

Discussion 4

Scheduling

02/23/24

Staff

### Announcements

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				Homework 2 Due	Homework 3 Release	
			Project 1 Due Turn in Peer Evals	Project 2 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.

#### 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 decreases response time but increases completion time

### Multi-Level Feedback Queue (MLFQ)

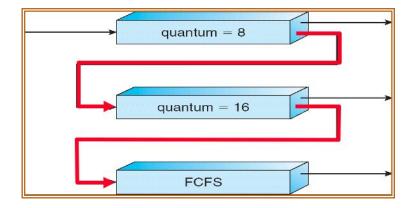
**Multi-level feedback queue (MLFQ)** uses multiple queues which each have a different priority.

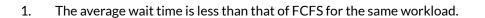
• Each queue has its own scheduling policy.

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.





2. It requires preemption to maintain uniform quanta.

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

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				

	KK (4-1)								
	Α	В	С	Α	В	С	Α	В	С
Wait Times	0	1	2	2	2	2	2	2	2
verage					5				

 $DD(\alpha-1)$ 

2. It requires preemption to maintain uniform quanta.

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

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				

	KK (4-1)								
	Α	В	С	Α	В	С	Α	В	С
Wait Times	0	1	2	2	2	2	2	2	2
Average					5				

 $DD(\alpha-1)$ 

2. It requires preemption to maintain uniform quanta.

True. Without preemption, a task would just run forever without adhering to the quantum.

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

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				

FCFC

	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				

DD /-- 11

2. It requires preemption to maintain uniform quanta.

True. Without preemption, a task would just run forever without adhering to the quantum.

3. 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.

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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

Time	Thread
0	
1	
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3 4 5 6	
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Queue					

Remaining						
Name	Tim					
Taj	5					
Kevin	5					
Neil	5					
Akshat	5					

William

Alina

3

5

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
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Queue
Taj

Remair	ing
Name	
Taj	
Kevin	
Neil	
Akshat	

William

Alina

Quantum

3

Time

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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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Queue	

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

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

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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	
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5	Akshat	5	
6			
7	William	11	
8			
9	Alina	14	

RR (q=3)

Just before time

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Queue		
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Remain	ing
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Neil	
Akshat	
William	

Alina

Time

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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
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Queue
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Quantum	0
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Remaining	
Name	Time
Taj	2
Kevin	5
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
6		
7	William	11
8		
9	Alina	14

RR (q=3)

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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
Taj	2
Kevin	5
Neil	5
Akshat	5
William	5

Alina

Quantum

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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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Neil		
Akshat		

William

Alina

Quantum

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Arrivals		
Time	Name	Priority
0	Taj	7
1		
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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Remaining		
Name	Time	
Taj	2	
Kevin	3	
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
8		
9	Alina	14

RR (q=3)

Just before time At time

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Name	Time
Taj	2
Kevin	3
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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Taj
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Neil
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Akshat

Quantum	0

Remaining		
Name	Time	
Taj	2	
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
6		
7	William	11
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9	Alina	14

RR (q=3)

Just before time
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Akshat
Kevin

Quantum	3

Remaining		
Name	Time	
Taj	2	
Kevin	2	
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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Queue
Taj
Akshat
Kevin

Remaining	
Name	Time
Taj	2
Kevin	2
Neil	4
Akshat	5
William	5

Alina

Quantum

2

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
0	Taj
1	Taj
2	Taj
3	Kevin
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6	Neil
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Queue	
Taj	
Akshat	
Kevin	
William	

		Remaining	
Queue	-	Name	Time
Тај	-	Тај	2
Akshat	-	Kevin	2
Kevin		Neil	4
William		Akshat	5

Quantum

William

Alina

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 3 4 5 6 7	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
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Queue	
Taj	
Akshat	
Kevin	
William	
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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
0	Taj
1	Taj
	Taj
3	Kevin
3 4	Kevin
5	Kevin
5 6 7	Neil
7	Neil
8	Neil
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12	
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Queue
Taj
Akshat
Kevin
William

Queue
Taj
Akshat
Kevin
William

Quantum	0

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

Quantum	0

Remaining		
Name	Time	
Taj	2	
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
2 3 4 5 6 7 8	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
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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	

<b>-</b> ·	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
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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
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Queue
Akshat
Kevin
William
Alina
Neil

Remaining	
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
2	Taj
3 4 5	Kevin
4	Kevin
5	Kevin
6	Neil
7	Neil
8	Neil
9	Тај
10	Тај
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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
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Queue
Kevin
William
Alina
Neil

Remai	ning
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
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Queue
Kevin
William
Alina
Neil

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
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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	
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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	
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Queue	
William	
Alina	
Neil	
Akshat	

Remaii	
(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
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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

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Time 0

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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
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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
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Queue
Alina
Neil
Akshat

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Name		
Taj		
Kevin		
Neil		
Akshat		

William

Alina

Time 0 0

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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
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
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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

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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	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
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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	
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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
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Queue
Neil
Akshat
William

Remaining		
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	
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Queue
Neil
Akshat
William

	Remain	ing
	Name	
	Тај	
	Kevin	
	Neil	
	Akshat	
	William	

Quantum

Alina

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Time 0

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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	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	
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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
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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

Remain	ing
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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Remaining		
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	
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Queue
William
Alina

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

Alina

2

2

Quantum

Arrivals			
Time	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

т:	Thread
Time	·
0	Taj
1	Taj
2	Тај
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	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	

Remaining	
Name	Time
Taj	0
Kevin	0
Neil	0
Akshat	0

William

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
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
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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
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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			

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
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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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Remaining		
Name	Tim	
Taj	0	
Kevin	0	
Neil	0	

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			
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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		
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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
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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

#### **Preemptive Priority**

Just before time
At time

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Queue	
Kevin	

Remaining			
Name	Time		
Taj	3		
Kevin	5		
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		

	Just before time
	At time

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	Ke	vin		

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	
8			
9	Alina	14	

	Just before time
	At time

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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	
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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	

Just before time
At time

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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
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5	Akshat	5
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7	William	11
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9	Alina	14

Just before time	
At time	

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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

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Time	Thread
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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
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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	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
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9	Alina	14

Just before time	
At time	

Time	Thread
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1	Taj
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4	Taj
3 4 5 6	Akshat
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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
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1	Тај
2	Taj
3	Taj
2 3 4 5 6 7	Taj
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6	Akshat
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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
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9	Alina	14

Just before time
At time

Time	Thread
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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
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5	Akshat	5
6		
7	William	11
8		
9	Alina	14

Just before time
At time

Time	Thread
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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	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	

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

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	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		
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	

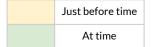
Time	Thread	
0	Taj	
1	Taj	
2	Taj	
3	Taj	
4	Taj	
5	Akshat	
6	Akshat	
7	William	
8	William	
9	Alina	
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

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**



	<del>-</del>	
Time	Thread	
0	Taj	
1	Taj	
2	Taj	
3	Taj	
4	Taj	
5 6	Akshat	
	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



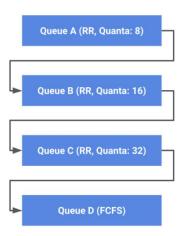
Remaining		
Name	Time	
Taj	0	
Kevin	0	
Neil	0	
Akshat	0	
William	0	
Alina	0	

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.

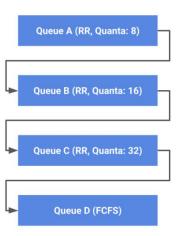
Assume that the CPU-intensive mining algorithm you've developed can be run in 10 tick intervals. Implement your mining program, and explain your design. The only functions you should use are mine (which runs for 10 ticks) and printf. Assume that your job is initially placed on Queue B.



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.

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.

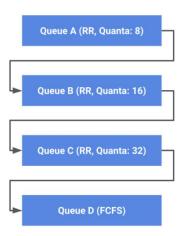


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1. You decide that the best strategy is to guarantee that your mining job will always be placed on Queues B and C.

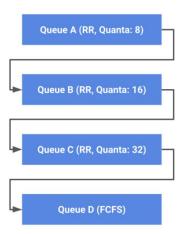
Assume that the CPU-intensive mining algorithm you've developed can be run in 10 tick intervals. Implement your mining program, and explain your design. The only functions you should use are mine (which runs for 10 ticks) and printf. Assume that your job is initially placed on Queue B.

```
void mine_forever() {
   while(1) {
     for (int i = 0; i < 4; 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.

