B.Sc. EXAMINATION
School of Computing
2 Hours

May 2012

Computer Systems 2B
Computer Architecture and Operating Systems (AC22005)

This examination paper contains **SIX** questions.

Attempt **TWO** questions from **Section A** and **TWO** questions from **Section B**.

Only calculators approved by the School of Computing for exam use may be used in this exam.

SECTION A
Attempt TWO questions from this Section.

Question 1

(a) (i) Describe how the **pipelining** of instructions in a microprocessor can be used to improve throughput. **[4 Marks]**

(ii) Name and briefly describe **two** types of **dependencies** which limit the operation of a pipeline. **[4 Marks]**

(iii) Explain how a **Branch Target Buffer** reduces the effect of one of these dependencies. **[4 Marks]**

(b) A certain microprocessor, with 32-bit data and address buses, incorporates a **Branch Target Buffer** which is 2-way set associative with 256 sets, and stores 2 history bits for each way of each set in the BTB.

(i) How many bits must be stored in the **tag** field in each way of the BTB? **[2 Marks]**

(ii) Sketch the layout of this BTB. **[3 Marks]**

(iii) Calculate how many bits in total are required to implement this BTB on the silicon chip. **[3 Marks]**

(c) Briefly discuss why **thread-level parallelism** is of increasing importance compared to **instruction-level parallelism**. **[5 Marks]**

Question 2

(a) **Memory management** was not required in early microcomputers, but it is a feature of modern PCs.

(i) explain why this is the case; **[3 Marks]**

(ii) name and describe the **three** sub-goals of memory management. **[6 Marks]**

(b) Modern PC buses, such as PCIE and SATA, differ from older types such as ATA/IDE and PCI/AGP.

(i) What are the main differences between the old and new types of bus? **[2 Marks]**

(ii) Why have these changes been adopted? **[3 Marks]**

(c) A particular 32-bit computer has 3GB of main memory, split into 64KB pages. A paged, byte-addressable virtual memory is in use. The processor is executing a program of size 250KB, split into four pages.

(i) How many bits are required to store the **frame number** in the page translation table? **[1 Mark]**

(ii) What are the remaining bits used for? **[1 Mark]**

(iii) Pages 0, 1 and 3 of the program are loaded into main memory frames 76, 23 and 8 respectively, while page 2 is in virtual memory. Draw the relevant part of the page translation table to reflect the current state of this program. **[5 Marks]**

(d) Intel introduced the **Execution Trace Cache** in the Pentium 4 processor; describe the operation of this architecture feature. **[4 Marks]**

Question 3

(a) In the context of building a C# program using Visual Studio:

(i) name **three** user interface components available from the Toolbox when building a C# graphical user interface in Design View; for **each** component, identify a human-computer interaction benefit or problem. **[3 Marks]**

(ii) C# Windows Forms Applications are an example of event-driven programs. Describe the key features of an event-driven program, giving an example. **[5 Marks]**

(iii) describe the key stages involved in programming a **button** in C# *without using the Design View or the Toolbox*. **[5 Marks]**

(b) Explain the principle of **I/O buffering.** **[4 Marks]**

(c) A process must read 3 blocks of data from hard disk and perform some calculations using each block. Reading a block from hard disk to main memory takes 100ms; the processing performed on each block takes 250ms. If I/O buffering is used, it takes 10ms to copy a block from the buffer to the process data area. Assuming that the process can re-commence running as soon as it becomes unblocked on I/O:

(i) how long will it take in total to read the blocks and perform the calculations when **no** I/O buffering is used? Use a timing diagram to illustrate your answer. **[4 Marks]**

(ii) how long will it take in total to read the blocks and perform the calculations when **single** I/O buffering is used? Use a timing diagram to illustrate your answer. **[4 Marks]**

SECTION B
Attempt TWO questions from this Section.

Question 4

(a) State concisely

(i) what the difference between a **program** and a **process** is; **[1 Mark]**

(ii) what **CPU scheduling** is; **[1 Mark]**

(iii) what **long-term**, **medium-term** and **short-term** scheduling are; **[3 Marks]**

(iv) why different CPU scheduling **algorithms** exist; **[1 Mark]**

(v) a feature of **user-oriented** scheduling. **[1 Mark]**

(b) Processes **P0, P1, P2, P3** and **P4** each have a total run-time requirement of T time units, as indicated:

P0 (T=5 units)

P1 (T=7 units)

P2 (T=4 units)

P3 (T=9 units)

P4 (T=14 units)

Draw a **Gantt chart** (timing chart) to illustrate the running of these processes when each of the following types of scheduling are used:

(i) Shortest Job First (Shortest Process Next); **[6 Marks]**

(ii) Round Robin. **[6 Marks]**

Should time-slicing be required, assume that the quantum (time slice) = 1 time unit. Assume that no blocking events will occur.

(c) For each of the two types of scheduling seen in sections **(b)(i)** and **(ii)** above, calculate:

(i) the total time that **each** process spends waiting; **[4 Marks]**

(ii) the overall average waiting time per process. **[2 Marks]**

Question 5

(a) Describe briefly, using a diagram in each case, each of the following **security threats**:

(i) Interruption **[2 Marks]**
(ii) Interception **[2 Marks]**
(iii) Modification **[2 Marks]**
(iv) Fabrication **[2 Marks]**

(b) Explain the principle of **"Least Privilege"** for security of computer systems, and name **three** other design principles for security measures in computer systems. **[5 Marks]**

(c) (i) Draw the following three features as they are found in **Microsoft® Windows™:**

- Access Token **[2 Marks]**
- Security Descriptor **[2 Marks]**
- Access Control List **[2 Marks]**

(ii) Describe how security measures operate in **Microsoft® Windows™**. Your answer should refer to the three features listed in section **(c)(i)** above. **[6 Marks]**

Question 6

(a) (i) State what **deadlock** is in a computer system. **[2 Marks]**

(ii) Cite a practical example of deadlock that might occur in a computer system. **[1 Mark]**

(iii) One of the **conditions** for the occurrence of deadlock is **Mutual Exclusion**. Explain what Mutual Exclusion is and why it is needed. **[3 Marks]**

(iv) List three other conditions which are required for deadlock to occur. **[3 Marks]**

(b) Describe a **counting (general) semaphore** and state what it is used for. **[3 Marks]**

(c) (i) Briefly explain the problem known as the **"Dining Philosophers Problem"**, and its relevance to the subject of deadlock. **[4 Marks]**

(ii) Develop a solution to the Dining Philosophers Problem using semaphores, justifying any restrictions that the semaphores impose on the behaviour of the philosophers. Produce your answer in pseudo-code. (You may assume that appropriate semaphore primitives already exist for use in your pseudo-code.) **[9 Marks]**

[End of Examination Paper]