

OPERATING SYSTEMS

(CS-3000)

Lecture-3

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Objective of this lecture

- Performance Metrics for CPU Scheduling
- Types of CPU Scheduling Strategies

Multi-Programming

- We have many processes ready to run.
- **Degree of multiprogramming** – The number of processes that can reside in the ready state at maximum

CPU Scheduling

- Decide the order of execution of processes when multiple are competing for system resources
- **Where** – In the Ready State
- **Who(se) Responsibility** – Short Term Scheduler
- **When** - Wherever there is queuing for the CPU!
 - Ready to Running
- **Function** – allocate CPU to process
- **Pre-emption** – Process is forcefully removed from CPU.
- **Non pre-emption** – Processes are not removed until they complete the execution.

Scheduling Criteria

- **Increase CPU Utilization**
 - CPU should not be idle as minimum time as possible.
- **Increase Throughput**
 - complete as many processes as possible per unit time
- **Minimize Average Waiting Time**
 - Waiting time: The time duration taken by a process waiting in the ready queue.
- **Minimize Average Turn Around Time**
 - Turnaround time: the time taken for a single process from start to completion.
- **Minimize Average Response time**
 - Response time: the time taken from the point that when the process enters into the ready queue to the point when the process goes into the running state
- **Fairness**
 - ensure that each process is given a fair share of the CPU based on some particular policy

Types of CPU Scheduling

- **Non preemptive**

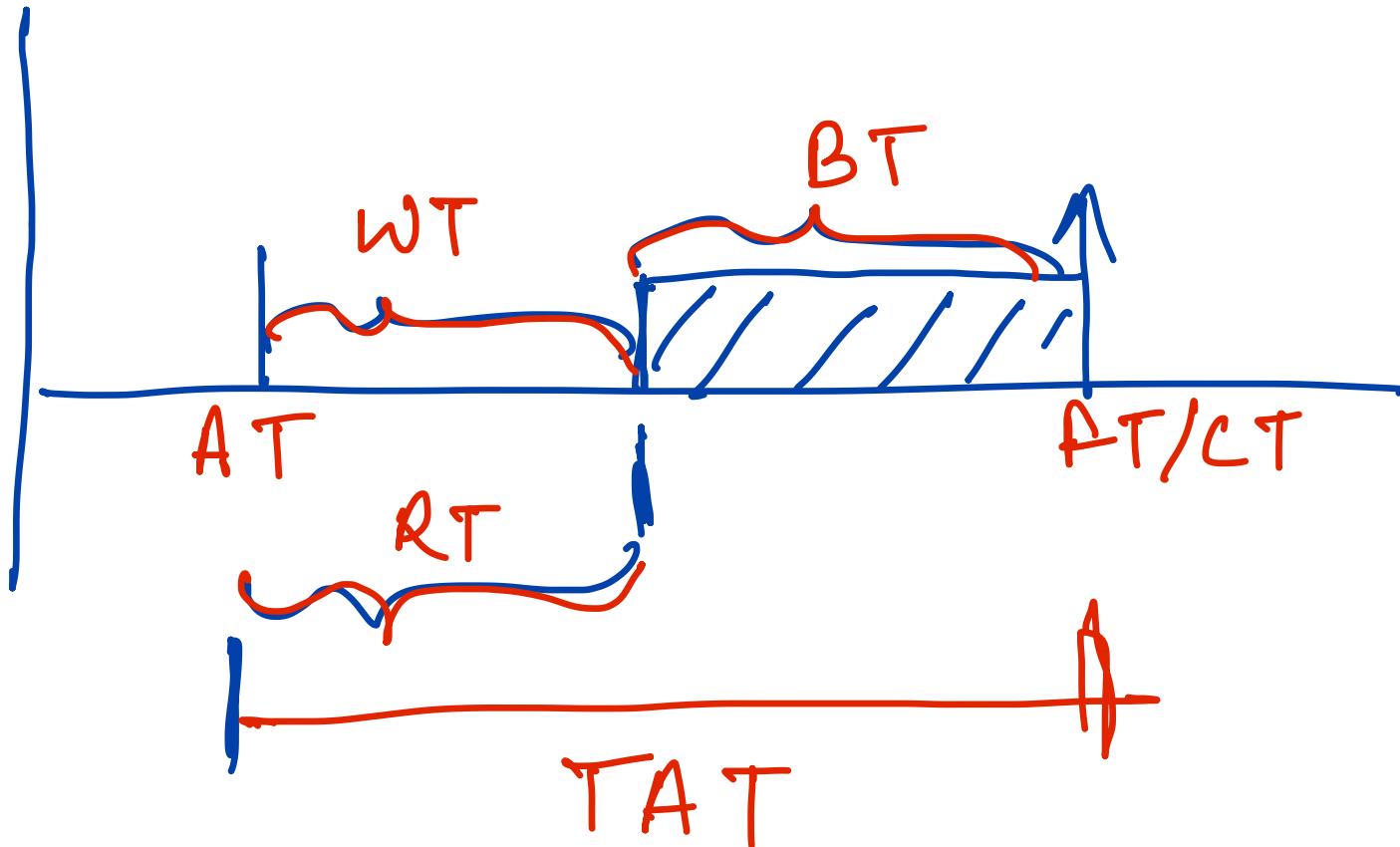
- FCFS
- SJF
- Priority
- HRRN

- **Preemptive**

- SRT
- RR
- Priority

Different Time based Parameters w.r.t. Process

- **Arrival Time (AT)** - Time the Process comes to the Ready State
- **Burst Time (BT)** – Execution time of the process – also referred as Service Time
- **Completion Time (CT)** – Time at which process completes its execution.
- **Turn Around Time (TAT)** - Time required for an application (process) to give an output to the end user
 - $TAT = CT - AT$
- **Waiting Time (WT)** - Time Difference between turn around time and burst time.
 - $WT = TAT - BT$
- **Response Time** – Time for the System to Respond to Process or User (First Response time on System Clock)
 - Time Since the Request is Submitted (AT) and the First Response Time



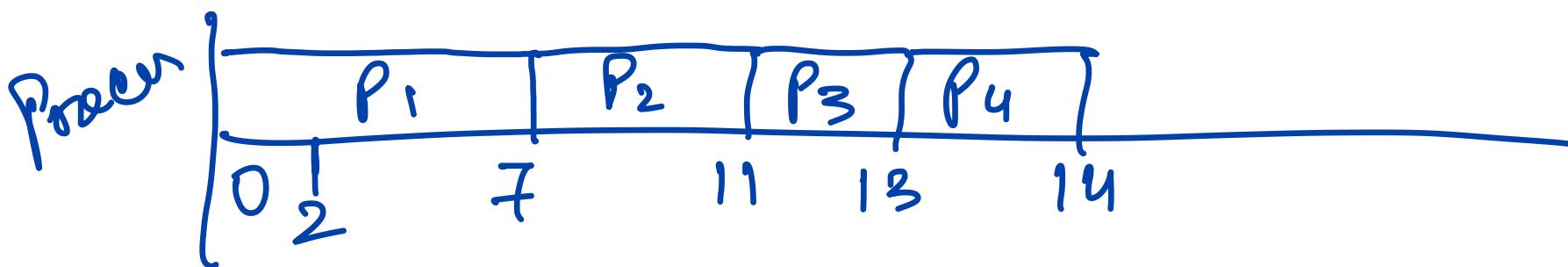
FCFS

PID/P#	AT	BT	CT/FT	TAT (CT-AT)	WT	RT
1	0	7	7	7	0	0
2	2	4	11	9	5	5
3	4	2	13	9	7	7
4	7	1	14	7	6	6
			Sum	32	18	18

$$\text{Av. TAT} = \frac{32}{4} = 8$$

$$A \cdot WT = \frac{18}{4} = 4.5$$

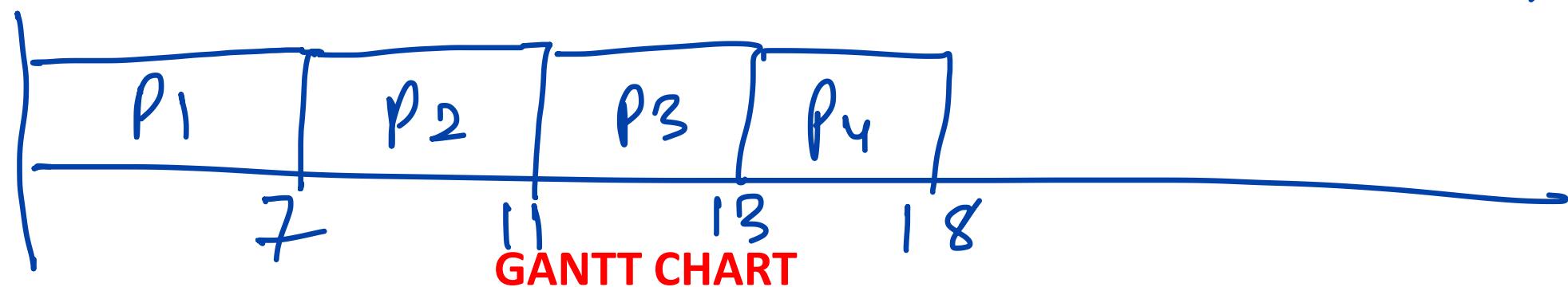
$$A \cdot RT = \frac{18}{4} = 4.5$$



GANTT CHART

FCFS

PID/P#	AT	BT	CT/FT	TAT	WT	RT
1	0	7	7	7	0	0
2	0	4	11	11	7	7
3	0	2	13	13	11	11
4	0	5	18	18	13	13
			Sum	49	31	31



$$\text{Av. TAT} = \frac{49}{4} = 12.25$$

$$\text{Av. WT} = \frac{31}{4} = 7.75$$

$$\text{Av. RT} = \frac{31}{4} = 7.75$$

Advantages and Disadvantages

- **Advantages**

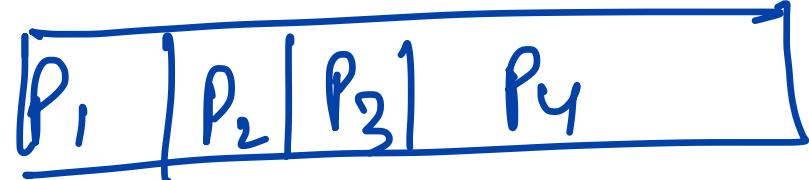
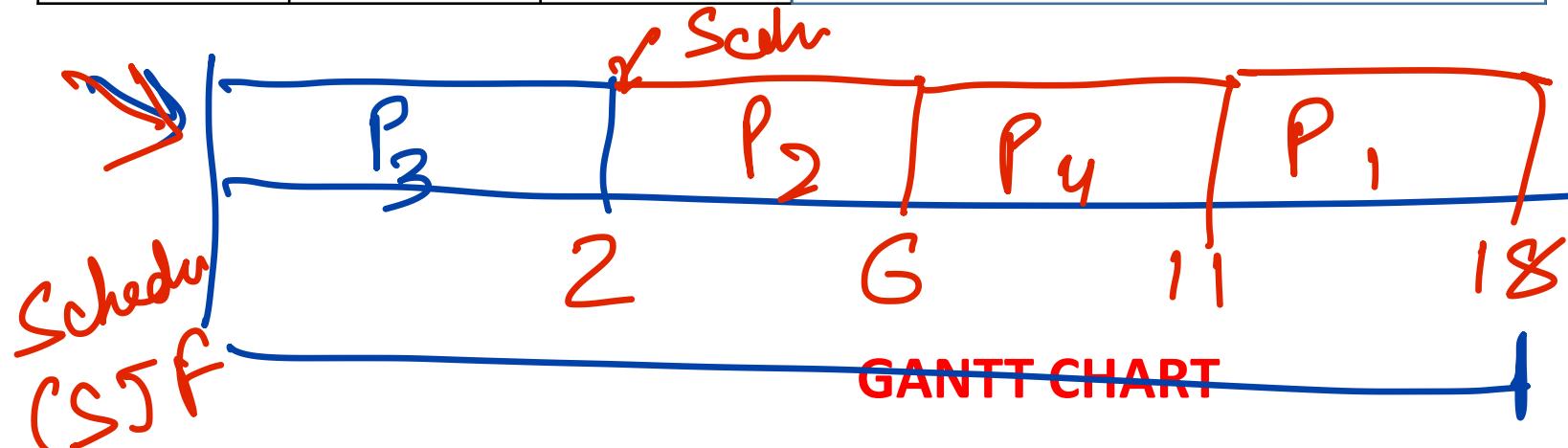
- Simple
- Fair

- **Disadvantages**

- Waiting time depends on arrival order
- Convoy effect

SJF

PID/P#	AT	BT	CT/FT	TAT	WT
1	0	7	18	18	11
2	0	4	6	6	2
3	0	2	2	2	0
4	0	5	11	11	6
				Sum	19



Ready Queue

$$\text{Av. TAT} = \frac{37}{4} = 9.25$$

$$\text{Av. WT} = \frac{19}{4} = 4.75$$

SJF

?

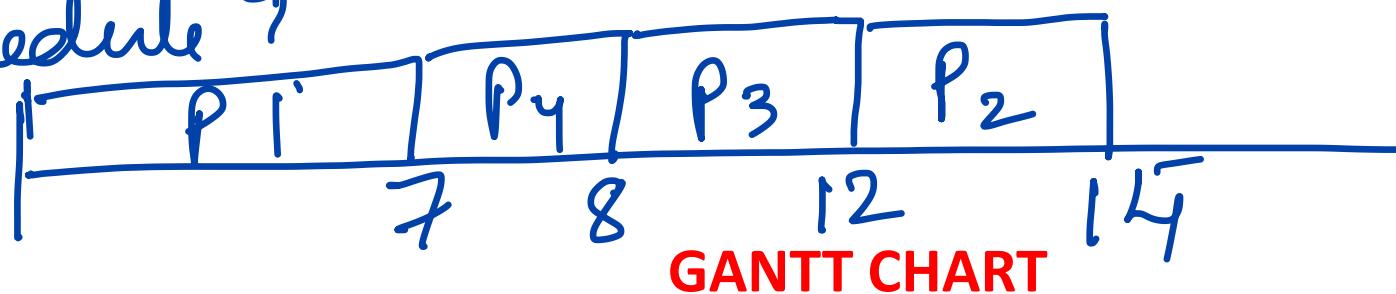
PID/P#	AT	BT	CT/FT	TAT	WT	RT
1	0	7	7	7	0	0
2	2	4	14	12	8	8
3	4	2	12	8	6	6
4	7	1	9	1	0	0

$$\text{Av. TAT} = 7.0$$

$$\text{Av. WT} = 3.5$$

$$\text{Av. RT} = 3.5$$

Schedule ?



Compare with
FCFS

Advantages and Disadvantages

- **Advantages**

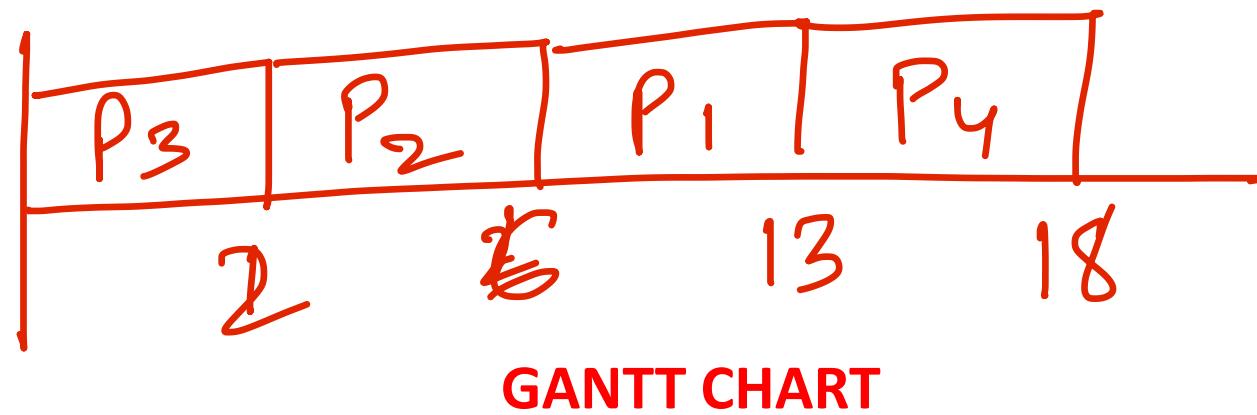
- Optimal: Min avg. waiting time and response time

- **Disadvantages**

- Difficult to predict burst time
- Starvation

Priority based Non-Preemptive Scheduling

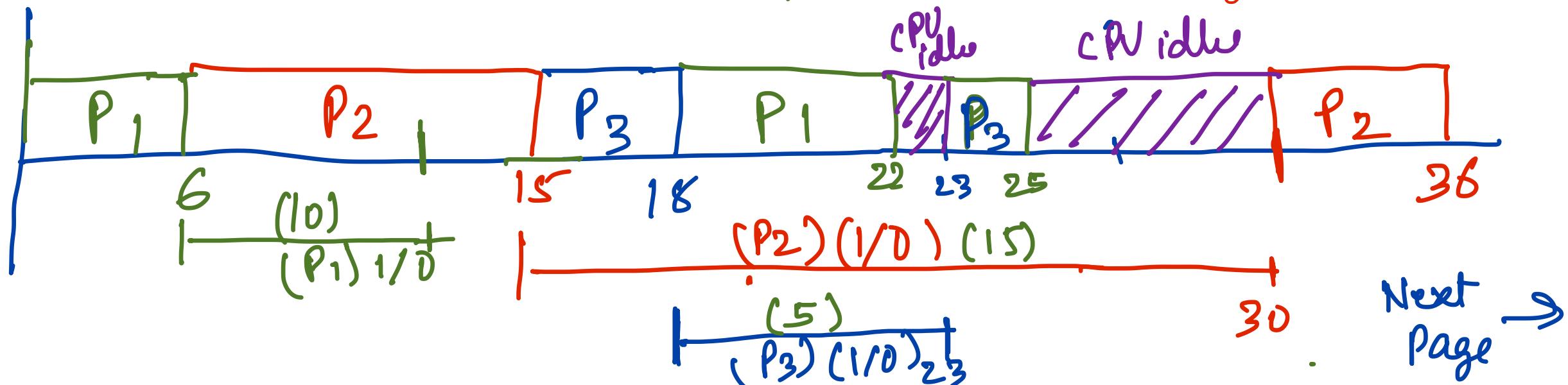
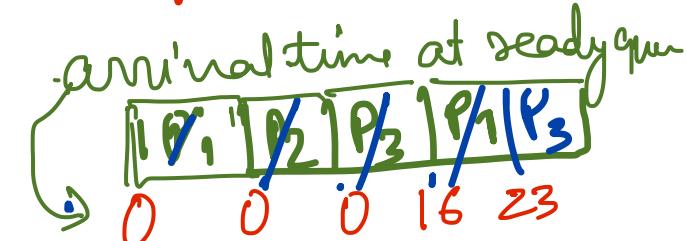
PID/P#	Priority	AT	BT	CT/FT	TAT	WT
1	3	0	7			
2	2	0	4			
3	1	0	2			
4	4	0	5			



→ First based on priority
 → for same priority processes, use FCF's

	<u>Processing</u>	AT	30% CPU	50% I/O	20% CPU	CT	TAT	WT	RT
P ₁	20	0	6	110	4	22	22	2	0
P ₂	30	0	9	115	6	36	36	6	6
P ₃	10	0	3	5	12	25	25	15	15

Apply FIFS, (Assume each processes requested different I/O devices)



CPV Utilization = $\frac{3D}{36} \times 100$ (How to estimate the Burst time?)

$$\text{Throughput} = \frac{\text{no. of Proc}}{\max(C_F) - \min(H_F)} = \frac{3}{3G}$$

Static

Process size

Process type

* Static will not give proper estimation

Dynamic

linear averaging

Exponential averaging

Linear Averaging

If P_1, P_2, \dots, P_n \rightarrow processes has completion
 t_1, \dots, t_n \rightarrow actual burst-time
after completion

Expected Burst time

$$\bar{t}_{n+1} = \frac{1}{n} \left(\sum_{i=1}^n t_i \right)$$

$t_i \Rightarrow$ actual burst time of i^{th} process

$\bar{t}_i \Rightarrow$ predicted / expected burst time

Exponential Averaging

$P_1, \dots, P_n \rightarrow$ Process

$t_1, \dots, t_n \rightarrow$ actual burst time

$\Sigma_1, \dots, \Sigma_n \rightarrow$ predicted

for any n^{th} process

$$\Sigma_{(n+1)} = \alpha t_n + (1-\alpha) \Sigma_n$$

\checkmark Predicted of $(n+1)^{th}$ process

weighing factor

\downarrow Predicted of n^{th}

actual for n^{th}

Example

	P1	P2	P3	P4
t_i	4	8	6	7

Given $\alpha = 0.5$, $\Sigma_1 = 10$

\Rightarrow It is given to verify on
actual burst time)
appneed

Find Σ_2 , Σ_3 , Σ_4 .

$$\Sigma_2 = 0.5 \times \frac{4}{(t_1)} + (1 - 0.5) \times \frac{10}{(\Sigma_1)} = 7$$

$$\Sigma_3 = 0.5 \times \frac{8}{(t_2)} + 0.5 \times \frac{7}{(\Sigma_2)} = 7.5$$

$$\Sigma_4 = 0.5 \times \frac{6}{(t_3)} + 0.5 \times \frac{7.5}{(\Sigma_3)} = 6.75$$

Note :-

- * Exponential averaging may predict burst time accurately sometimes,
- * ' α ' plays a major role for predicting the burst time.
- * deciding ' α ' is not easy, it depends on many factors.