Birkbeck
(University of London)

MSc Examination for Internal Students

School of Computer Science and Information Systems

Computer Systems (COIY060H7)
Credit Value: 15

Date of Examination: 20/05/2010
Duration of Paper: 14:30 - 16:30

There are five questions in this paper, each of them is compulsory and worth 20 marks.
The paper is not prior-disclosed;
The use of electronic calculators is not permitted.

Questions

1. (a) Name at least six stages in the instruction cycle. (5 marks)

   (b) How does the length of the pipeline differ for RISC and CISC machines? Explain your answer. (5 marks)

   (c) Why is branch prediction a vital aspect of modern processor design? Describe a dynamic branch prediction method typically used by CISC machines like the Pentium. (10 marks)

2. (a) Describe what superscalar processors are and how they can increase instruction level parallelism. (5 marks)

   (b) Explain the policy of 'out-of-order issue and out-of-order completion' and why it is commonly used by superscalar processors. (5 marks)

   (c) Show the pipeline activity using 'out-of-order issue and out-of-order completion' for the execution of the following instructions and calculate the number of delay slots because of dependencies. Assume that there are two fetch and decode units, one multiplier and one adder, and two store units. The instruction window is big enough to store all six instructions at the same time.

```
I1: Add R3, R3, R5     / R3 <- R3 + R5 /
I2: Mul R4, R3, 2      / R4 <- R3 * 2 /
I3: Add R5, R5, 1      / R5 <- R5 + 1 /
I4: Mul R7, R5, 2      / R7 <- R5 * 2 /
I5: Add R6, R7, 1      / R6 <- R7 + 1 /
I6: Add R3, R3, 1      / R3 <- R3 + 1 /
```

   (10 marks)

3. (a) Explain the concepts of race condition, critical section (or region) and mutual exclusion in the context of interprocess communication. (6 marks)

   (b) Briefly describe the technique called 'strict alternation' and discuss whether it provides a satisfactory solution to the critical section problem. (6 marks)

   (c) Consider the following pseudo-code:

```
shared boolean flag[2];
flag[0] = flag[1] = FALSE;
proc(int i) {
  while (TRUE) {
    while (flag[(i+1) mod 2] == TRUE);   // loop till FALSE
    flag[i] = TRUE;
    critical_section;
    flag[i] = FALSE;
  }
}
```

   Explain whether this code solves the critical section problem for two processes. (8 marks)

4. (a) Explain what virtual memory is and list some of its benefits. (5 marks)

   (b) Describe what hierarchical (a.k.a. multilevel) and inverted page tables are and compare their mutual advantages. (5 marks)

   (c) Assume that a computer uses a 32-bit virtual address, byte-level addressing and 4KB pages.

i. Determine the maximum size of the virtual address space per process. (3 marks)

ii. Compute the size of the single-level page table. (3 marks)

iii. Calculate the size of the root page table assuming a two-level page table. (4 marks)

5. (a) Define deadlock and describe three methods of dealing with deadlock. (8 marks)

(b) A system has four processes p_1, p_2, p_3, p_4 and three types of dedicated resources R_1, R_2, R_3. The existence vector is $E = (3, 2, 2)$.

- Process p_1 holds one unit of R_1 and requests one unit of R_2;
- Process p_2 holds two units of R_2 and requests two units of R_1 and one unit of R_3;
- Process p_3 holds one unit of R_1 and requests one unit of R_2;
- Process p_4 holds two units of R_3 and requests one unit of R_1.

i. Compute the availability vector. (2 marks)

ii. Explain whether the system is deadlocked. (4 marks)

iii. Determine whether this state of the system is safe. (6 marks)