# 1995 Paper 13 Question 11

**Computer Systems Modelling**

In queueing networks, what is meant by a *closed* system?                [4 marks]

Consider two closed systems. One has two devices, $A$ and $B$, and three customers, the other three devices, $A$, $B$ and $C$, and two customers. Both have exponentially distributed service times which are device dependent but customer independent. In the first system a customer completing service at a device always moves to the other device. In the second system a customer completing service moves to one of the other two devices with equal probability.

Draw state diagrams for the Markov chains representing these systems. Choose one system to solve for device utilisation in terms of service rates.                [10 marks]

For the chosen system, when the service rates are equal does the utilisation of each device correspond to that for a balanced system ($U = \frac{N}{N+K-1}$ where $N$ is the number of customers and $K$ the number of devices)?                [3 marks]

Describe the state space for a Markov chain for one of the systems if the service rates were both customer and server dependent.                [3 marks]