UNIVERSITY OF DUBLIN

TRINITY COLLEGE

Faculty of Engineering and Systems Sciences

Department of Computer Science

B.A.(Mod.) Computer Science — Trinity Term 1998
Senior Sophister Examination

4BA2 - Systems Modelling

Wednesday 27th May — Luce Hall — 14.00 - 17.00

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Attempt FIVE questions.
At least one from each section
Please use separate answer books for each section

N.B. Tables of Queueing Formulae are available from the invigilators.

SECTION A

1. Explain what is meant by 'event scheduling approach' and 'interval oriented approach in discrete system simulation.

   Using appropriate diagram, illustrate the "next event" time advance mechanism for simulating a single server queuing system. Assume: t_i = time of arrival of the $_i$th customer, s_i = service time for the ith customer, w_i = delay in queue of the ith customer, e_i = time of occurrence of the ith event (arrival or departure) and inter-arrival time and service time distributions are known.

   Comment on the limitations of simulation as a problem solving method.

2. A computer integrated manufacturing system has a cell composed of three workstations, each of which are fed by a buffer that can hold three jobs. Jobs arriving at a cell for processing attempt to enter each of the three buffers in turn, but if all the buffers are full, they leave without being processed.

A data collection exercise found that the inter-arrival time distribution of jobs at the cell had a negative exponential distribution with a mean of 15 minutes. The processing time per job was found to 30 ± 5 minutes, uniformly distributed.

Workstations breakdown, on an average, every 2 ± 0.5 hours and is immediately attended to by the operator (only one operator to look after three workstations) on duty. The probability of a breakdown was found to be 35% on Workstation 1, 40% on Workstation 2 and 25% on Workstation3, and the average repair time was 10 ± 2 minutes

Outline a real or pseudo simulation language program to simulate the operation of the cell for a period of 24 hours. What are the relevant statistics that you may collect from this simulation and what kinds of decisions might be taken based on the cell simulation?

SECTION B

3. You are asked to advise a client who is a new telecommunications operator setting up in Ireland. Your client would like to provide a diverse range of services including: a nation-wide mobile phone service, the provision of Internet services to corporate clients at speeds of up to 2Mbps and the provision of native ATM services to large corporations at speeds of up to 34Mbps. Assuming that it is possible to build a nation-wide fibre network, advise your client as to:

(a) what network multiplexing technologies are relevant for your client's backbone network,

(b) what devices are needed to support these technologies (e.g. routers, multiplexors, switches etc)
and

(c) what their strengths and weaknesses are.

Illustrate your answer with diagrams giving possible network topologies that should be considered.

4. Using X.400 as an example, discuss the main entities and protocols that are necessary to realise an electronic mail service. Compare this with the systems used to provide Internet mail services. Show how both services cope with addressing individual users, storing messages on arrival and transferring multi-media content. Comment on why you think Internet mail succeeded where X.400 failed.

SECTION C

5. a. Define the Coefficient of Variation Squared for a distribution. Why is this parameter used in queueing systems?

Give values (or ranges) for this parameter for

i. a deterministic distribution
ii. an exponential (Poisson) distribution
iii. a hypo-exponential distribution
iv. a hyper-exponential distribution

b. Sketch the graph of system wait time for a M/ M/ 1 queueing system vs. server utilisation ρ. Indicate on your sketch how this changes for three systems each with a service distibution of one of the other three distributions mentioned in Part a (i.e. M/ D/1, M/ Ek/1, and M/ Hk/1). Indicate on your sketch the penalty for variability in terms of

i. increasing ρ for a given wait and
ii. increasing wait for a given ρ.

c. Jobs finish at a user-accessible CD-Rom bank with an average time interval between them of 5 minutes. Use the information in part (a) and Takacs' formula below to estimate a value or range for the average time E[Wt] a user should expect to wait for use of the bank (where E[t] is the expected transaction time) if

i. the job transaction times take exactly five minutes?
ii. the job transaction times follow a Poisson distibution?
iii. the job transaction times follow a hypo-exponential distribution (also known as an Erlangian-k distribution)?
iv. the job transaction times follow a hyper-exponential distribution?

Takacs' formula for this "inspection paradox", with the usual notation is:

$$E[W_t] = \frac{1}{2}\left[E[\tau] + \frac{Var[\tau]}{E[\tau]} \right]$$

6. a. List what mainframes have, that PCs don't have, for enterprise computing. List what PCs have for enterprise computing that mainframes don't . Why have mainframes not been replaced by PCs?

b. Briefly discuss the 3-layer hybrid architecture which it is claimed is replacing the traditional mainframe.

c. Discuss briefly the two dominant views of the the mainframe of the future.

d. Comment on the likely model for enterprise computing in the future.

7. **a.** A branch office of a large engineering firm has a CAD workstation at a central location in a city which is available 16 hours per day. Engineers, who work throughout the city, drive to the branch office to use the workstation for making design calculations. The arrival pattern of engineers is random (Poisson) with an average of 20 persons per day using the workstation. The distribution of time spent by an engineer at the workstation is exponential with average time of 30 minutes. Thus the workstation is 5/8 utilised.
The branch manager has received complaints from the staff about the length of time many have to wait to use the terminal. He used an M/ M/ 1 queueing model to estimate the following statistics:

ρ	W	Wq	E[q|q>0]
5/8	80 minutes	50 minutes	80 minutes

The manager has decided that the average waiting time in queue should be less than 1 minute and the average waiting time of those who must wait should be less than 20 minutes. He feels four machines should be enough to meet these criteria, but cannot decide between spreading the 4 machines over 4 locations throughout the city or splitting the four over 2 locations with 2 workstations at each location. He has asked you to give him a recommendation based on computing the above statistics for the two alternatives. Compute the statistics and give your recommendation. Why is one alternative better than another?

b. A company has a computer system processing λ transactions per day at its head office. It has proposed to its 5 regional managers to replace this central machine with one five times as fast. The regional managers have collectively argued that the workload could be split over the 5 regions equally giving each region a machine of power equal to that presently at head office. Each region would then have its own machine of the same power as the machine being replaced and could then process their own workload independently. The cost of either alternative would be the same, but the regional managers argue that the response time would remain the same. Use queueing theory to refute their argument.

c. What is Streeter's "Scaling Effect" and why does it occur? In view of this effect, what arguments would you use to support decentralised computer systems?