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### COURSE NAME : 19CSB201 – OPERATING SYSTEMS

### II YEAR/ IV SEMESTER

### UNIT – II Process Scheduling And Synchronization

### Topic: CPU Scheduling : Scheduling Algorithms

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# CPU Scheduling Algorithms

There are many CPU scheduling algorithms for deciding which of the process in the ready queue is to be allocated to the CPU.

Types
- First Come First Serve Scheduling
- Shortest Job First Scheduling
- Priority Scheduling
- Round Robin Scheduling

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# First Come First Serve Scheduling

- It is the simplest CPU Scheduling algorithm

- In this, the process that requests the CPU first is allocated to the CPU first.

- The Implementation of FCFS is easily managed with a FIFO queue.

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# FIFO Queue



- The process enters the ready queue onto the tail of the queue
- When the CPU is free the process at the head of the queue will be allocated

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**Consider the following set of processes Arrives at time 0, with the length of the CPU burst time given in milliseconds**

| Process | Burst Time |
|---------|-----------|
| $P_1$ | 24 |
| $P_2$ | 3 |
| $P_3$ | 3 |

i. Draw gantt chart illustrating process execution for all scheduling

ii. Find Turn around time

iii. Find Waiting time

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## Gantt Chart

It is a bar chart that illustrates the process schedule, including the start and finish times of each participating processes.

## Waiting Time

Waiting Time is the sum of time period spent waiting in the ready queue.

## Turnaround Time

Turnaround time is the sum of period spent waiting to get into memory, waiting in the ready queue, executing on the CPU and doing I/O
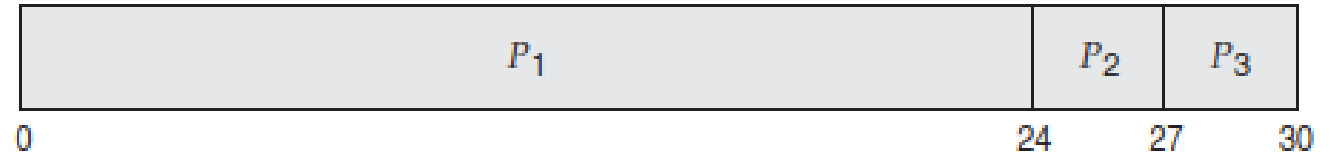
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Process | Burst Time
--- | ---
$P_1$ | 24
$P_2$ | 3
$P_3$ | 3

Arrives at time 0

**Gantt Chart**

| $P_1$ | $P_2$ | $P_3$ |
|---|---|---|
| 0 | 24 | 27 | 30 |

| Process | Burst Time | Waiting Time | Turnaround Time |
|---|---|---|---|
| P1 | 24 | 0 | 24 |
| P2 | 3 | 24 | 27 |
| P3 | 3 | 27 | 30 |
| Average Waiting Time/ Turnaround Time | | (51/3) = 17 | (81/3) = 27 |

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- Average Waiting Time(Wt) = ( Wt P1 + Wt P2 + Wt P3 ) / 3

  = ( 0+24+27 ) / 3

  = 51 / 3    = 17


- Average Turnaround Time(Tt) = ( Tt P1 + Tt P2 + Tt P3 ) / 3

  = ( 24+27+30 ) / 3

  = 81 / 3        = 27

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| Process | Burst Time |
|---------|------------|
| $P_1$ | 24 |
| $P_2$ | 3 |
| $P_3$ | 3 |

- Suppose that the processes arrive in the order: $P_1$ , $P_2$ , $P_3$
  The Gantt Chart for the schedule is:

| $P_1$ | | $P_2$ | $P_3$ |
|-------|---|-------|-------|
| 0 | | 24 | 27 30 |

- Waiting time for $P_1$ = 0; $P_2$ = 24; $P_3$ = 27

- Average waiting time:  (0 + 24 + 27)/3 = 17

- **Convoy effect** - short process behind long process

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Suppose that the processes arrive in the order:

$$P_2 , P_3 , P_1$$

- The Gantt chart for the schedule is:

| P$_2$ | P$_3$ | P$_1$ |
|---|---|---|
| 0 | 3 | 6 |

(with end time 30)

- Waiting time for $P_1$ = 6; $P_2$ = 0, $P_3$ = 3
- Average waiting time:  (6 + 0 + 3)/3 = 3
- Much better than previous case

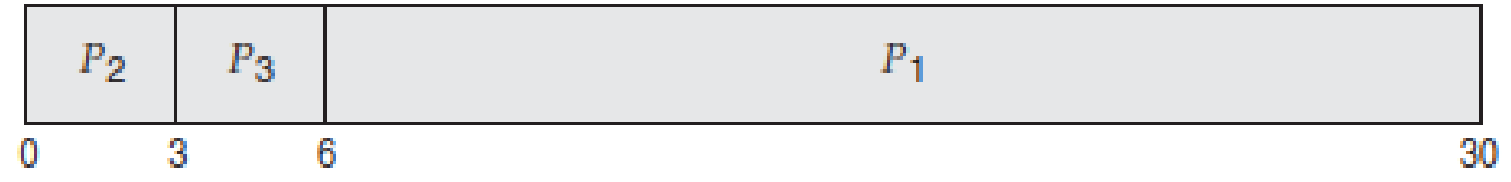19CSB201 – Operating Systems/ Unit-II/ Process Scheduling and Synchronization/ CPU Scheduling - Scheduling Algorithms/ Mrs.M.Lavanya/AP/CSE/SNSCT

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Example 2

## FCFS Scheduling

| Process | Burst Time | Arrival Time |
|---------|-----------|--------------|
| P1 | 24 | 3 |
| P2 | 3 | 0 |
| P3 | 3 | 1 |

**Gantt Chart**

| $P_2$ | $P_3$ | $P_1$ |
|-------|-------|-------|

0        3        6                                        30

| Process | Burst Time | Waiting Time | Turnaround Time |
|---------|-----------|--------------|-----------------|
| P1 | 24 | 6-3 = 3 | 3+24 = 27 |
| P2 | 3 | 0-0 = 0 | 0+3 = 3 |
| P3 | 3 | 3-1 = 2 | 2+3 = 5 |
| Average Waiting Time/ Turnaround Time | | (5/3) = 1.67 | (35/3) = 11.67 |

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# Formulae

## Waiting Time

Waiting Time = Starting Time – Arrival Time

## Turnaround Time

Turnaround time = Waiting Time + Burst Time

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| Process ID | Arrival Time | Burst Time |
|:---:|:---:|:---:|
| P1 | 4 | 5 |
| P2 | 6 | 4 |
| P3 | 0 | 3 |
| P4 | 6 | 2 |
| P5 | 5 | 4 |

**Gantt Chart**

| 0 | 3 | 4 | 9 | 13 | 17 | 19 |
|---|---|---|---|---|---|---|
| P3 | | P1 | P5 | P2 | P4 | |

The shaded box represents the idle time of CPU
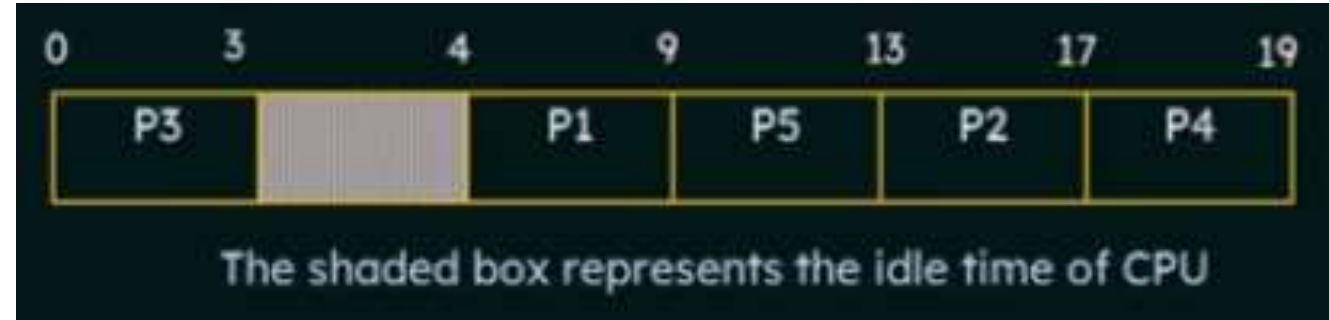
| Process ID | Completion Time | Turnaround Time | Waiting Time |
|:---:|:---:|:---:|:---:|
| P1 | 9 | 9 – 4 = 5 | 5 – 5 = 0 |
| P2 | 17 | 17 – 6 = 11 | 11 – 4 = 7 |
| P3 | 3 | 3 – 0 = 3 | 3 – 3 = 0 |
| P4 | 19 | 19 – 6 = 13 | 13 – 2 = 11 |
| P5 | 13 | 13 – 5 = 8 | 8 – 4 = 4 |

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# Formulae

## Turnaround Time

Turnaround Time = Completion Time – Arrival Time

## Waiting Time

Waiting Time = Turnaround Time – Burst Time

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Average Turn Around time $= (5 + 11 + 3 + 13 + 8) / 5$
$= 40 / 5$
$= 8$ units

Average waiting time $= (0 + 7 + 0 + 11 + 4) / 5$
$= 22 / 5$
$= 4.4$ units

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# Shortest Job First Scheduling

- This algorithm associate with each process the length of its next CPU burst
  - Use these lengths to schedule the process with the shortest time

- SJF is optimal – gives minimum average waiting time for a given set of processes
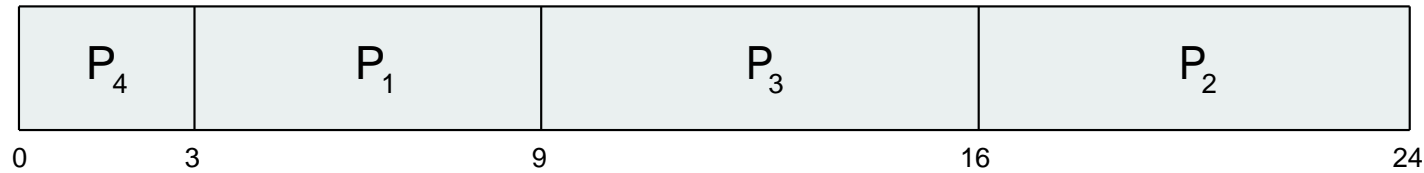  - The difficulty is knowing the length of the next CPU request

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| Process | Burst Time |
|---------|-----------|
| $P_1$ | 6 |
| $P_2$ | 8 |
| $P_3$ | 7 |
| $P_4$ | 3 |

- SJF scheduling chart

| $P_4$ | $P_1$ | $P_3$ | $P_2$ |
|-------|-------|-------|-------|

```
0        3             9            16             24
```

- Average waiting time = (3 + 16 + 9 + 0) / 4 = 7
- Average Turnaround time

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# Preemptive SJF

Preemptive version called **shortest-remaining-time-first**

| Process | *Arrival* Time | Burst Time |
|---------|----------------|------------|
| $P_1$ | 0 | 8 |
| $P_2$ | 1 | 4 |
| $P_3$ | 2 | 9 |
| $P_4$ | 3 | 5 |

- *Preemptive* SJF Gantt Chart

| $P_1$ | $P_2$ | $P_4$ | $P_1$ | $P_3$ |
|-------|-------|-------|-------|-------|

0  1      5          10           17              26
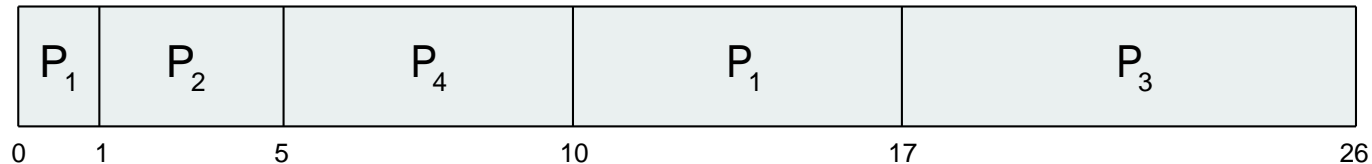
- Average waiting time = [(10-1)+(1-1)+(17-2)+5-3)]/4 = 26/4 = 6.5 msec

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# Priority Scheduling

- A priority number (integer) is associated with each process

- The CPU is allocated to the process with the highest priority
  (smallest integer ≡ highest priority)

Types
- Preemptive
- Nonpreemptive

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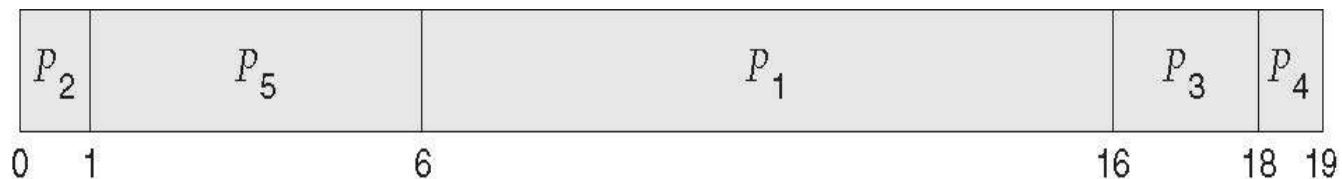
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# Priority Scheduling

- SJF is priority scheduling where priority is the inverse of predicted next CPU burst time

- Problem ≡ **Starvation** – low priority processes may never execute

- Solution ≡ **Aging** – as time progresses increase the priority of the process

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# Non-Preemptive

| Process | Burst Time | Priority |
|---------|------------|----------|
| $P_1$   | 10         | 3        |
| $P_2$   | 1          | 1        |
| $P_3$   | 2          | 4        |
| $P_4$   | 1          | 5        |
| $P_5$   | 5          | 2        |

- Priority scheduling Gantt Chart



- Average waiting time = 8.2 msec

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# Preemptive

| Process | Arrrival Time | Burst Time | Priority |
|---------|---------------|------------|----------|
| $P_1$ | 0 | 8 | 3 |
| $P_2$ | 1 | 4 | 1 |
| $P_3$ | 2 | 9 | 4 |
| $P_4$ | 3 | 5 | 2 |

- Priority scheduling Gantt Chart

| $P_1$ | $P_2$ | $P_4$ | $P_1$ | $P_3$ |
|-------|-------|-------|-------|-------|

```
0   1       5           10          17                  26
```

- Average waiting time = 6.5 msec

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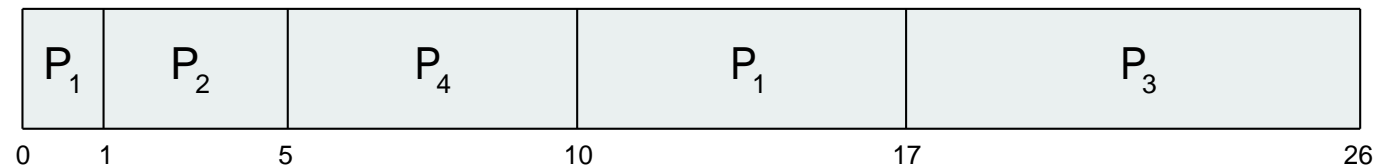
# Round Robin Scheduling

- It is similar to FCFS Scheduling, but preemption is added to enable switch between processes.

- A small unit of time called time quantum or time slice is defined.

- After the execution of time quantum period, the running process will be placed at back of ready queue & allows next process to occupy the CPU.
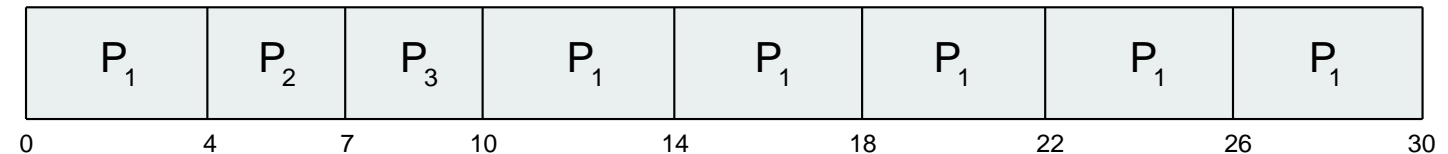
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- Each process gets a small unit of CPU time (**time quantum** $q$), usually 10-100 milliseconds. After this time has elapsed, the process is preempted and added to the end of the ready queue.

- If there are $n$ processes in the ready queue and the time quantum is $q$, then each process gets $1/n$ of the CPU time in chunks of at most $q$ time units at once. No process waits more than $(n-1)q$ time units.

- Timer interrupts every quantum to schedule next process

- Performance
  - $q$ large $\Rightarrow$ FIFO
  - $q$ small $\Rightarrow q$ must be large with respect to context switch, otherwise overhead is too high

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|  Process | Burst Time |
|:---:|:---:|
| $P_1$ | 24 |
| $P_2$ | 3 |
| $P_3$ | 3 |

If Time Quantum is 4 milliseconds

- The Gantt chart is:

| P$_1$ | P$_2$ | P$_3$ | P$_1$ | P$_1$ | P$_1$ | P$_1$ | P$_1$ |
|:---:|:---:|:---:|:---:|:---:|:---:|:---:|:---:|

0    4    7    10    14    18    22    26    30

Typically, higher average turnaround than SJF, but better *response*

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