UNIVERSITY OF EDINBURGH

FACULTY OF SCIENCE AND ENGINEERING

COMPUTER SCIENCE FOUR

MODELLING AND SIMULATION

Monday 1 May 2000

2:00 to 3:30

Examiners:

Prof. K. Turner (External)

Prof. G. Brebner (Chairman)

INSTRUCTIONS TO CANDIDATES

Answer any TWO questions.

All questions carry equal weight.

1. (a) A Markov process forms an *analytic* representation of a system whereas a simulation forms an *algorithmic* representation. Explain what is meant by the terms *analytic* and *algorithmic* in this context. [*2 marks*]

   (b) In the office of a small company a single server provides access to the Internet. The four employees in the office must remotely log in to this server whenever they want to access the World Wide Web. For each employee the mean time between Web accesses is $1/\lambda$, and the mean duration of a Web session is $1/\mu$. Assume that all times are exponentially distributed and that the duration of a session is unaffected by the number of sessions the server is currently hosting.

      i. What single random variable would you use to characterise this system and what values would this random variable take?

      ii. Draw the state transition diagram of the Markov process representing the system in terms of your chosen random variable. Label the states and transitions clearly.

      iii. Explain the significance of each of the assumptions. [*10 marks*]

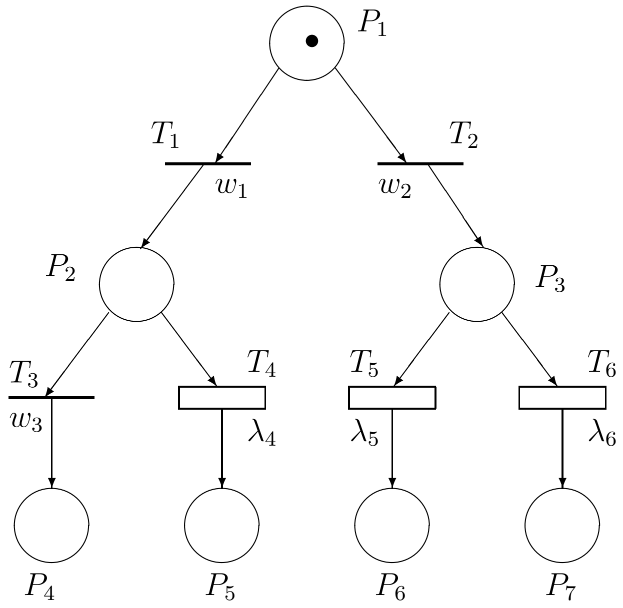
   (c) A new manager has been appointed for the office who does not approve of the employees surfing the web during office hours. Whenever she enters the office, any employee who is currently connected, instantly disconnects and no new connections are established until the manager is out of the office again. Fortunately, her job takes her out of the office periodically during the day; the mean duration of her visits to the office is ν and the mean duration of her absences is ψ. Again, you should assume that all times are exponentially distributed.

      i. What revisions would be necessary to the state transition diagram you gave in answer to part (b)ii. above in order to take into account the state of the manager?

      ii. Explain how, using your model, the manager would go about finding $\mathcal{W}$, the proportion of man hours lost surfing the Web. Your answer should include an expression for $\mathcal{W}$ in terms of the unknown steady state probabilities. [*8 marks*]

   (d) Would it be possible for the manager to use analysis based on operational laws to find $\mathcal{W}$? Justify your answer. [*5 marks*]

2. (a) Consider the GSPN shown below.



After two transitions have fired what is the probability that there is a token in each of the places:

i. P_4
ii. P_5
iii. P_6
iv. P_7

Justify your answer and show any calculation necessary in each case. *[6 marks]*

(b) Draw the reachability graph for the GPSN above and explain why it will not give rise to an ergodic Markov process. *[4 marks]*

(c) What is the difference between *event-based* and *process-based* discrete event simulation? *[2 marks]*

(d) In a widget processing plant, widgets arrive at machine A every a time units and take s time units to be processed. After every tenth widget the machine is taken off-line for routine servicing which takes r time units. Widgets that arrive when the machine is busy or being serviced wait in a queue.

Assume that a, s and r are random variables and that a simulation study is to be conducted to investigate the characteristics of the queue length.

i. List the events you would use in an event-based simulation of this system and outline in pseudo-code how you would represent each event.
ii. List the entities you would use in a process-based simulation of this system and outline in pseudo-code how you would represent each entity. *[13 marks]*

3. (a) What is *workload characterisation*? Explain the role it plays in performance modelling studies. [*2 marks*]

   (b) Monitoring a router within a network has shown that it corrupts 1% of packets, i.e. for every 100 packets routed, 99 are transmitted successfully and one will be transmitted but result in an error.

   Explain how such an event (e.g. transmission), with probabilistic outcome, would be modelled in each of the following formalisms:

   i. GSPN
   ii. PEPA
   iii. Queueing networks
   iv. SimJava.

   In each case your answer should include appropriate model fragments and an explanation of how the event and the different possible outcomes are represented. [*12 marks*]

   (c) The monitoring data also suggests that the average throughput of the router is 150 packets per second. However, results derived from a GSPN model of the network predict the router throughput to be 300 packets a second.

   i. Outline the approach you would take to try to resolve the difference between the measurement and the model data.
   ii. Explain the difference between *model validation* and *model verification*.
   iii. Is the approach that you propose above validation or verification? Justify your answer. [*7 marks*]

   (d) The design of a flexible manufacturing system has two robots on opposite sides of a conveyor belt. Each robot lifts parts from the belt and takes them for processing to a nearby machine. If the robots collide trying to lift the same part the whole system will need to be reset and there is a risk of damage to the robots. The designer wishes to estimate the probability of collision within the duration of the average shift. Is a GSPN model suitable for this purpose? Explain your answer. [*4 marks*]