UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2003

BSc Honours Degree in Mathematics and Computer Science Part II
MSci Honours Degree in Mathematics and Computer Science Part II
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the Royal College of Science

PAPER MC114

OPERATING SYSTEMS

Thursday 1 May 2003, 15:30
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators required

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

1 a McCann's fast food restaurant has four kinds of employees:
(1) Ordertakers, who take customers' orders (written on a piece of paper and placed on an order rack);
(2) Cooks, who take the order from the order rack and prepare the food and put it on a hotplate;
(3) Packaging Specialists, who put the food into bags from the hotplate;
(4) Cashiers, who give the bags to customers and take their money.

Each employee can be regarded as a communicating sequential process.

i) What form of interprocess communication do they use?

ii) The *Cook* and *Packaging Specialist* use an enclosed hot plate with only one door to open it to deposit and pick up burgers respectively. Write pseudocode for employee relationship operation using *semaphores*.

b Five batch jobs A through to E, arrive at the computer at almost the same time. They have estimated running times of 10, 6, 2, 4, and 8 minutes. Their (externally determined) priorities are 3, 5, 2, 1, and 4 respectively, with 5 being the highest priority. For each of the following scheduling algorithms, determine the mean processing turnaround time (process switching overhead should be ignored).

i) Round Robin
ii) Priority scheduling
iii) First-come first served (run order 10, 6, 2, 4, then 8)
iv) Shortest job first

For (i), assume that the system is multiprogrammed, and that each job gets its ***fair*** share of the CPU. For (ii) through (iv) assume that only one job at a time runs, until it finishes. All jobs are completely CPU bound.

The three parts carry, respectively, 60%, 40% of the marks.

2 a Why are output files for a printer normally spooled on disk before being printed?

b How much cylinder skew is needed for a 12,000-rpm disk with a track-to-track seek time of 800 μsec? The disk has 200 sectors.

c Disk requests come into the disk driver for cylinders 10, 22, 20, 2, 40, 6 and 38 in that order. A seek takes 6 msec per cylinder moved. In all cases the arm is initially at cylinder 20, how much seek time is needed for the following disk arm scheduling algorithms:

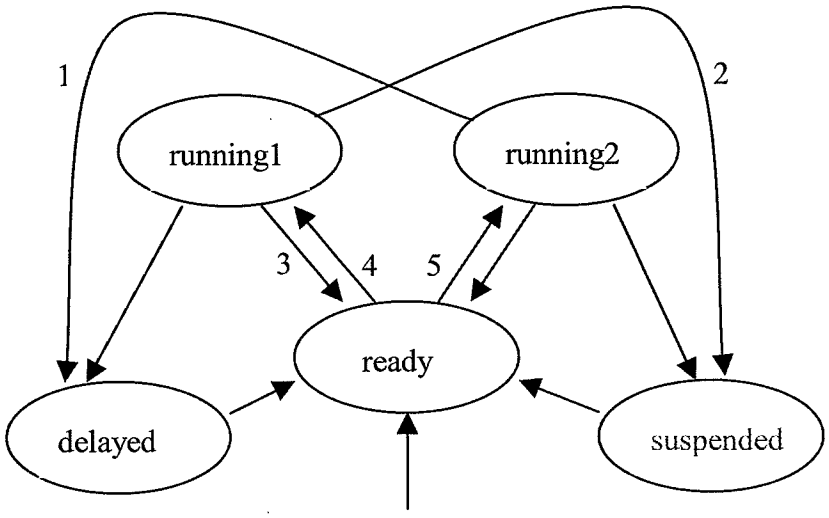
(i) First-come first served
(ii) Closest cylinder first
(iii) Elevator algorithm (initially moving forward)

d In the imaginary '*FENÊTRES 2002*' operating system, a single processor and an internal store were multiplexed among user computations using *swapping*. The amount of internal store required by each job during execution is known in advance. How could information about the expected workload be used to make swapping more efficient in terms of scheduling?

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

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

3 Consider the following diagram showing the process state transitions that take place in an enhanced Simple Kernel operating system designed to run on a shared memory multiprocessor computer with 2 CPUs. The process scheduling strategy used is static priority-based preemption with 4 priority levels (idle, low, medium and high).



a Concisely describe a scenario that leads to the process state transition labelled 1 and also a scenario that leads to the process state transition labelled 2.

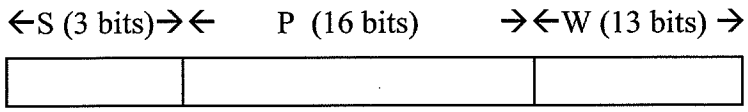
b Concisely describe two scenarios that lead to the process state transition labelled 3.

c Which Simple Kernel procedure implements process state transitions 4 and 5? Give pseudocode for this procedure in the 2 CPU environment shown above. You may assume the existence of a function `cpu_number()` that returns 0 or 1 depending on which CPU executes the function, and the function `pswitch(cpu,pcb_old,pcb_new)` which performs a context switch on CPU `cpu` (0 or 1) from the user process with process control block (PCB) `pcb_old` to the user process with PCB `pcb_new`.

d In a uniprocessor context, how is mutually exclusive access to kernel data structures by kernel procedures enforced? Will the same scheme work in a multiprocessor context? Justify your answer.

The four parts carry, respectively, 20%, 20%, 40% and 20% of the marks.

4 An operating system with a paged and segmented memory system has the following virtual address format:



a. Give two advantages of a paged and segmented memory system from a compiler writer's point of view. What is the primary disadvantage from a performance engineer's point of view?

b. What combination of read, write and execute protection bits are appropriate for a stack segment? Under what circumstances would it be appropriate to associate more than one stack segment with a process?

c. How big is the virtual address space associated with a process in the scheme described above? If there are 6 processes currently running on the system, how many segment tables and how many page tables are required? How many entries will there be in each segment table and in each page table?

d. Suppose a Translation Lookaside Buffer (TLB) is added to speed up address translation.

   i.) Given that the TLB is to be installed on a system that supports a maximum of 1GB physical RAM, draw a diagram to show the layout of each entry in the TLB (i.e. show the main components of each TLB entry with corresponding bit widths).

   ii.) If address translation time using the TLB is 10 times faster than using the usual segment and page table lookups, determine the TLB hit ratio necessary to reduce the average address translation time by 50%. You may assume that that segment and page table lookups only begin (where necessary) after a TLB miss.

The four parts carry, respectively, 15%, 15%, 25% and 45% of the marks.

End of paper