**CS2106 Introduction to Operating Systems**

**Lab 3**

**Answer Book**

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| **Name: Wu Xiao Yun** | **Name: Ang Koon Hwee** |
| **Student ID: A0221772J** | **Student ID: A0221986W** |
| **Lab Group: B06** | **Lab Group: B06** |

**Part 1**

Question 1.1 (1 mark)

The child processes got switched before it prints the numbers after the `usleep(250000)` in the loop. This suggests that the time quantum is smaller than 250000 microseconds.

Question 1.2 (1 mark)

A child process could read the value of the lock (1) and context switch happens before it is able to write the value of 0 back to the lock. As such, multiple child processes could claim the lock (before the new value of lock is written back to shared memory) and run simultaneously to print the lines “<some number> I am child X”.

Question 1.3 (1 mark)

#include <stdio.h>

#include <unistd.h>

#include <stdlib.h>

#include <sys/shm.h>

#include <sys/wait.h>

#define NUM\_PROCESSES 5

int main() {

int i, j, pid;

// create a new shared variable for turn

int \*turn;

int shmid;

shmid = shmget(IPC\_PRIVATE, sizeof(int), IPC\_CREAT | 0600);

// attach the shared memory region to this process

turn = shmat(shmid, NULL, 0);

turn[0] = 0; // intialize turn to 0

for(i=0; i<NUM\_PROCESSES; i++)

{

if((pid = fork()) == 0) {

break;

}

}

// busy waiting for my turn

while (turn[0] != i);

// it is currently my turn, execute my code

if(pid == 0) {

printf("I am child %d\n", i);

for(j = i\*10; j<i\*10 + 10; j++){

printf("%d ", j);

fflush(stdout);

usleep(250000);

}

printf("\n\n");

turn[0]++; // pass turn to next process

}

else {

for(i=0; i<NUM\_PROCESSES; i++)

wait(NULL);

// detach and destroy shared memory

shmdt(turn);

shmctl(shmid, IPC\_RMID, 0);

}

}

int \*turn;

int shmid; // these two lines create a shared variable for turn

shmid = shmget(IPC\_PRIVATE, sizeof(int), IPC\_CREAT | 0600); // creates a shared memory region with size of one integer

turn = shmat(shmid, NULL, 0); // attach the shared memory region to this process

turn[0] = 0; // intialize turn to 0

while (turn[0] != i); // busy waiting and do nothing when it is not current process’s turn, if executed pass this line, it means that it is current process’s turn and the process will execute the print lines.

turn[0]++; // pass turn to next process after current process has finished executing

// detach and destroy shared memory after all child processes have been executed

shmdt(turn);

shmctl(shmid, IPC\_RMID, 0);

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| Question 1.4 (1 mark)  sem\_init(sem\_t \*sem, int pshared, unsigned int value) initializes the semaphore variable pointed by sem to value amount   * sem points to a semaphore variable to be initialized * If pshared is non-zero, then the semaphore can be shared between processes; if pshared is zero, it can be only shared between threads instead of processes. * value is initial value of semaphore   sem\_wait(sem\_t \*sem)   * decrements semaphore value atomically * if the semaphore value <= 0, the calling process blocks * sem points to the semaphore variable to decrement the value   sem\_post(sem\_t \*sem)   * increments semaphore value atomically * if the semaphore value > 0, wakes up a blocked process waiting on the semaphore if any * sem points to the semaphore variable to increment the value |

Question 1.5 (1 mark)

The semaphore is not shared between the parent and child processes so the child process has another semaphore variable on its stack. When the parent process increments its semaphore with sem\_post(&sem), the child process is unaware of the increment as this semaphore is not shared and the semaphore in the child process still has a value of 0 (initial value). Hence, the child process does not wake up and the program hung.

Question 1.6 (1 mark)

**Part 2**

Question 2.1 (1 mark)

Question 2.2 (1 mark)

**Part 3**

Question 3.1 (1 mark)

Question 3.2 (1 mark)

Question 3.3 (1 mark)

**TOTAL:** \_\_\_\_\_\_ / 11