

# CS 3733: Operating Systems

## Assignment 2: CPU Scheduling and Classical Schedulers (100 Points)

### 1 Objectives:

- Enhance the understanding of CPU scheduling;
- Learn to implement basic steps of classical schedulers;
- Practice and Improve programming and coding skills;

### 2 Description:

**Overview:** This assignment is related to process and CPU scheduling. Basically, you will implement the four classical scheduler functions, which take the parameters of two (2) processes for their CPU and IO bursts. Each scheduler function will generate the process scheduling strings of R, r and w, and calculate the corresponding waiting time and CPU utilization.

**Details:** Your main C program should take seven (7) integer values as command line parameters, and run as follows:

```
./assign2 q x1 y1 z1 x2 y2 z2
```

where q stands for the quantum value needed for Round-Robin scheduler; (x1, y1, z1) represents the first process that has x1 units of CPU burst, followed by y1 units of I/O burst, and then followed by z1 units of CPU burst. Similarly, the second process is represented by (x2, y2, z2). **Suppose that both processes arrive at time 0 where process 1 arrives in the ready queue just before Process 2.** No other processes are in the system.

The main program should start by checking that there are exactly 7 parameters. It will exit with an appropriate error message, otherwise. If the number of command line parameters is correct, the program will print your name on a line in the following form:

```
CS 3733 / Assignment 2 / written by YOUR NAME / abc123
```

followed by printing out the 7 input values on a single line.

Then, the main program should call the four (4) scheduler functions one-by-one. For each scheduler function, it will display 5 lines: a blank line serves as a separator, followed by a heading line to indicate the scheduler function, the two output strings (each string on its own line, with the second string directly under the first string), followed by four numeric values in one line. Here, the first two values are integers that indicate the waiting time for the first and second processes (i.e., the number of times r occurs in the first and second string), respectively. The third value is the average waiting time (i.e., average of the two integers) and the last one indicates the CPU utilization (i.e., the total number of R's in the two strings divided by the length of the longer string).

The four scheduler functions (and any other needed functions) should be put in the file `pslibrary.c`. The prototypes of these functions should be in `pslibrary.h` and your main program `assign2.c` must include `pslibrary.h`.

**Part 1: FCFS Scheduler:** The first scheduler function is for First-Come First-Served (FCFS). It will ignore the first input parameter specifying a quantum and has the following prototype:

```
fcfs(char *s1, char *s2, int x1, int y1, int z1, int x2, int y2, int z2);
```

Here, the result process schedule strings will be returned through the first two parameters. The first process is represented by  $(x_1, y_1, z_1)$  and the second by  $(x_2, y_2, z_2)$ .

The scheduler function `fcfs()` needs to be implemented using a state machine design. A state machine has a state (the values of the variables) which changes over time. At each time step the state changes to a new state. The new state depends only on the old one and the input values. Here, the state of the system is the state of the two processes, including information about all of their remaining CPU and I/O bursts. The prototype code for the function can be obtained in the file `sm-proto.txt`. Insert the appropriate code so that it behaves like the `fcfs` algorithm. Note that, the prototype code handles some cases that are not related to FCFS, such as a quantum. You may delete the unnecessary code.

**Example:** For the input parameters: 0 4 2 7 3 6 5, the output from `fcfs()` should be:

## Scheduler FCFS:

```

RRR Rwwr RRRRRRR
rrrr RRRw wwww wr RRRRR
1 5 3.0 1.00000

```

Test the scheduler function `fcfs()` with the following inputs and manually check that it generates the correct output:

```
Test 1: 3 8 7 3 6 3 2  
Test 2: 3 8 7 3 6 7 2  
Test 3: 4 8 7 3 6 1 2  
Test 4: 3 3 3 4 2 1 2  
Test 5: 3 3 2 3 2 1 2  
Test 6: 3 5 2 5 4 1 1  
Test 7: 3 2 3 4 1 1 5  
Test 8: 3 2 3 4 1 4 1  
Test 9: 3 2 3 4 5 6 2
```

Include the output for the above test cases in your Report.txt.

**Part 2: SJF Scheduler:** Implement the non-preemptive SJF algorithm ( by ignoring the first input parameter) with the following prototype:

```
sjf(char *s1, char *s2, int x1, int y1, int z1, int x2, int y2, int z2);
```

and add the implementation in `pslibrary.c`. Implement this by modifying your fcfs code or the prototype. Add the code to test this scheduler in `assign2.c` by calling this function. Test the scheduler with the test cases listed above.

**Part 3: PSJF Scheduler:** Implement the **preemptive-SJF** algorithm ( by ignoring the first input parameter) with the following prototype:

```
psjf(char *s1, char *s2, int x1, int y1, int z1, int x2, int y2, int z2);
```

and add the implementation in `pslibrary.c`. Implement this by modifying your fcfs code or the prototype. Add the code to test this scheduler in `assign2.c` by calling this function. Test the scheduler with the test cases listed above.

**Part 4: RR Scheduler:** Implement the Round Robin algorithm with the following prototype:

```
rr(char *s1, char *s2, int q, int x1, int y1, int z1, int x2, int y2, int z2);
```

and add the implementation in `pslibrary.c`. Implement this by modifying your fcfs code or the prototype. Add the code to test this scheduler in `assign2.c` by calling this function. Test the scheduler with the test cases listed above. Note on breaking ties: Processes can enter the ready queue when they first arrive, when their quantum expires, or when their I/O completes. When the RR algorithm must choose the oldest process from the ready queue it needs a way to break ties. For our algorithms, we break a tie by having process 1 run before process 2. Make sure you understand this and make sure your solution works with the following input: 3 1 1 4 1 3 1 .

**Part 5: Final Comprehensive Test:** As a final test, get a copy of `runall.c` from Blackboard. Look at the source code and understand it. Compile it with your `pslibrary` and run the program. It should take less than a minute to complete and generate 4 files, each of about 40 megabytes and having the extension `.all`. Make sure you have no other files with this extension in your directory and execute:

```
ls -l *.all  
wc *.all  
md5sum *.all
```

Include the output from the above commands in your `Report.txt`. Each of the generated output files (`*.all`) should have 2,000,001 lines and 2,000,003 words. You may delete these large output files after you inserted their `md5sum` on the “program output” portion of `REPORT.txt`. You will **not** be submitting any of these output files.

### 3 Submission Requirements

The assignment needs to be submitted on Canvas. The submission includes two parts:

1. **Source code:** Compressed into a Zip archive, the following source files: `assign2.c`, `pslibrary.c` and `pslibrary.h` represent the entirety of your submission. Your program will be graded based on functional correctness and adherence to the stated requirements.
2. **REPORT.txt:** In addition to all of the above, in this `text` file, you will also need to list all other people that you may have collaborated with on this assignment (which should ideally be zero). For each person, indicate the degree of collaboration (small, medium, large) and write a few sentences describing the nature of this collaboration. Indicate whether you were mainly giving providing or receiving help.
3. **Submission:** Please have all the above files zipped into a single file `a2-abc123.zip` and upload the file on Blackboard, where `abc123` should be your myUTSA ID.