

**Gebze Technical University
Computer Engineering**

CSE 312 - 2021 Spring

HOMEWORK 2 REPORT

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1 INTRODUCTION

1.1 Problem Definition

Designing and implementing POSIX threads and thread system calls, handling multi-threading, handling interrupts using SPIM OS.

1.2 System Requirements

Any computer with Ubuntu 14.04 LTS 32-bit Operating System.

2 METHOD

2.1 Problem Solution Approach

Threads have own registers, stack and state. Everything else are shared between threads. Thread Table has 3 different state. These state are running, runnable and blocked. Round Robin is made by using a queue.

Mutexes are

CREATE_SYSCALL:

This syscall creates a thread object and adds into runnable queue.

JOIN_SYSCALL:

This syscall waits the given thread. If the thread is not terminated, it adds the current thread into runnable queue and decrease the program counter with 4. So, when the current thread is selected by timer_handler, it checks the given thread is terminated or not again.

EXIT_SYSCALL:

This syscall deletes the current thread and calls the timer_handler.

MUTEX_LOCK:

This syscall locks the thread (adds into the blocked queue), if the mutex value is false. If not, changes the mutex value from true to false.

MUTEX_UNLOCK:

This syscall changes the mutex value if the value is false. If someone locked due to the mutex, it wakes up the thread. (adds into the runnable queue)

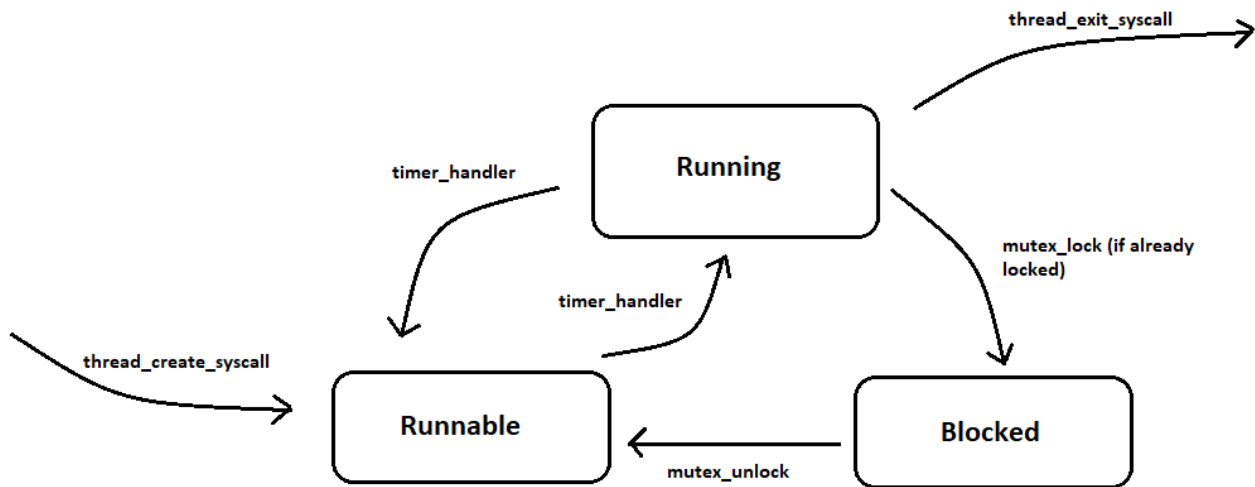
MUTEX_CREATE:

This syscall creates a mutex object with given value.

INIT_SYSCALL:

This syscall initialize the main thread.

2.2 Thread State Diagram



3 RESULT

3.1 Test Cases

SPIMOS GTU 1.s:

There is an array inside this kernel. The size of array 15.

Prints the array without sorting.

Creates 3 thread, each thread is sort the subarray using mergesort.

When all subarray are sorted, main thread merges the subarrays and prints the array.

Running output:

```

Terminal
cse312@ubuntu: ~/Desktop/CSE312/spimsimulator-code-r739/spim
$ ./SPIMOS_GTU_1.s
Loaded: /usr/share/spin/exceptions.s
.pname: asciz 0, 16, 26, 32, 76, 0, 122, 123, 61, 53, 42, 77, 16, 41, 187,
.cname: asciz Thread id:2 name:mergesort-thread2 status:runnable PC:4194580 SP:2147480144
.message: asciz Thread id:3 name:mergesort-thread3 status:runnable PC:4194580 SP:2147480144
.cmessage: asciz Thread id:0 name:init status:runnable PC:4194468 SP:2147480144
.mut1: asciz Thread id:1 name:mergesort-thread1 status:running PC:4194580 SP:2147480144
.mut2: asciz Thread Table Status:
.newlne: asciz Thread id:3 name:mergesort-thread3 status:runnable PC:4194580 SP:2147480144
Thread id:0 name:init status:runnable PC:4194468 SP:2147480144
Thread id:2 name:mergesort-thread2 status:running PC:4194580 SP:2147480144
Thread Table Status:
.globl main
main: Thread id:0 name:init status:runnable PC:4194468 SP:2147480144
Thread id:3 name:mergesort-thread3 status:running PC:4194580 SP:2147480144
Thread Table Status:
addi,$v0,$0,16
syscall
    0, 16, 26, 32, 36, 41, 42, 45, 53, 61, 76, 77, 122, 123, 187,
cse312@ubuntu:~/Desktop/CSE312/spimsimulator-code-r739/spim$ 
addi,$v0,$0,16
la,$a0,consume
la,$a1,cname
syscall

move $s0,$v0

addi,$v0,$0,16
la,$a0,produce
la,$a1,pname
syscall

move $s1,$v0

move $a0,$s0
addi,$v0,$0,15
syscall

move $a0,$s1
addi,$v0,$0,15
syscall

addi,$v0,$0,16
syscall

producer:
addi,$t0,$0,0
addi,$t1,$0,15

prod_loop:
```

SPIMOS_GTU_2.s:

Creates a producer thread and a consumer thread.

Producer thread increases the integer in the shared memory, consumer thread decreases the integer in the shared memory.

Without mutex, running output(consumer does not wait the producer):

The image shows a terminal window with two panes. The left pane displays the assembly code for a SPIMOS program, and the right pane shows the execution output.

Left Pane (Assembly Code):

```
.data
shared_int: word 0 #shared memory between thread
pname: .asciiz "producer"
cname: .asciiz "consumer"
#message: .asciiz "producer changes the value in shared memory"
#message: .asciiz "consumer reads the value in shared memory"
mut1: .asciiz "p_mutex"
mut2: .asciiz "c_mutex"
newline: .asciiz "\n"

.text

.globl main

main:
    addi $v0,$0,23
    syscall

    addi $v0,$0,18
    la $a0,consumer
    la $a1,cname
    syscall

    move $s0,$v0

    addi $v0,$0,18
    la $a0,producer
    la $a1,cname
    syscall

    move $s1,$v0

    move $a0,$s0
    addi $v0,$0,19
    syscall

    move $a0,$s1
    addi $v0,$0,19
    syscall

    addi $v0,$0,10
    syscall

producer:
    addi $t0,$0,0
    addi $t1,$0,15
prod_loop:
```

Right Pane (Execution Output):

```
cse312@ubuntu:~/Desktop/CSE312/spim simulator-code-r739/spin
cse312@ubuntu:~/Desktop/CSE312/spim simulator-code-r739/spin$ ./spin -f SPIMOS_G
U_2race.s
Loaded: /usr/share/spin/exceptions.s
Thread Table Status:
Thread id:2 name:producer status:runnable PC:4194436 SP:2147480144
Thread id:0 name:init status:runnable PC:4194408 SP:2147480144
Thread id:1 name:consumer status:running PC:4194520 SP:2147480144
consumer reads the value in shared memory, the value is:0
consumer reads the value in shared memory, the value is:-1
consumer reads the value in shared memory, the value is:-2
consumer reads the value in shared memory, the value is:-3
consumer reads the value in shared memory, the value is:-4
consumer reads the value in shared memory, the value is:-5
consumer reads the value in shared memory, the value is:-6
consumer reads the value in shared memory, the value is:-7
consumer reads the value in shared memory, the value is:-8
consumer reads the value in shared memory, the value is:-9
consumer reads the value in shared memory, the value is:-10
consumer reads the value in shared memory, the value is:-11
consumer reads the value in shared memory, the value is:-12
consumer reads the value in shared memory, the value is:-13
consumer reads the value in shared memory, the value is:-14
Thread Table Status:
Thread id:0 name:init status:runnable PC:4194408 SP:2147480144
Thread id:2 name:producer status:running PC:4194436 SP:2147480144
producer changes the value in shared memory, the value is:-15
producer changes the value in shared memory, the value is:-14
producer changes the value in shared memory, the value is:-13
producer changes the value in shared memory, the value is:-12
producer changes the value in shared memory, the value is:-11
producer changes the value in shared memory, the value is:-10
producer changes the value in shared memory, the value is:-9
producer changes the value in shared memory, the value is:-8
producer changes the value in shared memory, the value is:-7
producer changes the value in shared memory, the value is:-6
producer changes the value in shared memory, the value is:-5
producer changes the value in shared memory, the value is:-4
producer changes the value in shared memory, the value is:-3
producer changes the value in shared memory, the value is:-2
producer changes the value in shared memory, the value is:-1
Thread Table Status:
Thread id:0 name:init status:running PC:4194408 SP:2147480144
cse312@ubuntu:~/Desktop/CSE312/spim simulator-code-r739/spin$
```

With mutex,running output:

A terminal window showing the execution of a C program named 'splmsimulator-code-r739/splm'. The program simulates a producer-consumer scenario with two threads: 'producer' and 'consumer'. The output shows the state of the threads, including their names, IDs, and the status of the shared memory (S0, S1). The producer thread is blocked when the shared memory is full, and the consumer thread is blocked when the shared memory is empty. The program includes a 'main' function that initializes the threads and a 'prod_loop' function that handles the producer's logic. The terminal output is as follows:

```
Thread Id:0 name:producer status:blocked PC:4194496 SP:2147480144
Thread Id:2 name:consumer status:running PC:4194612 SP:2147480144
consumer reads the value in shared memory, the value is:2
consumer reads the value in shared memory, the value is:1
Thread Table Status:
message: as
Thread Id:1 name:producer status:runnable PC:4194496 SP:2147480144
cmessage: as
Thread Id:2 name:consumer status:blocked PC:4194612 SP:2147480144
mut1: .asciiz
Thread Id:0 name:init status:running PC:4194448 SP:2147480144
mut2: .asciiz
Thread Table Status:
newline: .asciiz
Thread Id:0 name:init status:runnable PC:4194448 SP:2147480144
Thread Id:2 name:consumer status:blocked PC:4194612 SP:2147480144
Thread Id:1 name:producer status:running PC:4194496 SP:2147480144
producer changes the value in shared memory, the value is:0
producer changes the value in shared memory, the value is:1
Thread Table Status:
main:
Thread Id:2 name:consumer status:runnable PC:4194612 SP:2147480144
Thread Id:1 name:producer status:blocked PC:4194496 SP:2147480144
Thread Id:0 name:init status:running PC:4194448 SP:2147480144
addi,$v0,$0,2
syscall
Thread Table Status:
addi,$v0,$0,1
Thread Id:0 name:init status:runnable PC:4194448 SP:2147480144
la,$a0,consumer
Thread Id:1 name:producer status:blocked PC:4194496 SP:2147480144
la,$a1,cname
Thread Id:2 name:consumer status:running PC:4194612 SP:2147480144
consumer reads the value in shared memory, the value is:2
consumer reads the value in shared memory, the value is:1
Thread Table Status:
move $s0,$v0
Thread Id:1 name:producer status:runnable PC:4194496 SP:2147480144
addi,$v0,$0,1
Thread Id:2 name:consumer status:blocked PC:4194612 SP:2147480144
la,$a0,producer
Thread Id:0 name:init status:running PC:4194448 SP:2147480144
la,$a1,pname
Thread Table Status:
move $s1,$v0
Thread Id:2 name:consumer status:blocked PC:4194612 SP:2147480144
Thread Id:1 name:producer status:running PC:4194496 SP:2147480144
producer changes the value in shared memory, the value is:0
producer changes the value in shared memory, the value is:1
Thread Table Status:
move $a0,$0
Thread Id:2 name:consumer status:runnable PC:4194612 SP:2147480144
addi,$v0,$0,1
Thread Id:0 name:init status:running PC:4194448 SP:2147480144
syscall
Thread Table Status:
move $a0,$s1
Thread Id:2 name:consumer status:runnable PC:4194612 SP:2147480144
addi,$v0,$0,1
Thread Id:0 name:init status:runnable PC:4194448 SP:2147480144
syscall
Thread Id:2 name:consumer status:running PC:4194612 SP:2147480144
consumer reads the value in shared memory, the value is:2
consumer reads the value in shared memory, the value is:1
Thread Table Status:
addi,$v0,$0,1
Thread Id:0 name:init status:running PC:4194448 SP:2147480144
syscall
Thread Table Status:
producer:
Thread Id:0 name:init status:running PC:4194460 SP:2147480144
cse312@ubuntu:~/Desktop/CSE312/splmsimulator-code-r739/splm$
addi,$t0,$0,0
addi,$t1,$0,15
prod_loop;
```