IMPERIAL COLLEGE LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2017

MSc and EEE/EIE PART III/IV: MEng, BEng and ACGI

Corrected copy

COMMUNICATION NETWORKS

Tuesday, 11 December 9:00 am

Time allowed: 3:00 hours

There are FOUR questions on this paper.

Answer ALL questions.

All questions carry equal marks

Any special instructions for invigilators and information for candidates are on page 1.

Examiners responsible First Marker(s) : J.A. Barria
Second Marker(s) : C. Ling

Special information for students

1. Mean delay for the M/M/1 system may be taken as

$$t_i = \frac{1}{\mu C_i - \lambda_i}$$

where,

$1/\mu$ = Average length of packet [bit/packet]

C_i = Transmission speed link i [bits/s]

μC_i = Service rate (link i) [packet/ s]

λ_i = Arrival rate (link i) [packet/ s]

2. Optimal Routing Problem (ORP)

$Min\ D(F)$ with respect to $F = \{F_i\}$

where, $D(F) = \sum_{i=1}^{L} \frac{F_i}{C_i - F_i}$

and,

C_i = Capacity of link l_i.

F_i = Flow carried by link l_i.

The Questions

1.

a)

i) Derive an approximation for the utilization of the following ARQ protocols:

- Stop and wait.
- Go back N (GbN).
- Selective reject (SR). [2]

Clearly state and explain your assumptions and approximations. [2]

ii) Assume that you know the probability $P = 10^{-3}$ of a single frame being transmitted in error. Calculate the Utilisation for the elements in the Table 1:

	$a = 0.1$	$a = 1.0$	$a = 10.0$	$a = 100.0$
Stop & Wait				
SR ($W = 50$)				
GbN ($W = 50$)				

[3]

Here, W is the window size and a, is the normalized propagation delay.

Discuss your results. [3]

b)

i) Describe the components in a Network Management Framework, and define their roles and functions. [5]

ii) Briefly describe a common usage of the SNMP protocol. [3]

iii) Give example of the information exchange by hosts and routers when using the ICMP protocol. [2]

2.

a) In the context of a packet network represented by Figure 2.1.

i) Identify the sources of packet delay and briefly describe how you will model them. [6]

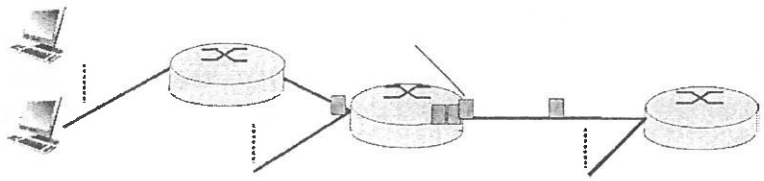

Figure 2.1:

ii) The mean network delay T on a Jackson network of queues is given by the following expression:

$$T = \frac{1}{\gamma} \sum_{i=1}^{L} \frac{F_i}{C_i - F_i}$$

Explain what is C_i, F_i and γ representing [3]

b) Consider an NxN time-slotted switch without input or output buffers.

The switch routes incoming packets, which are carried by *active time slots* to its output.

The switch does not have buffers hence, if two or more packets arrive destined to the same output one or more will be lost.

Assuming:

Active time slots are uncorrelated in time and across inputs

p: probability that a given time slot carries a packet (i.e. it is an *active time slot*)

p/N: probability that an *active time slot* is destined to a particular output.

i) Derive the probability that k *active time slots* arriving at the same time have the same output destination. [5]

ii) Derive the average number of *active time slots* that are intended for the same output, that is, that are lost. [6]

3.

a) In the context of TCP latency estimation, assume that the TCP protocol sends an object of size O.

i) Show that if the server does not receives an Acknowledgement for a segment before the server completes the transmission, the latency is augmented by a further delay:

$$(K-1)[S/R+RTT-WS/R]$$ [6]

Here, W is the size of the window; S is the size of the maximum segment size; R is the transmission rate of the link from server to client; and RTT is the round trip time.

ii) Define the parameter K in the above expression. [3]

b) Figure 3.1 represents a network of $M/M/1$ queues (links). This network is being fed with a stream of $\gamma_{13}=10$ packets/s.

The underlying routing algorithm objective in this network is to minimise the mean network delay.

i) If $C(1)=100$ and $C(3)=300$ find the minimum capacity $C(2)$ for the associated link to start carrying traffic. [4]

ii) Figure 3.1 also represents a system of interconnected elements. Assume that the reliability of link C(1) and link C(3) are equal with value 0.9.

If it is required that the reliability of the Origin-Destination ($1 \rightarrow 3$) connection has a reliability of 0.99.

- Calculate the reliability of the link C(2) that will accomplish the O-D requirement. [6]
- State clearly any assumption on your derivations. [1]

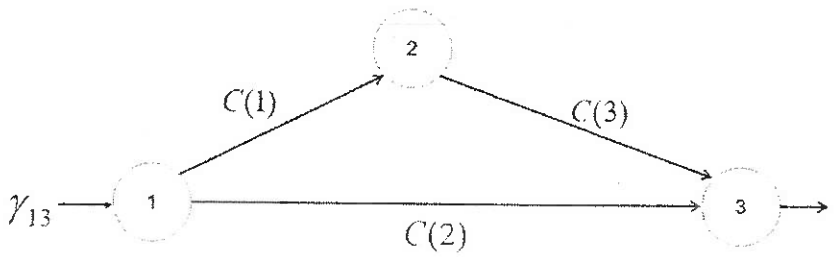

Figure 3.1.

4.

a) Multimedia networking and networks of queues.

i) Describe what is and how you would implement a WFQ (Weighted Fair Queueing) mechanism in the context of a scheduling policy. [3]

ii) Describe the mechanism and explain the implementation of the token bucket algorithm in the context of queue management. [3]

iii) For the implementation of differentiated service (DS), briefly describe the information that is interchanged between sender and received nodes by the resource reservation (RSVP) protocol. [5]

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b) In respect to the following IEEE wireless standards: 802.11, 802.15.4 and 802.15.1:

Compare and contrast them in terms of:

-Typical applications, [3]

-Strengths, [3]

-Weaknesses. [3]