UNIVERSITY OF EDINBURGH

FACULTY OF SCIENCE AND ENGINEERING

COMPUTER SCIENCE THREE

OPERATING SYSTEMS

Thursday 7 June 2001

14:00 to 15:30

Examiners:

K. Turner (External)

G. Plotkin (Chairman)

INSTRUCTIONS TO CANDIDATES

Answer any TWO questions.

All questions carry equal weight.

1. (a) Explain briefly what is meant by each of the following terms:

   i. Process
   ii. Thread
   iii. Interrupt
   iv. Exception
   v. Signal

   [*10 marks*]

   (b) *Recall that the* `mprotect` *Linux system call allows a program to set read/write access permissions on individual virtual pages of its process space.*

   Using `mprotect`, how might a process be able to monitor which virtual pages were used by an application? [*7 marks*]

   (c) *Now assume the existence of a* `sleep` *system call that suspends the execution of a thread for some number of milliseconds.*

   How could your scheme of part (b) be extended, using such a `sleep` system call, to produce a *page-usage trace* of the running application which would monitor the virtual pages it uses in *every* successive time-slice? [*8 marks*]

2. (a) Explain the operation of an indivisible *test-and-set* machine instruction and how it can be used to ensure mutual exclusion of concurrent processes from critical sections. [*4 marks*]

   (b) Give the definition of a *semaphore* and the associated **P** and **V** operations. [*3 marks*]

   (c) Explain how indivisible *test-and-decrement* and *increment-and-test* machine instructions can be used to implement **P** and **V** operations at the user level. [*3 marks*]

   (d) Explain how *deadlock* and *starvation* might occur when using semaphores for process synchronisation. What is meant by the term *busy-waiting*? How can busy-waiting be avoided? [*7 marks*]

   (e) Describe how the kernel of an operating system might implement semaphore operations and the data structures it might use. How could deadlock checking be incorporated? [*8 marks*]

3. (a) Describe problems which virtual memory segmentation overcomes and how it does so. *[6 marks]*

   (b) Briefly describe the segmentation system on the Intel Pentium processor and discuss its effectiveness. *[7 marks]*

   (c) What is meant by the term *Rings of Protection*? Explain how this is implemented on the Pentium. *[6 marks]*

   (d) Describe how paging can also be incorporated into an address translation mechanism in addition to segmentation. What benefits does this bring? *[6 marks]*