CSD1/1

DIPLOMA IN COMPUTER SCIENCE

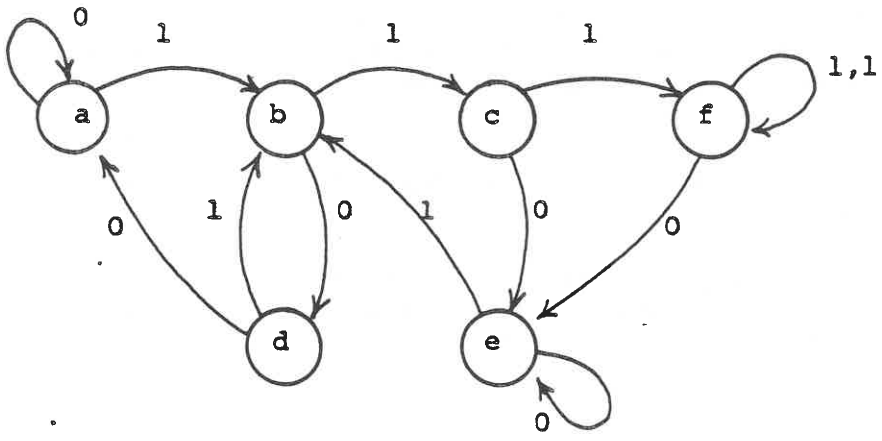
Thursday 2 June 1977. 9 to 12

PAPER 1

Answer two questions from Section A and one question from Section B. It is recommended that candidates spend not more than two hours in answering the question from section B.

SECTION A

1. What is the purpose and value of state reduction for a sequential machine? Outline a method for doing it and comment on the probable effects it would have on the implementation of a machine whose initial specification is given below.



TURN OVER

2. In modern mini-computers it is common to have various sub-units, such as the processor and store, connected together by a unified set of data paths described as a *bus*. Describe a possible structure for such a bus, explaining carefully what control signals are needed to ensure that it is never possible for two units to try to use the bus (incompatibly) at the same time.

3. In Algol W, quantities of type *procedure* or *array* may be passed as arguments in procedure calls but may not be assigned to variables. By considering the implications of extending the language to allow procedure and array variables, explain why this restriction was made.

4. Describe how material in excess of a storefull may be sorted efficiently using three magnetic tapes. How does your technique generalise to more than three tapes? Should one adopt any generalisations in practice?

5. A computer manufacturer is developing an operating system for a new range of computers and you have been asked to advise on the subject of command languages. There will be a variety of configurations ranging from small systems used for a few specific applications to large systems supporting, for example, a typical university work load. Discuss the advice that you would give having regard to the following:

(a) the question of machine, programming language, and application independence;

(b) the question of whether access to system control functions should be restricted to a single general-purpose command language.

6. Describe the functions of *segment* and *page* tables in a paged virtual memory system, paying special attention to control of access and to the sharing of pages. State what is meant by *thrashing* and indicate some of the measures that may be taken to control it.

SECTION B

The following questions involve the design of programs. This is to be taken to mean providing detailed notes, incorporating all major policy decisions, that could subsequently be used to guide a competent assistant in developing the program required. These notes may contain fragments of code or descriptions of data structures where these form an effective method of communicating design decisions to the assistant.

Any extra assumptions you need to produce satisfactory answers should be stated explicitly.

7. Students taking a course in logic design work entirely with NAND gates and JK flipflops. A circuit built up from these elements can be described by listing the connections between the various input and output terminals of individual logic elements, and by specifying the clock wave-forms used to drive it. Design a program that will read in a description of such a circuit, and simulate its behaviour. Pay particular attention to the detection of conditions that might lead to inconsistent or unpredictable output. For the purposes of this question you may assume that all logic waveforms have negligible rise and fall time: you should, however, simulate gate delays by making the output from a gate or flipflop lag behind the appropriate input signal by some fixed, small, time interval. Elaborate facilities for reading in circuits or displaying simulated wave-forms are not required.

8. A packet switching network is to be constructed using a number of *switching* computers connected in some manner by full-duplex transmission lines. *Host* computers (not more than 50) are each connected to a single switching computer by a similar transmission line. The purpose of the network is to enable messages (each containing a sequence of bytes) to be sent from host to host, with the restriction that at any one time only one message may be transmitted from one particular host to another particular host.

Messages are transmitted from and received by a host one byte at a time in a sequence of fixed-size packets, containing the following data: *code, source host address, destination host address, information byte, check sum.* All transmission line errors may be assumed to give rise to check sum failures; the only other error that can occur is memory congestion in a switching computer, which has adequate (but not infinite) memory and no backing store. Each transmission line is connected to a switching computer by a suitable controller containing control signals and input/output buffers, the hardware dealing with packet assembly and disassembly.

By defining meanings to various values of the code field of a packet, design a protocol to be implemented by the host and switching computers. Transmission line errors may be assumed to be transient and should give rise to the re-transmission of information. Memory congestion in a switching computer may be assumed to be rare, and should give rise to all packets of the relevant message being abandoned and both the source and destination hosts being informed accordingly. The entire network may be re-initialised at any time by some particular host transmitting a special *restart* packet. All messages in transit should be abandoned whenever this happens.

Design the program to control a switching computer. Alternative routing to optimise the network's performance is <u>not</u> to be implemented, and a simple routing table giving a line address for each host is provided for each switching computer.

TURN OVER

9. Following the success of TV games based on tennis and football, an electronics manufacturer wishes to produce a game simulator based on billiards. Initially, the programs for a much simplified version of the game are to be developed on a mainframe computer, and you have been given the task of designing those parts concerned with calculating the movement of balls.

The table size is 7 units by 5 units and there are pockets at each corner and midway down each of the longer edges. Up to 11 balls, each of diameter 0.1 units, may be on the table at any time, and each shot begins by one ball being given a specified speed in a specified direction and with all other balls initially at rest. Moving balls are slowed down by friction on the table surface so that their speed decays uniformly to zero. Balls which collide bounce off each other in a realistic manner. A ball meeting a table edge falls into a pocket if it is within 0.1 units of the centre of the pocket, otherwise it bounces ideally off the edge irrespective of how near it is to a pocket.

Explain how the program would trace through the consequences of a single shot; ignore the possibility of balls spinning and the technical problems of representing the action on the display. You may assume the existence of procedures that (a) given the relative motions of two colliding balls, provides their subsequent motion after impact, and (b) given the motion of a ball hitting an edge (but not a pocket), provides the subsequent motion after impact.