DIPLOMA IN COMPUTER SCIENCE

Friday 3 June 1977. 9 to 12

PAPER 2

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. Design, using JK flipflops, a 3-bit Gray-code counter.
The required count sequence, in binary, is

000, 001, 011, 010, 110, 111, 101, 100, 000,...

2. Discuss possible ways in which an interactive debugging
system may provide facilities for tracing the flow of control
in erroneous programs. Explain how a simple break-point
mechanism could be implemented for the NOVA.

A fragment of a DEBUG dialogue on the NOVA is shown below.
Explain each line and comment upon any bugs or peculiarities you
think the dialogue reveals. User input is underlined.

```
$;
ST+17/      LDA  3 OPN
X           JSR  @GO
GO/         NEXT+3/     STA 3 OP
NEXT+4      MOVR#  3 3 SNC
NEXT+5      MOVS   3 3
GO$B
ST+17$R
```

3. Discuss to what extent it would be possible to write a program to test whether a FORTRAN program violates the ANSI standard in any way. Show ways in which an ANSI standard FORTRAN program could produce different results on different machines.

4. Discuss, with examples, how some recursive functions may be rewritten more effectively. Estimate the number of procedure calls required to evaluate A(100) where A is defined in BCPL as follows:

$$\begin{aligned}
\text{LET } A(N) &= N<0 \rightarrow 0,\ B(N)+A(N-10) \\
\text{AND } B(N) &= N<0 \rightarrow 0,\ C(N)+B(N-5) \\
\text{AND } C(N) &= N<0 \rightarrow 0,\ 1
\end{aligned}$$

Suggest an alternative, more efficient definition of A.

Comment on the possibility of removing recursion from the following definition of the Binomial coefficients:

$$\begin{aligned}
\text{LET } C(N,R) = \ &R=0 \rightarrow 1, \\
&R=N \rightarrow 1, \\
&C(N-1,R-1)+C(N-1,R)
\end{aligned}$$

5. 2^{20} numbers, taken from a uniform distribution on the range $(0,1)$, are to be added. Describe in detail how errors propagate when the additions are done in a straightforward manner using <u>two</u> different rounding or truncation schemes.

Devise a way of performing this calculation so that the result is perturbed by no more than a few rounding errors in the basic precision of the arithmetic unit, and show how your improved method achieves the accuracy that it does.

6. Describe an efficient algorithm for discovering whether two nodes of a graph are connected or not. (If there are n nodes in a graph, efficient algorithms take no more than $O(n^3)$ steps.)

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 con-
tain 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.   The back-plane of a certain line of computers involves wired
connections between 50,000 pins. Although the wiring is performed
automatically, various kinds of error are made and as a result
the pins actually joined do not correspond exactly with the
specification. An automatic testing machine has been used to
provide a list of groups of pins that are actually connected
(directly or indirectly), and the original specification data
(assumed to be correct) which was used to drive the automatic
wiring machine is available.

    Design a program that will produce a report on the back-
plane, listing as concisely as possible connections that must be
removed, altered, or added. The method should be economic in
that the job when executed on a large computer will take a
matter of minutes and not hours. Show that this is so.

8. A 50×50 array holds valves <u>true</u> or <u>false</u> in a pattern that, if displayed, would be instantly recognizable as a typed upper-case letter. The letter is formed without serifs, it is the right way up and fills most of the array, but its <u>exact</u> size, position and orientation are unknown.

Assuming that all entries in the array are correct (there are no isolated or inconsistent cells representing dust or noise), design a program that will identify the letter represented.

9. A computer friendship bureau gets its customers to fill in a form asking about 70 questions about themselves and the kind of companion that they seek. To simplify processing, however, the bureau ignores all but the following five: *age, height, colour of hair, colour of eyes,* and *football team supported;* and introductions will be made on the basis of these alone.

Design the program that selects pairs of customers who are to be introduced to each other, bearing in mind the following:

(a) each customer must be sent a few names but not an overwhelmingly large number;

(b) names of customers are constantly being added to and removed from the bureau's register;

(c) when a customer requests a further selection of names, these are required to be different from any previously sent to him.