What is CPU utilization ?

Keep CPU busy as possible

What is CPU-I/O burst cycle ?

Process execution consists of a cycle of CPU execution and I/O wait
That means the CPU either work or wait for I/O

What is CPU scheduler (short-term scheduler) ?

Selects process from the ready queue to be execute

When the CU scheduler will take place (work)?

1. Switches from running to waiting state (I/O interrupt) **nonpreemptive**
2. Switches from running to ready state (timer interrupt) **preemptive**
3. Switches from waiting to ready(higher priority process arrive to ready queue) **preemptive**
4. Terminates **nonpreemptive**

What is the preemptive?

- **nonpreemptive** : once CPU given to the process it cannot be preempted until completes its CPU burst
- **preemptive** : if a new process arrives with CPU burst length less than remaining time of current executing process, preempt. This scheme is know as the Shortest-Remaining-Time-First (SRTF)

What is dispatcher ?

Dispatcher module gives control of the CPU to the process selected by the short-term scheduler

What is the task of dispatcher ?

- switching context
- switching to user mode
- jumping to the proper location in the user program to restart that program

What is the dispatcher latency ?

time it takes for the dispatcher to stop one process and start another running

What is the scheduling criteria ?

- **CPU utilization** : keep the CPU as busy as possible
- **Throughput** : # of processes that complete their execution per time unit
- **Turnaround time** : amount of time to execute a particular process
- **Waiting time** : amount of time a process has been waiting in the ready queue
- **Response time** : amount of time it takes from when a request was submitted until the first response is produced, not output (for time-sharing environment)

What we must keep for scheduling criteria ?

- **Max** CPU utilization
- **Max** throughput
- **Min** turnaround time
- **Min** waiting time
- **Min** response time

What is the types of scheduler algorithms ?

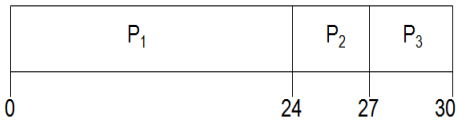
1- First come, first served (FCFS)
2- Shortest Job First (SJF)
3- Priority
4- Round robin (RR)
5- Multilevel queue

Explain FCFS scheduling ?

- **Advantages** : very simple in implementation
- **disadvantages** : when process with high burst time come first the other processes will wait for long time to start execute.

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:

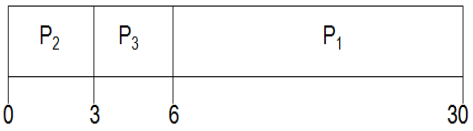


- Waiting time for P_1 = 0; P_2 = 24; P_3 = 27
- Average waiting time: (0 + 24 + 27)/3 = 17

Suppose that the processes arrive in the order

P_2 , P_3 , P_1

- The Gantt chart for the schedule is:



- 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
- *Convoy effect* short process behind long process

explain SJR scheduling ?

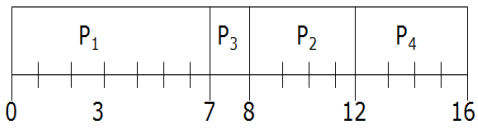
Associate with each process the length of its next CPU burst. Use these lengths to schedule the process with the shortest time

Advantages : SJF is optimal . gives minimum average waiting time for a given set of processes

Disadvantages : The difficulty is knowing the length of the next CPU request

Process	Arrival Time	Burst Time
P_1	0.0	7
P_2	2.0	4
P_3	4.0	1
P_4	5.0	4

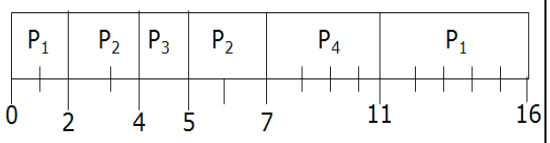
- SJF (non-preemptive)



- Average waiting time = (0 + 6 + 3 + 7)/4 = 4

Process	Arrival Time	Burst Time
P_1	0.0	7
P_2	2.0	4
P_3	4.0	1
P_4	5.0	4

- SJF (preemptive)



- Average waiting time = (9 + 1 + 0 +2)/4 = 3

explain the previous preemptive example ?

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	17
P1	7	6	5	5	5	5	5	5	5	5	5	5	4	3	2	1	**0**
P2	---	---	4	3	2	2	1	**0**									
P3	---	---	---	---	1	**0**											
P4	---	---	---	---	---	4	4	4	3	2	1	**0**					

How to Determining Length of Next CPU Burst ?

1. t_n = actual length of n^{th} CPU burst
2. τ_{n+1} = predicted value for the next CPU burst
3. $\alpha, 0 \le \alpha \le 1$
4. Define : $\tau_{n+1} = \alpha t_n + (1-\alpha)\tau_n$.

- If we assume that : **t0 = 6** and **T0 = 10**

CPU burst (t_i)	6	4	6	4	13	13	13	...
"guess" (τ_i)	10	8	6	6	5	9	11	12	...

Explain the priority scheduling ?

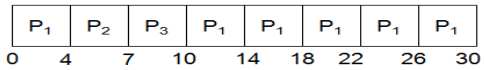
- A priority number (integer) is associated with each process
- The CPU is allocated to the process with the highest priority (smallest)
- SJF is a priority scheduling where priority is the predicted next CPU burst time
- **Problem** ≡ **Starvation** – low priority processes may never execute
- **Solution** ≡ **Aging** –as time progresses increase the priority of the process (over head)
- **Disadvantage** : not suitable to time sharing

Explain round robin scheduling ?

- Each process gets a small unit of CPU time (*time quantum*), 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.
- **Advantage** : not suitable to time sharing
- **Disadvantage** : higher average turnaround than SJF put better response
- **Performance**
  - *If q* large ⇒ FIFO
  - *If q* small ⇒ *overhead*

Process	Burst Time
P_1	24
P_2	3
P_3	3

- The Gantt chart is:



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

Are there a relation between time quantum and the average of turnaround ?

NO

Explain multilevel scheduling ?

- Ready queue is partitioned into separate queues:
  foreground (interactive)
  background (batch)
- Each queue has its own scheduling algorithm
  - foreground – RR
  - background – FCFS

What is types of scheduling between queues in multilevel scheduling ?

- **Fixed priority scheduling**: (i.e., serve all from foreground then from

background). Possibility of starvation.

- **Time slice** : each queue gets a certain amount of CPU time which it can schedule amongst its processes; i.e., 80% to foreground in RR and 20% to background in FCFS

Explain multilevel feedback queue ?

A process can move between the various queues

What is the parameters that Multilevel-feedback-queue scheduler defined by them ?

- number of queues
- scheduling algorithms for each queue
- method used to determine when to upgrade a process
- method used to determine when to demote a process
- method used to determine which queue a process will enter when that process needs service

Give example of multilevel feedback queue ?

- Three queues:
  - Q_0 – RR with time quantum 8 milliseconds
  - Q_1 – RR time quantum 16 milliseconds
  - Q_2 – FCFS
- Scheduling
  - A new job enters queue Q_0 which is served RR. When it gains CPU, job receives 8 milliseconds. If it does not finish in 8 milliseconds, job is moved to queue Q_1.
  - At Q_1 job is again served RR and receives 16 additional milliseconds. If it still does not complete, it is preempted and moved to queue Q_2.