Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Operating Systems

Date: Monday 25\textsuperscript{th} January 2010
Time: 09.45 – 11.45

Please answer Question ONE and any two from Questions TWO, THREE and FOUR
[Of note – All the questions carry equal weighting]

The use of electronic calculators is \textbf{NOT} permitted
1. **Compulsory**

   a) What is meant by the term *programmed I/O*? Give a brief answer – flowcharts are not required.  
      (2 marks)

   b) Briefly explain the difference between a *page* and a *segment* in a virtual memory system.  
      (2 marks)

   c) What is an input/output *status register* and what type of instructions use the status register?  
      (2 marks)

   d) A computer system has a 32-bit address bus. A *paged virtual memory* system is used in the computer with a page size of 16KB. In the *logical address* generated by the processor, how many bits are used to specify the *page number*?  
      (2 marks)

   e) An input/output (I/O) module in a computer system has a *Direct Memory Access (DMA)* interface. Explain what the DMA interface does.  
      (2 marks)

   f) What is meant by the term ‘working set;’ with respect to process memory pages?  
      (2 marks)

   g) Why do computers typically have two modes of operation, namely user mode and system mode (also known as supervisor mode, or kernel mode, or privileged mode)?  
      (2 marks)

   h) Briefly explain how Unix implements input redirection in a shell command.  
      (2 marks)

   i) What is the purpose of the *registry* in a Windows operating system?  
      (2 marks)

   j) What does it mean to say that a system is constructed using the *microkernel approach*?  
      (2 marks)
2. a) Describe the actions that occur when a context switch happens in an Operating System. (3 marks)

b) Draw a diagram showing the various states of a process in the system, and label the transitions between the states with comments explaining what causes a process to make that transition. (4 marks)

c) Given a set of jobs with known processing time, all available to run, outline the proof that the Shortest Job First schedule gives the lowest average turnaround time. (3 marks)

d) Why is a schedule giving lowest average turnaround time the same as that giving lowest average waiting time? (1 mark)

e) A Shortest Remaining Job First (SRJF) scheduler is modified as follows. Instead of considering the length of the remaining CPU burst of a process, it uses this length minus the length of time since the process last received a time quantum. (This latter value is initialised to zero.) If two, or more, processes are tied, the one with the shorter remaining CPU burst is chosen.

i) Illustrate the behaviour of this modified scheduler by showing what is run in each time quantum if the following processes are present at the start: process A with a CPU requirement of 3 quanta, process B with a CPU requirement of 6 quanta, process C with a CPU requirement of 7 quanta, and process D with a CPU requirement of 8 quanta. (5 marks)

ii) In the example above, what is the change in the average turnaround time? (2 marks)

iii) What defect of SRJF schedulers is this modification attempting to remedy, and how effective is it in this? (2 marks)
3. a) i) Explain the difference between threads and processes. (2 marks)

ii) What does it mean to say that a system has kernel-level threads rather than user-level threads? (3 marks)

iii) What differences might affect a user application, depending on whether its threads are kernel-level or user-level threads? (3 marks)

b) Given the following Java program:

class Mystery extends Thread {
    static int count1 = 0;
    static int count2 = 0;
    static Object gate = new Object();

    static void startWhat(boolean b) throws InterruptedException {
        synchronized(gate) {
            if (b) {
                while (count2 != 0) gate.wait();
                count1++;
            } else {
                while (count1 != 0) gate.wait();
                count2++;
            }
            // in part (iv) insert gate.notify() ; here
        }
    }

    static void endWhat(boolean b) {
        synchronized(gate) {
            if (b) count1--;
            else count2--;
            gate.notifyAll(); // in part(iv) gate.notify();
        }
    }

    int id;

    Mystery(int id) {
        this.id = id;
    }

    public void run() {
        boolean myside = (id % 2 == 0);
        try {
            startWhat(myside);
            System.out.println("I support " +
            (myside?"City":"United");
            sleep(10);
            System.out.println("They will beat " +
            (myside?"United":"City");
            endWhat(myside);
        } catch (Exception e) {;}
    }
}
public static void main(String[] args) {
    for (int i = 0; i < 20; i++)
        (new Mystery(i)).start();
}

i) Describe fully the possible outputs produced by running it. (4 marks)

ii) Explain the various possible behaviours of an individual thread in this code when it is run. (3 marks)

iii) What would be the effect of making the methods startWhat() and endWhat() synchronized? (2 marks)

iv) If the notifyall() at the end of endWhat() were replaced by notify(), and notify() were also inserted at the position indicated by the comment in startWhat(), would the behaviour be the same? Justify your answer. (3 marks)
4. a) Name three page replacement policies. Then, briefly describe the three page replacement policies. (6 marks)

b) A processor has an address bus width of 36 bits. The processor uses this address bus to generate the logical address for a virtual memory system. The computer system in which the processor resides has 1GB of main memory and uses a paged virtual memory system that has a page size of 64KB.

i) How many pages are there in the paged virtual memory system? (1 mark)

ii) How many page frames are there in main memory? (1 mark)

iii) The logical address generated by the processor is made up of two bit fields, a tag and an offset. How many bits in the logical address are allocated to the tag and how many to the offset? (3 marks)

iv) Explain how the logical address is translated into a physical address. Explain what a page fault is and what happens when a page fault is generated. (4 marks)

c) Segmented and paged virtual memory systems are often combined. Explain how a segmented paged virtual memory system is organised and explain the benefits of using such a system. (5 marks)

END OF EXAMINATION