Department of Computer Science
University College London

Cover Sheet for Examination Paper to be sat in May 2000

COMP3C32: Network Architecture

Time allowed 2.5 hours

Calculators are NOT allowed

Answer THREE questions

Checked by First Examiner: Date:

Approved by External Examiner: Date:

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Calculators are NOT allowed

1. a) *Automatic Repeat Request* (*ARQ*) protocols aim to provide reliable, sequenced, flow controlled packet delivery.

   i) Discuss the buffering and retransmission strategies which may be used at the receiver and transmitter in an ARQ protocol.

   [6 Marks]

   ii) Discuss the relationship between sequence numbers and window sizes in ARQ protocols.

   [6 Marks]

   iii) Illustrate how flow control is achieved by the Internet *Transmission Control Protocol (TCP)*.

   [5 Marks]

   iv) TCP employs a "three-way handshake at the start of a connection. Explain what this is and why it is necessary.

   [4 marks]

   b) The Fourier Transform *S(f)* of a signal *s(t)* is given by the relation

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

   i) Explain what is meant by the "effective bandwidth" of a signal and outline how a Fourier Transform may be used to estimate this quantity.

   [4 marks]

   ii) A signal consists of a single pulse of width T sec. Calculate the Fourier Transform of this signal and sketch the corresponding spectrum.

   [8 marks]

2. The “LAN Emulation” protocol (LANE) is designed to emulate an IEEE 802 LAN on an ATM network.

   a) Contrast the principle characteristics of the service provided by an IEEE 802 LAN with that provided by ATM.

   [6 marks]

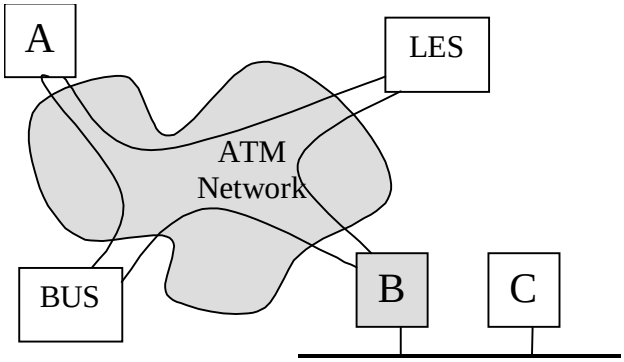
   b) Briefly outline the motivations behind LAN emulation from the points-of-view of manufacturers and users.

   [6 marks]

   c) What is the purpose of address resolution in LANE and how is it achieved?

   [6 marks]

   d) The diagram below shows host *A* and transparent MAC bridge *B* attached to an emulated LAN (ELAN). *B*, together with host *C*, is attached to an Ethernet. *A* and *B* have set up VCCs with the LES and the BUS. *A*, *B* have registered their own addresses with the LES. All ARP caches and *B*’s forwarding table are initially empty.



   Explain the steps which will take place as host *A* sends a MAC frame to host *C* and *C* replies. You should include information about any transactions with the LES and the BUS and about any VCCs that are set up.

   [15 marks]

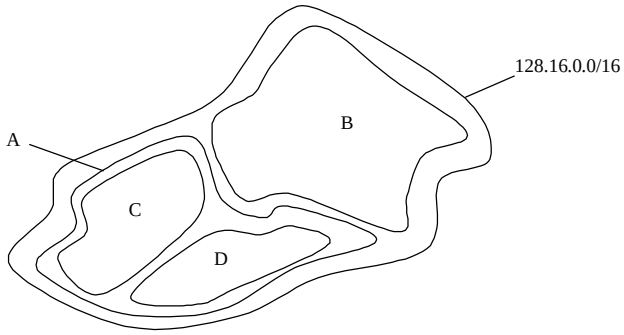
3. a) The IPv4 address space is considered to be too small to accommodate future Internet growth. Explain how the structure of IPv4 addresses has led to the wasting of substantial portions of the IPv4 address space.

[3 marks]

b) In recent years the concept of a “supernet” has been introduced in the Internet. What was the purpose of this introduction and what is its impact on Internet routing? Illustrate, with the aid of an example, how supernet addresses are constructed.

[7 marks]

c) The diagram below represents an IP network with the Class B IPv4 address 128.16.0.0/16. Two IP subnets A and B have been defined inside this network. Further subnets (C and D) have been defined within subnet A.



Suggest circumstances which might lead to the adoption of this configuration. Suggest an allocation of addresses to the subnets giving reasons for your choices.

[9 marks]

d) i) A TCP entity transmits 10,000 bytes of data in 2,000 byte segments (thus, including the TCP header, there will be 2,020 bytes of IP data for each segment). The IP entity is operating with a Maximum Transmission Unit (MTU) of 1024 bytes. Calculate how many packets the IP entity will transmit and justify your answer. (You may ignore errors and assume that IP headers are 20 bytes).

[3 marks]

ii) Calculate the optimal segment size for the TCP entity in part i) given that the objective is to minimise the number of packets sent. How many packets will be sent if this segment size is used?

[3 marks]

e) The Internet TCP protocol employs a "three-way handshake" when establishing a connection. Explain what is meant by a three-way handshake and why it is necessary to use it.

[8 marks]

4. a) You may find the following formulae useful in this part:

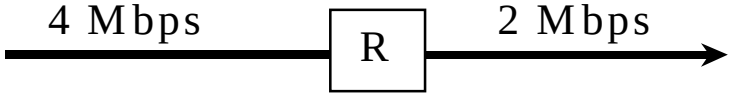
Given an M/M/1 queuing system with an infinite queue and customers arriving at mean rate λ with service rate μ:

The probability that there are n customers in the system is $\rho^n(1-\rho)$, *where* $\rho = \lambda/\mu$.

The mean number of customers in the system = $\frac{\rho}{1-\rho}$.

The mean time in the system per customer = $\frac{1}{\mu-\lambda}$.

The diagram below shows a router (*R*) with a 4 Mbps (4×10^6 bps) input link and a 2 Mbps (2×10^6 bps) output link. Packets have a mean size of 625 bytes (20-byte headers and 605 bytes of data). They arrive at *R* at a mean rate of 300 packets/sec. and the conditions for a M/M/1 queuing system are met.



i) Write down four important characteristics of a queuing system which allow it to be treated as an M/M/1 queuing system.

[3 marks]

ii) By treating the router as an M/M/1 queuing system, calculate the mean time for which packets remain at *R*.

[4 marks]

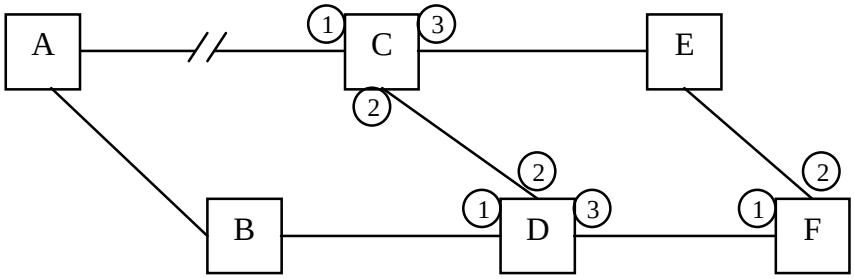
iii) What capacity would be needed on the output link to halve the time that packets remain at R?

[6 marks]

iv) The finance director refuses to pay for increased capacity on the output link but it is still essential to halve the delay calculated in ii) whilst maintaining the data rate. The network manager proposes to achieve this by reducing the mean size of the packets to 270 bytes (20-byte headers and 250 bytes of data). Will this work?

[9 marks]

b) i) The diagram below shows a configuration of Internet routers (*A*-*F*) which achieve dynamic routing through the use of a *Distance Vector* routing algorithm. The metric used is a simple hop-count (if two equal-length routes are available then the one via the lower numbered interface is chosen).



The link between *A* and *C* has been broken for some time and routing has stabilised to accommodate the situation. Each router maintains a routing table like the one below:

Routing table for Router F

Destination	Hop count	Interface	Next router
A	3	1	*D*
B	2	1	*D*
C	2	1	*D*
D	1	1	*D*
E	1	2	*E*
F	0	-	*F*

ii) Give the current routing table for router *C*.

[3 marks]

iii) Router *D* now discovers that the link between *B* and *D* has broken. Immediately after this (i.e. before *D* has reported the fact to any other routers), *D* receives distance vectors from *C* and *F* based on their *current* routing tables. Clearly outline the reasoning that *D* would use in calculating its new routing table entry for node *A* following receipt of the distance vectors from *C* and *F*.

[4 marks]

iv) How will *C*'s routing table for node *A* be amended next time it receives a distance vector from *D*? What problem of distance vector algorithms does this illustrate?

[4 marks]

5. a) Discuss the roles of "Interface Definition Languages", "Interface Compilers", "stubs" and "skeletons" in the implementation and operation of Remote Procedure Call (RPC) systems such as CORBA.

[12 marks]

b) i) Explain the terms "abstract syntax" and "transfer syntax".

[4 Marks]

ii) An application is to be designed which will allow the retrieval of students' public examination results across a network. An "*examination result*" includes the following information: *subject*, *examination board* (both text strings) and *mark obtained* (an integer). Records to be sent across the network consist of the student's *first* and *last names*, *year of birth* and *registration number* followed by an arbitrarily long list of *examination results*. Design a suitable syntax for these records using the *ISO Abstract Syntax Notation no.1* (ASN.1).

[7 marks]

c) In the context of the ITU X.500 Directory Service:

i) Briefly explain the terms *Directory System Agent* (DSA), *Directory User Agent* (DUA) and *Lightweight Directory Access Protocol* (LDAP).

[5 marks]

ii) When the local DSA is unable to answer a query, it may invoke the services of other DSAs. Illustrate the two principal modes of operation in which this collaboration between DSAs may occur. **[5 marks]**