

## Programming Projects

### Scheduling Algorithms

This project involves implementing several different process scheduling algorithms. The scheduler will be assigned a predefined set of tasks and will schedule the tasks based on the selected scheduling algorithm. Each task is assigned a priority and CPU burst. The following scheduling algorithms will be implemented:

- First-come, first-served (FCFS), which schedules tasks in the order in which they request the CPU.
- Shortest-job-first (SJF), which schedules tasks in order of the length of the tasks' next CPU burst.
- Priority scheduling, which schedules tasks based on priority.
- Round-robin (RR) scheduling, where each task is run for a time quantum (or for the remainder of its CPU burst).
- Priority with round-robin, which schedules tasks in order of priority and uses round-robin scheduling for tasks with equal priority.

Priorities range from 1 to 10, where a higher numeric value indicates a higher relative priority. For round-robin scheduling, the length of a time quantum is 10 milliseconds.

#### I. Implementation

The implementation of this project may be completed in either C or Java, and program files supporting both of these languages are provided in the source code download for the text. These supporting files read in the schedule of tasks, insert the tasks into a list, and invoke the scheduler.

The schedule of tasks has the form [*task name*] [*priority*] [*CPU burst*], with the following example format:

```
T1, 4, 20
T2, 2, 25
T3, 3, 25
T4, 3, 15
T5, 10, 10
```

Thus, task T1 has priority 4 and a CPU burst of 20 milliseconds, and so forth. It is assumed that all tasks arrive at the same time, so your scheduler algorithms do not have to support higher-priority processes preempting processes with lower priorities. In addition, tasks do not have to be placed into a queue or list in any particular order.

There are a few different strategies for organizing the list of tasks, as first presented in Section 5.1.2. One approach is to place all tasks in a single unordered list, where the strategy for task selection depends on the scheduling

algorithm. For example, SJF scheduling would search the list to find the task with the shortest next CPU burst. Alternatively, a list could be ordered according to scheduling criteria (that is, by priority). One other strategy involves having a separate queue for each unique priority, as shown in Figure 5.7. These approaches are briefly discussed in Section 5.3.6. It is also worth highlighting that we are using the terms *list* and *queue* somewhat interchangeably. However, a queue has very specific FIFO functionality, whereas a list does not have such strict insertion and deletion requirements. You are likely to find the functionality of a general list to be more suitable when completing this project.

## II. C Implementation Details

The file `driver.c` reads in the schedule of tasks, inserts each task into a linked list, and invokes the process scheduler by calling the `schedule()` function. The `schedule()` function executes each task according to the specified scheduling algorithm. Tasks selected for execution on the CPU are determined by the `pickNextTask()` function and are executed by invoking the `run()` function defined in the `CPU.c` file. A `Makefile` is used to determine the specific scheduling algorithm that will be invoked by `driver`. For example, to build the FCFS scheduler, we would enter

```
make fcfs
```

and would execute the scheduler (using the schedule of tasks `schedule.txt`) as follows:

```
./fcfs schedule.txt
```

Refer to the `README` file in the source code download for further details. Before proceeding, be sure to familiarize yourself with the source code provided as well as the `Makefile`.

## III. Java Implementation Details

The file `Driver.java` reads in the schedule of tasks, inserts each task into a `Java ArrayList`, and invokes the process scheduler by calling the `schedule()` method. The following interface identifies a generic scheduling algorithm, which the five different scheduling algorithms will implement:

```
public interface Algorithm
{
    // Implementation of scheduling algorithm
    public void schedule();

    // Selects the next task to be scheduled
    public Task pickNextTask();
}
```

The `schedule()` method obtains the next task to be run on the CPU by invoking the `pickNextTask()` method and then executes this `Task` by calling the static `run()` method in the `CPU.java` class.

The program is run as follows:

```
java Driver fcfs schedule.txt
```

Refer to the README file in the source code download for further details. Before proceeding, be sure to familiarize yourself with all Java source files provided in the source code download.

## IV. Further Challenges

Two additional challenges are presented for this project:

1. Each task provided to the scheduler is assigned a unique task (tid). If a scheduler is running in an SMP environment where each CPU is separately running its own scheduler, there is a possible race condition on the variable that is used to assign task identifiers. Fix this race condition using an atomic integer.

On Linux and macOS systems, the `__sync_fetch_and_add()` function can be used to atomically increment an integer value. As an example, the following code sample atomically increments `value` by 1:

```
int value = 0;
__sync_fetch_and_add(&value, 1);
```

Refer to the Java API for details on how to use the `AtomicInteger` class for Java programs.

2. Calculate the average turnaround time, waiting time, and response time for each of the scheduling algorithms.