

Discussion 4

Scheduling

10/09/24

Staff

Announcements

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Homework 2 Due	Homework 3 Release	Project 2 Release				
Tioniework 2 Due	Project 1 Due Turn in Peer Evals	FTOJECT Z Release				
					Project 2 Design Doc Due	

Scheduling

Scheduling

Scheduling is the process of deciding which threads are given access to resources from moment to moment.

Usually pertains to CPU but can be anything (e.g disk access)

For simplification, assume each user has one single-threaded program, and these programs are independent of each other.

Goals and Criteria

Minimize completion time

- Completion time is the combination of the waiting time plus the run time of a process.
- Crucial for time sensitive tasks (e.g. I/O)

Maximize throughput

- Throughput is the rate at which tasks are completed.
- Related but not the same as completion time
- Need to minimize overhead (e.g. context switching), using resources efficiently.

Maintain fairness

- Fairness refers to sharing resources in some equitable manner.
- Not very well defined.
- Usually contradicts minimizing completion time.

Definitions

Wait time:

• The total time a process spends on the ready queue

Response time:

• The total time it takes for a process to finish its execution

Completion time:

Same as response time

These definitions vary from textbook to textbook, instructor to instructor, etc., but we will be using these

First Come First Serve (FCFS)

First come first serve (FCFS) schedule tasks in the order they arrive.

Simple to implement.

Good for throughput since it minimizes overhead of context switching.

Average completion time can very significantly according to arrival order.

Suffers from Convoy effect where short tasks get stuck behind long tasks.

Shortest Job First (SJF) / Shortest Remaining Time First (SRTF)

Shortest job first (SJF) schedules the shortest task first.

Shortest remaining time first (SRTF) is a preemptive version of SJF.

 Preempt resource if a task arrives and has a shorter completion time than the current running task.

Provably optimal for minimizing average completion time for non-preemptive, preemptive policies, respectively.

Involves the impossible idea of knowing how long a task is going to take.

Round Robin (RR)

Round robin (RR) schedules tasks such that each take turn using the resource for a small amount of time known as the **time quantum** (q).

 After q expires, task is preempted and added to the end of the ready queue.

Large $q \rightarrow$ resembles FCFS, small $q \rightarrow$ lots of interleavings.

 Need q to be large with respect to context switching otherwise suffers from low throughput.

Ensures fairness in terms of sharing resources.

 n tasks → each task gets 1/n amount of resource, will not wait for more than (n-1)q time units.

Small scheduling quantum increases completion time.

Multi-Level Feedback Queue (MLFQ)

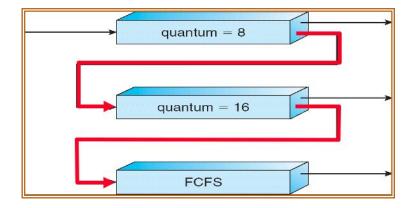
Multi-level feedback queue (MLFQ) uses multiple queues which each have a different priority.

• Each queue has its own scheduling policy.

Task starts at the highest priority queue and moves down to the next queue.

- Uses up resource → move down a level.
- Does not use up all resource → move up a level

Ensures long running tasks (e.g. CPU bound) don't hog all resources while short running tasks (e.g. I/O bound) will remain at higher priority.



1.	The average wait time is less than that of FCFS for the same workload.
2.	If a quantum is constantly updated to become the number of cpu ticks since boot, RR becomes FCFS.

3. Ideally, you should set the time quanta of round robin generally to be significantly smaller than the average CPU burst time of a task.

1. The average wait time is less than that of FCFS for the same workload.

False. Generally not true when the time quantum is small.

	FCFS								
	Α	Α	Α	В	В	В	С	С	С
Wait Times		0			3			6	
Average					3				

		RR (q=1)								
	Α	В	С	Α	В	С	Α	В	С	
Wait Times	0	1	2	2	2	2	2	2	2	
Average					5					

2. If a quantum is constantly updated to become the number of cpu ticks since boot, RR becomes FCFS.

3. Ideally, you should set the time quanta of round robin generally to be significantly smaller than the average CPU burst time of a task.

1. The average wait time is less than that of FCFS for the same workload.

False. Generally not true when the time quantum is small.

	FCFS								
	Α	Α	Α	В	В	В	С	С	С
Wait Times		0			3			6	
Average					3				

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	KK (Q=1)								
	Α	В	С	Α	В	С	Α	В	С
Wait Times	0	1	2	2	2	2	2	2	2
verage					5				

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2. If a quantum is constantly updated to become the number of cpu ticks since boot, RR becomes FCFS.

True. Quantum never gets used for any task since it always increases as the task progresses.

3. Ideally, you should set the time quanta of round robin generally to be significantly smaller than the average CPU burst time of a task.

1. The average wait time is less than that of FCFS for the same workload.

False. Generally not true when the time quantum is small.

	FCFS								
	Α	Α	Α	В	В	В	С	С	С
Wait Times		0			3			6	
Average					3				

	KR (q=1)								
	Α	В	С	Α	В	С	Α	В	С
Wait Times	0	1	2	2	2	2	2	2	2
verage					5				

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2. If a quantum is constantly updated to become the number of cpu ticks since boot, RR becomes FCFS.

True. Quantum never gets used for any task since it always increases as the task progresses.

3. Ideally, you should set the time quanta of round robin generally to be significantly smaller than the average CPU burst time of a task.

False. This results in poor turnaround time since tasks have to wait multiple cycles for their turns. Ideally, you'd want the quanta to be large enough to absorb most CPU bursts, but small enough to prevent short-running tasks being starved by long ones.

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5. If no new threads are entering the system all threads will get a chance to run in the cpu every QUANTA*SECONDS_PER_TICK*NUMTHREADS seconds, assuming QUANTA is in ticks.

4. Cache performance is likely to improve relative to FCFS.

False. RR usually results in more context switches when compared to FCFS, meaning the cache will have more misses.

5. If no new threads are entering the system all threads will get a chance to run in the cpu every QUANTA*SECONDS_PER_TICK*NUMTHREADS seconds, assuming QUANTA is in ticks.

4. Cache performance is likely to improve relative to FCFS.

False. RR usually results in more context switches when compared to FCFS, meaning the cache will have more misses.

5. If no new threads are entering the system all threads will get a chance to run in the cpu every QUANTA*SECONDS_PER_TICK*NUMTHREADS seconds, assuming QUANTA is in ticks.

False. There exists context switching overhead.

Suppose the following threads (priorities given in parentheses) arrive in the ready queue at the clock ticks shown. Assume all threads arrive unblocked and that each takes 5 clock ticks to finish executing. Assume threads arrive in the queue at the beginning of the time slices shown and are ready to be scheduled in that same clock tick. This means you update the ready queue with the arrival before you schedule/execute that clock tick. Assume you only have one physical CPU.

Determine the order and time allocations of execution for each given scheduler scenario.

- RR (q = 3)
- SRTF
- Strict priority scheduling with preemptions.

Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time

At time

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Name		
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Kevin		
Neil		
Akshat		
William		

Alina

Quantum

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	Arrivals	
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time At time

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	Arrivals	
Time	Name	Priority
0	Taj	7
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2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

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Remaining		
Name	Time	
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Kevin	5	
Neil	5	
Akshat	5	
William	5	
Alina	5	

Arrivals			
Time	Name	Priority	
0	Taj	7	
1			
2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

RR (q=3)

Just before time At time

Time	Thread
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2 3 4 5 6 7 8	
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Name	Time	
Taj	3	
Kevin	5	
Neil	5	
Akshat	5	
William	5	
Alina	5	

Arrivals			
Time	Name	Priority	
0	Taj	7	
1			
2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

RR (q=3)

Just before time

At time

Time	Thread
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Remaining		
Name	Time	
Taj	3	
Kevin	5	
Neil	5	
Akshat	5	
William	5	
Alina	5	

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

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Taj	2		
Kevin	5		
Neil	5		
Akshat	5		
William	5		

Alina

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Arrivals		
Time	Name	Priority
0	Taj	7
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2	Kevin	1
3	Neil	3
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5	Akshat	5
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7	William	11
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9	Alina	14

RR (q=3)

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Name	Time	
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Kevin	5	
Neil	5	
Akshat	5	
William	5	
Alina	5	

Arrivals			
Time	Name	Priority	
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2	Kevin	1	
3	Neil	3	
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5	Akshat	5	
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7	William	11	
8			
9	Alina	14	

RR (q=3)

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Remaining	
Name	Time
Taj	2
Kevin	5
Neil	5
Akshat	5
William	5
Alina	5

	Arrivals	
Time	Name	Priority
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2	Kevin	1
3	Neil	3
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5	Akshat	5
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7	William	11
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9	Alina	14

RR (q=3)

Just before time

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		Akshat	
		William	

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Arrivals			
Time	Name	Priority	
0	Taj	7	
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2	Kevin	1	
3	Neil	3	
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5	Akshat	5	
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7	William	11	
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9	Alina	14	

RR (q=3)

Just before time
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Name	Time	
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Akshat	5	
William	5	
Alina	5	

	Arrivals	
Time	Name	Priority
0	Taj	7
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2	Kevin	1
3	Neil	3
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5	Akshat	5
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7	William	11
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RR (q=3)

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Remaining		
Name	Time	
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Kevin	3	
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William	5	
Alina	5	

	Arrivals	
Time	Name	Priority
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2	Kevin	1
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7	William	11
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9	Alina	14

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Name	Time
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Neil	5
Akshat	5
William	5
Alina	5

Arrivals		
Time	Name	Priority
0	Taj	7
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2	Kevin	1
3	Neil	3
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5	Akshat	5
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7	William	11
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9	Alina	14

RR (q=3)

Just before time
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Time	Thread
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Remaining	
Name	Time
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Kevin	2
Neil	5
Akshat	5
William	5
Alina	5

Arrivals		
Time	Name	Priority
0	Taj	7
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2	Kevin	1
3	Neil	3
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5	Akshat	5
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7	William	11
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9	Alina	14

RR (q=3)

Just before time
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Time	Thread
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Remaining		
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Kevin	2	
Neil	4	
Akshat	5	
William	5	

Alina

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Quantum

Arrivals			
Time	Name	Priority	
0	Taj	7	
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2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
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7	William	11	
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9	Alina	14	

RR (q=3)

Just before time
At time

Time	Thread
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Akshat	-	Kevin	2	
Kevin		Neil	4	
William		Akshat	5	

Quantum

William

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Arrivals			
Time	Name	Priority	
0	Taj	7	
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2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

RR (q=3)

Just before time
At time

Time	Thread
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Queue	
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Kevin	
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	Remair	Remaining	
Queue	Name	Time	
Тај	Taj	2	
Akshat	Kevin	2	
Kevin		_	
William	Neil	3	
vviiiiaiii	Akshat	5	
	William	5	

Quantum

Alina

	Arrivals	
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

	Just before time
	At time

Time	Thread
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4	Kevin
5	Kevin
6	Neil
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Queue	
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Quantum

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	Arrivals	
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Тај
1	Taj
2	Taj
3 4 5 6 7	Kevin
4	Kevin
5	Kevin
6	Neil
	Neil
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Kevin	
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kshat		Kevin	2
(evin		Neil	2
'illiam			_
\!!		Akshat	5
Alina		William	5

Quantum

Alina

0

Arrivals		
Time	Name	Priority
0	Тај	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time	
At time	

- ·	Thusad
Time	Thread
0	Taj
1	Taj
2	Тај
3	Kevin
4	Kevin
5	Kevin
1 2 3 4 5 6 7	Neil
7	Neil
8	Neil
9	
10	
11	
12	
13	
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27	
28	
29	
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Queue
Taj
Akshat
Kevin
William
Alina
Neil

Remaining	
Name	Time
Taj	2
Kevin	2
Neil	2
Akshat	5
William	5
Alina	5

Quantum

3

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time	
At time	

- ·	Thread
Time	
0	Taj
1	Taj
2	Тај
1 2 3 4 5 6 7	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	
11	
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30	

Queue
Akshat
Kevin
William
Alina
Neil

	Remaining	
eue	Name	Time
nat	Taj	1
rin	Kevin	2
am	Keviii	
	Neil	2
าล	Akshat	5
il ———	William	5
	Alina	5

Quantum

2

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
1 2 3 4	Kevin
4	Kevin
5	Kevin
5 6 7	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	
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30	

Queue
Akshat
Kevin
William
Alina
Neil

Remain	ing
Name	Time
Taj	0
Kevin	2
Neil	2
Akshat	5
William	5

Alina

Quantum

1

	Arrivals	
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time	
At time	

Time	Thread
0	Taj
1	Taj
	Taj
2	Kevin
3 4 5	
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Тај
10	Тај
11	
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Queue
Akshat
Kevin
William
Alina
Neil

Quantum	3

Remaining	
Name	Time
Taj	0
Kevin	2
Neil	2
Akshat	5
William	5
Alina	5

	Arrivals	
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
3 4 5	Kevin
5	Kevin
6 7	Neil
	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	
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Queue
Kevin
William
Alina
Neil

Remai	aining	
Name	Time	
Taj	0	
Kevin	2	
Neil	2	
Akshat	4	
William	5	
	Taj Kevin Neil Akshat	

Quantum

Alina

2

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

	Just before time	
	At time	

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
3 4 5 6 7	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	
14	
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Queue
Kevin
William
Alina
Neil

Remain	Remaining	
Name	Time	
Taj	0	
Kevin	2	
Neil	2	
Akshat	3	
William	5	

Alina

5

Quantum

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time	
At time	

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
3 4 5 6 7	Kevin
5	Kevin
6	Neil
	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	
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Queue
Kevin
William
Alina
Neil

	Remaining
Queue	Name
Kevin	Taj
Villiam	Kevin
Alina	
Neil	Neil
TYCII	Akshat
	William

Quantum

Alina

0

Time 0

> 2 5

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time

At time

Time	Thread
0	Taj
1	Taj
2	Taj
2	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	
15	
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Queue
Kevin
William
Alina
Neil
Akshat

Remaining	
Name	Time
Taj	0
Kevin	2
Neil	2
Akshat	2
William	5

Alina

Quantum

3

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

	Just before time
	At time

Time	Thread
0	Тај
1	Taj
2	Taj
3	Kevin
3 4 5 6 7	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	
16	
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Queue	
William	
Alina	
Neil	
Akshat	

	Remaining
(ueue	Name
/illiam	Tai
Alina	Taj
Neil	Kevin
	Neil
kshat	Akshat
	William

Quantum

Alina

2

Time 0

> 2 5

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	
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Queue
William
Alina
Neil
Akshat

	Remaini	Remaining	
Queue	Name		
William	Taj		
Alina	Kevin		
Neil	Neil		
Akshat			
	Akshat		
	William		

Quantum

Alina

Time 0 0

> 2 5

Arrivals			
Time	Name	Priority	
0	Taj	7	
1			
2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

RR (q=3)

Just before time At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	
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Queue	
William	
Alina	
Neil	
Akshat	

	Remaining	5
Queue	Name	
William	Taj	
Alina	Kevin	
Neil	Neil	
Akshat	INell	
7 11.01.01	Akshat	
	William	

Quantum

Alina

3

Time 0

0

2 5

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
	Kevin
3	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	
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Queue
Alina
Neil
Akshat

Remaining	
Name	Time
Taj	0
Kevin	0
Neil	2
Akshat	2
William	4

Alina

Quantum

2

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
3	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	
19	
20	
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Queue
Alina
Neil
Akshat

Remain	ir
Name	
Taj	
Kevin	
Neil	
Akshat	

William

Alina

Time 0 0

2

3

5

Quantum

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
3 4 5	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	
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Queue
Alina
Neil
Akshat

	Remaining
Queue	Name
Alina	Taj
Neil	Kevin
Akshat	Neil
	Akshat
	William

Alina

Quantum	0

Time 0 0

2

	Arrivals	
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	
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Queue
Alina
Neil
Akshat
William

Queue
Alina
Neil
Akshat
William

Quantum	3

Remaining		
Name	Time	
Taj	0	
Kevin	0	
Neil	2	
Akshat	2	
William	2	
Alina	5	

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3 4	Kevin
	Kevin
5	Kevin
	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	
21	
22	
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Queue
Neil
Akshat
William

Queue
Neil
Akshat
William

Quantum	2
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Remaining		
Name	Time	
Taj	0	
Kevin	0	
Neil	2	
Akshat	2	
William	2	
Alina	4	

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	Alina
21	
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Queue
Neil
Akshat
William

Remain	ning
Name	Time
Taj	0
Kevin	0
Neil	2
Akshat	2
William	2

3

Quantum

Alina

	Arrivals	
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time

At time

Time	Thread
0	Taj
1	Taj
2	Taj
	Kevin
3 4 5 6 7	
4	Kevin
5	Kevin
6	Neil
	Neil
8	Neil
9	Taj
10	Тај
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	Alina
21	Alina
22	
23	
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Queue
Neil
Akshat
William

	Remaining	
	Name	
	Тај	
	Kevin	
	Neil	
	Akshat	
	William	

Quantum

Alina

0

Time 0

0

2

	Arrivals	
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	Alina
21	Alina
22	
23	
24	
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26	
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Queue
Neil
Akshat
William
Alina

Queue
Neil
Akshat
William
Alina

Quantum	3
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Remaining		
Name	Time	
Taj	0	
Kevin	0	
Neil	2	
Akshat	2	
William	2	
Alina	2	

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
3	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	Alina
21	Alina
22	Neil
23	
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Queue
Akshat
William
Alina

Remaining	
Name	Time
Taj	0
Kevin	0
Neil	1
Akshat	2
William	2

Alina

Quantum

2

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	Alina
21	Alina
22	Neil
23	Neil
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Queue
Akshat
William
Alina

Remaining		
Name	Time	
Taj	0	
Kevin	0	
Neil	0	
Akshat	2	
William	2	

2

2

Quantum

Alina

	Arrivals	
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5 6	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	Alina
21	Alina
22	Neil
23	Neil
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Queue
Akshat
William
Alina

Queue
Akshat
William
Alina

Quantum	3
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Remain	ing
Name	Time
Taj	0
Kevin	0
Neil	0
Akshat	2
William	2
Alina	2

	Arrivals	
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	Alina
21	Alina
22	Neil
23	Neil
24	Akshat
25	
26	
27	
28	
29	
30	

Queue
William
Alina

Remaining	
Name	Time
Тај	0
Kevin	0
Neil	0
Akshat	1
William	2

Alina

2

2

Quantum

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time	Thread	
0	Taj	
1	Taj	
2	Taj	
	Kevin	
3 4 5	Kevin	
5	Kevin	
6	Neil	
7	Neil	
8	Neil	
9	Tai	
10	Taj	
11	Akshat	
12	Akshat	
13	Akshat	
14	Kevin	
15	Kevin	
16	William	
17	William	
18	William	
19	Alina	
20	Alina	
21	Alina	
22	Neil	
23	Neil	
24	Akshat	
25	Akshat	
26		
27		
28		
29		
30		

Queue
William
Alina

7	Remaining	
_	Name	Time
_	Taj	0
_	Kevin	0
_	Neil	0
_	Akshat	0
	William	2

Alina

2

Quantum

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time	
At time	

Time	Thread	
0	Taj	
1	Taj	
2	Taj	
3	Kevin	
4	Kevin	
5	Kevin	
6	Neil	
7	Neil	
8	Neil	
9	Taj	
10	Taj	
11	Akshat	
12	Akshat	
13	Akshat	
14	Kevin	
15	Kevin	
16	William	
17	William	
18	William	
19	Alina	
20	Alina	
21	Alina	
22	Neil	
23	Neil	
24	Akshat	
25	Akshat	
26		
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Queue
William
Alina

Queue
William
Alina

Quantum	3
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Remaining		
Name	Time	
Taj	0	
Kevin	0	
Neil	0	
Akshat	0	
William	2	
Alina	2	

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time
At time

Time Thread 0 Taj 1 Taj 2 Taj 3 Kevin 4 Kevin 5 Kevin 6 Neil 7 Neil 8 Neil 9 Taj 10 Taj 11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29 30		
1 Taj 2 Taj 3 Kevin 4 Kevin 5 Kevin 6 Neil 7 Neil 8 Neil 9 Taj 10 Taj 11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	Time	Thread
2 Taj 3 Kevin 4 Kevin 5 Kevin 6 Neil 7 Neil 8 Neil 9 Taj 10 Taj 11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	0	,
3 Kevin 4 Kevin 5 Kevin 6 Neil 7 Neil 8 Neil 9 Taj 10 Taj 11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	1	
4 Kevin 5 Kevin 6 Neil 7 Neil 8 Neil 9 Taj 10 Taj 11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	2	Taj
4 Kevin 5 Kevin 6 Neil 7 Neil 8 Neil 9 Taj 10 Taj 11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	3	Kevin
6 Neil 7 Neil 8 Neil 9 Taj 10 Taj 11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	4	Kevin
6 Neil 7 Neil 8 Neil 9 Taj 10 Taj 11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	5	Kevin
8 Neil 9 Taj 10 Taj 11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	6	Neil
9 Taj 10 Taj 11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	7	Neil
10 Taj 11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	8	Neil
11 Akshat 12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	9	Taj
12 Akshat 13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	10	Taj
13 Akshat 14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	11	Akshat
14 Kevin 15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	12	Akshat
15 Kevin 16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	13	Akshat
16 William 17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	14	Kevin
17 William 18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	15	Kevin
18 William 19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	16	William
19 Alina 20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	17	William
20 Alina 21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	18	William
21 Alina 22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	19	Alina
22 Neil 23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	20	Alina
23 Neil 24 Akshat 25 Akshat 26 William 27 28 29	21	Alina
24 Akshat 25 Akshat 26 William 27 28 29	22	Neil
25 Akshat 26 William 27 28 29	23	Neil
26 William 27 28 29	24	1 11 12 1 12 1
27 28 29	25	
28 29	26	William
29	27	
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30	29	
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Queue
Alina

	Re
Queue	Name
Alina	Taj
	Kevin
	Neil
	Akshat
	William

Remain	ing
Name	Time

Quantum

Alina

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time	
At time	

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	Alina
21	Alina
22	Neil
23	Neil
24	Akshat
25	Akshat
26	William
27	William
28	
29	
30	

Queue
Alina

Remain	Remaining	
Name		
Taj		
Kevin		
Neil		
Akshat		
William		

Alina

Quantum

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

RR (q=3)

Just before time	
At time	

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	Alina
21	Alina
22	Neil
23	Neil
24	Akshat
25	Akshat
26	William
27	William
28	
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Queue				
Alina				

(Que	ue	
	Alin	а	

Quantum	3
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Remaining			
Name	Time		
Taj	0		
Kevin	0		
Neil	0		
Akshat	0		
William	0		
Alina	2		

Arrivals			
Time	Name	Priority	
0	Taj	7	
1			
2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

RR (q=3)

	Just before time	
	At time	

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	Alina
21	Alina
22	Neil
23	Neil
24	Akshat
25	Akshat
26	William
27	William
28	Alina
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Queue			
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Remair	ning
Name	Tim
Taj	0
Kevin	0
Neil	0
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Akshat

William

Alina

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Quantum

Arrivals			
Time	Name	Priority	
0	Taj	7	
1			
2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

RR (q=3)

Just before time	
At time	

Time	Thread
0	Taj
1	Taj
2	Taj
3	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Taj
10	Taj
11	Akshat
12	Akshat
13	Akshat
14	Kevin
15	Kevin
16	William
17	William
18	William
19	Alina
20	Alina
21	Alina
22	Neil
23	Neil
24	Akshat
25	Akshat
26	William
27	William
28	Alina
29	Alina
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Queue			
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Remaining			
Name	Time		
Taj	0		
Kevin	0		
Neil	0		

Akshat

William

Alina

2

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Quantum

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

SRTF

Just before time

At time

Time	Thread
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Arrivals		
Name	Priority	
Taj	7	
Kevin	1	
Neil	3	
Akshat	5	
William	11	
Alina	14	
	Name Taj Kevin Neil Akshat William	

SRTF

Just before time	
At time	

Time	Thread
0	Taj
1	Taj
2	Taj
3	Taj
4	Taj
5	Kevin
6	Kevin
7	Kevin
8	Kevin
9	Kevin
10	Neil
11	Neil
12	Neil
13	Neil
14	Neil
15	Akshat
16	Akshat
17	Akshat
18	Akshat
19	Akshat
20	William
21	William
22	William
23	William
24	William
25	Alina
26	Alina
27	Alina
28	Alina
29	Alina
30	

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

Preemptive Priority

Just before time

At time

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Queue		

Remaining		
Name	Time	
Taj	5	
Kevin	5	
Neil	5	
Akshat	5	
William	5	
Alina	5	

Arrivals			
Time	Name	Priority	
0	Taj	7	
1			
2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

Preemptive Priority

Just before time	
At time	

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Remaining		
Name	Time	
Taj	5	
Kevin	5	
Neil	5	
Akshat	5	
William	5	
Alina	5	

Arrivals			
Time	Name	Priority	
0	Taj	7	
1			
2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

Preemptive Priority

	Just before time
	At time

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Queue	•

Remaining		
Name	Time	
Taj	4	
Kevin	5	
Neil	5	
Akshat	5	
William	5	
Alina	5	

Arrivals			
Time	Name	Priority	
0	Taj	7	
1			
2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

Preemptive Priority

	Just before time
	At time

Time	Thread
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Queue	

Remaining		
Name	Time	
Taj	3	
Kevin	5	
Neil	5	
Akshat	5	
William	5	
Alina	5	

Arrivals					
Time	Name	Priority			
0	Taj	7			
1					
2	Kevin	1			
3	Neil	3			
4					
5	Akshat	5			
6					
7	William	11			
8					
9	Alina	14			

Just before time
At time

Time	Thread
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Que	eue
Kev	/in

Remain	ing
Name	Time
Taj	3
Kevin	5
Neil	5
Akshat	5
William	5
Alina	5

Arrivals			
Time	Name	Priority	
0	Taj	7	
1			
2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

	Just before time
	At time

Time	Thread
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(Qu	eue	•	
	Ke	vin		

Remaining	
Name	Time
Taj	2
Kevin	5
Neil	5
Akshat	5
William	5
Alina	5

Arrivals			
Time Name Priorit			
0	Taj	7	
1			
2	Kevin	1	
3	Neil	3	
4			
5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

	Just before time
	At time

Time	Thread
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Queue
Neil
Kevin

Remaining	
Name	Time
Taj	2
Kevin	5
Neil	5
Akshat	5
William	5
Alina	5

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

Just before time
At time

Time	Thread
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Queue
Neil
Kevin

Remaining	
Name	Time
Taj	1
Kevin	5
Neil	5
Akshat	5
William	5
Alina	5

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

Just before time
At time

	TI 1
Time	Thread
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Queue	
Neil	
Kevin	

Remaining	
Name	Time
Taj	0
Kevin	5
Neil	5
Akshat	5
William	5
Alina	5

Arrivals		
Name	Priority	
Taj	7	
Kevin	1	
Neil	3	
Akshat	5	
William	11	
Alina	14	
	Name Taj Kevin Neil Akshat William	

Just before time
At time

T ·	Thusad
Time	Thread
0	Taj
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2	Тај
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Queue
Akshat
Neil
Kevin

Remaining	
Name	Time
Taj	0
Kevin	5
Neil	5
Akshat	5
William	5
Alina	5

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

Just before time
At time

Time	Thread
0	Тај
1	Taj
2	Taj
3	Taj
4	Taj
3 4 5	Akshat
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Queue
Neil
Kevin

Remaining	
Name	Time
Taj	0
Kevin	5
Neil	5
Akshat	4
William	5
Alina	5

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Taj
4	Taj
3 4 5 6	Akshat
6	Akshat
7	
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10	
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12	
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Queue	e
Neil	
Kevin	

Remaining	
Name	Time
Taj	0
Kevin	5
Neil	5
Akshat	3
William	5
Alina	5

Arrivals		
Name	Priority	
Taj	7	
Kevin	1	
Neil	3	
Akshat	5	
William	11	
Alina	14	
	Name Taj Kevin Neil Akshat William	

Just before time
At time

Time	Thread
0	Тај
1	Тај
2	Taj
3	Taj
2 3 4 5 6 7	Taj
5	Akshat
6	Akshat
8	
9	
10	
11	
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Queue
William
Neil
Kevin

Remaining	
Name	Time
Taj	0
Kevin	5
Neil	5
Akshat	3
William	5
Alina	5

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

Just before time
At time

Time	Thread
0	Taj
1	Taj
2	Taj
3	Taj
3 4 5	Taj
5	Akshat
6 7	Akshat
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Queue
William
Akshat
Neil
Kevin

Remaining		
Name	Time	
Taj	0	
Kevin	5	
Neil	5	
Akshat	3	
William	5	
Alina	5	

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

Just before time	
At time	

Time	Thread
0	Тај
1	Taj
2	Taj
3	Taj
2 3 4 5 6 7	Taj
5	Akshat
6	Akshat
7	William
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Queue
Akshat
Neil
Kevin

Remaining		
Name	Time	
Taj	0	
Kevin	5	
Neil	5	
Akshat	3	
William	4	
Alina	5	

Arrivals		
Name	Priority	
Taj	7	
Kevin	1	
Neil	3	
Akshat	5	
William	11	
Alina	14	
	Name Taj Kevin Neil Akshat William	

Just before time
At time

Time	Thread
0	Тај
1	Тај
2	Taj
3	Taj
4	Taj
3 4 5 6 7	Akshat
6	Akshat
7	William
8	William
9	
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Queue
Akshat
Neil
Kevin

Remaining		
Name	Time	
Taj	0	
Kevin	5	
Neil	5	
Akshat	3	
William	3	
Alina	5	

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

Just before time
At time

Time	Thread
0	Taj
1	Тај
2	Taj
3	Taj
2 3 4 5 6 7	Taj
5	Akshat
6	Akshat
7	William
8	William
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	

Queue
Alina
Akshat
Neil
Kevin

Remain	ing
Name	Time
Taj	0
Kevin	5
Neil	5
Akshat	3
William	3
Alina	5

Arrivals		
Time	Name	Priority
0	Taj	7
1		
2	Kevin	1
3	Neil	3
4		
5	Akshat	5
6		
7	William	11
8		
9	Alina	14

Just before time
At time

Time	Thread
0	Taj
1	Тај
2	Taj
3	Taj
2 3 4 5 6	Taj
5	Akshat
6	Akshat
7	William
8	William
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	

Queue
Alina
William
Akshat
Neil
Kevin

Remaining	
Name	Time
Taj	0
Kevin	5
Neil	5
Akshat	3
William	3
Alina	5

Arrivals			
Time Name Priori			
Taj	7		
Kevin	1		
Neil	3		
Akshat	5		
William	11		
Alina	14		
	Name Taj Kevin Neil Akshat William		

	Just before time
	At time

Time	Thread
0	Тај
1	Тај
2	Taj
3	Taj
4	Taj
5	Akshat
6	Akshat
7	William
8	William
9	Alina
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	

Queue
William
Akshat
Neil
Kevin

Remaining		
Name	Time	
Taj	0	
Kevin	5	
Neil	5	
Akshat	3	
William	3	
Alina	4	

Arrivals				
Name	Priority			
Taj	7			
Kevin	1			
Neil	3			
Akshat	5			
William	11			
Alina	14			
	Name Taj Kevin Neil Akshat William			

Preemptive Priority

Just before time

At time

Time	Thread	
0	Taj	
1	Taj	
2	Taj	
3	Taj	
4	Taj	
5	Akshat	
5 6 7	Akshat	
7	William	
8	William	
9	Alina	
10	Alina	
11	Alina	
12	Alina	
13	Alina	
14	William	
15	William	
16	William	
17	Akshat	
18	Akshat	
19	Akshat	
20	Neil	
21	Neil	
22	Neil	
23	Neil	
24	Neil	
25	Kevin	
26	Kevin	
27	Kevin	
28	Kevin	
29	Kevin	
30		

No more threads arrive

 \downarrow

Threads complete in order of priority



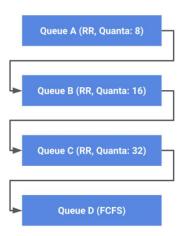
Remaining			
Name	Time		
Taj	0		
Kevin	0		
Neil	0		
Akshat	0		
William	0		
Alina	0		

Arrivals				
Time	Name	Priority		
0	Taj	7		
1				
2	Kevin	1		
3	Neil	3		
4				
5	Akshat	5		
6				
7	William	11		
8				
9	Alina	14		

You are a Bitcoin miner, and you've developed an algorithm that can run on an unsuspecting machine and mine Bitcoin. You now need to write a program that will run your mining algorithm forever. While you want your mining job to be scheduled often, you also don't want to attract too much suspicion from system users or administrators. Fortunately, you know that the machines you're targeting use a MLFQ algorithm to schedule jobs, outlined below.

1. You decide that the best strategy is to guarantee that your mining job will always be placed on Queues B and C.

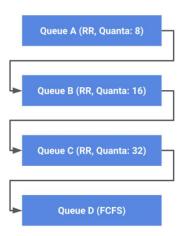
Assume that the CPU-intensive mining algorithm you've developed can be run in 10 tick intervals. Implement your mining program, and explain your design. The only functions you should use are mine (which runs for 10 ticks) and printf. Assume that your job is initially placed on Queue B.



You are a Bitcoin miner, and you've developed an algorithm that can run on an unsuspecting machine and mine Bitcoin. You now need to write a program that will run your mining algorithm forever. While you want your mining job to be scheduled often, you also don't want to attract too much suspicion from system users or administrators. Fortunately, you know that the machines you're targeting use a MLFQ algorithm to schedule jobs, outlined below.

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Assume that the CPU-intensive mining algorithm you've developed can be run in 10 tick intervals. Implement your mining program, and explain your design. The only functions you should use are mine (which runs for 10 ticks) and printf. Assume that your job is initially placed on Queue B.

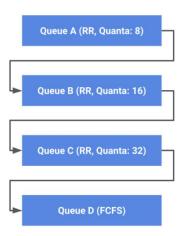


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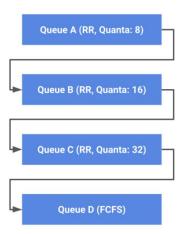
Assume that the CPU-intensive mining algorithm you've developed can be run in 10 tick intervals. Implement your mining program, and explain your design. The only functions you should use are mine (which runs for 10 ticks) and printf (which runs for 0 ticks). Assume that your job is initially placed on Queue B.

```
void mine_forever() {
   while(1) {
     for (int i = 0; i < 3; i++)
        mine();
   printf("Not a bitcoin miner!!!");
   }
}</pre>
```



You are a Bitcoin miner, and you've developed an algorithm that can run on an unsuspecting machine and mine Bitcoin. You now need to write a program that will run your mining algorithm forever. While you want your mining job to be scheduled often, you also don't want to attract too much suspicion from system users or administrators. Fortunately, you know that the machines you're targeting use a MLFQ algorithm to schedule jobs, outlined below.

2. Explain why, regardless of how you implement your mining program, your job will never be placed on Queue A twice in a row.



You are a Bitcoin miner, and you've developed an algorithm that can run on an unsuspecting machine and mine Bitcoin. You now need to write a program that will run your mining algorithm forever. While you want your mining job to be scheduled often, you also don't want to attract too much suspicion from system users or administrators. Fortunately, you know that the machines you're targeting use a MLFQ algorithm to schedule jobs, outlined below.

Explain why, regardless of how you implement your mining program, your job will never be
placed on Queue A twice in a row.
 Since the mining algorithm can only be run in 10 tick intervals, any implementation will always
exceed the Queue A quanta before the CPU can be voluntarily yielded. This will cause the job to

be placed on Queue B, since the Queue A quanta expired.

Queue B (RR, Quanta: 16)

Queue C (RR, Quanta: 32)

Queue D (FCFS)