Module 9 - CPU scheduler Code and Report

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Date: 10/29/2018 Language used: C++

1. Introduction

The current CPU scheduler assignment implements a Multilevel Feedback Queue 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 a set of given results of a Shortest Job First scheduler, and with previous simulated FCFS scheduler. The scheduler was implemented using the C++ language. I expected to see that MLFQ will have the lowest average response time, since all processes start in queue 1, but are given only a 5 units time quantum, thus decreasing the response time of each process. Most of my prediction matched the results of the scheduler, although I was surprised to see that MLFQ has the best CPU utilization. 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 (std::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	
Р3	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%		
Process(MLFQ results)			
P1	0	50	275
P2	5	134	561
P3	9	198	590
P4	14	17	501
P5	17	266	575
P6	22	179	394
P7	27	243	571
P8	32	151	460
AVG	15.75	154.75	490.875
CPU utilization	93.7288%		

3. Discussion of the results:

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

MLFQ

- b. Which algorithm (MLFQ, FCFS or SJF) has the worst CPU utilization? SJF
- c. How many context switches are in the simulation of MLFQ?96
- d. Which algorithm (MLFQ, FCFS or SJF) has the lowest average waiting time. SJF
- e. Which algorithm (MLFQ, FCFS or SJF) has the lowest average response time. MLFQ
- f. Which algorithm (MLFQ, FCFS or SJF) has the lowest average turnaround time. SJF
- g. How well did the results match your prediction?

My prediction were close to the results given by the FCFS and MLFQ simulator. Results that match my prediction are: MLFQ will have the most context switches, SJF will have the lowest average waiting time, SJF will have the lowest average turnaround time, MLFQ will have the lowest average response 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)

FIRST 50 units

Current Time: 0

Next Process on the CPU: P1 CPU burst: 5

.....

List of processes in Queue1:

Process		Burst
P2	4	
P3	8	
P4	3	
P5	16	
P6	11	
P7	14	
P8	4	

List of processes i	n Queue2:	
Process [empty]	Burs	t
List of processes i	n Queue3:	
Process [empty]	Burs	t
List of processes i	n I/O:	
Process [empty]		aining I/O time
No completed pro	cesses	
	•••••	::::
Current Time: 5		
Next Process on the		CPU burst: 4
List of processes i		
Process	Burs	t
P3	8	
P4	3	
P5	16	
P6	11	
P7	14	
P8	4	
•••••	•••••	
List of processes i	n Queue2:	
Process	Burs	f
[empty]	Durs	•
[empty]		
List of processes i	n Queue3:	

Process [empty]		Burst
	•••••	
List of processes	in I/O:	
Process P1	27	Remaining I/O time
No completed pro	ocesses	
:::::::::::::::::::::::::::::::::::::::	::::::::::	:::::::::::
Current Time: 9		
Next Process on t		J: P3 CPU burst: 8
List of processes	in Queı	ue1:
Process P4 P5 P6 P7 P8	3 16 11 14 4	Burst
List of processes	in Queı	ıe2:
Process [empty]		Burst
List of processes	in Queı	ıe3:
Process [empty]		Burst
List of processes	in I/O:	
Process P1	23	Remaining I/O time

P2	48		
•••••		•••••	
No completed pro	ocesses		
:::::::::::::::::::::::::::::::::::::::	:::::::::::		
Current Time: 14			
Next Process on t		J: P4 CPU burst: 3	
List of processes	in Queı	ue1:	
Process		Burst	
P5	16	Buist	
P6	11		
P7	14		
P8	4		
List of processes	in Queı	ue2:	
Process		Burst	
P3	3		
List of processes	in Quei	ıe3:	
Process		Burst	
[empty]			
List of processes in I/O:			
Process		Remaining I/O time	
P1	18		
P2	43		
No completed processes			
	:::::::::::	::::::::::::::::::::::::::::::::::::::	

Current Time: 17

Next Process of		U: P5
List of processe		
Process P6 P7 P8	11 14 4	Burst
List of processe	es in Que	eue2:
Process P3	3	Burst
List of processe	es in Que	eue3:
Process [empty]		Burst
List of processe	es in I/O:	
Process P1 P2 P4	15 40 35	Remaining I/O time
No completed p	processes	3
:::::::::::::::::::::::::::::::::::::::	•••••	
Current Time:	22	
	n the CP	U: P6
List of processe	es in Que	eue1:
Process P7 P8	14 4	Burst

List of processe	es in Que	eue2:
Process		Burst
P3	3	Barse
P5	11	
List of processe	es in Que	eue3:
Process		Burst
[empty]		
List of processe	es in I/O:	
Process		Remaining I/O time
P1	10	
P2	35	
P4	30	
Current Time:		
		U: P7
List of processe	es in Que	eue1:
Process		Burst
P8	4	Daise
List of processe	es in Que	eue2:
Process		Burst
P3	3	
P5	11	
P6	6	
10	0	
••••••	••••••	••••••

List of processes in Queue3:

Process [empty]		Burst	
List of processes			
Process P1 P2 P4	5 30 25	Remainir	ng I/O time
No completed pr	cocesses	S	
Current Time: 32	2		
Next Process on			PU burst: 4
List of processes	s in Que	eue1:	
Process P1	3	Burst	
List of processes	s in Que	eue2:	
Process P3 P5 P6 P7	3 11 6 9	Burst	
List of processes	s in Que	eue3:	
Process [empty]		Burst	
List of processes	s in I/O:		

Remaining I/O time

Process

P2 P4	25 20		
No completed p	processes	S	
	::::::::::	:::::::::::::::::::::::::::::::::::::::	::
Current Time: 3	36		
Next Process or			CPU burst: 3
List of processe	es in Que	eue1:	
Process [empty]		Burst	
List of processe	es in Que	eue2:	
Process		Burst	
P3	3		
P5	11		
P6	6		
P7	9		
List of processe			
Process		Burst	
[empty]		Duist	
List of processe	es in I/O	:	
Process		Rema	ining I/O time
P2	21		
P4	16		
P8	14		
NT 1 / 1		-	
No completed p	processes	S	
			::

Current Time: 39)		
Next Process on			CPU burst: 3
List of processes	in Que	eue1:	
Process [empty]		Burst	
List of processes	in Que	eue2:	
Process P5 P6 P7	11 6 9	Burst	
List of processes	in Que	eue3:	
Process [empty]		Burst	
List of processes			
Process P2 P4 P8 P1	18 13 11 31	Rema	ining I/O time
No completed pr	ocesses	3	
:::::::::::::::::::::::::::::::::::::::	•••••		::
Current Time: 42	2		
Next Process on			CPU burst: 11
List of processes Process	in Que	eue1: Burst	

[empty]		
List of processe	s in Que	eue2:
Process		Burst
P6	6	
P7	9	
List of processe	s in Que	eue3:
Process		Burst
[empty]		
List of processe	s in I/O:	
Process		Remaining I/O time
P2	15	remaining i o time
P4	10	
P8	8	
P1	28	
P3	33	
No completed p	rocesses	S
	••••••	
Current Time: 5	0	
Next Process on		U: P8 CPU burst: 5
List of processe	s in Que	eue1:
Process		Burst
[empty]		20150
List of processe	s in Que	eue2:
Process		Burst
P6	6	
P7	9	

P5	3		
List of process			
Process [empty]		Burst	
List of process			
Process P2 P4 P1 P3	7 2 20 25		ining I/O time
No completed			
	:::::::::::::::::::::::::::::::::::::::		::
Current Time:	55		
Next Process o			CPU burst: 4
List of process	es in Que	eue1:	
Process [empty]		Burst	
List of process	es in Quo	eue2:	
Process P6 P7 P5	6 9 3	Burst	
List of process	es in Que	eue3:	
Process [empty]		Burst	

List of processes in I/O:

P2 2 P1 15 P3 20 P8 33 No completed processes	Process	Remaining I/O time
P3 20 P8 33 No completed processes LAST 50 units Current Time: 532 Next Process on the CPU: [IDLE] List of processes in Queue1: Process Burst [empty] List of processes in Queue2: Process Burst [empty] List of processes in Queue3: Process Burst [empty]	P2	2
No completed processes LAST 50 units Current Time: 532 Next Process on the CPU: [IDLE] List of processes in Queue1: Process Burst [empty] List of processes in Queue2: Process Burst [empty] List of processes in Queue3: Process Burst [empty]	P1	15
No completed processes LAST 50 units Current Time: 532 Next Process on the CPU: [IDLE] List of processes in Queue1: Process Burst [empty] List of processes in Queue2: Process Burst [empty] List of processes in Queue3: Process Burst [empty]	P3	20
LAST 50 units Current Time: 532 Next Process on the CPU: [IDLE] List of processes in Queue1: Process Burst [empty] List of processes in Queue2: Process Burst [empty] List of processes in Queue3: Process Burst [empty]	P8	33
LAST 50 units Current Time: 532 Next Process on the CPU: [IDLE] List of processes in Queue1: Process Burst [empty] List of processes in Queue2: Process Burst [empty] List of processes in Queue3: Process Burst [empty]		•••••
LAST 50 units Current Time: 532 Next Process on the CPU: [IDLE] List of processes in Queue1: Process Burst [empty] List of processes in Queue2: Process Burst [empty] List of processes in Queue3: Process Burst [empty]	No completed pro-	cesses
Next Process on the CPU: [IDLE] List of processes in Queue1: Process Burst [empty] List of processes in Queue2: Process Burst [empty] List of processes in Queue3: Process Burst [empty]		
List of processes in Queue1: Process Burst [empty] List of processes in Queue2: Process Burst [empty] List of processes in Queue3: Process Burst [empty]		
Process Burst [empty] List of processes in Queue2: Process Burst [empty] List of processes in Queue3: Process Burst [empty]		
[empty] List of processes in Queue2: Process Burst [empty] List of processes in Queue3: Process Burst [empty]	List of processes i	n Queue1:
List of processes in Queue2: Process Burst [empty] List of processes in Queue3: Process Burst [empty]		Burst
Process Burst [empty] List of processes in Queue3: Process Burst [empty]		
[empty] List of processes in Queue3: Process Burst [empty]	List of processes i	n Queue2:
List of processes in Queue3: Process Burst [empty]		Burst
Process Burst [empty]		
[empty]	List of processes i	n Queue3:
[empty]	Process	Burst
		20100
List of processes in I/O:	[empty]	
List of processes in I/O:		
	List of processes is	n I/O:
Process Remaining I/O time	Process	Remaining I/O time
P2 19	P2	_
P3 16	P3	
P7 27		
P5 13		

Completed: P1, P4, P6, P	78,
	::::::::::
Current Time: 545	
Next Process on the CPU	
List of processes in Queu	e1:
Process [empty]	Burst
List of processes in Queu	e2:
Process [empty]	Burst
List of processes in Queu	e3:
Process [empty]	Burst
List of processes in I/O:	
Process P2 6 P3 3 P7 14	Remaining I/O time
Completed: P1, P4, P6, P	8,
Current Time: 548	
Next Process on the CPU	
List of processes in Queu	e1:

Process [empty]		urst	
List of processes	in Queue2	:	
Process [empty]		urst	
List of processes	in Queue3	:	
Process [empty]		urst	
List of processes	in I/O:		
Process P2 P7 P5	3 11 11		ning I/O time
Completed: P1, l	P4, P6, P8,		
			:
Current Time: 55	53		
Next Process on	the CPU: P	P2	CPU burst: 8
List of processes	in Queue1	:	
Process [empty]	В	urst	
List of processes	in Queue2	:	
Process [empty]	В	urst	

List of processe	es in Que	eue3:
Process [empty]		Burst
List of processe	es in I/O:	
Process P7 P5 P3	6 6 31	Remaining I/O time
Completed: P1	, P4, P6,	P8,
	::::::::::	
Current Time:	561	
Next Process o	n the CP	U: P7 CPU burst: 10
List of processor Process [empty]	es in Que	Burst
List of processe		
Process [empty]		Burst
List of processe	es in Que	eue3:
Process P5	4	Burst
List of processe	es in I/O:	
Process P3	23	Remaining I/O time

Completed: P1, P2	, P4, P6, P8,						
Current Time: 571							
Next Process on the	e CPU: P5 CPU burst: 4						
List of processes in	Queue1:						
Process [empty]	Burst						
List of processes in							
Process [empty]	Burst						
List of processes in							
Process [empty]	Burst						
List of processes in	I/O:						
_	Remaining I/O time						
Completed: P1, P2							
Current Time: 575							
Next Process on the							
List of processes in	Queue1:						
Process	Burst						

[empty]			
List of processes	in Queu	ıe2:	
Process [empty]		Burst	
•••••	••••••	•••••	
List of processes	in Queu	ıe3:	
Process [empty]		Burst	
	••••••	•••••	
List of processes	in I/O:		
Process P3	9	Remai	ning I/O time
	••••••	•••••	
Completed: P1, P	2, P4, F	25, P6, F	P7, P8,
:::::::::::::::::::::::::::::::::::::::	••••••	••••••	:
Current Time: 58	4		
Next Process on t			CPU burst: 6
List of processes	in Queu	ie1:	
Process [empty]		Burst	
	••••••		
List of processes	in Queu	ıe2:	
Process [empty]		Burst	
List of processes	in Queu	ıe3:	
Process [empty]		Burst	

	•••••
List of processes in I/O:	
Process [empty]	Remaining I/O time
Completed: P1, P2, P4, P	5, P6, P7, P8,
Current Time: 590	
Next Process on the CPU	_
	•••••
List of processes in Queu	e1:
Process [empty]	Burst
List of processes in Queu	
Process [empty]	Burst
List of processes in Queu	
Process [empty]	Burst
List of processes in I/O:	
Process [empty]	Remaining I/O time
Completed: P1, P2, P3, P	

Finished

Total time: 590

CPU utilization: 93.7288 %

Response time:

P1 P2 P3 P4 P5 P6 P7 P8 0 5 9 14 17 22 27 32

Average response time: 15.75

Waiting time:

P1 P2 P3 P4 P5 P6 P7 P8 50 134 198 17 266 179 243 151

Average waiting time: 154.75

Turnaround time:

P1 P2 P3 P4 P5 P6 P7 P8 275 561 590 501 575 394 571 460

Average turnaround time: 490.875

5. Partial Gantt chart

	P1	P2	P3	P4	P5	P6	P7	P8	P1	P3	P5	P8	P4	P2	P6	
0		5	9 1	4	17 2	2 2	27 3	32	36 3	9 4	42	50	55 5	59	64 7	70
	P1	P7	P5	P3	P8	P3	P4	P6	P2	P8	P3	P1	P6	P5	P2	
7	0	75	84				00 1	05 1	08 1	13 1	14 1	18 1	22 1	23 1	33 1	35
	P7	P1	P6	P4		P1										
1	35 1	40 1	145 15	50 15	3 163	3 164	4									

6. Instructions

Download the MLFQ.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. To view the output in a text file go to Project – Properties – Configuration Properties – Debugging. Write > output. txt in Command Arguments. The file ouput.txt will be in the project folder after running.