UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2004

MSc in Computing Science
for Internal Students of the Imperial College of Science, Technology and Medicine

PAPER M2

ARCHITECTURE AND OPERATING SYSTEMS

Tuesday 4 May 2004, 14:30
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators required

Section A *(Use a separate answer book for this Section)*

1a Briefly explain the concept of cylinder skew.

b How much cylinder skew is needed for a 6,000-rpm disk with a track-to-track seek time of 2 msec and 200 sectors per track?

c A request arrives at the I/O module to read a block on cylinder 15. While the seek to cylinder 15 is in progress, new read requests come in for cylinders 1, 36, 16, 34, 9 and 12, in that order. They are entered into a table of requests.

i What data structure would you use to represent this list of requests and why?

ii Using the FCFS algorithm calculate the total number of cylinders traversed to read the data.

iii Using the SSF algorithm calculate the total number of the cylinders traversed to read the data.

iv Using the Elevator algorithm with SSF, calculate the total number of cylinders traversed to read the data.

d Outline a good scheduling algorithm for a disk in which the seek time is much faster than the rotational delay?

The four parts carry, respectively, 10%, 20%, 55%, 15% *of the marks.*

Section B *(Use a separate answer book for this Section)*

2 This question concerns memory management.

a Consider a dynamic partition storage management system which allocates each process a contiguous region of physical memory corresponding exactly to the amount of memory the process requires for its code and data.

i State three problems of this dynamic partition memory management system that are overcome by using paging.

ii State two ways in which paging incurs an overhead compared with the memory management system described above.

b Consider a paged memory management system with 32-bit virtual addresses, 32-bit physical addresses and a page size of 4MB. How much memory is required for holding the page table? State any assumptions you have to make.

c Assume that the following program fragment is running on a computer system using paging, with a word size of 4 bytes (i.e. integers are 4 bytes), a page size of 4KB and 8MB of available physical memory.

We represent a drawing in 2D space by a collection of points and other data, such as edges connecting the points. Points consist of two integer co-ordinates x and y and we assume that the other data can be held in an array of 14 integers. The program fragment you are asked to consider is a loop which repeatedly modifies the x and y co-ordinates but leaves the other data unchanged.

```
/*  The type point is a structure consisting of
    integers x, y and other data. */
typedef struct {
  int x;
  int y;
  int otherdata[14];
} point;

/* Declare an array of points. /
point array[(1024*1024)];

for( int count = 0; count < 100; count++ ) {
  for( int i = 0; i < (1024*1024); i++ ) {
    array[i].x = /* new value */;
    array[i].y = /* new value */;
  }
}
```

Explain briefly why this program performs very poorly and suggest a simple change to this program that would significantly improve its performance.

The three parts carry, respectively, 50%, 20%, 30% of the marks.

Section C *(Use a separate answer book for this Section)*

3 a i Outline the differences between the synchronous and asynchronous schemes for communication over a bus. Include any advantages and disadvantages of each.

ii Explain why bus arbitration might be required

iii Describe *briefly* the two types of bus arbitration and how each could be implemented

b i List the elements of the IEEE 754 standard for representation of single-precision floating point numbers, explaining their function and how many bits are used for each.

ii Suggest how the range of numbers that can be represented could be increased. Include what other consequence this would have for the numbers and explain why.

iii What decimal number is represented in the IEEE 754 standard by 418C0000?

c i The following C function returns the product of two non-negative integers

```
int product(int x,y)
{
    int i = 0;
    int j = y;
    while (j > 0)
    {
        i = i + x;
        j = j - 1;
    }
    return i;
}
```

Write the equivalent subroutine in 8086 assembler. Your solution should use a stack frame, preserve the contents of any registers used, and include **EQU**ate statements and informative comments.

ii The following C function returns a non-negative integer raised to the power of another non-negative integer

```
int power(int m,n)
{
    if (n == 0)
        return 1;
    else return product(m,power(m,n-1));
}
```

Write the equivalent subroutine in 8086 assembler. Your solution should use a stack frame, preserve the contents of any registers used, and include **EQU**ate statements and informative comments.

The three parts carry, respectively, 30%, 30%, 40% of the marks

4 a An assembler takes a file containing source code and generates an executable (machine code) version. The source code of an 8086 program may include

i CPU instructions

ii Assembler directives

iii BIOS calls

iv Comments

Explain what each is, with an example, and describe how it is processed by the assembler.

b The following hexadecimal digits represent values stored at successive byte locations in the memory of an 8086-based microcomputer

2468							246F
FF	14	88	08	A7	13	4D	45

Consider the 8086 instructions

```
mov ax,[246c]
add ax, 246A
```

What is the decimal representation of the final contents of ax?

c i State the rules for overflow to occur in addition with two's complement arithmetic

ii Complete the corresponding truth table, with the sign bits of the two operands and the sign bit of the result as inputs and the Overflow flag as output.

iii Sketch a corresponding logic circuit (hint: the Exclusive NOR gate - NOT XOR - is sometimes referred to as the "equivalence gate").

The three parts carry, respectively, 30%, 30%, 40% of the marks

Section C *(Use a separate answer book for this Section)*

3a Briefly explain the concept of cylinder skew?

b How much cylinder skew is needed for a 60,000-rpm disk with a track-to-track seek time of 2 msec?

c A request arrives at the IO module to read a block on cylinder 15. While the seek to cylinder 11 is in progress, new requests come in for cylinders 1, 36, 16, 34, 9 and 12, in that order. They are entered into a table of requests.

i) What data structure would you use to represent this list of requests and why?
ii) Using the FCFS algorithm, calculate the total number of seeks the system must perform to read data
iii) Using the SSF algorithm, calculate the total number of seeks the system must perform to read data.
iv) Using the Elevator algorithm with SSF, calculate the total number of seeks the system must perform to read data.

d How would the scheduling algorithm change if the seek time was much faster than the rotational delay.

The four parts carry, respectively, 10%, 20%, 55%, and 15% *of the marks.*