

# CSE 321 Operating Systems HW #3 Report

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This report includes four parts. First part will be explaining how to process table and the timer interrupt handling is implemented. The second part will be explaining which system calls are implemented and how they work. The third part will be telling about the kernel flavors. And the last part will be showing the running results.

## Part 1 – Process Table, Timer Interrupt Handling and Scheduling

### 1.1 Process Table and Process Table Entries

For this assignment, process table is implemented in kernel flavors. The implementation is as follows:

- There is an pre-allocated array that holds 10 process entry address.
- For each 10 process, process pid, process name, process status, process memory contents (registers, and PC value) are pre-allocated.
- Each process entry is an pre-allocated array that holds the addresses of the values mentioned above.

### 1.2 Timer Interrupt Handling

Normally timer interrupts get resolved in SPIM's SPIM\_timerHandler function. To achieve scheduling in kernel flavors, this function is rewritten to first save the memory contents of the current running process to process table and then reading memory contents of the init process from the table. Then PC is loaded to be the scheduler's label address in the kernel flavor, so the scheduler can be run to do the handling.

When init process is first registered to the process table scheduler address and process table start address are initialized in the C++ side of this assignment to do certain calculations.

### 1.3 Scheduling

Once timer handler function deals with the memory content reads/saves and loads the new PC value, scheduler on the kernel flavors starts to run. In procedure is as follows:

- First kernel uses a system call to get the running current process's PID.
- Then by using Round Robin logic ( `current_process= (current_process+1) % process_table_size` ) the next available process is looked up by calculating each entry's starting address and reaching to their status value to see if they are ready or not.
- Once the new process is found the control is given to that process by using a system call called `GIVE_CNT` (which will be mentioned in the second part of this report)

## Part 2 – System Calls

### 2.1 CREATE\_INIT\_PROCESS

This system call is the system call that is called when a kernel flavor starts. It registers the process as the init process with a pid 0 and with a name "init".

This system call takes 2 parameters:

- Process table address with a0
- Scheduler address with a1

And these parameters are used to initialize some variables at the C++ side of the assignment.

### 2.2 FORK

This system call is used to create new processes. In C++ part of this assignment there is a variable that

is used to keep track of the next possible PID number to be given. With that number this system call finds the area that corresponds to this PID and then copies init process's contents completely except the PC value is increased by 4 and the PID is the variable that is just mentioned but not 0. At the end of the system call the newly registered process gets the return value of 0, and the calling parent process gets the value of the newly created process's PID. To achieve this required values are loaded to the return register (v0) of the processes.

### **2.3 EXECVE**

This system call is used to change the image of the process to be another program. This system call takes a parameter which is the process name. First the calling process's name is changed to the requested name. Then, symbol table of SPIM is initialized and the assembly file which has the process name is read in to SPIM. After the reading to run the new program, the main label is looked up to change the PC value. After changing the PC value new program can finally run.

### **2.4 GET\_CURRENT\_PROCESS**

This system call returns the current running process's PID to the assembly side of the assignment.

### **2.5 PROCESS\_EXIT**

This system call is used when process's are exiting. The status of the calling process is changed to finished and PC is reduced by 4 to not run non-instructions since SPIM increases PC after calling a system call.

### **2.6 WAITPID**

This system call is used to wait for a particular process. This system call gets one parameter from a0 which is the PID of the process which will be waited. After getting the parameter this system call looks to the status of the process by doing some address calculations and checks if it is finished or not. If it is not finished the PC of the calling process is reduced by 4 so the process don't run new instructions.

### **2.7 RAND\_INT**

This system call returns a random number between 0-3. It is used in kernel flavors to select which programs to run.

### **2.8 SET\_RAND\_INT\_SEED**

This system call sets the seed in the rand function. It is used in kernel flavors.

### **2.9 GIVE\_CNT**

This system call gives control to the requested process. This system call gets a parameter from a0 which is the PID of the process which will get the control. First the system call sets the current running process's status to be ready then it uses the a0 parameter to set the process with the given PID's status to be running. Then the memory contents of that process is loaded in to SPIM and PC is reduced by 4 instruction since SPIM increases PC after calling a system call.

## **Part 3 – Kernel Flavors**

### **3.1 SPIMOS\_GTU\_1.s**

First, microkernel registers itself as the init process, then 4 fork syscall is called. Each child process created by these fork syscalls calls an execve with a different program name. First one calls LinearSearch, second one calls BinarySearch, third one calls Collatz and the fourth one calls Palindrome. And the init process who is the parent to all these child processes wait for their PIDs until

all the child processes end, then exits.

### 3.2 SPIMOS\_GTU\_2.s

First, microkernel registers itself as the init process then a random number is generated. Depending on the random number the program name is selected and 5 fork syscalls are made to create 5 child processes. After that 5 child processes use execve to change their images to the selected program. The init process who is the parent to all these child processes wait for the 5 different process pid's, then exits when they all finish.

### 3.3 SPIMOS\_GTU\_3.s

First, microkernel registers itself as the init process then a random number is generated. Depending on the random number the program names are selected and 3 fork syscalls are made to create 3 child processes. Then the child processes do an exec system call to change their image with the first decided program name. Then another 3 fork syscalls are made to create 3 child processes. Then the child processes do an exec system call to change their image with the second decided program name. And then another 3 fork syscalls are made to create 3 child processes. Then the child processes do an exec system call to change their image with the third decided program name. Each child process' PID is saved into an array. Then the init process who is the parent to all these child process waits for these 9 processes whose PIDs are saved in to an array and then exits when they all finish.

Each kernel flavor has a scheduler routine which is mentioned in the Part 1's Section 1.3.

## Part 4 – Running Results

PS: There is one known issue which is:

Palindrome alone works as requested but when multiple palindromes and other programs are scheduled the palindrome results are shown by the last entered user input. Thinking it is an IO related issue but couldn't find the main reason.

### 4.1 SPIMOS\_GTU\_1.s

1

```
cse312@ubuntu:~/Desktop/171044079_CSE312_HW3$ ./spim -f SPIMOS_GTU_1.s
cse312@ubuntu:~/Desktop/171044079_CSE312_HW3$ spim -f SPIMOS_GTU_1.s
Loaded: /usr/share/spin/exceptions.s

===== PROCESS SWITCH =====
PID: 0 Process name: Int Process state: Running PC: 4194604
PID: 1 Process name: Int Process state: Ready PC: 4194472
PID: 2 Process name: Int Process state: Ready PC: 4194488
PID: 3 Process name: Int Process state: Ready PC: 4194504
PID: 4 Process name: Int Process state: Ready PC: 4194520
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
        LINEAR SEARCH
Given array ls: 3 4 5 9 7 4 1 2
Target number ls: 9
Target number found at index: 3
=====
===== PROCESS SWITCH =====
PID: 0 Process name: Int Process state: Ready PC: 4194604
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: Int Process state: Ready PC: 4194488
PID: 3 Process name: Int Process state: Ready PC: 4194504
PID: 4 Process name: Int Process state: Ready PC: 4194520
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
        BINARY SEARCH
Given array ls: 2 6 7 8 9 10 12
Target Number ls: 12
Target number found at index: 6
=====
===== PROCESS SWITCH =====
PID: 0 Process name: Int Process state: Ready PC: 4194604
PID: 1 Process name: LinearSearch Process state: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Int Process state: Ready PC: 4194504
PID: 4 Process name: Int Process state: Ready PC: 4194520
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
```

2

```
cse312@ubuntu:~/Desktop/171044079_CSE312_HW3$ ./spim -f SPIMOS_GTU_1.s
cse312@ubuntu:~/Desktop/171044079_CSE312_HW3$ spim -f SPIMOS_GTU_1.s
Loaded: /usr/share/spin/exceptions.s

===== PROCESS SWITCH =====
COLLATZ
25:76 38 19 58 29 88 44 22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
24:12 6 3 10 5 16 8 4 2 1
23:70 35 106 53 166 80 40 20 10 5 16 8 4 2 1
22:11 34 17 52 26 13 40 20 10 5 16 8 4 2
=====
        PROCESS SWITCH
=====
PID: 0 Process name: Int Process state: Ready PC: 4194604
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Ready PC: 4195392
PID: 4 Process name: Palindrome Process state: Running PC: 4195816
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
1: anna: Palindrome
2: kayak: Palindrome
3: mom: Palindrome
=====
===== PROCESS SWITCH =====
PID: 0 Process name: Int Process state: Ready PC: 4194604
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Ready PC: 4195392
PID: 4 Process name: Palindrome Process state: Ready PC: 4195816
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
        PROCESS SWITCH
=====
PID: 0 Process name: Int Process state: Ready PC: 4194604
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Ready PC: 4195392
PID: 4 Process name: Palindrome Process state: Ready PC: 4195816
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
1
21:64 32 16 8 4 2 1
```

3

```
cse312@ubuntu: ~/Desktop/171044079_CSE312_HW3
cse312@ubuntu: ~/Desktop/spimsimulator-code/spim

=====
1:21:64 32 16 8 4 2 1
20:10 5 16 8 4 2 1
19:58 29 88 44 22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
18:9 28 23 10 35 106 53 100 80 40 20 10 5 16 8 4 2 1
17:52 26 13 40 20 10 5 16 8 4 2 1
16:8 4 2 1
15:7 21 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
14:40 20 10 5 16 8 4 2 1
13:6 3 10 5 16 8 4 2 1
11:34 17 52 26 13 40 20 10 5 16 8 4 2 1
10:5 16

===== PROCESS SWITCH =====
PID: 0 Process name: Init Process state: Ready PC: 4194628
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Running PC: 4195332
PID: 4 Process name: Palindrome Process state: Ready PC: 4195816
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
Badges: Palindrome
5: Noon: Palindrome
6: Wow: Palindrome
7: Ada: Palindrome
8:

===== PROCESS SWITCH =====
PID: 0 Process name: Init Process state: Ready PC: 4194628
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Ready PC: 4195332
PID: 4 Process name: Palindrome Process state: Running PC: 4195756
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
1:28 14 7 22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
8:4 2 1
7:22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
6:3 10 5 16 8 4 2 1
5:6 8 4 2 1
4:2 1
3:10 5 16 8 4 2 1
2:1
1:1

===== PROCESS SWITCH =====
PID: 0 Process name: init Process state: Ready PC: 4194628
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
Abba: Palindrome
9: Level: Palindrome
10: Radar: Not Palindrome
11: Radar: Not Palindrome
12: Happy: Not Palindrome
13: Available: Not Palindrome
14: Noon: Not Palindrome
15: Football: Not Palindrome
16: Operating: Not Palindrome
17: Systems: Not Palindrome
18: Homework: Not Palindrome
19: Three: Not Palindrome
20: Busy: Not Palindrome
21: Stressed: Not Palindrome
```

5

```
cse312@ubuntu: ~/Desktop/171044079_CSE312_HW3
cse312@ubuntu: ~/Desktop/spimsimulator-code/spim

18: 0 Workhour: Not Palindrome
19: Three: Not Palindrome
20: Busy: Not Palindrome
21: Stressed: Not Palindrome
22: Good: Not Palindrome
23: Luck: Not Palindrome
24: Failure: Not Palindrome
25: Success: Not Palindrome
26: Impossible: Not Palindrome
27: Kernel: Not Palindrome
28: Flavor: Not Palindrome
29: Palindrome: Not Palindrome
30: Collatz: Not Palindrome
31: Input: Not Palindrome
32: Output: Not Palindrome
33: Hesitate: Not Palindrome
34: Cat: Not Palindrome
35: Dog: Not Palindrome
36: Alan: Not Palindrome

===== PROCESS SWITCH =====
PID: 0 Process name: Init Process state: Ready PC: 4194628
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Running PC: 4195736
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
1:0 Process name: init Process state: Running PC: 4194640
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collate Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Ready PC: 4195736
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
1:0 Process name: init Process state: Ready PC: 4194640
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collate Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Ready PC: 4195796
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
37: Turing: Not Palindrome
38: Computer: Not Palindrome
39: Keyboard: Not Palindrome
40: Mouse: Not Palindrome
```

4

```
cse312@ubuntu: ~/Desktop/171044079_CSE312_HW3
cse312@ubuntu: ~/Desktop/spimsimulator-code/spim

=====
PID: 0 Process name: init Process state: Running PC: 4194628
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Ready PC: 4195332
PID: 4 Process name: Palindrome Process state: Ready PC: 4195756
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
8:4 2 1
9:22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
8:4 2 1
7:22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
6:3 10 5 16 8 4 2 1
5:6 8 4 2 1
4:2 1
3:10 5 16 8 4 2 1
2:1
1:1

===== PROCESS SWITCH =====
PID: 0 Process name: init Process state: Ready PC: 4194628
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Ready PC: 4195756
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
Abba: Palindrome
9: Level: Palindrome
10: Radar: Not Palindrome
11: Radar: Not Palindrome
12: Happy: Not Palindrome
13: Available: Not Palindrome
14: Noon: Not Palindrome
15: Football: Not Palindrome
16: Operating: Not Palindrome
17: Systems: Not Palindrome
18: Homework: Not Palindrome
19: Three: Not Palindrome
20: Busy: Not Palindrome
21: Stressed: Not Palindrome
```

6

```
cse312@ubuntu: ~/Desktop/171044079_CSE312_HW3
cse312@ubuntu: ~/Desktop/spimsimulator-code/spim

37: Turing: Not Palindrome
38: Computer: Not Palindrome
39: Keyboard: Not Palindrome
40: Mouse: Not Palindrome
41: Hedgehog: Not Palindrome
42: Fox: Not Palindrome
43: Bunny: Not Palindrome
44: Penguin: Not Palindrome

===== PROCESS SWITCH =====
PID: 0 Process name: init Process state: Ready PC: 4194640
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Running PC: 4195796
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
1:0 Process name: init Process state: Running PC: 4194640
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Ready PC: 4195796
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
45: Long: Not Palindrome
46: Short: Not Palindrome
47: Fat: Not Palindrome
48: Thin: Not Palindrome
49: Rich: Not Palindrome
50: Poor: Not Palindrome
51: Coffee: Not Palindrome
52: Tea: Not Palindrome
53: Series: Not Palindrome
54: Phone: Not Palindrome
55: Cafe: Not Palindrome
56: Vaccination: Not Palindrome
57: Doctor: Not Palindrome
58: Nurse: Not Palindrome
59: Corona: Not Palindrome
```

7

```
cse312@ubuntu: ~/Desktop/171044079_CSE312_HW3
cse312@ubuntu: ~/Desktop/spimsimulator-code/spim
56: Vaccination: Not Palindrome
57: Doctor: Not Palindrome
58: Nurse: Not Palindrome
59: Corona: Not Palindrome
60: Bored: Not Palindrome
61: Number: Not Palindrome
62: Name: Not Palindrome
63: Picture: Not Palindrome
64: Hoping: Not Palindrome
65: To: Not Palindrome
66: Get: Not Palindrome
67: High: Not Palindrome
68:
===== PROCESS SWITCH =====
PID: 0 Process name: init Process state: Ready PC: 4194640
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Running PC: 4195756
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
PID: 0 Process name: init Process state: Running PC: 4194640
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Ready PC: 4195756
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
From: Not Palindrome
69: This: Not Palindrome
70: Assignment: Not Palindrome
71: Hard: Not Palindrome
72: Really: Not Palindrome
73: Hard: Not Palindrome
74: On: Not Palindrome
75: It: Not Palindrome
76: Thanks: Not Palindrome
77: Have: Not Palindrome
78: Safe: Not Palindrome
```

8

```
cse312@ubuntu: ~/Desktop/171044079_CSE312_HW3
cse312@ubuntu: ~/Desktop/spimsimulator-code/spim
=====
From: Not Palindrome
69: This: Not Palindrome
70: Assignment: Not Palindrome
71: Hard: Not Palindrome
72: Really: Not Palindrome
73: Hard: Not Palindrome
74: On: Not Palindrome
75: It: Not Palindrome
76: Thanks: Not Palindrome
77: Have: Not Palindrome
78: Safe: Not Palindrome
79: And: Not Palindrome
80: Although: Not Palindrome
81: Days: Not Palindrome
82: Car: Not Palindrome
83: Bus: Not Palindrome
84: Motorcycle: Not Palindrome
85: Holiday: Not Palindrome
86: Exams: Not Palindrome
87: Projects: Not Palindrome
88: Computer: Not Palindrome
89: Technical: Not Palindrome
90: University: Not Palindrome
91: Pencils: Not Palindrome
92: Notebooks: Not Palindrome
93: Papers: Not Palindrome
94: Students: Not Palindrome
95: Teachers: Not Palindrome
96: Vacation: Not Palindrome
97: Work: Not Palindrome
98: To: Not Palindrome
99: Finish: Not Palindrome
100: Dictionary: Not Palindrome
Do you want to continue (y/n)?
y
===== PROCESS SWITCH =====
PID: 0 Process name: init Process state: Ready PC: 4194640
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Running PC: 4195864
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
PID: 0 Process name: init Process state: Ready PC: 4194640
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Running PC: 4195864
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
```

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```
cse312@ubuntu: ~/Desktop/171044079_CSE312_HW3
cse312@ubuntu: ~/Desktop/spimsimulator-code/spim
=====
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
Please enter the last word:
anna
=====
PID: 0 Process name: init Process state: Ready PC: 4194640
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Running PC: 4195964
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
PID: 0 Process name: init Process state: Running PC: 4194640
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Ready PC: 4195964
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
101: anna: Palindrome
Goodbye..
=====
PID: 0 Process name: init Process state: Ready PC: 4194640
PID: 1 Process name: LinearSearch Process state: Finished PC: 4194884
PID: 2 Process name: BinarySearch Process state: Finished PC: 4195216
PID: 3 Process name: Collatz Process state: Finished PC: 4195436
PID: 4 Process name: Palindrome Process state: Finished PC: 4196096
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
PID: 0 Process name: Process state: None PC: 0
=====
cse312@ubuntu: ~/Desktop/171044079_CSE312_HW3
```



### **4.3 SPIMOS\_GTU\_3.s**

1

```
ces312@ubuntu:~/Desktop/171044079_CSE312_HW3
ces312@ubuntu:~/Desktop/spinsimulator-code/spin
ces312@ubuntu:~/Desktop/171044679_CSE312_HW3S spin -f SPIMOS_GTU_3.s
Loaded: /usr/share/spin/exceptions.s

===== PROCESS SWITCH =====
PID: 0 Process name: init Process state: Running PC: 4194828
PID: 1 Process name: init Process state: Ready PC: 4194644
PID: 2 Process name: init Process state: Ready PC: 4194644
PID: 3 Process name: init Process state: Ready PC: 4194644
PID: 4 Process name: init Process state: Ready PC: 4194688
PID: 5 Process name: init Process state: Ready PC: 4194688
PID: 6 Process name: init Process state: Ready PC: 4194688
PID: 7 Process name: init Process state: Ready PC: 4194732
PID: 8 Process name: init Process state: Ready PC: 4194732
PID: 9 Process name: init Process state: Ready PC: 4194732

===== LINEAR SEARCH =====
Given array is: 3 4 3 9 7 4 1 2
Target number is: 9
Target number found at index: 3

===== PROCESS SWITCH =====
PID: 0 Process name: init Process state: Ready PC: 4194828
PID: 1 Process name: LinearSearch Process state: Finished PC: 4195084
PID: 2 Process name: init Process state: Ready PC: 4194644
PID: 3 Process name: init Process state: Ready PC: 4194644
PID: 4 Process name: init Process state: Ready PC: 4194688
PID: 5 Process name: init Process state: Ready PC: 4194688
PID: 6 Process name: init Process state: Ready PC: 4194688
PID: 7 Process name: init Process state: Ready PC: 4194732
PID: 8 Process name: init Process state: Ready PC: 4194732
PID: 9 Process name: init Process state: Ready PC: 4194732

===== LINEAR SEARCH =====
Given array is: 3 4 3 9 7 4 1 2
Target number is: 9
Target number found at index: 3

===== PROCESS SWITCH =====
PID: 0 Process name: init Process state: Ready PC: 4194828
PID: 1 Process name: LinearSearch Process state: Finished PC: 4195084
PID: 2 Process name: LinearSearch Process state: Finished PC: 4195324
PID: 3 Process name: init Process state: Ready PC: 4194644
PID: 4 Process name: init Process state: Ready PC: 4194688
PID: 5 Process name: init Process state: Ready PC: 4194688
PID: 6 Process name: init Process state: Ready PC: 4194688
PID: 7 Process name: init Process state: Ready PC: 4194732
PID: 8 Process name: init Process state: Ready PC: 4194732
PID: 9 Process name: init Process state: Ready PC: 4194732
```

2

```
cse312@ubuntu: ~/Desktop/171044079_CSE312_HW3
cse312@ubuntu: ~/Desktop/spimsimulator-code/spim
=====
    LINEAR SEARCH
=====
Given array is: 3 4 3 9 7 4 1 2
Target number is: 9
Target number found at index: 3

=====
        PROCESS SWITCH =====
PID: 0 Process name: lnt Process state: Ready PC: 4194828
PID: 1 Process name: LinearSearch Process state: Finished PC: 4195084
PID: 2 Process name: LinearSearch Process state: Finished PC: 4195324
PID: 3 Process name: lnt Process state: Ready PC: 4195564
PID: 4 Process name: lnt Process state: Ready PC: 4194688
PID: 5 Process name: lnt Process state: Ready PC: 4194688
PID: 6 Process name: lnt Process state: Ready PC: 4194688
PID: 7 Process name: lnt Process state: Ready PC: 4194732
PID: 8 Process name: lnt Process state: Ready PC: 4194732
PID: 9 Process name: lnt Process state: Ready PC: 4194732
=====

=====
    BINARY SEARCH
=====
Given array is: 2 6 7 8 9 10 12
Target Number is: 12
Target number found at index: 6

=====
        PROCESS SWITCH =====
PID: 0 Process name: init Process state: Ready PC: 4194828
PID: 1 Process name: LinearSearch Process state: Flnsihed PC: 4195084
PID: 2 Process name: LinearSearch Process state: Finished PC: 4195324
PID: 3 Process name: lnt Process state: Flnsihed PC: 4195564
PID: 4 Process name: BnarySearch Process state: Finished PC: 4195896
PID: 5 Process name: lnt Process state: Ready PC: 4194688
PID: 6 Process name: lnt Process state: Ready PC: 4194688
PID: 7 Process name: lnt Process state: Ready PC: 4194732
PID: 8 Process name: lnt Process state: Ready PC: 4194732
PID: 9 Process name: lnt Process state: Ready PC: 4194732
=====

=====
    BINARY SEARCH
=====
Given array is: 2 6 7 8 9 10 12
Target Number is: 12
Target number found at index: 6

=====
        PROCESS SWITCH =====
PID: 0 Process name: init Process state: Ready PC: 4194828
PID: 1 Process name: LinearSearch Process state: Flnsihed PC: 4195084
PID: 2 Process name: LinearSearch Process state: Finished PC: 4195324
PID: 3 Process name: lnt Process state: Flnsihed PC: 4195564
PID: 4 Process name: BnarySearch Process state: Finished PC: 4195896
PID: 5 Process name: BnarySearch Process state: Finished PC: 4196228
PID: 6 Process name: lnt Process state: Ready PC: 4194688
PID: 7 Process name: lnt Process state: Ready PC: 4194732
```

3

4

```
cse312@ubuntu: ~/Desktop/171044079_CSE312_HW3
cse312@ubuntu: ~/Desktop/spimimulator/code/spim
22:37 35 106 53 160 80 40 20 10 5 16 8 4 2 1
22:11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
21:64 32 16 8 4 2 1
20:10 5 16 8 4 2 1
19:58 29 88 44 22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
18:9 28 14 7 22 11 34 17 52
=====
PROCESS SWITCH =====
PID: 0 Process name: init Process state: Ready PC: 4194828
PID: 1 Process name: LinearSearch Process state: Finished PC: 4195884
PID: 2 Process name: LinearSearch Process state: Finished PC: 4195324
PID: 3 Process name: LinearSearch Process state: Finished PC: 4195654
PID: 4 Process name: BinarySearch Process state: Finished PC: 4195896
PID: 5 Process name: BinarySearch Process state: Finished PC: 4196228
PID: 6 Process name: BinarySearch Process state: Finished PC: 4196560
PID: 7 Process name: Collatz Process state: Ready PC: 4196726
PID: 8 Process name: Collatz Process state: Running PC: 4196940
PID: 9 Process name: init Process state: Ready PC: 4194732
=====
COLLATTZ
=====
25:76 38 19 58 29 88 44 22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
24:12 6 3 10 15 16 8 4 2 1
23:70 35 106 53 160 80 40 20 10 5 16 8 4 2 1
22:11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
21:64 32 16 8 4 2 1
20:10 5 16 8 4 2 1
19:58 29 88 44 22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
18:9 28 14 7 22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
17:52 26 13 40 20 10 5 16 8 4 2 1
16:8 4 2 1
15:46 23 10 35 106 53 160 80 40 20 10 5 16
=====
PROCESS SWITCH =====
PID: 0 Process name: init Process state: Ready PC: 4194828
PID: 1 Process name: LinearSearch Process state: Finished PC: 4195084
PID: 2 Process name: LinearSearch Process state: Finished PC: 4195324
PID: 3 Process name: LinearSearch Process state: Finished PC: 4195654
PID: 4 Process name: BinarySearch Process state: Finished PC: 4195896
PID: 5 Process name: BinarySearch Process state: Finished PC: 4196228
PID: 6 Process name: BinarySearch Process state: Finished PC: 4196560
PID: 7 Process name: Collatz Process state: Ready PC: 4196716
PID: 8 Process name: Collatz Process state: Ready PC: 4196940
PID: 9 Process name: Collatz Process state: Running PC: 4197160
=====
PROCESS SWITCH =====
PID: 0 Process name: init Process state: Running PC: 4194828
PID: 1 Process name: LinearSearch Process state: Finished PC: 4195084
PID: 2 Process name: LinearSearch Process state: Finished PC: 4195324
PID: 3 Process name: LinearSearch Process state: Finished PC: 4195654
```

