MLFQ ⇒ Multi level feedback queue

(1)

Job list

J0 ⇒	starttime 0 ,	runtime 8 &	iofreq 7
J1 ⇒	0	12	3
J2 ⇒	0	51	4

Queues = 3

allotment = 1 for each queue

quantum length = 10 for each queue

Q2 J0 for 7 , I/O for 5

J1 for 3 ,

J2 for 4 ,

Q1 J

Q0

$RT_{J0} = 0$

$RT_{J1} = 7$

$TT_{J0} =$

$RT'_{J2} = 10$

$q = 2$,

	start time	runtime	io freq
J0 ⇒	0	6	2
J1 ⇒	0	8	4

Q2 J0 0
1
I/O 2
J1 2
3
Q1 J1 4
5
J0 7
J0 8 — I/O J1

(not sure we assume)

Q2 wait 6
wait 9
wait 10
wait 11
J1 12
J1 13
Q3 J1 14

} I/O J0

X I/O multiple not single like CPU

J1 15
wait 16
J0 17 I/O J1
J0 18
Jwait 19
20
21

Attempt 2

Q2 J0 0
1
I/Ostart 2
J1 2
J1 3
Q1 J1 4
J1 5
J1 I/Ostart 6
IDLE 6
J0 7
J0 8
J0 I/Ostart 9
IDLE 9

	IDLE	10
Q2	J1	11
	J1	12
	J1	13
	J1	14
	J1 finished	15
	J0	15
	J0	16
	J0 finished	17

$RT_{J0} = 0$ $\quad TT_{J0} = 17$

$RT_{J1} = 2$ $\quad TT_{J1} = 15$

WithoutI/O

J0 = 0, 6, 0

J1 = 0, 8, 0

Q2	J0	0
	J0	1
	J1	2
	J1	3
Q1	J0	4
	J0	5

	J1	6
	J1	7
Q2	J0	8
	J0	9
	J1	10
	J1	11
	J1	12
	J1	13

with different quantum for each level 1, 2, 3

J0 = 0, 6, 0

J1 = 0, 8, 0

Q2	J0	0
	J1	1
Q1	J0	2
	J0	3
	J1	4
	J1	5
Q0	J0	6
	J0	7
	J0	8

J1 9
J1 10
J1 11
J1 12
J1 13

② Example 1
Single long running job
-q 2 -l 0, 10, 0 -c

```
Job List:
  Job  0: startTime   0 - runTime  10 - ioFreq   0


Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 9 (of 10) ]
[ time 1 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 8 (of 10) ]
[ time 2 ] Run JOB 0 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 7 (of 10) ]
[ time 3 ] Run JOB 0 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 6 (of 10) ]
[ time 4 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 5 (of 10) ]
[ time 5 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 4 (of 10) ]
[ time 6 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 3 (of 10) ]
[ time 7 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 2 (of 10) ]
[ time 8 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 1 (of 10) ]
[ time 9 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 0 (of 10) ]
[ time 10 ] FINISHED JOB 0

Final statistics:
  Job  0: startTime   0 - response   0 - turnaround  10
```

· Example 2
Along came a short job
-q 2 -l 0,16,0:10,4,0 -c

```
Job List:
  Job  0: startTime   0 - runTime  16 - ioFreq   0
  Job  1: startTime  10 - runTime   4 - ioFreq   0


Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 15 (of 16) ]
[ time 1 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 14 (of 16) ]
[ time 2 ] Run JOB 0 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 13 (of 16) ]
[ time 3 ] Run JOB 0 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 12 (of 16) ]
[ time 4 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 11 (of 16) ]
[ time 5 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 10 (of 16) ]
[ time 6 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 9 (of 16) ]
[ time 7 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 8 (of 16) ]
[ time 8 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 7 (of 16) ]
[ time 9 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 6 (of 16) ]
[ time 10 ] JOB BEGINS by JOB 1
[ time 10 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 3 (of 4) ]
[ time 11 ] Run JOB 1 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 2 (of 4) ]
[ time 12 ] Run JOB 1 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 1 (of 4) ]
[ time 13 ] Run JOB 1 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 0 (of 4) ]
[ time 14 ] FINISHED JOB 1
[ time 14 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 5 (of 16) ]
[ time 15 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 4 (of 16) ]
[ time 16 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 3 (of 16) ]
[ time 17 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 2 (of 16) ]
[ time 18 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 1 (of 16) ]
[ time 19 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 0 (of 16) ]
[ time 20 ] FINISHED JOB 0
```

Example 3 Mixed I/O-intensive and CPU intensive workload

-q 2 -l 0,15,0:5,5,1 -i 2 -S -c

-S ⇒ reset and stay at same level on issue of I/O

quantum length

```
Job List:
  Job  0: startTime   0 - runTime  15 - ioFreq   0
  Job  1: startTime   5 - runTime   5 - ioFreq   1


Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 14 (of 15) ]
[ time 1 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 13 (of 15) ]
[ time 2 ] Run JOB 0 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 12 (of 15) ]
[ time 3 ] Run JOB 0 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 11 (of 15) ]
[ time 4 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 10 (of 15) ]
[ time 5 ] JOB BEGINS by JOB 1
[ time 5 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 4 (of 5) ]
[ time 6 ] IO_START by JOB 1
IO DONE
[ time 6 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 9 (of 15) ]
[ time 7 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 8 (of 15) ]
[ time 8 ] IO_DONE by JOB 1
[ time 8 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 3 (of 5) ]
[ time 9 ] IO_START by JOB 1
IO DONE
[ time 9 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 7 (of 15) ]
[ time 10 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 6 (of 15) ]
[ time 11 ] IO_DONE by JOB 1
[ time 11 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 2 (of 5) ]
[ time 12 ] IO_START by JOB 1
IO DONE
[ time 12 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 5 (of 15) ]
[ time 13 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 4 (of 15) ]
[ time 14 ] IO_DONE by JOB 1
[ time 14 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 1 (of 5) ]
[ time 15 ] IO_START by JOB 1
IO DONE
[ time 15 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 3 (of 15) ]
[ time 16 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 2 (of 15) ]
[ time 17 ] IO_DONE by JOB 1
[ time 17 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 0 (of 5) ]
[ time 18 ] FINISHED JOB 1
[ time 18 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 1 (of 15) ]
[ time 19 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 0 (of 15) ]
[ time 20 ] FINISHED JOB 0
```

Example 4 Priority boost

-q 2 -l 0,16,0:10,5,1:10,5,1 -S -i 1 -c

J1 J2

Long CPU intensive job gets starved by J1, J2 which stay on level q2 (highest) due to short CPU work plus -S ⇒ reset quantum on I/O

shorter jobs arriving later

Without priority boost

```
Job List:
  Job  0: startTime   0 - runTime  16 - ioFreq   0
  Job  1: startTime  10 - runTime   5 - ioFreq   1
  Job  2: startTime  10 - runTime   5 - ioFreq   1

Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 15 (of 16) ]
[ time 1 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 14 (of 16) ]
[ time 2 ] Run JOB 0 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 13 (of 16) ]
[ time 3 ] Run JOB 0 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 12 (of 16) ]
[ time 4 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 11 (of 16) ]
[ time 5 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 10 (of 16) ]
[ time 6 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 9 (of 16) ]
[ time 7 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 8 (of 16) ]
[ time 8 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 7 (of 16) ]
[ time 9 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 6 (of 16) ]
[ time 10 ] JOB BEGINS by JOB 1
[ time 10 ] JOB BEGINS by JOB 2
[ time 10 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 4 (of 5) ]
[ time 11 ] IO_START by JOB 1
IO DONE
[ time 11 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 4 (of 5) ]
[ time 12 ] IO_START by JOB 2
IO DONE
[ time 12 ] IO_DONE by JOB 1
[ time 12 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 3 (of 5) ]
[ time 13 ] IO_START by JOB 1
IO DONE
[ time 13 ] IO_DONE by JOB 2
[ time 13 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 3 (of 5) ]
[ time 14 ] IO_START by JOB 2
IO DONE
[ time 14 ] IO_DONE by JOB 1
[ time 14 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 2 (of 5) ]
[ time 15 ] IO_START by JOB 1
IO DONE
[ time 15 ] IO_DONE by JOB 2
[ time 15 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 2 (of 5) ]
[ time 16 ] IO_START by JOB 2
IO DONE
```

```
[ time 16 ] IO_DONE by JOB 1
[ time 16 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 1 (of 5) ]
[ time 17 ] IO_START by JOB 1
IO DONE
[ time 17 ] IO_DONE by JOB 2
[ time 17 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 1 (of 5) ]
[ time 18 ] IO_START by JOB 2
IO DONE
[ time 18 ] IO_DONE by JOB 1
[ time 18 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 0 (of 5) ]
[ time 19 ] FINISHED JOB 1
[ time 19 ] IO_DONE by JOB 2
[ time 19 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 0 (of 5) ]
[ time 20 ] FINISHED JOB 2
[ time 20 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 5 (of 16) ]
[ time 21 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 4 (of 16) ]
[ time 22 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 3 (of 16) ]
[ time 23 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 2 (of 16) ]
[ time 24 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 1 (of 16) ]
[ time 25 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 0 (of 16) ]
[ time 26 ] FINISHED JOB 0

Final statistics:
  Job  0: startTime   0 - response   0 - turnaround  26
  Job  1: startTime  10 - response   0 - turnaround   9
  Job  2: startTime  10 - response   1 - turnaround  10

  Avg  2: startTime n/a - response 0.33 - turnaround 15.00
```

with priority boost (every 5)

```
  Job  0: startTime   0 - runTime  16 - ioFreq   0
  Job  1: startTime  10 - runTime   5 - ioFreq   1
  Job  2: startTime  10 - runTime   5 - ioFreq   1

Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 15 (of 16) ]
[ time 1 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 14 (of 16) ]
[ time 2 ] Run JOB 0 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 13 (of 16) ]
[ time 3 ] Run JOB 0 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 12 (of 16) ]
[ time 4 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 11 (of 16) ]
[ time 5 ] BOOST ( every 5 )
[ time 5 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 10 (of 16) ]
[ time 6 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 9 (of 16) ]
[ time 7 ] Run JOB 0 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 8 (of 16) ]
[ time 8 ] Run JOB 0 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 7 (of 16) ]
[ time 9 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 6 (of 16) ]
[ time 10 ] BOOST ( every 5 )
[ time 10 ] JOB BEGINS by JOB 1
[ time 10 ] JOB BEGINS by JOB 2
[ time 10 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 5 (of 16) ]
[ time 11 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 4 (of 16) ]
[ time 12 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 4 (of 5) ]
[ time 13 ] IO_START by JOB 1
IO DONE
[ time 13 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 4 (of 5) ]
[ time 14 ] IO_START by JOB 2
IO DONE
[ time 14 ] IO_DONE by JOB 1
[ time 14 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 3 (of 5) ]
[ time 15 ] IO_START by JOB 1
IO DONE
[ time 15 ] BOOST ( every 5 )
[ time 15 ] IO_DONE by JOB 2
[ time 15 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 3 (of 16) ]
[ time 16 ] IO_DONE by JOB 1
[ time 16 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 2 (of 16) ]
[ time 17 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 3 (of 5) ]
[ time 18 ] IO_START by JOB 2
IO DONE
[ time 18 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 2 (of 5) ]
[ time 19 ] IO_START by JOB 1
IO DONE
[ time 19 ] IO_DONE by JOB 2
[ time 19 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 2 (of 5) ]
[ time 20 ] IO_START by JOB 2
IO DONE
[ time 20 ] BOOST ( every 5 )
[ time 20 ] IO_DONE by JOB 1
[ time 20 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 1 (of 16) ]
[ time 21 ] IO_DONE by JOB 2
[ time 21 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 0 (of 16) ]
[ time 22 ] FINISHED JOB 0
[ time 22 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 1 (of 5) ]
[ time 23 ] IO_START by JOB 1
IO DONE
[ time 23 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 1 (of 5) ]
[ time 24 ] IO_START by JOB 2
IO DONE
[ time 24 ] IO_DONE by JOB 1
[ time 24 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 0 (of 5) ]
[ time 25 ] FINISHED JOB 1
[ time 25 ] BOOST ( every 5 )
[ time 25 ] IO_DONE by JOB 2
[ time 25 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 0 (of 5) ]
[ time 26 ] FINISHED JOB 2

Final statistics:
  Job  0: startTime   0 - response   0 - turnaround  22
  Job  1: startTime  10 - response   2 - turnaround  15
  Job  2: startTime  10 - response   3 - turnaround  16

  Avg  2: startTime n/a - response 1.67 - turnaround 17.67
```

Gaming tolerance

- With reset on every level

-q 2 -l 0,25,0:10,10,1 -i 1 -S -c

```
Job List:
  Job  0: startTime   0 - runTime  25 - ioFreq   0
  Job  1: startTime  10 - runTime  10 - ioFreq   1


Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 24 (of 25) ]
[ time 1 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 23 (of 25) ]
[ time 2 ] Run JOB 0 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 22 (of 25) ]
[ time 3 ] Run JOB 0 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 21 (of 25) ]
[ time 4 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 20 (of 25) ]
[ time 5 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 19 (of 25) ]
[ time 6 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 18 (of 25) ]
[ time 7 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 17 (of 25) ]
[ time 8 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 16 (of 25) ]
[ time 9 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 15 (of 25) ]
[ time 10 ] JOB BEGINS by JOB 1
[ time 10 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 9 (of 10) ]
[ time 11 ] IO_START by JOB 1
IO DONE
[ time 11 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 14 (of 25) ]
[ time 12 ] IO_DONE by JOB 1
[ time 12 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 8 (of 10) ]
[ time 13 ] IO_START by JOB 1
IO DONE
[ time 13 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 13 (of 25) ]
[ time 14 ] IO_DONE by JOB 1
[ time 14 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 7 (of 10) ]
[ time 15 ] IO_START by JOB 1
IO DONE
[ time 15 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 12 (of 25) ]
[ time 16 ] IO_DONE by JOB 1
[ time 16 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 6 (of 10) ]
[ time 17 ] IO_START by JOB 1
IO DONE
[ time 17 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 11 (of 25) ]
[ time 18 ] IO_DONE by JOB 1
[ time 18 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 5 (of 10) ]
[ time 19 ] IO_START by JOB 1
IO DONE
IO DONE
[ time 19 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 10 (of 25) ]
[ time 20 ] IO_DONE by JOB 1
[ time 20 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 4 (of 10) ]
[ time 21 ] IO_START by JOB 1
IO DONE
[ time 21 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 9 (of 25) ]
[ time 22 ] IO_DONE by JOB 1
[ time 22 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 3 (of 10) ]
[ time 23 ] IO_START by JOB 1
IO DONE
[ time 23 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 8 (of 25) ]
[ time 24 ] IO_DONE by JOB 1
[ time 24 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 2 (of 10) ]
[ time 25 ] IO_START by JOB 1
IO DONE
[ time 25 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 7 (of 25) ]
[ time 26 ] IO_DONE by JOB 1
[ time 26 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 1 (of 10) ]
[ time 27 ] IO_START by JOB 1
IO DONE
[ time 27 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 6 (of 25) ]
[ time 28 ] IO_DONE by JOB 1
[ time 28 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 0 (of 10) ]
[ time 29 ] FINISHED JOB 1
[ time 29 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 5 (of 25) ]
[ time 30 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 4 (of 25) ]
[ time 31 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 3 (of 25) ]
[ time 32 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 2 (of 25) ]
[ time 33 ] Run JOB 0 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 1 (of 25) ]
[ time 34 ] Run JOB 0 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 0 (of 25) ]
[ time 35 ] FINISHED JOB 0

Final statistics:
  Job  0: startTime   0 - response   0 - turnaround  35
  Job  1: startTime  10 - response   0 - turnaround  19

  Avg  1: startTime n/a - response 0.00 - turnaround 27.00
```

Lower priority, longer quanta

-l 0,140,0:0,140,0 -Q 10,20,40
-a 2 -c

-q 1 -A ⇒ how many time-slices per level a process can be run
Q 2 = 10 * 2 = 20

(3) Making it behave as a RR scheduler

-n 1 q=50 -j 2
single queue, with a time slice then jobs run in round robin fashion

(4) Game the scheduler, by exploiting 4a, 4b rules

-q 2 -l 0,10,1:5,10,3 -i 1 -S -c

```
master  1● python3 mlfq.py -q 2 -l 0,10,1:5,10,3 -i 1 -S -c
Here is the list of inputs:
OPTIONS jobs 2
OPTIONS queues 3
OPTIONS allotments for queue  2 is   1
OPTIONS quantum length for queue  2 is   2
OPTIONS allotments for queue  1 is   1
OPTIONS quantum length for queue  1 is   2
OPTIONS allotments for queue  0 is   1
OPTIONS quantum length for queue  0 is   2
OPTIONS boost 0
OPTIONS ioTime 1
OPTIONS stayAfterIO True
OPTIONS iobump False


For each job, three defining characteristics are given:
  startTime : at what time does the job enter the system
  runTime   : the total CPU time needed by the job to finish
  ioFreq    : every ioFreq time units, the job issues an I/O
              (the I/O takes ioTime units to complete)

Job List:
  Job  0: startTime   0 - runTime  10 - ioFreq   1
  Job  1: startTime   5 - runTime  10 - ioFreq   3


Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 9 (of 10) ]
[ time 1 ] IO_START by JOB 0
IO DONE
[ time 1 ] IDLE
[ time 2 ] IO_DONE by JOB 0
[ time 2 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 8 (of 10) ]
[ time 3 ] IO_START by JOB 0
IO DONE
[ time 3 ] IDLE
[ time 4 ] IO_DONE by JOB 0
[ time 4 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 7 (of 10) ]
[ time 5 ] IO_START by JOB 0
IO DONE
```

```
IO DONE
[ time 5 ] JOB BEGINS by JOB 1
[ time 5 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 9 (of 10) ]
[ time 6 ] IO_DONE by JOB 0
[ time 6 ] Run JOB 1 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 8 (of 10) ]
[ time 7 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 6 (of 10) ]
[ time 8 ] IO_START by JOB 0
IO DONE
[ time 8 ] Run JOB 1 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 7 (of 10) ]
[ time 9 ] IO_START by JOB 1
IO DONE
[ time 9 ] IO_DONE by JOB 0
[ time 9 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 5 (of 10) ]
[ time 10 ] IO_START by JOB 0
IO DONE
[ time 10 ] IO_DONE by JOB 1
[ time 10 ] Run JOB 1 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 6 (of 10) ]
[ time 11 ] IO_DONE by JOB 0
[ time 11 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 4 (of 10) ]
[ time 12 ] IO_START by JOB 0
IO DONE
[ time 12 ] Run JOB 1 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 5 (of 10) ]
[ time 13 ] IO_DONE by JOB 0
[ time 13 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 3 (of 10) ]
[ time 14 ] IO_START by JOB 0
IO DONE
[ time 14 ] Run JOB 1 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 4 (of 10) ]
[ time 15 ] IO_START by JOB 1
IO DONE
[ time 15 ] IO_DONE by JOB 0
[ time 15 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 2 (of 10) ]
[ time 16 ] IO_START by JOB 0
IO DONE
[ time 16 ] IO_DONE by JOB 1
[ time 16 ] Run JOB 1 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 3 (of 10) ]
[ time 17 ] IO_DONE by JOB 0
[ time 17 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 1 (of 10) ]
[ time 18 ] IO_START by JOB 0
IO DONE
[ time 18 ] Run JOB 1 at PRIORITY 0 [ TICKS 0 ALLOT 1 TIME 2 (of 10) ]
[ time 19 ] IO_DONE by JOB 0
[ time 19 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 0 (of 10) ]
[ time 20 ] FINISHED JOB 0
```

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[ time 20 ] Run JOB 1 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 1 (of 10) ]
[ time 21 ] IO_START by JOB 1
IO DONE
[ time 21 ] IDLE
[ time 22 ] IO_DONE by JOB 1
[ time 22 ] Run JOB 1 at PRIORITY 0 [ TICKS 1 ALLOT 1 TIME 0 (of 10) ]
[ time 23 ] FINISHED JOB 1

Final statistics:
  Job  0: startTime   0 - response   0 - turnaround  20
  Job  1: startTime   5 - response   0 - turnaround  18

  Avg  1: startTime n/a - response 0.00 - turnaround 19.00
```

(5) q = 10ms in highest queue

single-long-running job gets at least 5% of the CPU

Boost

-q 10 -l 0,50 50:1,18,9:2,18,9:3,18,9 -i 1 -c -B 30

Not sure of percent usage but boosts all jobs

```
er  1● python3 mlfq.py -q 10 -l 0,50,50:1,18,9:2,18,9:3,18,9 -i 1 -c -B
Here is the list of inputs:
OPTIONS jobs 4
OPTIONS queues 3
OPTIONS allotments for queue  2 is   1
OPTIONS quantum length for queue  2 is  10
OPTIONS allotments for queue  1 is   1
OPTIONS quantum length for queue  1 is  10
OPTIONS allotments for queue  0 is   1
OPTIONS quantum length for queue  0 is  10
OPTIONS boost 30
OPTIONS ioTime 1
OPTIONS stayAfterIO False
OPTIONS iobump False


For each job, three defining characteristics are given:
  startTime : at what time does the job enter the system
  runTime   : the total CPU time needed by the job to finish
  ioFreq    : every ioFreq time units, the job issues an I/O
              (the I/O takes ioTime units to complete)

Job List:
  Job  0: startTime   0 - runTime  50 - ioFreq  50
  Job  1: startTime   1 - runTime  18 - ioFreq   9
  Job  2: startTime   2 - runTime  18 - ioFreq   9
  Job  3: startTime   3 - runTime  18 - ioFreq   9


Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] Run JOB 0 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 49 (of 50) ]
[ time 1 ] JOB BEGINS by JOB 1
[ time 1 ] Run JOB 0 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 48 (of 50) ]
[ time 2 ] JOB BEGINS by JOB 2
[ time 2 ] Run JOB 0 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 47 (of 50) ]
[ time 3 ] JOB BEGINS by JOB 3
[ time 3 ] Run JOB 0 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 46 (of 50) ]
[ time 4 ] Run JOB 0 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 45 (of 50) ]
[ time 5 ] Run JOB 0 at PRIORITY 2 [ TICKS 4 ALLOT 1 TIME 44 (of 50) ]
[ time 6 ] Run JOB 0 at PRIORITY 2 [ TICKS 3 ALLOT 1 TIME 43 (of 50) ]
[ time 7 ] Run JOB 0 at PRIORITY 2 [ TICKS 2 ALLOT 1 TIME 42 (of 50) ]
[ time 8 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 41 (of 50) ]
[ time 9 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 40 (of 50) ]
[ time 10 ] Run JOB 1 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 17 (of 18) ]
[ time 11 ] Run JOB 1 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 16 (of 18) ]
[ time 12 ] Run JOB 1 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 15 (of 18) ]
[ time 13 ] Run JOB 1 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 14 (of 18) ]
[ time 14 ] Run JOB 1 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 13 (of 18) ]
[ time 15 ] Run JOB 1 at PRIORITY 2 [ TICKS 4 ALLOT 1 TIME 12 (of 18) ]
[ time 16 ] Run JOB 1 at PRIORITY 2 [ TICKS 3 ALLOT 1 TIME 11 (of 18) ]
[ time 17 ] Run JOB 1 at PRIORITY 2 [ TICKS 2 ALLOT 1 TIME 10 (of 18) ]
[ time 18 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 9 (of 18) ]
[ time 19 ] IO_START by JOB 1
IO DONE
[ time 19 ] Run JOB 2 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 17 (of 18) ]
[ time 20 ] IO_DONE by JOB 1
[ time 20 ] Run JOB 2 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 16 (of 18) ]
[ time 21 ] Run JOB 2 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 15 (of 18) ]
[ time 22 ] Run JOB 2 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 14 (of 18) ]
[ time 23 ] Run JOB 2 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 13 (of 18) ]
[ time 24 ] Run JOB 2 at PRIORITY 2 [ TICKS 4 ALLOT 1 TIME 12 (of 18) ]
[ time 25 ] Run JOB 2 at PRIORITY 2 [ TICKS 3 ALLOT 1 TIME 11 (of 18) ]
[ time 26 ] Run JOB 2 at PRIORITY 2 [ TICKS 2 ALLOT 1 TIME 10 (of 18) ]
[ time 27 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 9 (of 18) ]
[ time 28 ] IO_START by JOB 2
IO DONE
[ time 28 ] Run JOB 3 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 17 (of 18) ]
[ time 29 ] IO_DONE by JOB 2
[ time 29 ] Run JOB 3 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 16 (of 18) ]
[ time 30 ] BOOST ( every 30 )
[ time 30 ] Run JOB 3 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 15 (of 18) ]
[ time 31 ] Run JOB 3 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 14 (of 18) ]
[ time 32 ] Run JOB 3 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 13 (of 18) ]
[ time 33 ] Run JOB 3 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 12 (of 18) ]
[ time 34 ] Run JOB 3 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 11 (of 18) ]
[ time 35 ] Run JOB 3 at PRIORITY 2 [ TICKS 4 ALLOT 1 TIME 10 (of 18) ]
[ time 36 ] Run JOB 3 at PRIORITY 2 [ TICKS 3 ALLOT 1 TIME 9 (of 18) ]
[ time 37 ] IO_START by JOB 3
IO DONE
[ time 37 ] Run JOB 1 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 8 (of 18) ]
[ time 38 ] IO_DONE by JOB 3
[ time 38 ] Run JOB 1 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 7 (of 18) ]
[ time 39 ] Run JOB 1 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 6 (of 18) ]
[ time 40 ] Run JOB 1 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 5 (of 18) ]
```

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[ time 41 ] Run JOB 1 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 4 (of 18) ]
[ time 42 ] Run JOB 1 at PRIORITY 2 [ TICKS 4 ALLOT 1 TIME 3 (of 18) ]
[ time 43 ] Run JOB 1 at PRIORITY 2 [ TICKS 3 ALLOT 1 TIME 2 (of 18) ]
[ time 44 ] Run JOB 1 at PRIORITY 2 [ TICKS 2 ALLOT 1 TIME 1 (of 18) ]
[ time 45 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 0 (of 18) ]
[ time 46 ] FINISHED JOB 1
[ time 46 ] Run JOB 2 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 8 (of 18) ]
[ time 47 ] Run JOB 2 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 7 (of 18) ]
[ time 48 ] Run JOB 2 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 6 (of 18) ]
[ time 49 ] Run JOB 2 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 5 (of 18) ]
[ time 50 ] Run JOB 2 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 4 (of 18) ]
[ time 51 ] Run JOB 2 at PRIORITY 2 [ TICKS 4 ALLOT 1 TIME 3 (of 18) ]
[ time 52 ] Run JOB 2 at PRIORITY 2 [ TICKS 3 ALLOT 1 TIME 2 (of 18) ]
[ time 53 ] Run JOB 2 at PRIORITY 2 [ TICKS 2 ALLOT 1 TIME 1 (of 18) ]
[ time 54 ] Run JOB 2 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 0 (of 18) ]
[ time 55 ] FINISHED JOB 2
[ time 55 ] Run JOB 0 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 39 (of 50) ]
[ time 56 ] Run JOB 0 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 38 (of 50) ]
[ time 57 ] Run JOB 0 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 37 (of 50) ]
[ time 58 ] Run JOB 0 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 36 (of 50) ]
[ time 59 ] Run JOB 0 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 35 (of 50) ]
[ time 60 ] BOOST ( every 30 )
[ time 60 ] Run JOB 0 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 34 (of 50) ]
[ time 61 ] Run JOB 0 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 33 (of 50) ]
[ time 62 ] Run JOB 0 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 32 (of 50) ]
[ time 63 ] Run JOB 0 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 31 (of 50) ]
[ time 64 ] Run JOB 0 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 30 (of 50) ]
[ time 65 ] Run JOB 0 at PRIORITY 2 [ TICKS 4 ALLOT 1 TIME 29 (of 50) ]
[ time 66 ] Run JOB 0 at PRIORITY 2 [ TICKS 3 ALLOT 1 TIME 28 (of 50) ]
[ time 67 ] Run JOB 0 at PRIORITY 2 [ TICKS 2 ALLOT 1 TIME 27 (of 50) ]
[ time 68 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 26 (of 50) ]
[ time 69 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 25 (of 50) ]
[ time 70 ] Run JOB 3 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 8 (of 18) ]
[ time 71 ] Run JOB 3 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 7 (of 18) ]
[ time 72 ] Run JOB 3 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 6 (of 18) ]
[ time 73 ] Run JOB 3 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 5 (of 18) ]
[ time 74 ] Run JOB 3 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 4 (of 18) ]
[ time 75 ] Run JOB 3 at PRIORITY 2 [ TICKS 4 ALLOT 1 TIME 3 (of 18) ]
[ time 76 ] Run JOB 3 at PRIORITY 2 [ TICKS 3 ALLOT 1 TIME 2 (of 18) ]
[ time 77 ] Run JOB 3 at PRIORITY 2 [ TICKS 2 ALLOT 1 TIME 1 (of 18) ]
[ time 78 ] Run JOB 3 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 0 (of 18) ]
[ time 79 ] FINISHED JOB 3
[ time 79 ] Run JOB 0 at PRIORITY 1 [ TICKS 9 ALLOT 1 TIME 24 (of 50) ]
```

```
[ time 79 ] FINISHED JOB 3
[ time 79 ] Run JOB 0 at PRIORITY 1 [ TICKS 9 ALLOT 1 TIME 24 (of 50) ]
[ time 80 ] Run JOB 0 at PRIORITY 1 [ TICKS 8 ALLOT 1 TIME 23 (of 50) ]
[ time 81 ] Run JOB 0 at PRIORITY 1 [ TICKS 7 ALLOT 1 TIME 22 (of 50) ]
[ time 82 ] Run JOB 0 at PRIORITY 1 [ TICKS 6 ALLOT 1 TIME 21 (of 50) ]
[ time 83 ] Run JOB 0 at PRIORITY 1 [ TICKS 5 ALLOT 1 TIME 20 (of 50) ]
[ time 84 ] Run JOB 0 at PRIORITY 1 [ TICKS 4 ALLOT 1 TIME 19 (of 50) ]
[ time 85 ] Run JOB 0 at PRIORITY 1 [ TICKS 3 ALLOT 1 TIME 18 (of 50) ]
[ time 86 ] Run JOB 0 at PRIORITY 1 [ TICKS 2 ALLOT 1 TIME 17 (of 50) ]
[ time 87 ] Run JOB 0 at PRIORITY 1 [ TICKS 1 ALLOT 1 TIME 16 (of 50) ]
[ time 88 ] Run JOB 0 at PRIORITY 1 [ TICKS 0 ALLOT 1 TIME 15 (of 50) ]
[ time 89 ] Run JOB 0 at PRIORITY 0 [ TICKS 9 ALLOT 1 TIME 14 (of 50) ]
[ time 90 ] BOOST ( every 30 )
[ time 90 ] Run JOB 0 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 13 (of 50) ]
[ time 91 ] Run JOB 0 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 12 (of 50) ]
[ time 92 ] Run JOB 0 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 11 (of 50) ]
[ time 93 ] Run JOB 0 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 10 (of 50) ]
[ time 94 ] Run JOB 0 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 9 (of 50) ]
[ time 95 ] Run JOB 0 at PRIORITY 2 [ TICKS 4 ALLOT 1 TIME 8 (of 50) ]
[ time 96 ] Run JOB 0 at PRIORITY 2 [ TICKS 3 ALLOT 1 TIME 7 (of 50) ]
[ time 97 ] Run JOB 0 at PRIORITY 2 [ TICKS 2 ALLOT 1 TIME 6 (of 50) ]
[ time 98 ] Run JOB 0 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 5 (of 50) ]
[ time 99 ] Run JOB 0 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 4 (of 50) ]
[ time 100 ] Run JOB 0 at PRIORITY 1 [ TICKS 9 ALLOT 1 TIME 3 (of 50) ]
[ time 101 ] Run JOB 0 at PRIORITY 1 [ TICKS 8 ALLOT 1 TIME 2 (of 50) ]
[ time 102 ] Run JOB 0 at PRIORITY 1 [ TICKS 7 ALLOT 1 TIME 1 (of 50) ]
[ time 103 ] Run JOB 0 at PRIORITY 1 [ TICKS 6 ALLOT 1 TIME 0 (of 50) ]
[ time 104 ] FINISHED JOB 0

Final statistics:
  Job  0: startTime   0 - response   0 - turnaround 104
  Job  1: startTime   1 - response   9 - turnaround  45
  Job  2: startTime   2 - response  17 - turnaround  53
  Job  3: startTime   3 - response  25 - turnaround  76

  Avg  3: startTime n/a - response 12.75 - turnaround 69.50
```

(6) Flag -I ⇒ moves the jobs with I/O finished to front of the queue

Without -I ⇒ Job 1 continues to use CPU

```
Job List:
  Job  0: startTime   0 - runTime  50 - ioFreq   1
  Job  1: startTime   1 - runTime  50 - ioFreq  10


Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] Run JOB 0 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 49 (of 50) ]
[ time 1 ] IO_START by JOB 0
IO DONE
[ time 1 ] JOB BEGINS by JOB 1
[ time 1 ] Run JOB 1 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 49 (of 50) ]
[ time 2 ] IO_DONE by JOB 0
[ time 2 ] Run JOB 1 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 48 (of 50) ]
[ time 3 ] Run JOB 1 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 47 (of 50) ]
[ time 4 ] Run JOB 1 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 46 (of 50) ]
[ time 5 ] Run JOB 1 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 45 (of 50) ]
[ time 6 ] Run JOB 1 at PRIORITY 2 [ TICKS 4 ALLOT 1 TIME 44 (of 50) ]
[ time 7 ] Run JOB 1 at PRIORITY 2 [ TICKS 3 ALLOT 1 TIME 43 (of 50) ]
[ time 8 ] Run JOB 1 at PRIORITY 2 [ TICKS 2 ALLOT 1 TIME 42 (of 50) ]
[ time 9 ] Run JOB 1 at PRIORITY 2 [ TICKS 1 ALLOT 1 TIME 41 (of 50) ]
[ time 10 ] Run JOB 1 at PRIORITY 2 [ TICKS 0 ALLOT 1 TIME 40 (of 50) ]
[ time_11 ] IO_START by JOB 1
```

With -I ⇒ Job 0 forces Job 1 to stop using CPU

```
Job List:
  Job  0: startTime   0 - runTime  50 - ioFreq   1
  Job  1: startTime   1 - runTime  50 - ioFreq  10


Execution Trace:

[ time 0 ] JOB BEGINS by JOB 0
[ time 0 ] Run JOB 0 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 49 (of 50) ]
[ time 1 ] IO_START by JOB 0
IO DONE
[ time 1 ] JOB BEGINS by JOB 1
[ time 1 ] Run JOB 1 at PRIORITY 2 [ TICKS 9 ALLOT 1 TIME 49 (of 50) ]
[ time 2 ] IO_DONE by JOB 0
[ time 2 ] Run JOB 0 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 48 (of 50) ]
[ time 3 ] IO_START by JOB 0
IO DONE
[ time 3 ] Run JOB 1 at PRIORITY 2 [ TICKS 8 ALLOT 1 TIME 48 (of 50) ]
[ time 4 ] IO_DONE by JOB 0
[ time 4 ] Run JOB 0 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 47 (of 50) ]
[ time 5 ] IO_START by JOB 0
IO DONE
[ time 5 ] Run JOB 1 at PRIORITY 2 [ TICKS 7 ALLOT 1 TIME 47 (of 50) ]
[ time 6 ] IO_DONE by JOB 0
[ time 6 ] Run JOB 0 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 46 (of 50) ]
[ time 7 ] IO_START by JOB 0
IO DONE
[ time 7 ] Run JOB 1 at PRIORITY 2 [ TICKS 6 ALLOT 1 TIME 46 (of 50) ]
[ time 8 ] IO_DONE by JOB 0
[ time 8 ] Run JOB 0 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 45 (of 50) ]
[ time 9 ] IO_START by JOB 0
IO DONE
[ time 9 ] Run JOB 1 at PRIORITY 2 [ TICKS 5 ALLOT 1 TIME 45 (of 50) ]
[ time 10 ] IO_DONE by JOB 0
[ time 10 ] Run JOB 0 at PRIORITY 2 [ TICKS 4 ALLOT 1 TIME 44 (of 50) ]
[ time 11 ] IO_START by JOB 0
IO DONE
```