

=== ASSIGNMENT 3 REPORT ===

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Course: CS 433 Operating Systems

Assignment 3: Scheduling Algorithms

Due: Thu 08 April 2021

Updated with Priority & Round Robin info (attempted for extra credit)

=== FILES ===

Driver files schedule_fcfs.cpp schedule_sjf.cpp schedule_priority.cpp schedule_rr schedule_priority_rr.cpp	Executables fcfs sjf priority rr priority_rr
Header files PCB.h PCBTable.h ReadyQueue.h	Implementation files PCB.cpp PCBTable.cpp ReadyQueue.cpp
Make file: Makefile	Text data files: schedule.txt, sched.txt

=== INSTRUCTIONS TO COMPILE AND RUN ===

make

./fcfs schedule.txt

./sjf schedule.txt

./priority schedule.txt

./rr schedule.txt 6

./priority_rr schedule.txt 6

=== RESULTS ===

FCFS

```
=== 8 processes in PCB TABLE ===
PID  T1 | PRIORITY  4 | BURST  20 | TERMINATED
      turn-around time = 20
      waiting time = 0
PID  T2 | PRIORITY  3 | BURST  25 | TERMINATED
      turn-around time = 45
      waiting time = 20
PID  T3 | PRIORITY  3 | BURST  25 | TERMINATED
      turn-around time = 70
      waiting time = 45
PID  T4 | PRIORITY  5 | BURST  15 | TERMINATED
      turn-around time = 85
      waiting time = 70
PID  T5 | PRIORITY  5 | BURST  20 | TERMINATED
      turn-around time = 105
      waiting time = 85
PID  T6 | PRIORITY  1 | BURST  10 | TERMINATED
      turn-around time = 115
      waiting time = 105
PID  T7 | PRIORITY  3 | BURST  30 | TERMINATED
      turn-around time = 145
      waiting time = 115
PID  T8 | PRIORITY 10 | BURST  25 | TERMINATED
      turn-around time = 170
      waiting time = 145

Average turn-around time = 94.375
Average waiting time = 73.125
The ReadyQueue has been destructed.
[bustr003@cs433 bustr003]$
```

SJF

```
=== SHORTEST JOB FIRST ===

Running task = [T6] [1] [10] for 10 units.
Running task = [T4] [5] [15] for 15 units.
Running task = [T1] [4] [20] for 20 units.
Running task = [T5] [5] [20] for 20 units.
Running task = [T2] [3] [25] for 25 units.
Running task = [T3] [3] [25] for 25 units.
Running task = [T8] [10] [25] for 25 units.
Running task = [T7] [3] [30] for 30 units.

=== 8 processes in PCB TABLE ===
PID  T1 | PRIORITY  4 | BURST  20 | TERMINATED
      turn-around time = 45
      waiting time = 25
PID  T2 | PRIORITY  3 | BURST  25 | TERMINATED
      turn-around time = 90
      waiting time = 65
PID  T3 | PRIORITY  3 | BURST  25 | TERMINATED
      turn-around time = 115
      waiting time = 90
PID  T4 | PRIORITY  5 | BURST  15 | TERMINATED
      turn-around time = 25
      waiting time = 10
PID  T5 | PRIORITY  5 | BURST  20 | TERMINATED
      turn-around time = 65
      waiting time = 45
PID  T6 | PRIORITY  1 | BURST  10 | TERMINATED
      turn-around time = 10
      waiting time = 0
PID  T7 | PRIORITY  3 | BURST  30 | TERMINATED
      turn-around time = 170
      waiting time = 140
PID  T8 | PRIORITY 10 | BURST  25 | TERMINATED
      turn-around time = 140
      waiting time = 115

Average turn-around time = 82.5
Average waiting time = 61.25
The ReadyQueue has been destructed.
```

PRIORITY

```
=== PRIORITY ===

Running task = [T8] [10] [25] for 25 units.
Running task = [T4] [5] [15] for 15 units.
Running task = [T5] [5] [20] for 20 units.
Running task = [T1] [4] [20] for 20 units.
Running task = [T2] [3] [25] for 25 units.
Running task = [T3] [3] [25] for 25 units.
Running task = [T7] [3] [30] for 30 units.
Running task = [T6] [1] [10] for 10 units.

=== 8 processes in PCB TABLE ===
PID  T1 | PRIORITY  4 | BURST  20 | TERMINATED
      turn-around time = 80
      waiting time = 60
PID  T2 | PRIORITY  3 | BURST  25 | TERMINATED
      turn-around time = 105
      waiting time = 80
PID  T3 | PRIORITY  3 | BURST  25 | TERMINATED
      turn-around time = 130
      waiting time = 105
PID  T4 | PRIORITY  5 | BURST  15 | TERMINATED
      turn-around time = 40
      waiting time = 25
PID  T5 | PRIORITY  5 | BURST  20 | TERMINATED
      turn-around time = 60
      waiting time = 40
PID  T6 | PRIORITY  1 | BURST  10 | TERMINATED
      turn-around time = 170
      waiting time = 160
PID  T7 | PRIORITY  3 | BURST  30 | TERMINATED
      turn-around time = 160
      waiting time = 130
PID  T8 | PRIORITY 10 | BURST  25 | TERMINATED
      turn-around time = 25
      waiting time = 0

Average turn-around time = 96.25
Average waiting time = 75
The ReadyQueue has been destructed.
[bustr003@cs433 bustr003]$
```

RR

```
=== 8 processes in PCB TABLE ===
PID  T1 | PRIORITY   4 | BURST  20 | TERMINATED
      turn-around time = 135
      waiting time = 115
PID  T2 | PRIORITY   3 | BURST  25 | TERMINATED
      turn-around time = 162
      waiting time = 137
PID  T3 | PRIORITY   3 | BURST  25 | TERMINATED
      turn-around time = 163
      waiting time = 138
PID  T4 | PRIORITY   5 | BURST  15 | TERMINATED
      turn-around time = 115
      waiting time = 100
PID  T5 | PRIORITY   5 | BURST  20 | TERMINATED
      turn-around time = 149
      waiting time = 129
PID  T6 | PRIORITY   1 | BURST  10 | TERMINATED
      turn-around time = 82
      waiting time = 72
PID  T7 | PRIORITY   3 | BURST  30 | TERMINATED
      turn-around time = 169
      waiting time = 139
PID  T8 | PRIORITY  10 | BURST  25 | TERMINATED
      turn-around time = 170
      waiting time = 145

Average turn-around time = 143.125
Average waiting time = 121.875
The ReadyQueue has been destructed.
[bustr003@cs433 bustr003]$
```

Priority with RR - incomplete

```
=== 8 processes in PCB TABLE ===
PID  T1 | PRIORITY  4 | BURST  20 | TERMINATED
      turn-around time = 85
      waiting time = 65
PID  T2 | PRIORITY  3 | BURST  25 | TERMINATED
      turn-around time = 168
      waiting time = 141
PID  T3 | PRIORITY  3 | BURST  25 | TERMINATED
      turn-around time = 169
      waiting time = 142
PID  T4 | PRIORITY  5 | BURST  15 | TERMINATED
      turn-around time = 65
      waiting time = 47
PID  T5 | PRIORITY  5 | BURST  20 | TERMINATED
      turn-around time = 62
      waiting time = 40
PID  T6 | PRIORITY  1 | BURST  10 | TERMINATED
      turn-around time = 179
      waiting time = 169
PID  T7 | PRIORITY  3 | BURST  30 | TERMINATED
      turn-around time = 167
      waiting time = 137
PID  T8 | PRIORITY 10 | BURST  25 | TERMINATED
      turn-around time = 25
      waiting time = 0

Average turn-around time = 115
Average waiting time = 92.625
The ReadyQueue has been destructed.
[bustr003@cs433 bustr003]$
```

=== FEATURES IMPLEMENTED ===

PCB

- **reference used:** Assignment 1 code from myself
- A process is represented by a process control block (PCB)
- The attributes of a process are:
 - **unchanging attributes**
 - process identifier
 - priority
 - length of CPU burst length needed
 - the time that the process arrived in the system
 - **attributes that will be changed throughout the process' time in the system**
 - state
 - remaining CPU burst length that still needs to be run
 - the time that the process most recently began to run
 - the time that the process most recently stopped running
 - **attributes that are finalized after the process is terminated**
 - turnaround time
 - waiting time

PCB Table

- The PCB Table is an array that holds the processes that are in the system.
- The PCB Table can be searched to find the index of a process that has a specific id
 - The worst case scenario to find a process is $O(\log n)$.
 - The best case scenario to find a process is $O(1)$.

ReadyQueue

- **reference used:** Assignment 1 code from myself
- **reference used:** CS 311 Homework (Linked List and Queue)
- The ReadyQueue is implemented as a linked list.
- A PCB can be added to the ReadyQueue based on priority or burst length, or may simply be added to the front of the ReadyQueue on arrival.
- A PCB can be removed from the ReadyQueue based on id. Otherwise, the front PCB will be removed.

FCFS

- **reference used:** Assignment 3 sample code from Dr. Zhang
- Set up a PCB Table and a ReadyQueue.
- Upon arrival, add the PCB to the back of the ReadyQueue.
- Always remove the front element from the queue and run its entire burst length. Repeat until the queue is empty.
- Determine turnaround time and waiting time for each process.
- Calculate average turnaround time and average waiting time for the set of processes.

SJF

- **reference used:** Assignment 3 sample code from Dr. Zhang
- Set up a PCB Table and a ReadyQueue.
- Upon arrival, add the PCB to the ReadyQueue. The position in the ReadyQueue is determined by the process' burst length.
 - Processes with shorter burst lengths are at the front.
 - If two processes have the same burst length, the process arriving earlier is in front of the other process.
- Always remove the front element from the queue and run its entire burst length. Repeat until the queue is empty.
- Determine turnaround time and waiting time for each process.
- Calculate average turnaround time and average waiting time for the set of processes.

Priority

- **reference used:** Assignment 3 sample code from Dr. Zhang
- Set up a PCB Table and a ReadyQueue.
- Upon arrival, add the PCB to the ReadyQueue. The position in the ReadyQueue is determined by the process' priority.
 - Processes with higher priorities are at the front.
 - If two processes have the priority, the process arriving earlier is in front of the other process.
- Always remove the front element from the queue and run its entire burst length. Repeat until the queue is empty.
- Determine turnaround time and waiting time for each process.
- Calculate average turnaround time and average waiting time for the set of processes.

RR

- **reference used:** Assignment 3 sample code from Dr. Zhang
- Determine the time quantum.
- Set up a PCB Table and a ReadyQueue.
- Upon arrival, add the PCB to the back of the ReadyQueue.
 - Processes with higher priorities are at the front.
 - If two processes have the priority, the process arriving earlier is in front of the other process.
- Always remove the front element from the queue.
 - The amount of time to run the process will either be smaller than or equal to the time quantum.
 - If the entire time quantum is run and the process still has CPU burst needing to run, add that process to the back of the ReadyQueue and change the state to READY.
 - If the entire time quantum is run and the process is finished, change the process' state to TERMINATED.
 - If the time ran is smaller than the time quantum, change the process' state to TERMINATED.

- Repeat until all processes have no CPU burst length needing to run.
- Determine turnaround time and waiting time for each process.
- Calculate average turnaround time and average waiting time for the set of processes.

Priority & RR

- Set up a PCB Table and a ReadyQueue.
 - Organize first queue by priority.
 - For processes with same priority, use a second queue for RR.
- NOTE: All algorithms assume that all tasks arrived at time 0.

=== FEATURES MISSING ===

n/a

=== LESSONS LEARNED ===

- I learned how to run the professor's sample programs.
- I learned how to use IDEs (Visual Studio Code and repl.it) to write and run code outside of the Putty terminal.
- I became more comfortable with using a SFTP client (WinSCP) to transfer files between Putty and my local storage.
- I learned how to accept arguments when executing a file.
- I learned how to set up multiple executables using a Makefile.
- I learned how to use different types of ReadyQueue methods for different types of scheduling algorithms.
- I gained a better understanding of the concept of turnaround time.

=== CONTRIBUTIONS ===

This assignment was completed by Mhealyssah Bustria.

=== FUTURE IMPROVEMENTS ===

- The following would be interesting to implement:
 - Including processes that do not all arrive at the same time.

=== COMMENTS ===

n/a