UNIVERSITY OF EDINBURGH

FACULTY OF SCIENCE AND ENGINEERING

COMPUTER SCIENCE FOUR

MODELLING AND SIMULATION

Tuesday 15 April 1997

09:30 to 11:00

Examiners:

G. Birtwhistle (External)

M. P. Fourman (Chairman)

INSTRUCTIONS TO CANDIDATES

Answer any TWO questions.

All questions carry equal weight.

1. (a) i. Explain how information about the timing and probability of events is incorporated into stochastic Petri nets (SPN).

[2 marks]

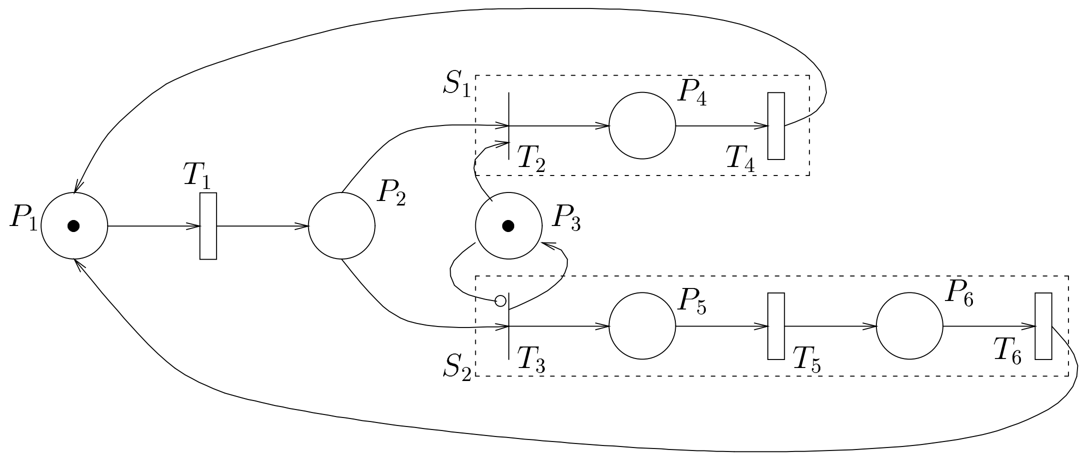
ii. What are the additional features of generalised stochastic Petri nets (GSPN) compared with SPN?

[2 marks]

iii. What impact do these features have on state space generation?

[4 marks]

(b) Consider the GSPN model shown below. After the customer passes through central processing at P_1, P_2 and T_1 the customer will either visit subsystem S_1, represented by T_2, P_4 and T_4, or subsystem S_2, represented by T_3, P_5, T_5, P_6 and T_6, before returning for central processing.



i. How does the customer decide which subsystem to visit on each occasion?

[2 marks]

ii. Write down all the markings of this GSPN and clearly indicate which are the vanishing markings.

[4 marks]

iii. Draw the reduced reachability graph corresponding to this model.

[2 marks]

QUESTION CONTINUES ON NEXT PAGE

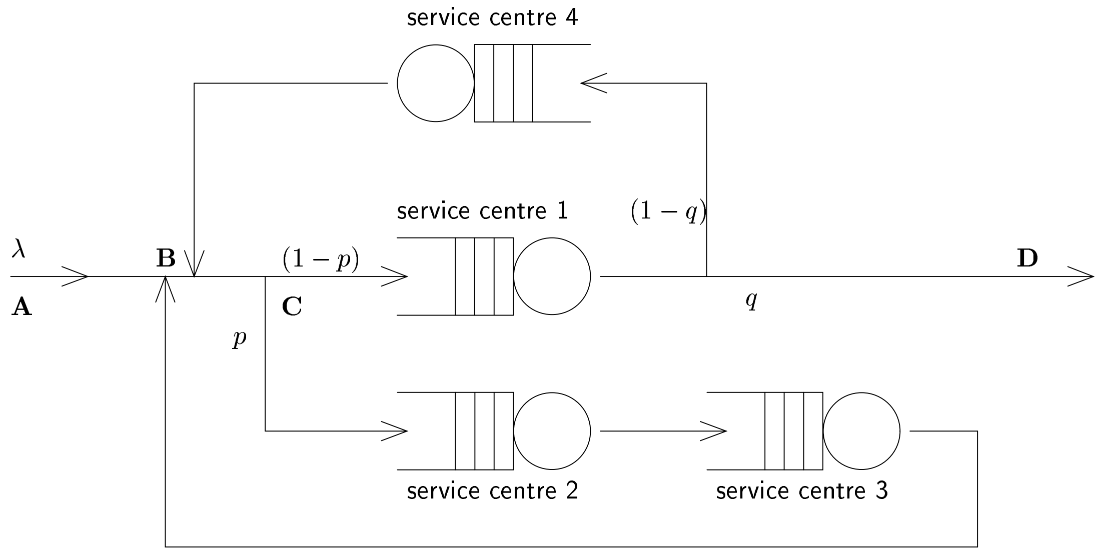
(c) i. Explain what is meant by *verification* and *validation* of models.

[4 marks]

ii. Imagine that the GSPN above is modelled using the tool SPNP. Suggest how an assertion could be used to verify and/or validate the model. Your answer should include a suitable assertion and explanation of how it would be used.

[5 marks]

2. (a) Consider the queueing network model shown below:



i. Explain what is happening to customers at each of the points labelled **A**, **B**, **C** and **D** in the model.

[4 marks]

ii. If $\lambda = 3/2$, $p = 1/4$, $q = 1/3$, and the service rate at service centre 3, μ_3, is 5, then what is the *traffic intensity* at service centre 3? Explain how you arrived at your answer.

[8 marks]

(b) How is synchronisation or cooperation between two active entities represented in a DEMOS simulation model? Your answer should include details of the modelling entities involved and the roles that they play.

[6 marks]

(c) What forms of interaction between entities can be represented in a queueing network? How could these forms of interaction be represented in a DEMOS model?

[7 marks]

3. (a) A Markov process forms an *analytic* representation of a system whereas a simulation model forms an *algorithmic* representation.

   i. Explain what is meant by the terms *analytic* and *algorithmic* in this context.

   [2 marks]

   ii. What are the consequences for deriving performance measures based on each of these styles of representation?

   [4 marks]

   iii. Explain when, and why, simulation models are considered preferable to Markovian models.

   [6 marks]

(b) The Department has 3 photocopiers, each of which is subject to periodic breakdown. When a photocopier breaks down a repairman is despatched. After some delay, he arrives and then works to repair the machine. In the meantime, the remaining photocopiers might break down, either before the repairman arrives or while he is working. The repairman continues to work until all the machines are working. At that point he leaves immediately. You may assume that the average time between breakdowns is the same, but independent for each machine. Similarly, you may assume that the average repair time is the same for each machine.

   i. Identify two random variables which together may be used to characterise the states of this system. Give the values which might be assigned to each random variable based on observations of the system.

   [2 marks]

   ii. Assuming all times are exponentially distributed, draw the state transition diagram to represent the system as a Markov process. Use the state characterisation you have described in part (i) above and label each arc clearly.

   [6 marks]

   iii. If an operational photocopier is always busy and copies at a rate of 50 sheets per minute, describe how you would calculate the average throughput of the complete set of photocopiers.

   [5 marks]