^{-(\mu-\lambda)t}$ where λ is the mean arrival rate and μ is the mean service rate. Calculate the capacity required on the output link based on these assumptions.

[3 marks]

ii) Illustrate that if different assumptions are made about the arrival process (whilst keeping the means constant) much more capacity might be needed.

[6 marks]

[Question 4 continued on next page]

[Question 4 continued]

c) 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 show that the maximum time for which the peak rate can be maintained is given by *b/(p-r) sec*.

[4 marks]

iii) Given a token bucket of size *b* bytes with replenishment rate *r* bytes/sec and an output link capacity of *R* bytes/sec it can be shown that the delay is approximately bounded by *b/R*. What should be the bucket size for the packet arrivals in b) given an output link capacity of 2 Mbps and a delay target of 20ms? What is the maximum time that a peak arrival rate of 1.6 Mbps can be maintained without violating the token bucket regime?

[5 marks]

5. a) What is meant by address resolution? Give examples of how address resolution may be achieved in broadcast and non-broadcast networks.

[8 Marks]

b) i) Produce pseudo-code or otherwise explain how a *transparent MAC bridge* processes a single frame. [You do not need to consider problems arising from topologies which include loops].

[8 Marks]

ii) 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) Explain what is meant by "*Classless Inter-Domain Routing*" (CIDR) and why it was introduced to the Internet. Briefly describe the way in which CIDR operates.

[11 Marks]

[END OF PAPER]