## Module 8 – CPU scheduler Code and Report

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Language used: C++

1. Introduction

The current CPU scheduler assignment implements a First Come First Serve algorithm to schedule a given set of processes with cpu and i/o time. The results calculated by the simulator (waiting time, response time, turnaround time, cpu utilization) have to be compared with given results of a Shortest Job First scheduler. The scheduler was implemented using the C++ language. I expected to see that the SJF scheduler will have lower average waiting times and lower average turnaround times than the FCFS scheduler. Most of my prediction matched the results of the scheduler, although I was surprised to see that FCFS has a better CPU utilization than SJF. The most difficult part in developing the program was to take into account all the conditions that had to be applied and working with the containers of choice (st::list) and iterators was also difficult.

2. Table with simulation results

| Process(SFJ results) | RT | WT | TT |
|---|---|---|---|
| P1 | 11 | 43 | 268 |
| P2 | 3 | 73 | 500 |
| P3 | 16 | 276 | 668 |
| P4 | 0 | 50 | 534 |
| P5 | 109 | 237 | 546 |
| P6 | 24 | 121 | 336 |
| P7 | 47 | 149 | 477 |
| P8 | 7 | 119 | 428 |

| AVG | 27.125 | 133.5 | 469.625 |
|---|---|---|---|
| CPU utilization | 82.78% | | |
| **Process(FCFS results)** | | | |
| P1 | 0 | 170 | 395 |
| P2 | 5 | 164 | 591 |
| P3 | 9 | 165 | 557 |
| P4 | 17 | 164 | 648 |
| P5 | 20 | 221 | 530 |
| P6 | 36 | 230 | 445 |
| P7 | 47 | 184 | 512 |
| P8 | 61 | 184 | 493 |
| AVG | 24.375 | 185.25 | 521.375 |
| CPU utilization | 85.34% | | |

3. Discussion of the results:

a. Which algorithm (FCFS or SJF) has the best CPU utilization?

FCFS

b. Which algorithm (FCFS or SJF) has the worst CPU utilization?

SJF

c. How many context switches are in the simulation of FCFS?

75

d. How many context switches are in the simulation of SJF?

77

e. How does the number of context switches effect the performance of the algorithm?

Context switches are overhead, the cpu is idle during that time.

f. Which algorithm (FCFS or SJF) has the lowest average waiting time.

SJF

g. Which algorithm (FCFS or SJF) has the lowest average response time.

FCFS

h. Which algorithm (FCFS or SJF) has the lowest average turnaround time.

SJF

  i.     How well did the results match your prediction?

My prediction were close to the results given by the FCFS simulator, but some answers I still can't verify until having the results of the MLFQ simulator. Results that match my prediction are: FCFS has the least context switches, SJF will have the lowest average waiting time, SJF will have the lowest average turnaround time. One wrong prediction was that FCFS will have the worst CPU utilization, but the results were not confirming that prediction.

4.  Sample Program Output (First and last 50 units)

**SJF**

Current Time: 0

Next process on the CPU::  P4

...............................................

List of processes in the ready queue:

```
       Process    Burst
       P2      4
       P8      4
       P1      5
       P3      8
       P6      11
       P7      14
       P5      16
```

...............................................

List of processes in  I/O:

```
       Process    Remaining I/O time
       [empty]
```

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Current Time: 3

Next process on the CPU::  P2

……………………………………………

List of processes in the ready queue:

```
     Process    Burst
     P8      4
     P1      5
     P3      8
     P6      11
     P7      14
     P5      16
```
……………………………………………

List of processes in  I/O:

```
  Process    Remaining I/O time
      P4         35
```

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Current Time: 7

Next process on the CPU::  P8
……………………………………………

List of processes in the ready queue:

```
     Process    Burst
     P1      5
     P3      8
     P6      11
     P7      14
     P5      16
```
……………………………………………

List of processes in  I/O:

```
     Process    Remaining I/O time
     P2      48
     P4      31
```

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Current Time: 11

Next process on the CPU:: P1
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List of processes in the ready queue:

```
     Process    Burst
     P3      8
     P6      11
     P7      14
     P5      16
```
.................................................

List of processes in  I/O:

```
      Process    Remaining I/O time
     P2      44
     P4      27
     P8      14
```

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Current Time: 16

Next process on the CPU::  P3
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List of processes in the ready queue:

```
     Process    Burst
     P6      11
     P7      14
     P5      16
```
.................................................

List of processes in  I/O:

```
      Process    Remaining I/O time
     P1      27
```

```
        P2      39
        P4      22
        P8      9
```

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Current Time: 24

Next process on the CPU::  P6

..................................................

List of processes in the ready queue:

```
        Process    Burst
        P7      14
        P5      16
```

..................................................

List of processes in  I/O:

```
        Process    Remaining I/O time
        P1      19
        P2      31
        P3      33
        P4      14
        P8      1
```

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Current Time: 35

Next process on the CPU::  P8

..................................................

List of processes in the ready queue:

```
        Process    Burst
        P7      14
        P5      16
```

..................................................

List of processes in  I/O:

      Process   Remaining I/O time
    P1     8
    P2    20
    P3    22
    P4    3
    P6    22

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Current Time: 40

Next process on the CPU::  P4

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List of processes in the ready queue:

      Process   Burst
    P7     14
    P5     16

.................................................

List of processes in  I/O:

      Process   Remaining I/O time
    P1     3
    P2    15
    P3    17
    P6    17
    P8    33

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Current Time: 44

Next process on the CPU::  P1

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List of processes in the ready queue:

    Process   Burst
    P7      14
    P5      16
...................................................

List of processes in  I/O:

       Process    Remaining I/O time
    P2      11
    P3      13
    P4      41
    P6      13
    P8      29


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Current Time: 47

Next process on the CPU::  P7
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List of processes in the ready queue:

    Process   Burst
    P5      16
...................................................

List of processes in  I/O:

       Process    Remaining I/O time
    P1      31
    P2      8
    P3      10
    P4      38
    P6      10
    P8      26

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Current Time: 61

Next process on the CPU::  P6
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List of processes in the ready queue:

       Process   Burst
     P2     5
     P3    12
     P5    1
.................................................

List of processes in  I/O:

       Process   Remaining I/O time
     P1    17
     P4    24
     P7    46
     P8    12

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## LAST 50 UNITS


Current Time: 600


Next process on the CPU::  [idle]

..................................................


List of processes in the ready queue:


       Process   Burst

      [empty]

.................................................

List of processes in  I/O:

      Process    Remaining I/O time
        P3      26

.................................................

Completed:   P1, P2, P4, P5, P6, P7, P8

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Current Time: 626

Next process on the CPU::  P3

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List of processes in the ready queue:

      Process    Burst
        [empty]

.................................................

List of processes in  I/O:

      Process    Remaining I/O time
        [empty]

.................................................

Completed:   P1, P2, P4, P5, P6, P7, P8

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Current Time: 631

Next process on the CPU:: [idle]

................................................

List of processes in the ready queue:

     Process   Burst

       [empty]

................................................

List of processes in  I/O:

     Process   Remaining I/O time

       P3    31

................................................

Completed:   P1,  P2,  P4,  P5,  P6,  P7,  P8

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Current Time: 662

Next process on the CPU::  P3

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List of processes in the ready queue:

     Process   Burst

[empty]

.................................................

List of processes in  I/O:

     Process   Remaining I/O time
       [empty]

.................................................

Completed:   P1, P2, P4, P5, P6, P7, P8


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Current Time: 668

Next process on the CPU::  [idle]

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List of processes in the ready queue:

     Process   Burst
       [empty]

.................................................

List of processes in  I/O:

     Process   Remaining I/O time
       [empty]

.................................................

Completed:   P1, P2, P3, P4, P5, P6, P7, P8

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Finished


Total Time:        668

CPU Utilization:    82.7844%


Waiting Times      P1   P2   P3   P4   P5   P6   P7   P8

                   43   73   276  50   237  121  149  119

Average Wait:      133.5


Turnaround Times   P1   P2   P3   P4   P5   P6   P7   P8

                   268  500  668  534  546  336  477  428

Average Turnaround: 469.625


Response Times     P1   P2   P3   P4   P5   P6   P7   P8

                   11   3    16   0    109  24   47   7

Average Response:   27.125



## FCFS

Current Time: 0


Next Process on the CPU: P1

...............................................


List of processes in the ready queue:


    Process              Burst

    P2              4

| | |
|---|---|
| P3 | 8 |
| P4 | 3 |
| P5 | 16 |
| P6 | 11 |
| P7 | 14 |
| P8 | 4 |

.................................................

List of processes in I/O:

| Process | Remaining I/O time |
|---|---|
| [empty] | |

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Current Time: 5

Next Process on the CPU: P2

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List of processes in the ready queue:

| Process | Burst |
|---|---|
| P3 | 8 |
| P4 | 3 |
| P5 | 16 |
| P6 | 11 |
| P7 | 14 |
| P8 | 4 |

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List of processes in I/O:

Process                     Remaining I/O time

P1              27

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Current Time: 9

Next Process on the CPU: P3

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List of processes in the ready queue:

Process                     Burst

P4              3

P5              16

P6              11

P7              14

P8              4

...............................................

List of processes in I/O:

Process                     Remaining I/O time

P1              23

P2              48

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Current Time: 17

Next Process on the CPU: P4

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List of processes in the ready queue:

| Process | Burst |
|---------|-------|
| P5 | 16 |
| P6 | 11 |
| P7 | 14 |
| P8 | 4 |

................................................

List of processes in I/O:

| Process | Remaining I/O time |
|---------|--------------------|
| P1 | 15 |
| P2 | 40 |
| P3 | 33 |

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Current Time: 20

Next Process on the CPU: P5

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List of processes in the ready queue:

| Process | Burst |
|---------|-------|
| P6 | 11 |
| P7 | 14 |

P8            4

.................................................

List of processes in I/O:

| Process | Remaining I/O time |
|---------|--------------------|
| P1      | 12                 |
| P2      | 37                 |
| P3      | 30                 |
| P4      | 35                 |

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Current Time: 36

Next Process on the CPU: P6

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List of processes in the ready queue:

| Process | Burst |
|---------|-------|
| P7      | 14    |
| P8      | 4     |
| P1      | 3     |

.................................................

List of processes in I/O:

| Process | Remaining I/O time |
|---------|--------------------|
| P2      | 21                 |
| P3      | 14                 |

P4              19

P5              24

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Current Time: 47

Next Process on the CPU: P7

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List of processes in the ready queue:

| Process | Burst |
| --- | --- |
| P8 | 4 |
| P1 | 3 |

..............................................

List of processes in I/O:

| Process | Remaining I/O time |
| --- | --- |
| P2 | 10 |
| P3 | 3 |
| P4 | 8 |
| P5 | 13 |
| P6 | 22 |

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Current Time: 61

Next Process on the CPU: P8

..............................................

List of processes in the ready queue:

    Process               Burst

| Process | Burst |
|---------|-------|
| P1 | 3 |
| P3 | 12 |
| P4 | 4 |
| P2 | 5 |
| P5 | 17 |

...............................................

List of processes in I/O:

| Process | Remaining I/O time |
|---------|--------------------|
| P6 | 8 |
| P7 | 46 |

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LAST 50 UNITS

Current Time: 591

Next Process on the CPU:  [IDLE]

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List of processes in the ready queue:

| Process | Burst |
|---------|-------|
| [empty] | |

...............................................

List of processes in I/O:

    Process                 Remaining I/O time
    P4              54

Complete: P1, P2, P3, P5, P6, P7, P8,
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Current Time: 645

Next Process on the CPU: P4
...............................................

List of processes in the ready queue:

    Process                 Burst
    [empty]
...............................................

List of processes in I/O:

    Process                 Remaining I/O time
    [empty]

Complete: P1, P2, P3, P5, P6, P7, P8,
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Current Time: 648

Next Process on the CPU:  [IDLE]

.................................................

List of processes in the ready queue:

    Process             Burst

    [empty]

.................................................

List of processes in I/O:

    Process             Remaining I/O time

    [empty]

Complete: P1, P2, P3, P4, P5, P6, P7, P8,

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Finished

Total time: 648

CPU utilization: 85.3395

Response time:

| P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|----|----|----|----|----|----|----|----|
| 0  | 5  | 9  | 17 | 20 | 36 | 47 | 61 |

Average response time:    24.375

Waiting time:

| P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|----|----|----|----|----|----|----|----|

| 170 | 164 | 165 | 164 | 221 | 230 | 184 | 184 |
|---|---|---|---|---|---|---|---|

Average waiting time:     185.25

Turnaround time:

| P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|
| 395 | 591 | 557 | 648 | 530 | 445 | 512 | 493 |

Average turnaround time: 521.375

5. Partial Gantt chart

| P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P1 | P3 | P4 | P2 | P5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

0     5     9     17     20     36     47     61     65     68     80     84     89     106

| P6 | P8 | P1 | P7 | P6 | P3 | P4 |
|---|---|---|---|---|---|---|

106     110     115     120     137     142     160     165
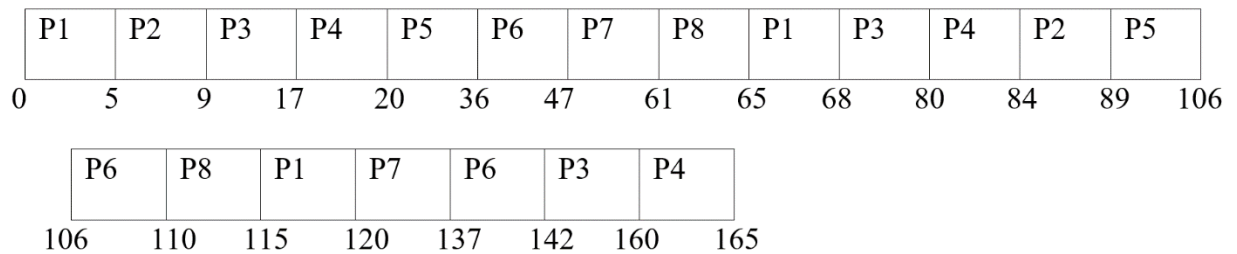
6. Instructions

Download the FCFS.cpp source file. Open Visual Studio 2015 and start a new empty project. Click on Project, then Add Existing Item, and select FCFS.cpp. To run the simulator go to Debug, Start without Debugging. The output will appear in a console window.