SNS COLLEGE OF TECHNOLOGY

Kurumbapalayam (Po), Coimbatore – 641 107

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COURSE NAME : **23CST202-OPERATING SYSTEMS**

II YEAR / IV SEMESTER

Unit 2- PROCESS SCHEDULING AND SYNCHRONIZATION

Topic : CPU Scheduling

Basic Concepts

CPU scheduling is the basis of multi programmed O.S

- Our Goal →Maximum CPU utilization
- Several processes are kept in memory at one time. When one processes has to wait (for say i/o), the O.S's CPU scheduler takes the CPU away from that process and gives the CPU to another process.
- The process in memory and ready to run are kept in the ready queue.
- The O.S scheduler →CPU scheduler (or short term scheduler) selects a job from the ready queue to run.
- Ready queue is not necessarily in first-in-first-out (FIFO) order. A ready queue may be implemented as a FIFO queue, a priority queue, a tree or simply an unordered link list.
- The records in the ready queue are the PCBs
- Process execution generally consists of alternative *cycles*of CPU execution and I/O wait.→CPU burst cycle–I/O Burst Cycle

Alternating Sequence of CPU And I/O Bursts

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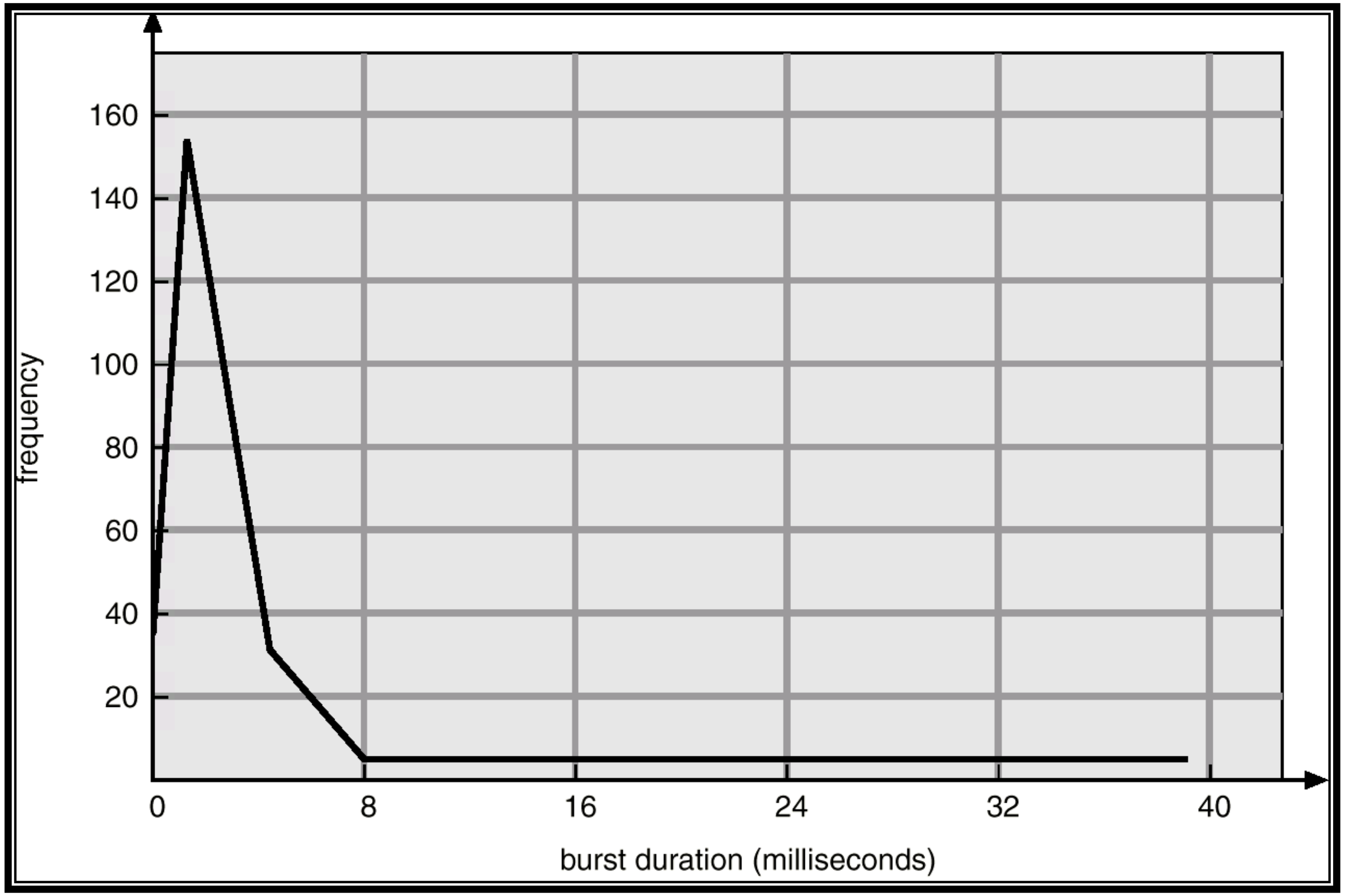
Histogram of CPU-burst Times



CPU Scheduler

Selects from among the processes in memory that are ready to execute, and allocates the CPU to one of them.

CPU scheduling decisions may take place when a process:

1. Switches from running to waiting state.
2. Switches from running to ready state.
3. Switches from waiting to ready.
4. Terminates.

Scheduling under 1 and 4 is *nonpreemptive*.

All other scheduling is *preemptive.*

Dispatcher

Dispatcher module gives control of the CPU to the process selected by the short-term scheduler; this involves:

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

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

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)

Optimization Criteria

Max CPU utilization

Max throughput

Min turnaround time

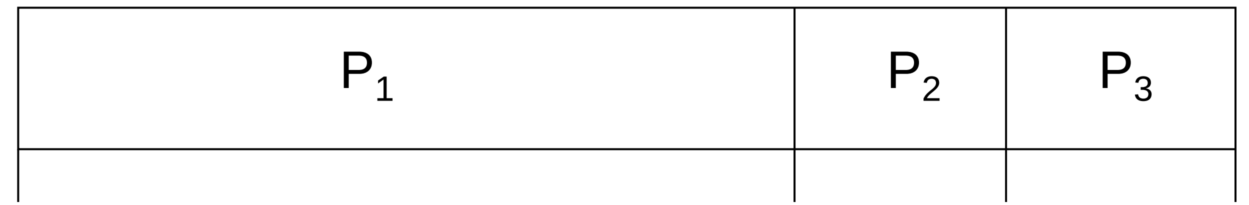
Min waiting time

Min response time

First-Come, First-Served (FCFS) Scheduling

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:



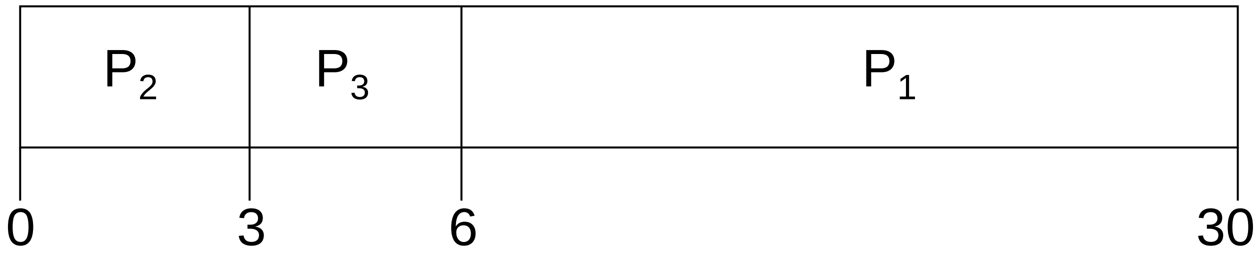
Waiting time for P_1 = 0; P_2 = 24; P_3 = 27
Average waiting time: (0 + 24 + 27)/3 = 17

FCFS Scheduling (Cont.)

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

Shortest-Job-First (SJR) Scheduling

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

Two schemes:

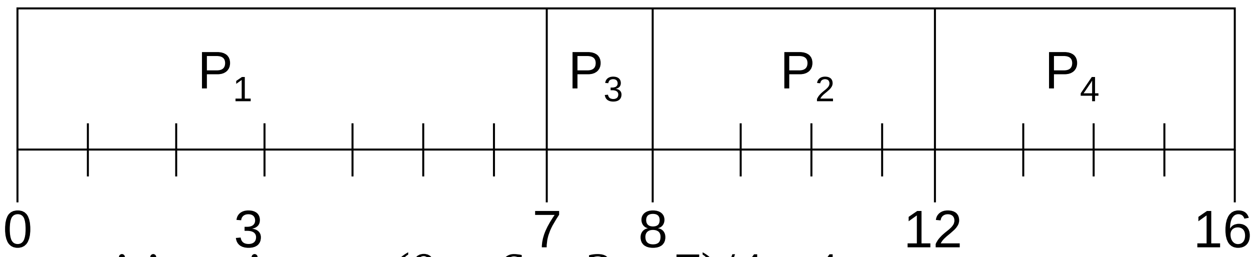
- nonpreemptive – once CPU given to the process it cannot be preempted until completes its CPU burst.
- preemptive – if a new process arrives with CPU burst length less than remaining time of current executing process, preempt. This scheme is know as the Shortest-Remaining-Time-First (SRTF).

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

Example of Non-Preemptive SJF

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)

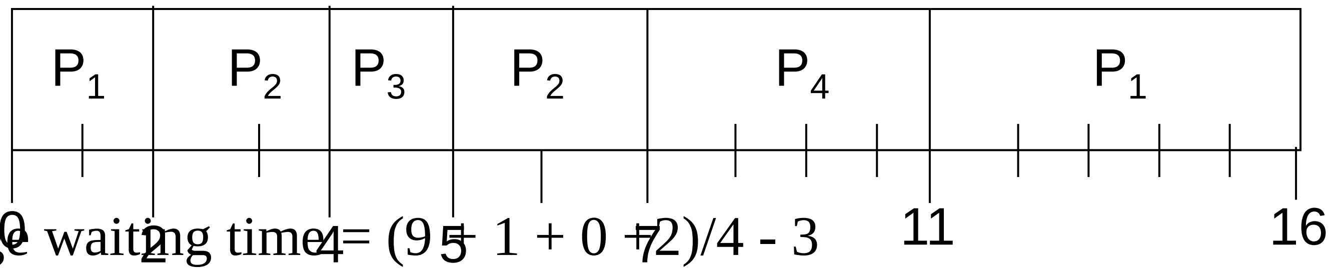


Average waiting time = (0 + 6 + 3 + 7)/4 - 4

Example of Preemptive SJF

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

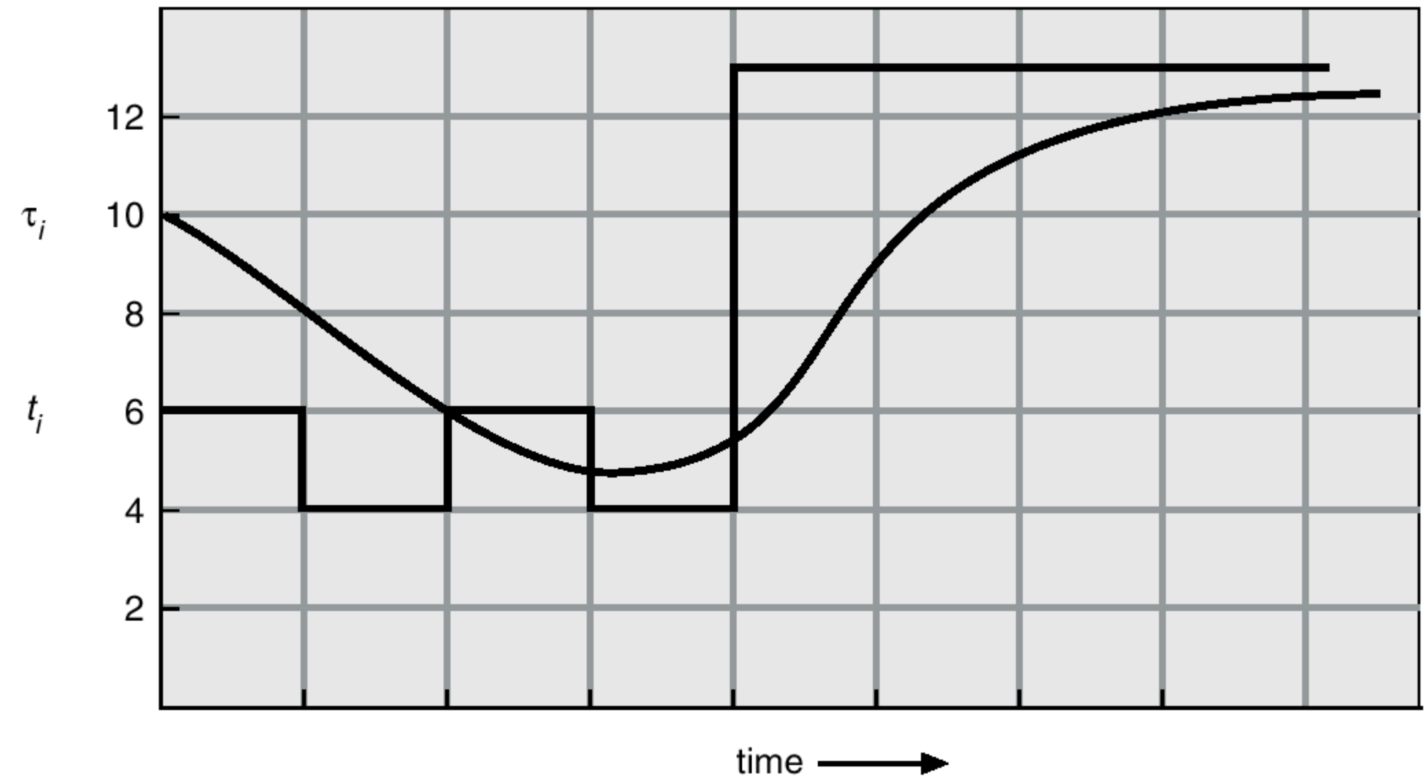
Determining Length of Next CPU Burst

Can only estimate the length.
Can be done by using the length of previous CPU bursts, using exponential averaging.

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

$$\tau_{n=1} = \alpha\, t_n + (1-\alpha)\tau_n .$$

Prediction of the Length of the Next CPU Burst



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

Examples of Exponential Averaging

$\alpha = 0$

$\tau_{n+1} = \tau_n$

Recent history does not count.

$\alpha = 1$

$\tau_{n+1} = t_n$

Only the actual last CPU burst counts.

If we expand the formula, we get:

$$\tau_{n+1} = \alpha\, t_n + (1 - \alpha)\, \alpha\, t_n - 1 + \ldots$$
$$+ (1 - \alpha)^j\, \alpha\, t_n - 1 + \ldots$$
$$+ (1 - \alpha)^{n=1}\, t_n\, \tau_0$$

Since both α and $(1 - \alpha)$ are less than or equal to 1, each successive term has less weight than its predecessor.

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).

- Preemptive
- nonpreemptive

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.

Round Robin (RR)

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.

Performance

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

Example of RR with Time Quantum = 20

Process	Burst Time
P_1	53
P_2	17
P_3	68
P_4	24

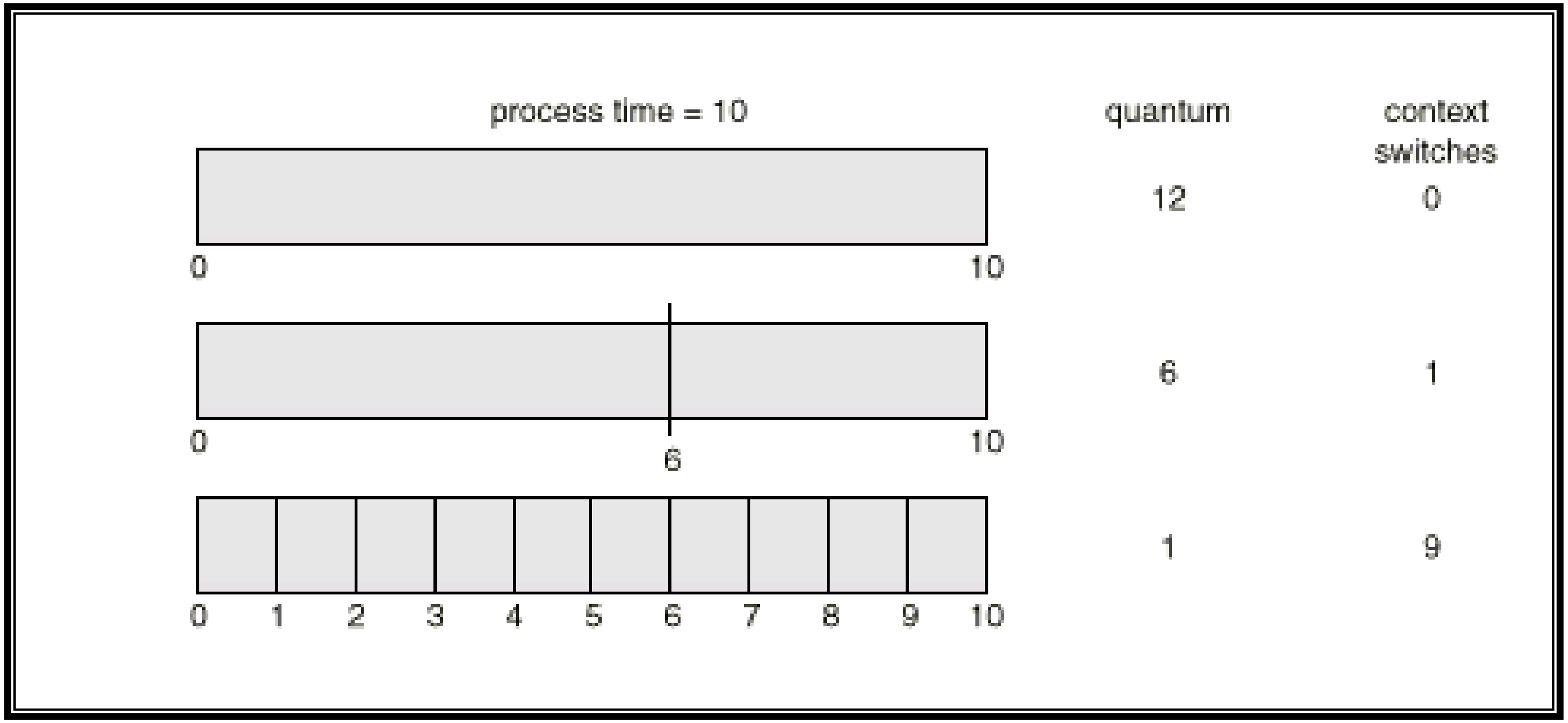
The Gantt chart is:

P_1	P_2	P_3	P_4	P_1	P_3	P_4	P_1	P_3	P_3

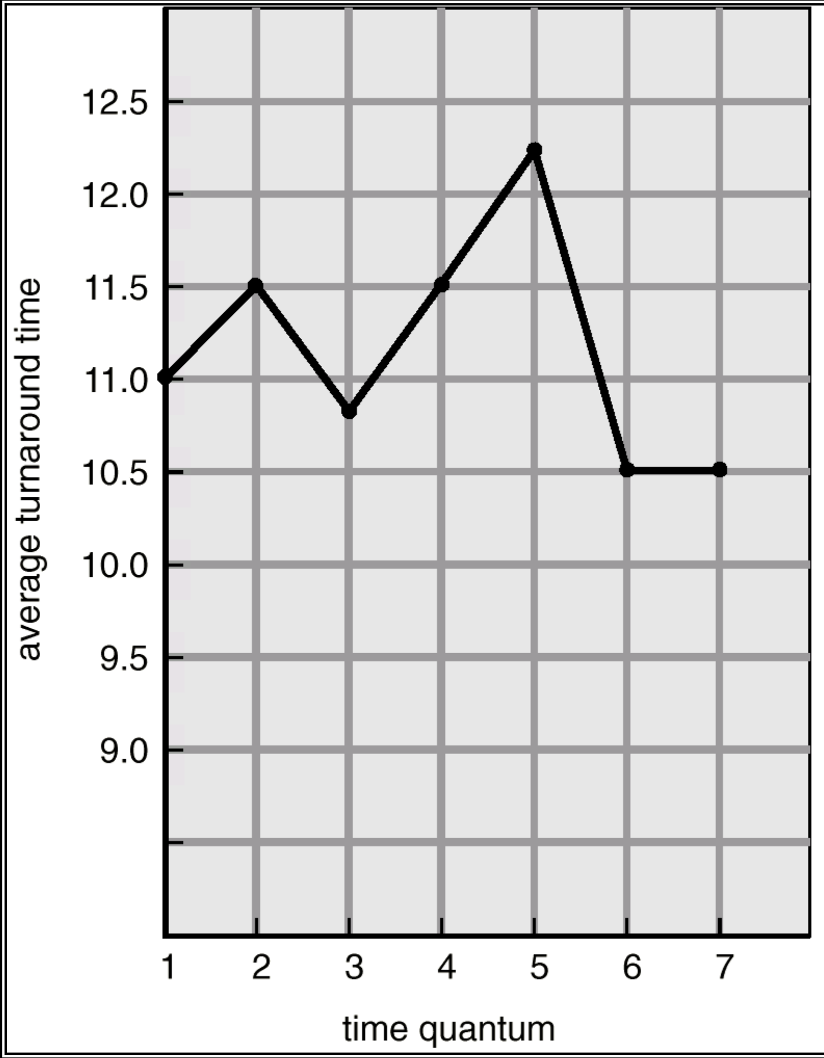
0 20 37 57 77 97 117 121 134 154 162

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

Time Quantum and Context Switch Time



Turnaround Time Varies With The Time Quantum



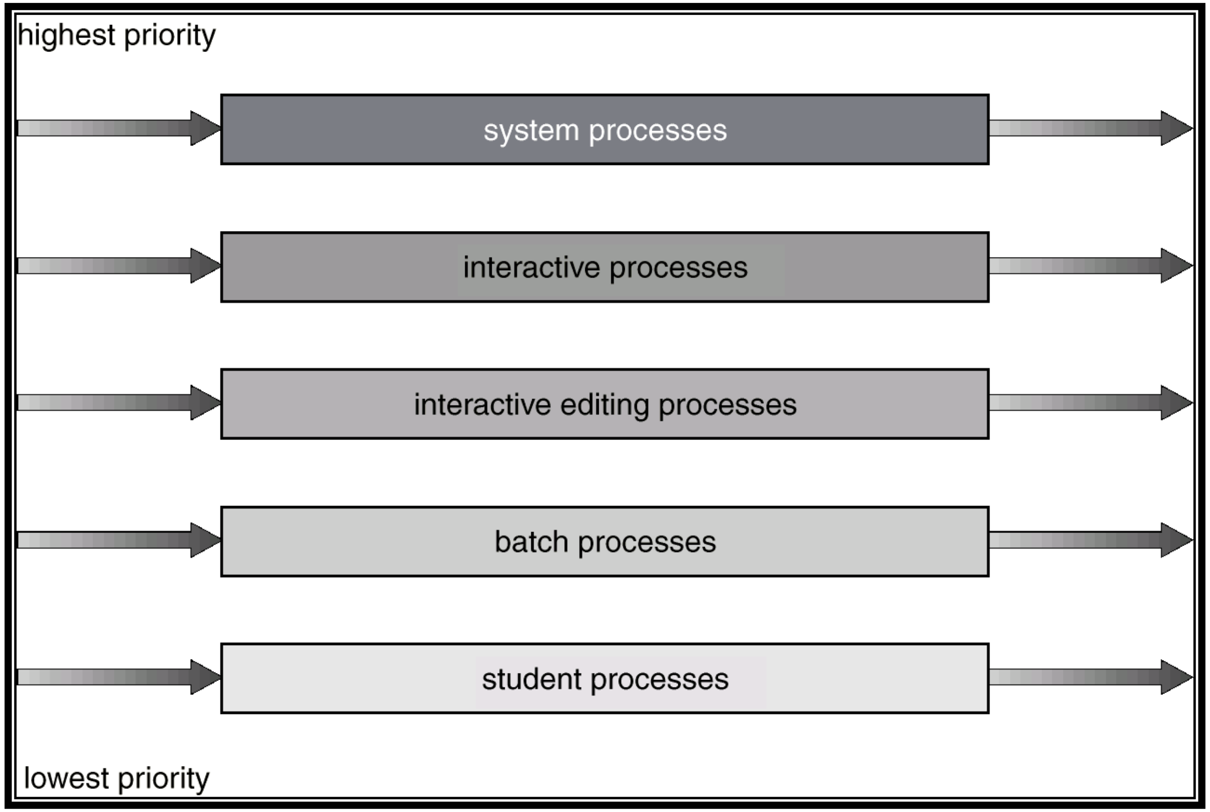
process	time
P_1	6
P_2	3
P_3	1
P_4	7

Multilevel Queue

Ready queue is partitioned into separate queues:
foreground (interactive)
background (batch)
Each queue has its own scheduling algorithm,
foreground – RR
background – FCFS
Scheduling must be done between the queues.

- 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
- 20% to background in FCFS

Multilevel Queue Scheduling



Multilevel Feedback Queue

A process can move between the various queues; aging can be implemented this way.

Multilevel-feedback-queue scheduler defined by the following parameters:

- 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

Example of Multilevel Feedback Queue

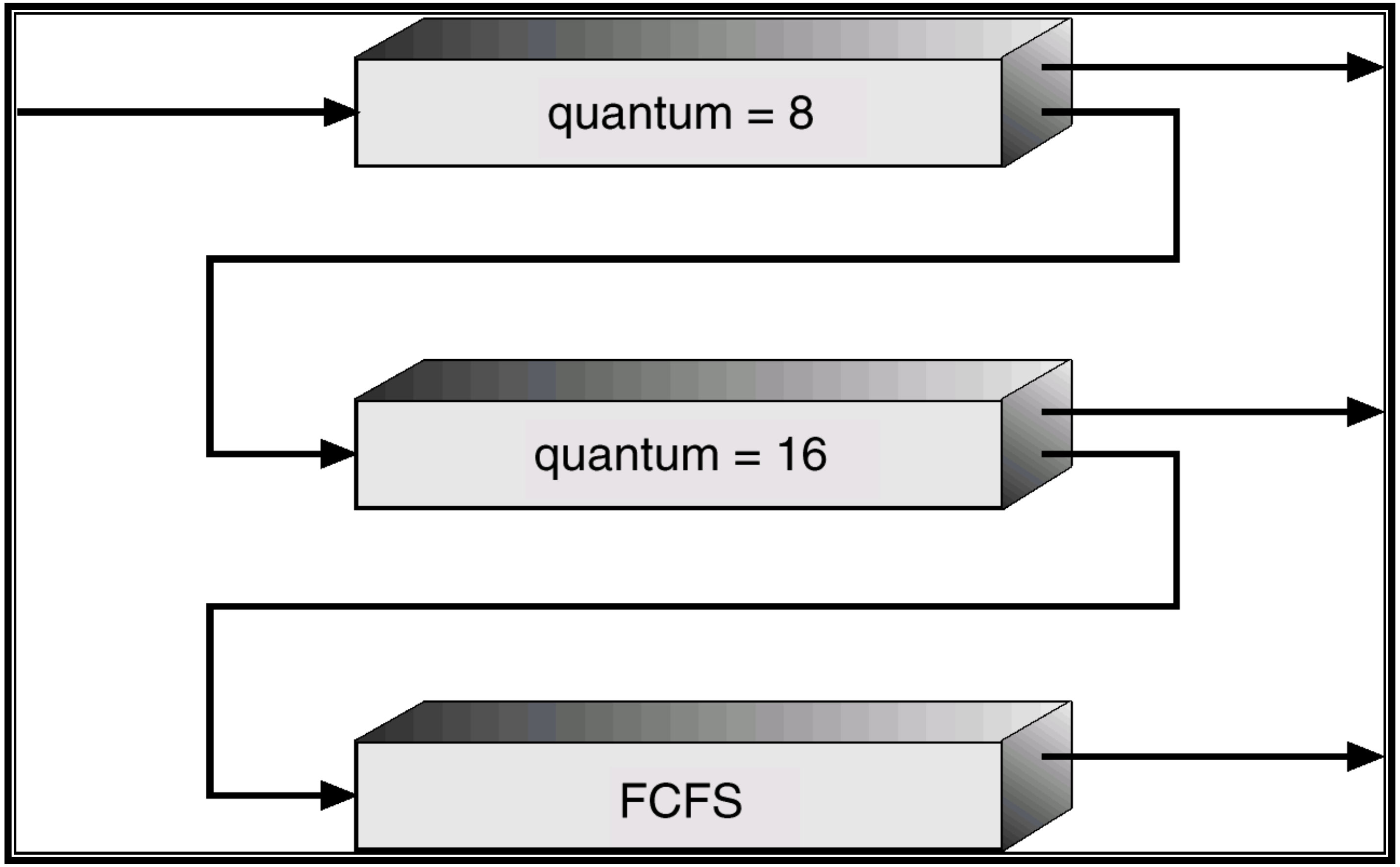
Three queues:

- Q_0 – time quantum 8 milliseconds
- Q_1 – time quantum 16 milliseconds
- Q_2 – FCFS

Scheduling

- A new job enters queue Q_0 which is served FCFS. 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 FCFS and receives 16 additional milliseconds. If it still does not complete, it is preempted and moved to queue Q_2.

Multilevel Feedback Queues



Multiple-Processor Scheduling

CPU scheduling more complex when multiple CPUs are available.
Homogeneous processors within a multiprocessor.
Load sharing
Asymmetric multiprocessing – only one processor accesses the system data structures, alleviating the need for data sharing.

THANK YOU