# CS & IT ENGINEERING

## Operating Systems

CPU Scheduling

**Lecture No. 1**

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TOPICS TO BE COVERED

- Performance of SJF
- LRTF
- Priority and Round Robin

Q. Consider the following four processes with arrival times (in milliseconds) and their length of CPU bursts (in milliseconds) as shown below:

| Process | $P_1$ | $P_2$ | $P_3$ | $P_4$ |
|---|---|---|---|---|
| Arrival time | 0 | 1 | 3 | 4 |
| CPU burst time | 3 | 1 | 3 | Z |

These processes are run on a single processor using preemptive Shortest Remaining Time First (SRTF) Scheduling Algorithm. If the average waiting time of the processes is 1 millisecond, then the value of $Z$ is

| P.No | A.T | B.T | |
|---|---|---|---|
| 1 | 0 | 3 | × |
| 2 | 1 | 1 | × |
| 3 | 3 | 3 | |
| 4 | 4 | $z$ | |

## S.R.T.F

$4+3-3$

CPU

| $P_1$ | $P_2$ | $P_1$ | $P_4$ | $P_3$ |
|---|---|---|---|---|
| 0–1 | 1–2 | 2–4 | 4–$4+z$ | $4+z$–$7+z$ |

I. if '$z$' $< 3$

$$Av.W.T = \frac{1+0+(z+1)+0}{4} = 1$$

$\therefore z+2 = 4$

$\Rightarrow \boxed{z = 2}$ ✓

II. if '$z$' $> 3$

CPU

| $P_1$ | $P_2$ | $P_1$ | $P_3$ | $P_4$ |
|---|---|---|---|---|
| 0–1 | 1–2 | 2–4 | 4–7 | 7–$7+z$ |

$$Av.W.T = \frac{1+0+1+3}{4} = \frac{5}{4} = \boxed{1.25}$$

## NAT

Consider the following CPU processes with arrival times (in milliseconds) and length of CPU bursts (in milliseconds) as given below:

If the pre-emptive shortest remaining time first scheduling algorithm is used to schedule the processes, then the average waiting time across all processes is ___ milliseconds.

| Process | Arrival Time | Burst Time |
|---|---|---|
| $P_1$ | 0 | 7 |
| $P_2$ | 3 | 3 |
| $P_3$ | 5 | 5 |
| $P_4$ | 6 | 2 |

| P.No | A.T | B.T |
| --- | --- | --- |
| 1 | 0 | ~~7~~ 4 |
| 2 | 3 | 3 |
| 3 | 5 | 5 |
| 4 | 6 | 2 |

$$Av.R.T = \frac{0+0+7+0}{4} = \frac{7}{4} = \underline{\underline{1.75}}$$

| CPU | $P_1$ | $P_2$ | $P_4$ | $P_1$ | $P_3$ | |
| --- | --- | --- | --- | --- | --- | --- |
| 0 | 3 | 6 | 8 | 12 | 17 | |

$P_v$

$$Av.W.T = \frac{5+0+7+0}{4} = \frac{12}{4} = 3$$

# NAT

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 |
|---|---|---|
| $P_1$ | 0 | ~~12~~ 10 |
| $P_2$ | 2 | 4 × |
| $P_3$ | 3 | ~~6~~ 4 × |
| $P_4$ | 8 | 5 |

The average waiting time (in milliseconds) of the processes is 5.5

CPU

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

0 2 6 12 17 27

$$\text{Av. W.T} = \frac{15+0+3+4}{4} = \frac{22}{4} = 5.5$$

## MCQ

Consider the following set of processes that needs to be scheduled on a single CPU. All the times are given in milliseconds. Using the shortest remaining time first scheduling algorithm, the average process turn around time (in msec) is _

| Process Name | Arrival Time | Execution Time |
|---|---|---|
| A | 0 | $\cancel{6}$ 3 |
| B | 3 | 2 |
| C | 5 | 4 |
| D | 7 | 6 |
| E | 10 | 3 |

(A) 7.2

(B) 8

(C) 7

(D) 7.5

| CPU | A | B | A | C | E | D |
|---|---|---|---|---|---|---|
| | 0 | 3 | 5 | 8 | 12 | 15 |

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$$\text{Av. TAT} = \frac{8+2+7+14+5}{5} = \frac{36}{5} = 7.2$$

# Performance of S.J.F:

⟹ Always Favors Shorter Processes;

SJF is optimal Algo

## Advantage

- → $\Delta T$
- → Max. of Thruput
- → Min. of AV.TAT & AV. W.T

## Drawback

→ Cause Starvation to longer Processes;

At the out set, S.J.F has a practical limitation;

Criteria : B.T

't'

RQ $\boxed{P_1\ P_2\ P_3\ P_4}$

CPU

# Reasons for S.J.F

(i) Benchmark

(ii) Impl. with Predicted B.T's

Since B.T's of Processes are NOT known apriori

∴ S.J.F is practically non-Implementation;

# Predicting B.T of Process using Exponential Averaging Technique

(Next CPU B.T)

[Aging Algo]

→ Let $P_i$ be process;

Let '$t_i$' be completed B.T of Process $P_i$

Let $\tilde{T}_i$ be Predicted B.T of $P_i$;

Let $\tilde{T}_{n+1}$ : Next CPU B.T

Completed 'n' B.T

$\langle t_1, t_2 \cdots t_n \rangle$

Initial guess

| | $\tilde{T}_1$ | $t_1$ | | $\tilde{T}_2$ | $t_2$ | $t\,(\tilde{T}_3)$ | |
|---|---|---|---|---|---|---|---|
| | $W.T_1$ | $B.T_1$ | IOBT | $W.T_2$ | $B.T_2$ | $WT_3$ | ? |
| $P_i$ | R.Q | CPU | IOD | R.Q | CPU | R.Q | CPU |
| | A.T | | | | | Pr | |

$$\boxed{\tilde{T}_{n+1} = \alpha t_n + (1-\alpha)\tilde{T}_n}$$

"Recurrence"

$$\boxed{0 \le \alpha \le 1}$$

$\tilde{T}_1 = c \quad [c > 0]$

(guess)

$$\boxed{f(n) = n * f(n-1)}$$

$f(0) = 1$

## Back-Substitution :

$$\tilde{T}_{n+1} = \alpha t_n + (1-\alpha)\tilde{T}_n \quad \text{--- (1)}$$

$$\tilde{T}_n = \underline{\alpha t_{n-1} + (1-\alpha)\tilde{T}_{n-1}} \quad \text{--- (2)}$$

$$\tilde{T}_{n+1} = \alpha t_n + (1-\alpha)\left[\alpha t_{n-1} + (1-\alpha)\tilde{T}_{n-1}\right]$$

$$= \alpha t_n + \alpha(1-\alpha)t_{n-1} + (1-\alpha)^2 \underline{\underline{\tilde{T}_{n-1}}} \quad \text{--- (3)}$$

$$= \alpha t_n + \alpha(1-\alpha)t_{n-1} + \alpha(1-\alpha)^2 t_{n-2} + (1-\alpha)^3 \tilde{T}_{n-2} \quad \text{--- (4)}$$

$\tilde{T}_1$

Q) Consider a System using Expo. Avgng Technique for Predicting Next CPU B.T;

In its Previous run, the process $P_i$ has Consumed CPU bursts of $\underline{\overset{t_1}{7}, \overset{t_2}{8}, \overset{t_3}{10}, \overset{t_4}{9}}$ units respectively;

If $\alpha = 0.5$ & $\tau_1 = 12$, What is Next CPU B.T of $P_i$?

$$\tau_5 = \frac{1}{2}(t_4 + \tau_4) = \frac{1}{2}(9 + \tau_4) = \frac{1}{2}(9 + 9.375) = \frac{18.375}{2} = \boxed{9.1875}$$

$$\tau_4 = \frac{1}{2}(t_3 + \tau_3) = \frac{1}{2}(10 + \tau_3) = \frac{1}{2}(10 + 8.75) = \frac{18.75}{2} = \underline{\underline{9.375}}$$

$$\tau_3 = \frac{1}{2}(t_2 + \tau_2) = \frac{1}{2}(8 + \tau_2) = \frac{1}{2}(8 + 9.5) = \frac{17.5}{2} = 8.75$$

$$\tau_2 = \frac{1}{2}(t_1 + \tau_1) = \frac{1}{2}(7 + 12) = \frac{19}{2} = 9.5$$

## 4) Longest Remaining Time First (LRTF)

Criteria : B.T

Mode of op'n : PreEmptive

Tie breaking:

"In Case of a tie b/w Processes w.r.to B.T's, then Favor the Process having lower Pid"

LJF

| | | | |
|---|---|---|---|
| CPU | $P_3$ | $P_2$ | $P_1$ |
| 0 | 8 | 12 | 14 |

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Using LRTF Scheduler Calculate Avg. TAT? (2M)

| P.No | A.T | B.T |
|---|---|---|
| 1 | 0 | ~~2~~ 1 |
| 2 | 0 | ~~4~~ ~~3~~ ~~2~~ 1 |
| 3 | 0 | ~~8~~ ~~4~~ ~~3~~ ~~2~~ 1 |

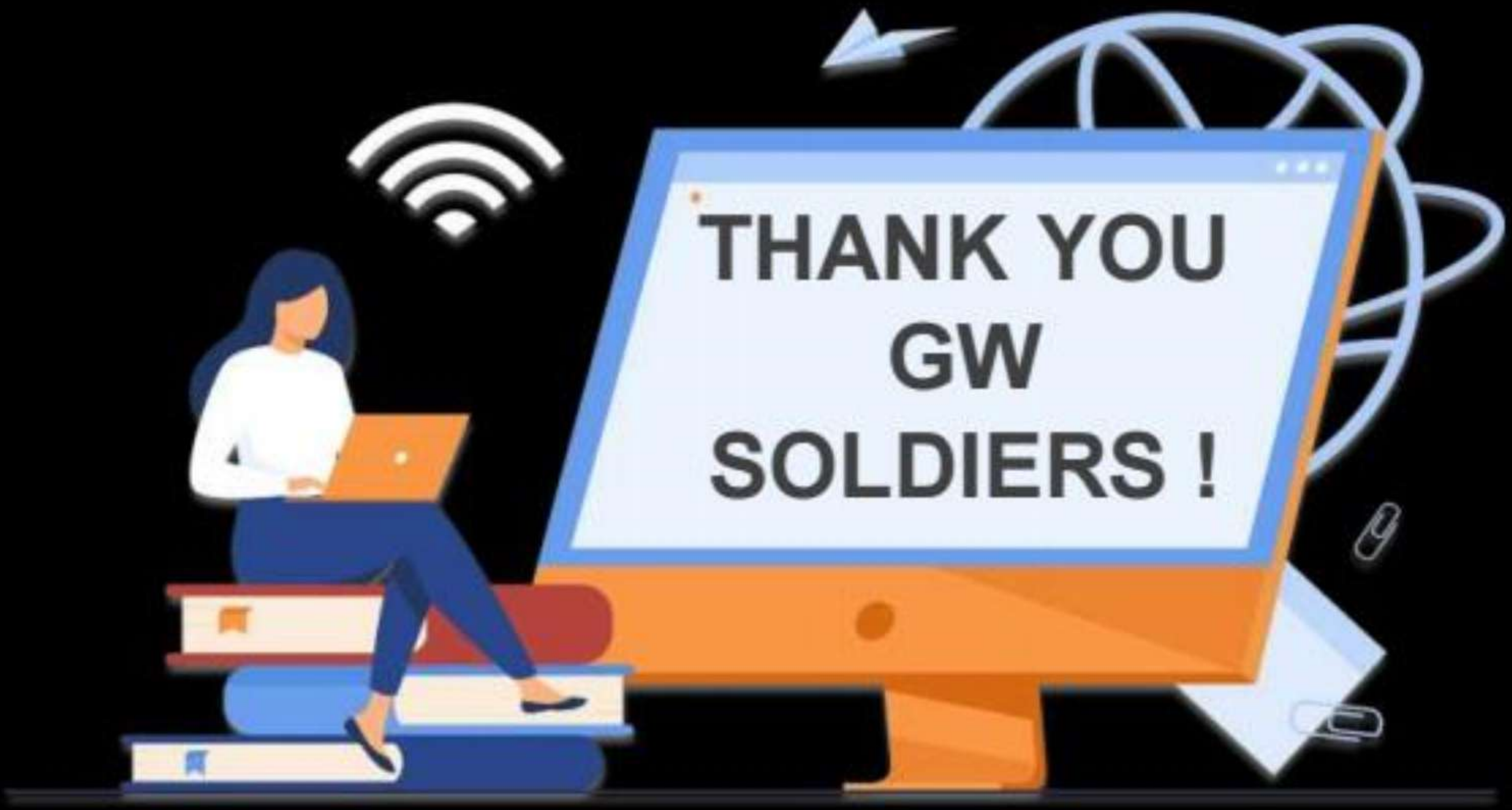
# of Context Switches : 11

| CPU | $P_3$ | $P_2$ | $P_3$ | $P_2$ | $P_3$ | $P_1$ | $P_2$ | $P_3$ | $P_1$ | $P_2$ | $P_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | 0–4 | 4–5 | 5–6 | 6–7 | 7–8 | 8–9 | 9–10 | 10–11 | 11–12 | 12–13 | 13–14 |

Pr Pr Pr Pr Pr Pr Pr Pr

S.J.F ✓
SRTF ✓
LJF ✓

$$\text{Av. TAT} = \frac{12+13+14}{3} = \frac{39}{3} = 13$$


THANK YOU
GW
SOLDIERS !