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Operating System Revision: Part 2

Special class

Vishvadeep Gothi • June 8, 2023

Operating System:
CPU Scheduling

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FCFS (First Come First Serve)

- Criteria:
  - Tie-breaker:
- Type:

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FCFS (First Come First Serve)

Process	Burst Time
P1	30
P2	6
P3	6

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FCFS (First Come First Serve)

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	0	30			
P2	0	6			
P3	0	6			

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FCFS (First Come First Serve)

Process	Arrival Time	Burst Time
P1	0	4
P2	1	2
P3	2	3
P4	3	5
P5	4	6
P6	5	1

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FCFS (First Come First Serve)

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	0	4			
P2	1	2			
P3	2	3			
P4	3	5			
P5	4	6			
P6	5	1			

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FCFS (First Come First Serve)

Process	Arrival Time	Burst Time
P1	4	4
P2	8	2
P3	6	3
P4	3	1
P5	2	6
P6	7	7

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FCFS (First Come First Serve)

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	4	4			
P2	8	2			
P3	6	3			
P4	5	3			
P5	2	1			
P6	7	7			

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Convoy Effect

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FCFS (First Come First Serve)

Advantages:

1. Easy to implement
2. No complex logic
3. No starvation

Disadvantages:

1. No option of Preemption
2. Convoy effect makes the system slow

SJF (Shortest Job First)

- Criteria: smallest BT first
  - Tie-breaker: FCFS → first AT, then process id
- Type: non-preemptive

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SJF (Shortest Job First)

Process	RT	Burst Time
P1	0	9
P2	0	6
P3	0	8

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SJF (Shortest Job First)

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	0	30			
P2	0	5			
P3	0	5			

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SJF (Shortest Job First)

Process	Arrival Time	Burst Time
P1	0	6
P2	0	3
P3	~~0~~ 4	4
P4	2	2
P5	3	1
P6	4	5
P7	6	2

P2	P5	P4	P7	P3	P6	P1

0 3 4 6 8 12 17 23

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SJF (Shortest Job First)

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	0	6			
P2	0	3			
P3	1	4			
P4	2	2			
P5	3	1			
P6	4	5			
P7	6	2			

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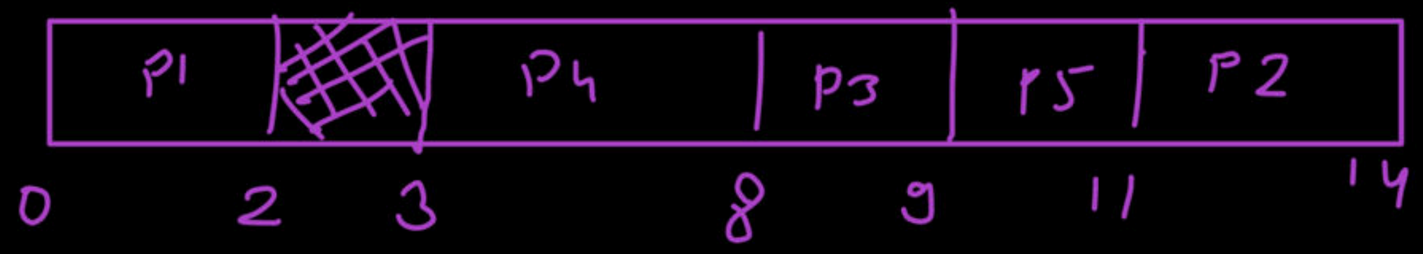
SJF (Shortest Job First)

Process	Arrival Time	Burst Time
P1	0	2
P2	4	3
P3	6	1
P4	3	5
P5	8	2



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SJF (Shortest Job First)

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	0	4			
P2	4	3			
P3	6	1			
P4	3	5			
P5	8	2			

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SRTF (Shortest Remaining Time First)

- Criteria: smallest B.T. first
  - Tie-breaker: FCFS
- Type: Preemptive

no preemption when

1. all processes arrive together
2. when for 2 processes P_i, P_j

$AT_i > AT_j$

& $BT_i \geq BT_j$ for all i, j

& $i \neq j$

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SRTF (Shortest Remaining Time First)

Process	Arrival Time	Burst Time	CT	TAT	WT
P1	0	6	17	17	11
P2	1	4	9	8	4
P3	2	1	3	1	0
P4	3	2	5	2	0
P5	4	1	6	2	1
P6	5	3	12	7	4

P1	P2	P3	P4	P5	P2	P6	P1

0 1 2 3 ~~4~~ 5 6 9 12 17

avg $WT = \frac{20}{6}$

avg $TAT = \frac{32}{6}$

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SRTF (Shortest Remaining Time First)

Process	Arrival Time	Burst Time
P1	0	6
P2	1	4
P3	2	1
P4	3	2
P5	4	1
P6	5	3

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SRTF (Shortest Remaining Time First)

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	0	6			
P2	1	4			
P3	2	1			
P4	3	2			
P5	4	1			
P6	5	3			

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Question GATE-2006

Consider three CPU intensive processes, which require 10, 20 and 30 time units and arrive at times 0, 2 and 6 respectively. How many context switches are needed if the operating system implements a shortest remaining time first scheduling algorithm?

Do not count the context switches at time zero and at the end

(A) 1 (C) 3

(B) 2 (D) 4

→ if n processes

no preemptn, & no idle period

↓

no. of context switches = $n-1$

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Question GATE-2006

P0	2 1
P1	4 3 2 1
P2	8 4 3 2 1

Consider three processes (process id 0, 1, 2 respectively) with compute time bursts 2, 4 and 8 time units. All processes arrive at time zero. Consider the longest remaining time first (LRTF) scheduling algorithm. In LRTF ties are broken by giving priority to the process with the lowest process id. The average turn around time is:

(A) 13 units (B) 14 units

(C) 15 units (D) 16 units

	P0	P1	P2
0	12	13	14

	BT
P0	2
P1	4
P2	8

P2	P1	P2	P1	P2	P0	P1	P2	P0	P1	P2

0 1 5 6 7 8 9 10 11 12 13 14

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P0	0	6
P1	0	2
P2	0	4
P3	0	9

LRTF

P3	P0	P3	P1	P3	P0	P2	P4	P0	P2	P4	P0	P1	P2	P3	P0	P1	P2	P3

0 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

Question GATE-2014

An operating system uses shortest remaining time first scheduling algorithm for pre-emptive scheduling of processes. Consider the following set of processes with their arrival times and CPU burst times (in milliseconds):

Process	Arrival Time	Burst Time
P1	0	12
P2	2	4
P3	3	6
P4	8	5

The average waiting time (in milliseconds) of the processes is _____.

$$\frac{15+0+3+4}{4} = \frac{22}{4} = 5.5$$

P1	P2	P3	P4	P1

0 2 6 12 17 27

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Problems with SJF & SRTF

1. Starvation
2. No fairness
3. Practical Implementation is not possible

→ Because B.T. are not known in advance

SJF & SRTF are also priority based algo,

where priority of process = BT. of process

small Number higher priority

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HRRN (Highest Response Ratio Next)

- Objective: Not only favors short jobs but decreases the WT of longer jobs
- Criteria:
  - Tie-breaker:
- Type:

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HRRN (Highest Response Ratio Next)

- Objective: Not only favors short jobs but decreases the WT of longer jobs
- Criteria:
  - Tie-breaker:

$$RR = \frac{W + S}{S}$$

W = Wait Time

S = Service/Burst Time

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HRRN (Highest Response Ratio Next)

Process	Arrival Time	Burst Time
P1	0	3
P2	2	6
P3	4	4
P4	6	5
P5	8	2

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HRRN (Highest Response Ratio Next)

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	0	3			
P2	2	6			
P3	4	4			
P4	6	5			
P5	8	2			

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Priority Based Scheduling

- Criteria: Priority
  - Tie-breaker: given in Quest^n
- Type: pre 4

  non-preempt

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Priority

- Static
- Dynamic

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Priority Based Scheduling

Process	Arrival Time	Burst Time	Priority
P1	0	4	4
P2	1	2	5
P3	2	3	6
P4	3	1	10(Highest)
P5	4	2	9
P6	5	6	7

P1	P4	P5	P6	P3	P2

0 4 5 7 13 16 18

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Priority Scheduling: Non-Preemptive

Process	Arrival Time	Burst Time	Priority	Completion Time	Turnaround Time	Waiting Time
P1	0	4	4			
P2	1	2	5			
P3	2	3	6			
P4	3	1	10(Highest)			
P5	4	2	9			
P6	5	6	7			

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Priority Scheduling: Non-Preemptive

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Priority Scheduling: Preemptive

Process	Arrival Time	Burst Time	Priority	Completion Time	Turnaround Time	Waiting Time
P1	0	4	4			
P2	1	2	5			
P3	2	3	6			
P4	3	1	10(Highest)			
P5	4	2	9			
P6	5	6	7			

P1	P2	P3	P4	P5	P6	P3	P2	P1

0 1 2 3 4 6 12 14 15 18

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Priority Scheduling: Preemptive

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Starvation

Solⁿ → aging

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Solution of Starvation

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	AT	BT	Priority
P1	0	6	2
P2	1	3	3
P3	2	5	4
P4	4	2	1
P5	12	4	5

Larger no. higher priority

Preemptive priority

P1	P2	P3	P2	P1	P5	P1	P4

0 1 2 7 9 12 16 18 20

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Question

preemptive priority

Process	Arrival Time	Burst Time	Priority
P1	0	7	6
P2	1	4	4
P3	2	6	3
P4	3	2	1(Highest)
P5	4	3	5
P6	6	5	2

P1	P2	P3	P4	P3	P6	P3	P2	P5	P1

0 1 2 3 5 6 11 15 18 21 27

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Round-Robin

- Criteria: AT + Q
  - Tie-breaker: New v process arriving
- Type:

Preemptive

→ but no preempt is (FCFS)

Max(BT) ≤ Q

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Round-Robin

Process	Arrival Time	Burst Time
P1	0	3
P2	0	6
P3	0	4
P4	0	5

Q=2

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Round-Robin

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	0	3			
P2	0	6			
P3	0	4			
P4	0	5			

Q=2

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Round-Robin

R.Q. ⇒ ~~P1~~ ~~P2~~, ~~P3~~, ~~P1~~, ~~P4~~, ~~P5~~, ~~P2~~, ~~P6~~, ~~P3~~

Process	Arrival Time	Burst Time
P1	0	~~4~~ ~~0~~
P2	1	~~5~~ ~~3~~ ~~1~~
P3	2	~~6~~ ~~4~~ ~~2~~
P4	3	~~3~~ ~~1~~
P5	4	~~2~~ ~~0~~
P6	5	~~4~~ ~~2~~

Q=2

P1	P2	P3	P1	P4	P5	P2	P6	P3	P4	P2	P6	P3

0 2 4 6 8 10 12 14 16 18 19 20 22 24

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RR, Q = 3

~~P1~~ ~~P2~~ P3 P4 P1, P5, P2

Process	AT	BT
P1	0	9
P2	1	8
P3	2	4
P4	3	5
P5	4	2

P1	P2	P3	P4	P1	P5	P2	P3	P4	P1	P2

0 3 6 9 12 15 17 20 21 23 26 28

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Round-Robin

Process	Arrival Time	Burst Time
P1	5	6
P2	8	7
P3	3	8
P4	6	3
P5	2	2
P6	4	4

Q=3

~~P5~~

~~P5~~, ~~P6~~, P1, ~~P4~~, P3, P2, ~~P6~~

	P5	P3	P6	P1	P4	P3	P2	P6	P1	P3	P2	P2

0 2 4 7 10 13 16 19 22 23 25 28 31 32

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no. of context switches in RR

$$\left(\sum_{i=1}^{n} \left\lceil \frac{BT_i}{Q} \right\rceil \right) \quad \text{--- } 1$$

for n processes

P_1 to P_n

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What Should Be the Quantum Value?

Q

- very-very small
  - CPU efficiency ≃ 0
- small
  - Interactive
- large
  - less interactive
- very-very large
  - RR degrades to FCFS

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Question

If the time-slice used in the round-robin scheduling policy is more than the maximum time required to execute any process, then the policy will?

(A) degenerate to shortest job first

(B) degenerate to priority scheduling

(C) degenerate to first come first serve

(D) none of the above

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Question

Four processes to be executed on a single processor system arrives at time 0+ in the order A, B, C and D. Their CPU burst time requirements are 4, ~~1~~, 8, ~~1~~ time units respectively. The completion time of A under Round-Robin scheduling with time slice of one time unit is?

A	B	C	D	A	C	A	C	A

0 1 2 3 4 5 6 7 8 9

Ans = 9

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Question GATE-2013

A scheduling algorithm assigns priority proportional to the waiting time of a process. Every process starts with priority zero (the lowest priority). The scheduler re-evaluates the process priorities every T time units and decides the next process to schedule. Which one of the following is TRUE if the processes have no I/O operations and all arrive at time zero?

(A) This algorithm is equivalent to the first-come-first-serve algorithm

(B) This algorithm is equivalent to the round-robin algorithm. with Q = r

(C) This algorithm is equivalent to the shortest-job-first algorithm

(D) This algorithm is equivalent to the shortest-remaining-time-first algorithm

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Question

Four processes to be executed on a single processor system arrives at time 0+ in the order A, B, C and D. Their CPU burst time requirements are 4, 1, 8, 1 time units respectively. The completion time of A under Round-Robin scheduling with time slice of one time unit is?

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Question

Consider the following set of processes. Calculate average waiting time of processes for following algorithms:

FCFS, Non-preemptive SJF, and Round-robin (quantum = 10ms)

Process	Arrival Time	Burst Time
P1	0	10ms
P2	0	29ms
P3	0	3ms
P4	0	7ms
P5	0	12ms

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Solution: FCFS

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	0	10ms			
P2	0	29ms			
P3	0	3ms			
P4	0	7ms			
P5	0	12ms			

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Solution: SJF

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	0	10ms			
P2	0	29ms			
P3	0	3ms			
P4	0	7ms			
P5	0	12ms			

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Solution: RR (Q=10)

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
P1	0	10ms			
P2	0	29ms			
P3	0	3ms			
P4	0	7ms			
P5	0	12ms			

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Question GATE-2006

Consider three CPU intensive processes, which require 10, 20 and 30 time units and arrive at times 0, 2 and 6 respectively. How many context switches are needed if the operating system implements a shortest remaining time first scheduling algorithm?

Do not count the context switches at time zero and at the end

(A) 1
(B) 2
(C) 3
(D) 4

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Question

If the waiting time for a process is p and there are n processes in the memory, then the CPU utilization is?

cpu utilization $= 1 - p^n$

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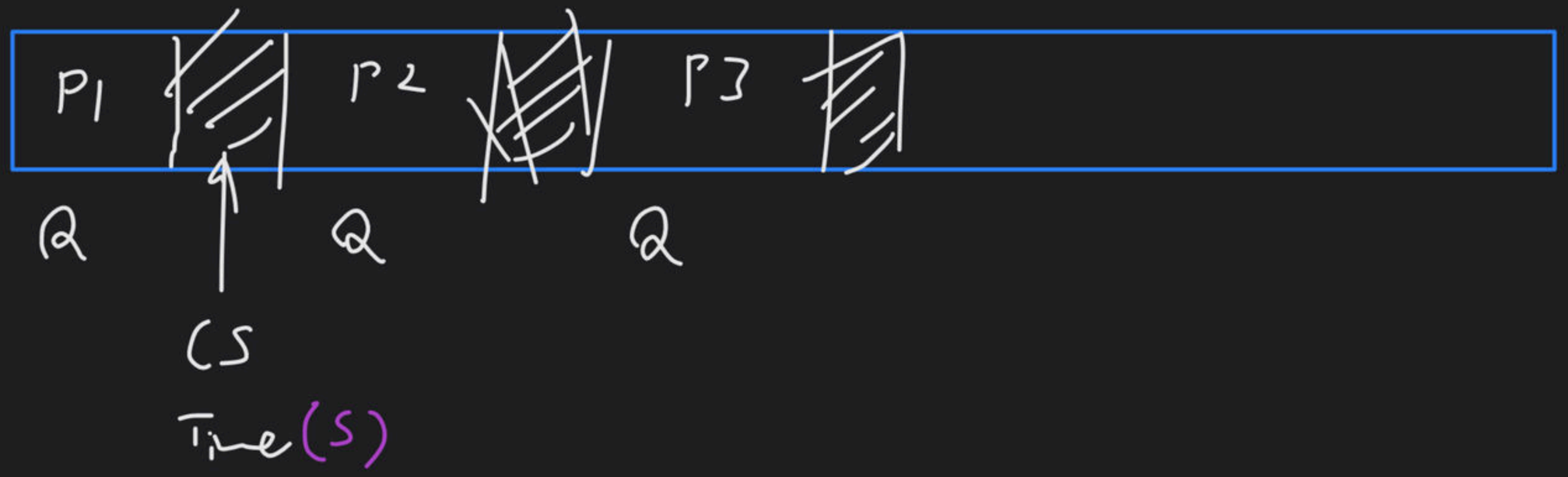
RR.



$$\text{CPU utilizat}^n = \frac{Q}{Q+S}$$

Multilevel Queue (MLQ) Scheduling

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Multilevel Queue (MLQ) Scheduling

System Processes

Foreground Processes

Background Processes

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Scheduling Among Queues

1. Fixed priority preemptive scheduling method
2. Time slicing

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Question

higher priority

Queue 1: RR with Q=2

Queue 2: FCFS

Process	Arrival Time	Burst Time	Queue
P1	0	4	1
P2	0	3	1
P3	0	9	2
P4	9	4	1

Q1 :- ~~P1~~, ~~P2~~, P4

Q2 :- P3

P1	P2	P1	P2	P3	P4	P1	P3

0 2 4 6 7 9 11 13 20

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Multilevel Queue (MLQ) Scheduling

Disadvantages:

1. Some processes may starve for CPU if some higher priority queues are never becoming empty.
2. It is inflexible in nature.

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Multilevel Feedback Queue (MLFQ) Scheduling

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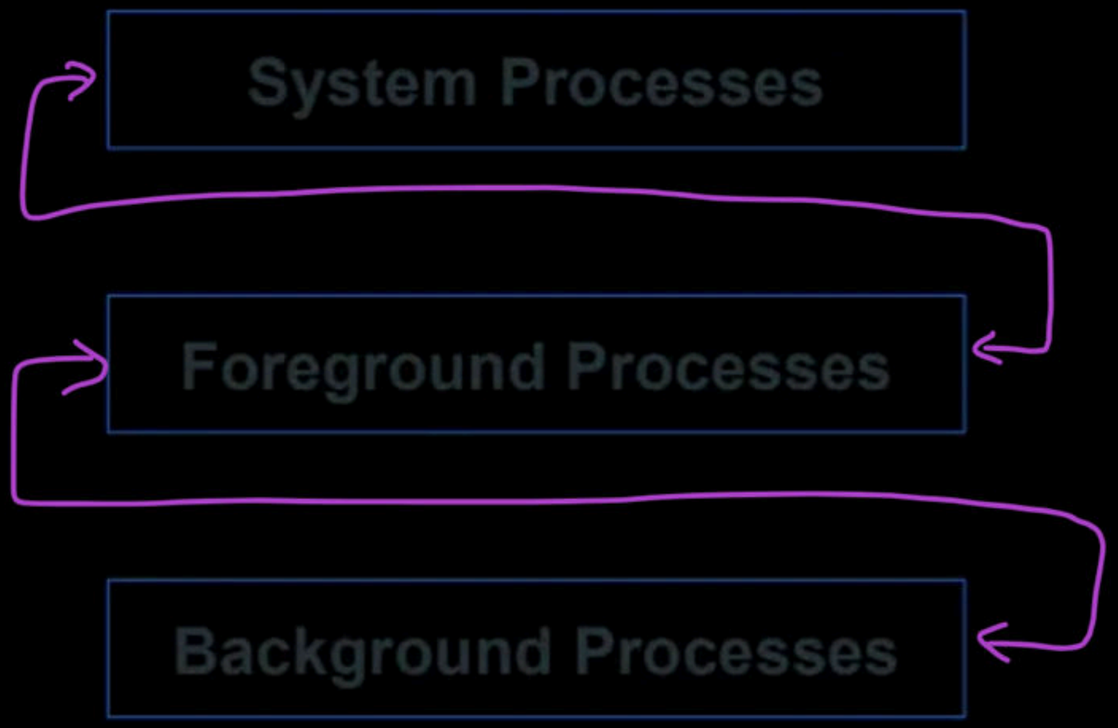
Multilevel Feedback Queue (MLFQ) Scheduling



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Multilevel Feedback Queue (MLFQ) Scheduling

Disadvantage:

1. Some processes may starve for CPU if some higher priority queues are never becoming empty.

Advantage:

1. Flexible

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Adv. & Disadv. of Scheduling Algo^{s}

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FCFS

Advantages:

1. Easy to implement
2. No complex logic
3. No starvation

Disadvantages:

1. No option of Preemption
2. Convoy effect makes the system slow

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SJF

Advantages:

1. Minimum average waiting time among non-preemptive scheduling
2. Better throughput in continue run

Disadvantages:

1. No practical implementation because Burst time is not known in advance
2. No option of Preemption
3. Longer Processes may suffer from ~~deadlock~~ starvation

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SRTF

Advantages:

1. Minimum average waiting time among all scheduling algorithm
2. Better throughput in continue run

Disadvantages:

1. No practical implementation because Burst time is not known in advance
2. Longer Processes may suffer from ~~deadlock~~

Starvat^n

Priority Based Algorithm

Advantages:

1. Better response for real time situations

Disadvantages:

1. Low Priority Processes may suffer from ~~deadlock~~ starvation

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Round Robin Algorithm

Advantages:

1. All processes execute one by one, so no starvation
2. Better interactiveness
3. Burst time is not required to be known in advance

Disadvantages:

1. Average waiting time and turnaround time is more
2. Can degrade to FCFS

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Synch. → Tom.

11:00 am

2:00 PM

Happy Learning.!