**THE AUSTRALIAN NATIONAL UNIVERSITY**

Final Examinations (Semester 2) 2010

# Sample Exam

COMP3300/COMP6330
(Operating Systems Implementation)
Final Exam

**Writing Period:** 3 hours duration
**Study Period:** 15 minutes duration
- you may read text files and pdfs but you are not permitted to start answering questions.

**Permitted Materials:** none
Note the standard lab tools are available including : gcc, ooffice, gedit, dia, gcc, man, linux source code, ...

Please Read The Following Instructions Carefully.

This exam will be marked out of 100 and consists of 4 questions. Questions are of unequal value. The value of each question is shown in square brackets. Questions that are partitioned into parts show the number of marks given to each part within square brackets.

Students should attempt all questions. Answers must be saved into each question's directory (Q1, Q2, Q3, Q4) using the file(s) described in the question statement. Marks may be lost for giving information that is irrelevant.

Network traffic may be monitored for inappropriate communications between students, or attempts to gain access to the Internet.

# Question 1 - Short Answer [40 marks]

Highest marks are gained by providing: clear, concise, and short answers. Save your answers in the in the file 'Q1Answers.odt' in the directory Q1. This file can be edited using 'ooffice'. Please make certain that this file is saved both as you progress through the exam and before the exam ends.

i. [3 marks] What is the distinction between mechanism and policy in operating system design. Give an example.
ii. [3 marks] What is the distinction between a preemptive and non-preemptive scheduler?
iii. [3 marks] In UNIX what do the 'fork' and 'execve' system calls do?
iv. [3 marks] Why is a Longest Job First scheduler a bad idea?
v. [3 marks] What is the purpose of the sk_buff (or skbuff in old versions) within Linux's network kernel code? Which network layer (or layers) is the sk_buff associated with?
vi. [3 marks] What is the distinction between the 'memory management unit' and the 'memory manager'? How do these entities relate?
vii. [3 marks] What is copy-on-write?
viii. [3 marks] Why is it impossible to implement a Shortest Job First (SJF) scheduler?
ix. [3 marks] What is Read Copy Update (RCU)? What are some advantages and disadvantages of using this approach?
x. [3 marks] What is priority inversion? How can it be addressed?
xi. [3 marks] Why should linux kernel code always use 'copy_from_user' or 'copy_to_user' when dealing with references to user space memory?
xii. [3 marks] Explain how Linux is a superior operating system to M$ windows.
xiii. [4marks] Explain the distinction between a microkernel and a monolithic kernel design.

## Question 2 - Lab [20 marks]

The objective of this lab question is to create a new system call that enables you to toggle process forking. The first time the system call is called forking is disabled, the next time it is enabled, etc.

i. [5 marks] Locate the file in which you will place the system call. Make a note of how you located this file.

ii. [5 marks] Modify kernel source code to add this system call to the kernel. Include a 'diff' of all the files you changed.

iii. [5 marks] Create a user space program that will enable you to test your new system call. Include this user space program in a .c file in this directory.

iv. [5 marks] Generate the list of commands you would use to test your entire modification.

Note, part marks may be given, so even if you can not generate the exact commands you can still gain marks by including descriptive comments. Place all your answers in text files in this directory.

# Question 3 Lab [20 marks]

i) [15 marks] The mprotect() system call allows you to set the protections on a set of pages in your processes address space. Write a program that allocates some memory then sets this memory to non-writeable. Also install a signal handler to catch a segmentation fault. You will then attempt to write to the memory and your signal handler will be called as the memory management hardware detects a fault. Inside your signal handler you will use mprotect to make the memory writeable again then return. The write to the memory complete and the program will continue.
Your answer for this question must be in 'protect.c' in the Q3 directory.

ii) [5 marks] Using the above approach create a thread that monitors a region of memory (this region is used within the rest of the process). The thread determines if the memory has been referenced (either read or write) over a sequence of fixed periods of time. This reference string could be printed to standard output and be 0 if the region of memory had not been referenced and 1 if it had. Suppose the period of time is set to 1 second and the memory was referenced in the first, third, fourth seconds but not in the second and fifth seconds then the reference string would be 10110.
Your answer for this question must be in 'reference.c' in the Q3 directory.

# Question 4 Lab [20 marks]

Save your answer in this directory in a file called "Q4answers.odt". Use 'ooffice' to edit this 'odt' file.

i. [10 marks] Suppose we have a demand-paged memory. The page table is held in registers. It takes 8 milliseconds to service a page fault if an empty page is available or the replaced page is not modified, and 20 milliseconds if the replaced page is modified. Memory access time is 100 nanoseconds.

Assume that the page to be replaced is modified 70 percent of the time. What is the maximum acceptable page-fault rate for an effective access time of no more than 200 nanoseconds? Show your calculations.

iii. [10 marks] Suppose you are given the task of designing a new processor that supports segmentation.

Segments are also paged and memory is byte addressed. Two possible virtual address formats are being considered.

Format 1:

| | | |
|---|---|---|
| 5 bit segment number | 4 bit page number | 7 bit offset |

Format 2:

| | | |
|---|---|---|
| 2 bit segment number | 7 bit page number | 7 bit offset |

A segment descriptor occupies 6 bytes and a page descriptor occupies 2 bytes.

- How many distinct bytes can be addressed with format 1? With format 2?
- How many distinct pages can be addressed with format 1? With format 2?
- How many distinct segments can be addressed with format 1? With format 2?
- Which format requires that the least amount of memory be devoted to page and segment tables? Justify your answer by showing your calculations of the memory requirements for both formats.