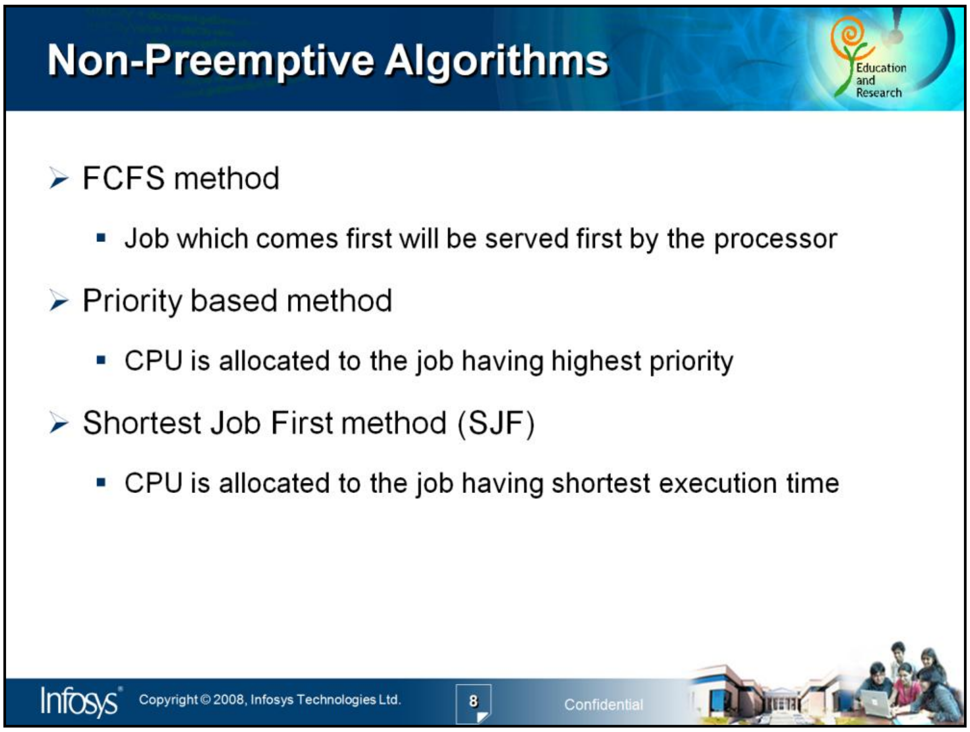
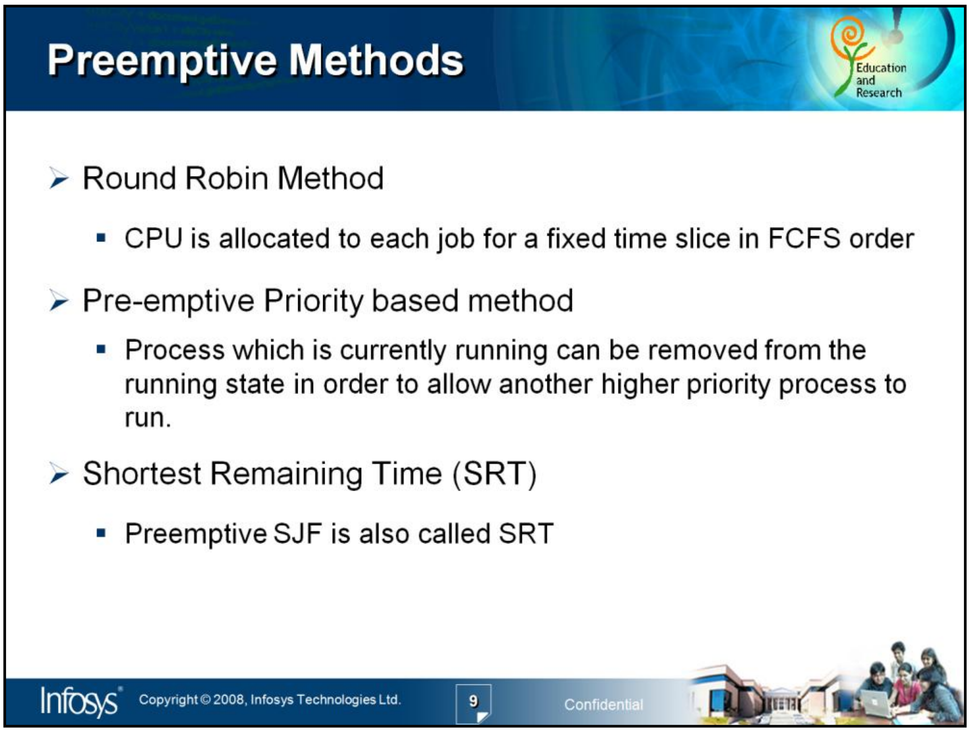


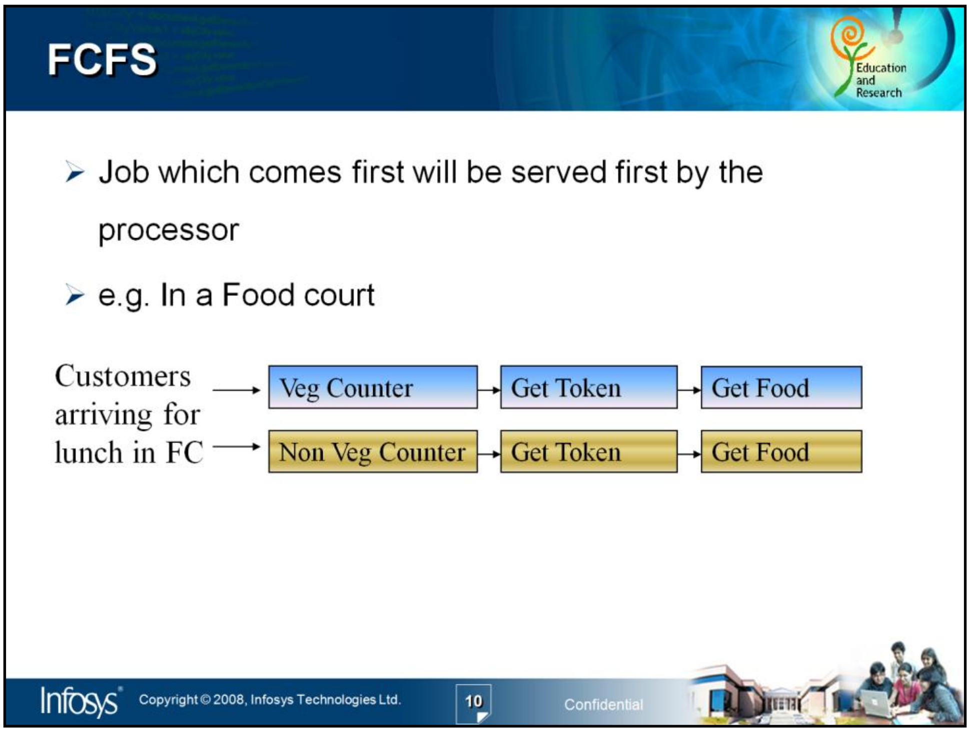
Non-Preemptive Algorithms

- FCFS method
  - Job which comes first will be served first by the processor
- Priority based method
  - CPU is allocated to the job having highest priority
- Shortest Job First method (SJF)
  - CPU is allocated to the job having shortest execution time



Preemptive Methods

- Round Robin Method
  - CPU is allocated to each job for a fixed time slice in FCFS order
- Pre-emptive Priority based method
  - Process which is currently running can be removed from the running state in order to allow another higher priority process to run.
- Shortest Remaining Time (SRT)
  - Preemptive SJF is also called SRT



Education
and
Research

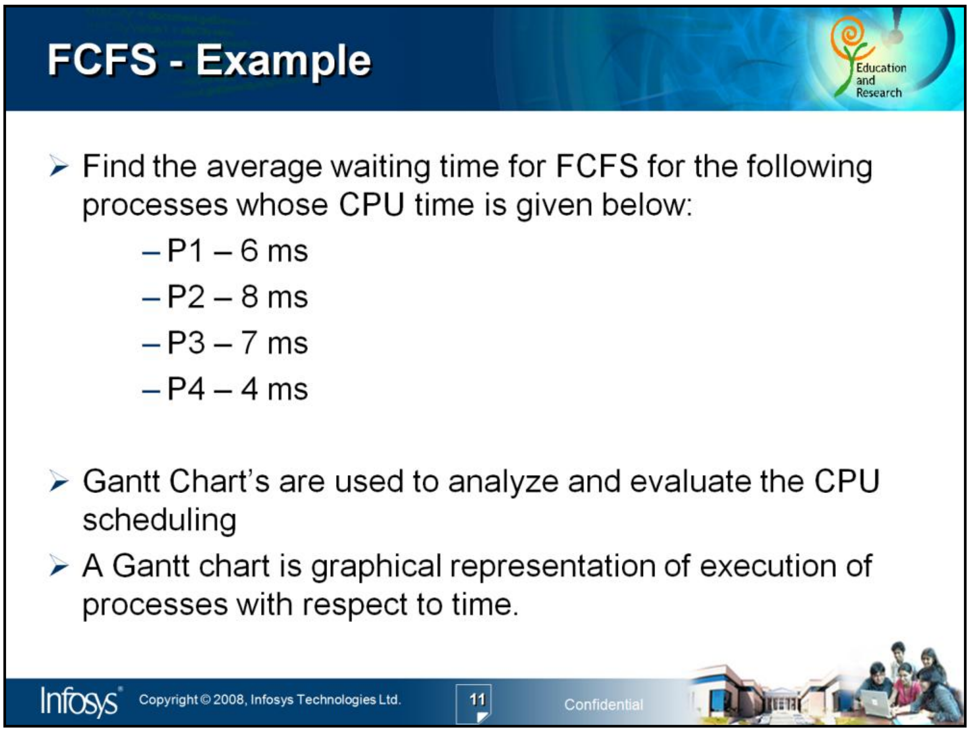
FCFS

- Job which comes first will be served first by the processor
- e.g. In a Food court

Customers arriving for lunch in FC

Veg Counter → Get Token → Get Food

Non Veg Counter → Get Token → Get Food



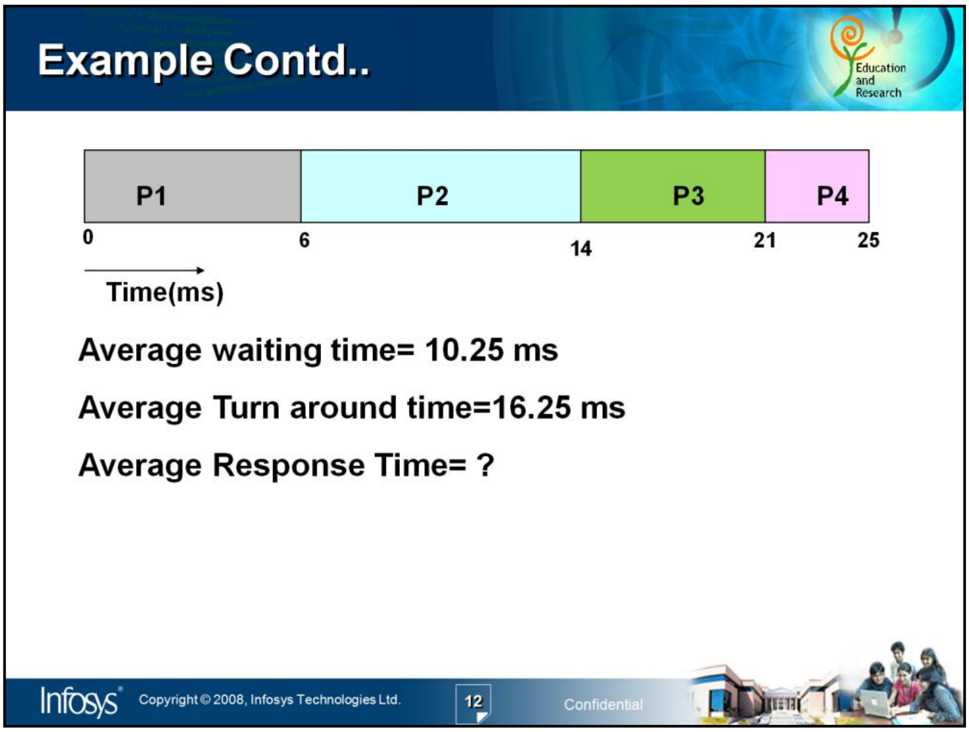
FCFS - Example

Education and Research

- Find the average waiting time for FCFS for the following processes whose CPU time is given below:
  - P1 – 6 ms
  - P2 – 8 ms
  - P3 – 7 ms
  - P4 – 4 ms

- Gantt Chart's are used to analyze and evaluate the CPU scheduling
- A Gantt chart is graphical representation of execution of processes with respect to time.

Infosys



Example Contd..

Average waiting time= 10.25 ms

Average Turn around time=16.25 ms

Average Response Time= ?

Solution:

Waiting time for P1 = 0ms

Waiting time for P2 = 6ms

Waiting time for P3 = 14ms

Waiting time for P4 = 21ms

Average waiting time = 41/4 = 10.25ms

Average Turn around time=(6+14+21+25)/4=16.5ms

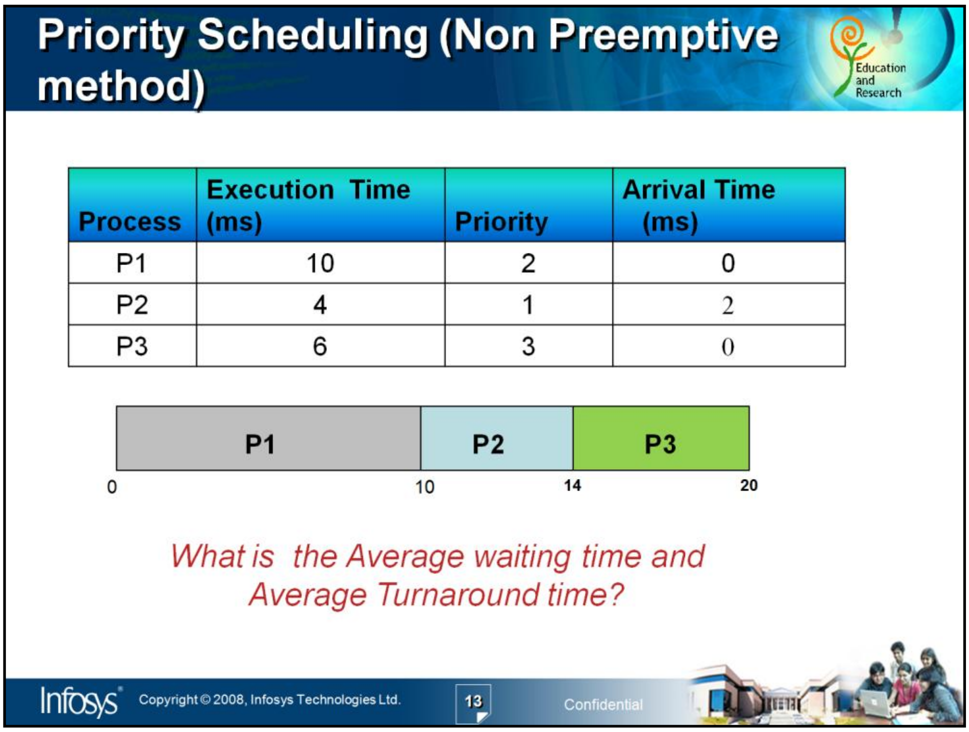
In above example note that we have assumed that all the process has arrived at the same point of time.

WT for P1=0,P2=6,P3=14 and P4=21.

Hence AWT=41/4=10.25

The A.T.A.T =A.W.T+ A.Exec.Time=10.25+ (6+8+7+4)/4=16.5

A.R.T= (0+6+14+21)/4=10.25



Priority Scheduling (Non Preemptive method)

Process	Execution Time (ms)	Priority	Arrival Time (ms)
P1	10	2	0
P2	4	1	2
P3	6	3	0

P1	P2	P3

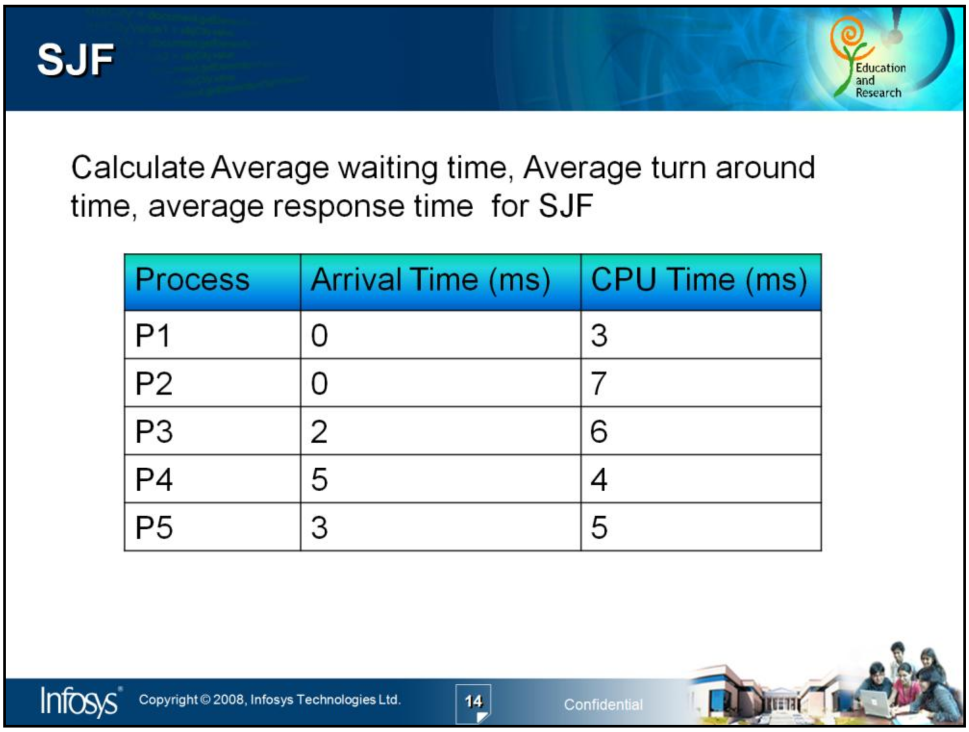
0 10 14 20

What is the Average waiting time and Average Turnaround time?

AWT=(0+(10-2)+(14))/3=7.33

A.T.A.T=7.33+20/3=7.33+6.67=14

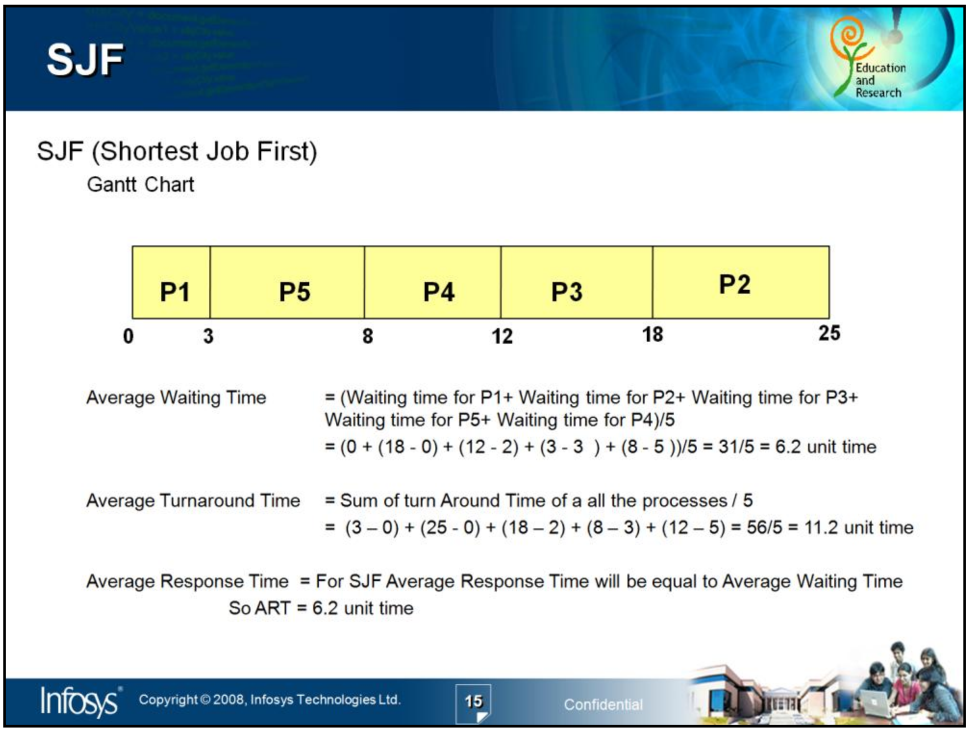
A.R.T=(0+8+14)/3=7.33



SJF

Calculate Average waiting time, Average turn around time, average response time for SJF

Process	Arrival Time (ms)	CPU Time (ms)
P1	0	3
P2	0	7
P3	2	6
P4	5	4
P5	3	5



SJF

Education and Research

SJF (Shortest Job First)

Gantt Chart

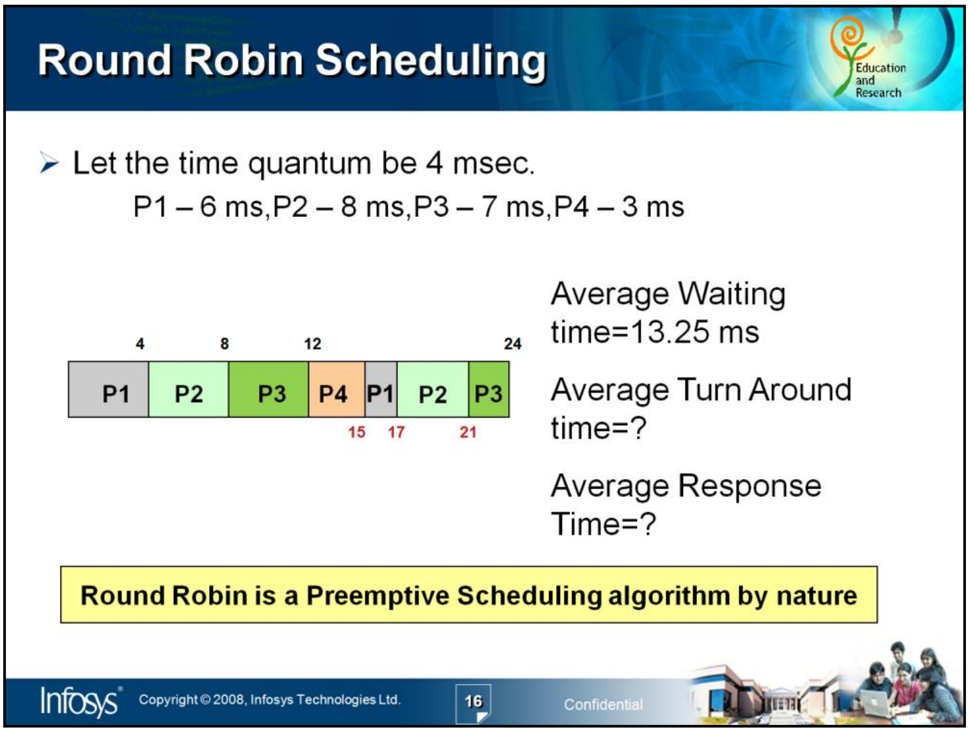
P1	P5	P4	P3	P2

0 3 8 12 18 25

Average Waiting Time = (Waiting time for P1+ Waiting time for P2+ Waiting time for P3+ Waiting time for P5+ Waiting time for P4)/5
= (0 + (18 - 0) + (12 - 2) + (3 - 3) + (8 - 5))/5 = 31/5 = 6.2 unit time

Average Turnaround Time = Sum of turn Around Time of a all the processes / 5
= (3 – 0) + (25 - 0) + (18 – 2) + (8 – 3) + (12 – 5) = 56/5 = 11.2 unit time

Average Response Time = For SJF Average Response Time will be equal to Average Waiting Time
So ART = 6.2 unit time



Round Robin Scheduling

- Let the time quantum be 4 msec.

  P1 – 6 ms,P2 – 8 ms,P3 – 7 ms,P4 – 3 ms

4
8
12
24
P1
P2
P3
P4
P1
P2
P3
15
17
21

Average Waiting time=13.25 ms

Average Turn Around time=?

Average Response Time=?

Round Robin is a Preemptive Scheduling algorithm by nature

Education and Research

Average Waiting time:

Waiting time for P1= Quantum Allocated to P2,P3,P4 in First Round=11

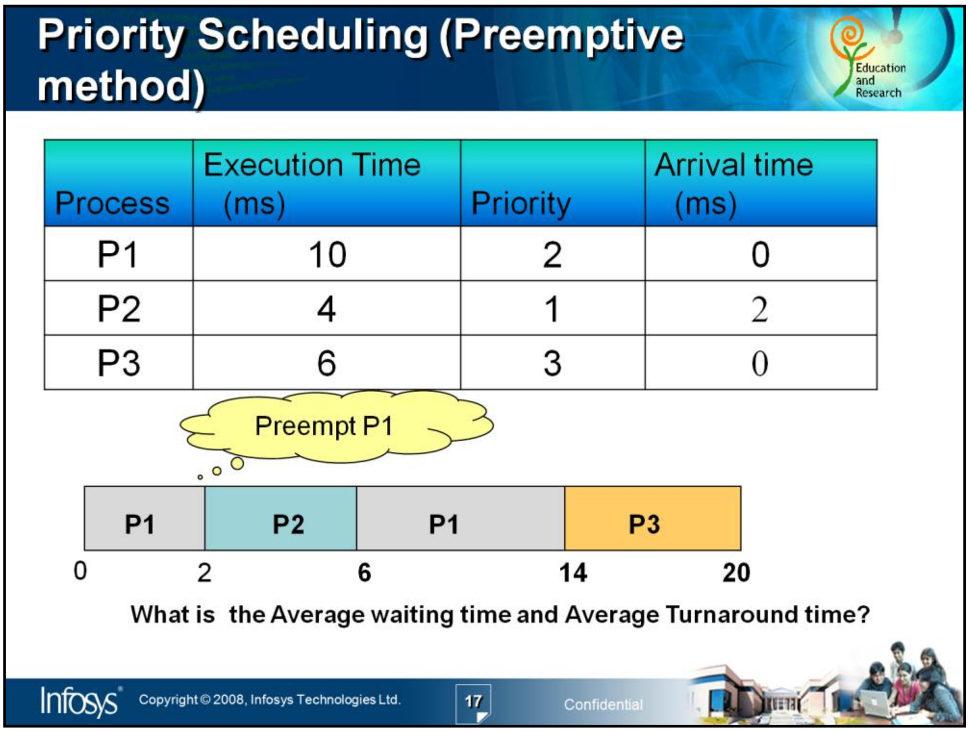
Waiting time for P2= Quantum Allocated to P1,P3,P4 in First Round=13

Waiting time for P3= Quantum Allocated to P1,P2,P4 in First Round and Quantum Allocated to P1 &P2 =17

Waiting time for P4= Quantum Allocated to P1,P2,P3 in First Round=12

Average waiting time=(11+13+17+12)/4=13.25

TAT=AWT+ Total Exec time of all processes.



Priority Scheduling (Preemptive method)

Process	Execution Time (ms)	Priority	Arrival time (ms)
P1	10	2	0
P2	4	1	2
P3	6	3	0

Preempt P1

P1	P2	P1	P3

0 2 6 14 20

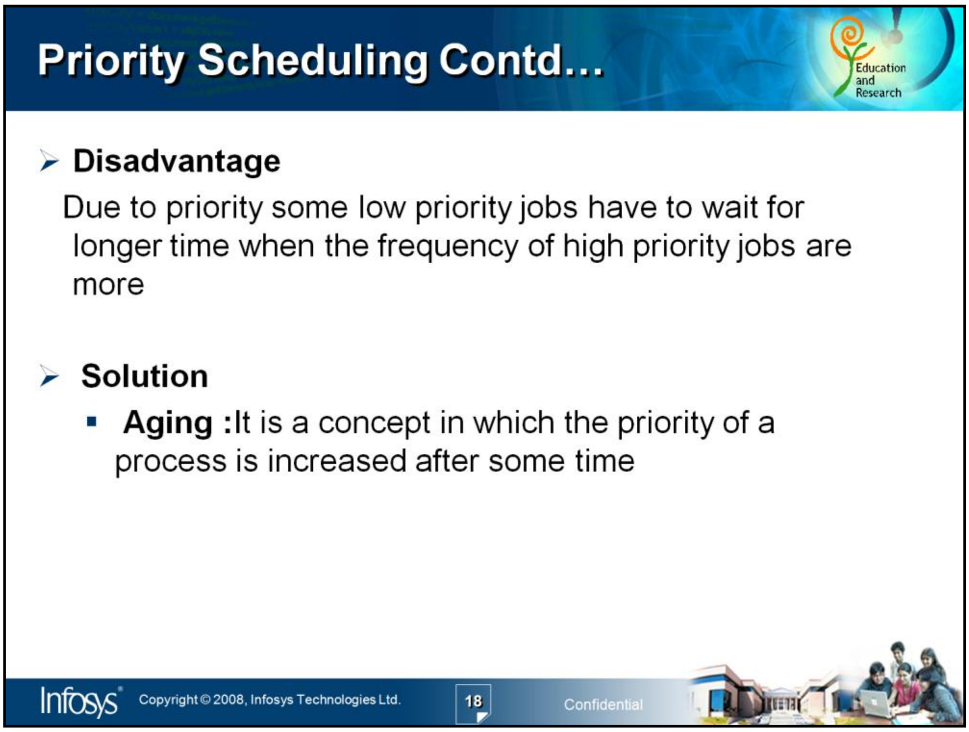
What is the Average waiting time and Average Turnaround time?

17 Confidential

AWT=((0+4)+0+14)/3=6

A.T.A.T=6+20/3=6+6.67=12.67

A.R.T=(0+0+14)/3=4.67

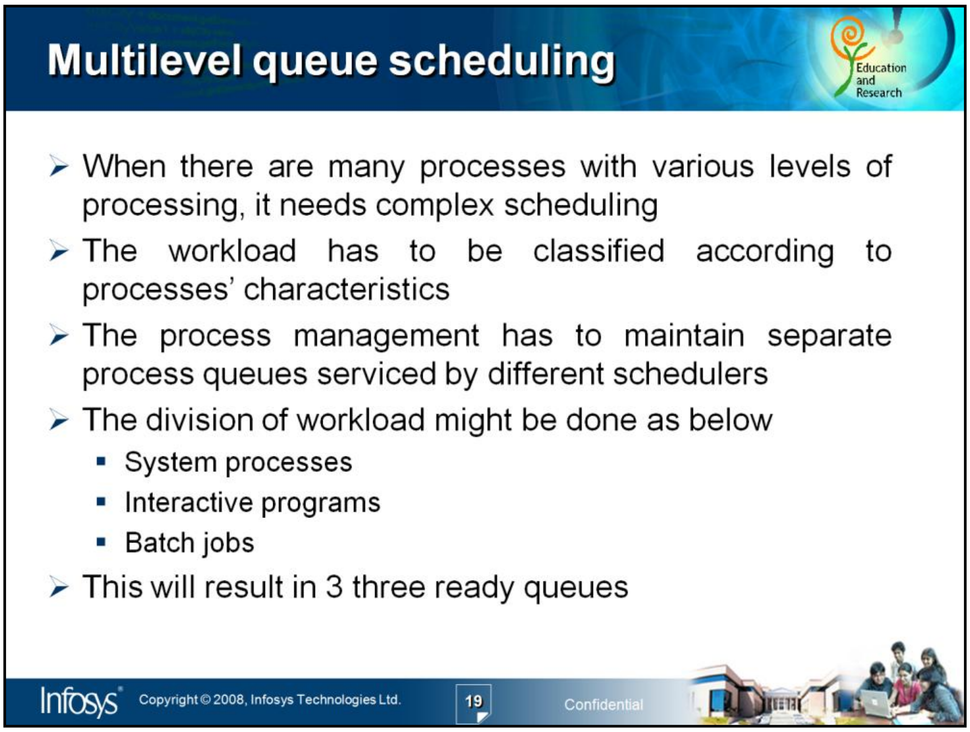


Priority Scheduling Contd…

- **Disadvantage**

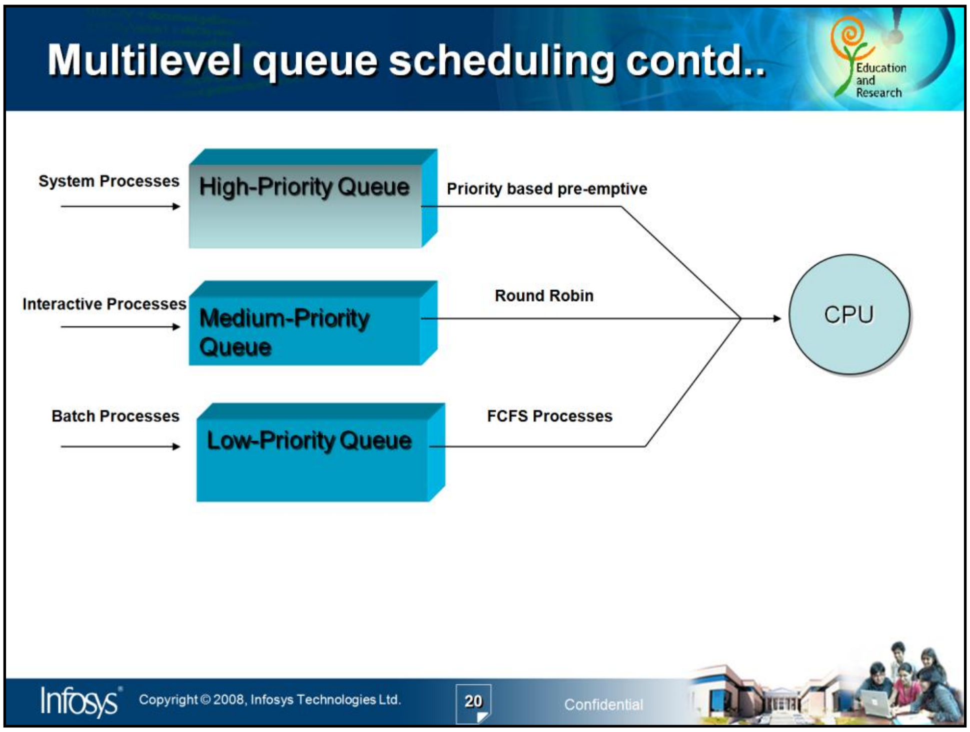
  Due to priority some low priority jobs have to wait for longer time when the frequency of high priority jobs are more

- **Solution**
  - **Aging :**It is a concept in which the priority of a process is increased after some time



Multilevel queue scheduling

- When there are many processes with various levels of processing, it needs complex scheduling
- The workload has to be classified according to processes' characteristics
- The process management has to maintain separate process queues serviced by different schedulers
- The division of workload might be done as below
  - System processes
  - Interactive programs
  - Batch jobs
- This will result in 3 three ready queues



Multilevel queue scheduling contd..

The three queues are implemented as below

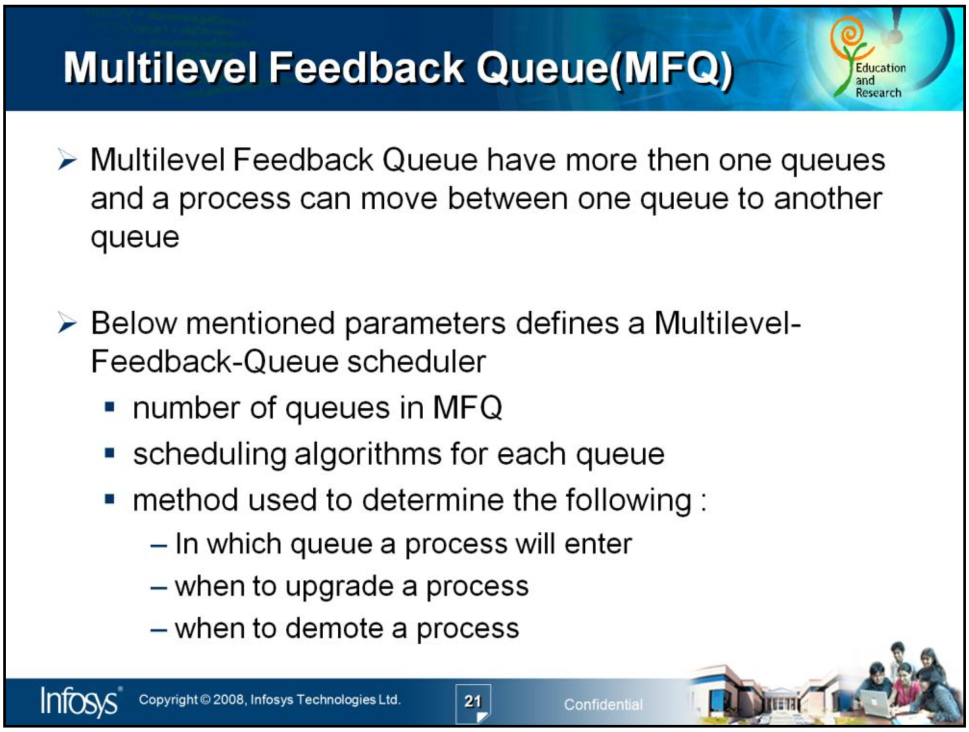
A process may be assigned to one of the above three queue based on some characteristics of the process. E.g system process , interactive process or Batch process. User can also specify the characteristics.

•The processes from the highest priority queue are serviced until that queue becomes empty. The scheduling policy is priority based pre-emptive.

•When the first queue (highest-priority) becomes empty, the next queue may be serviced using RR policy.

•When both the above queues are empty, the third (lowest-priority) queue is serviced using FCFS.

A lower priority process may be preempted when a higher-priority process arrives in one of the upper-level queues.

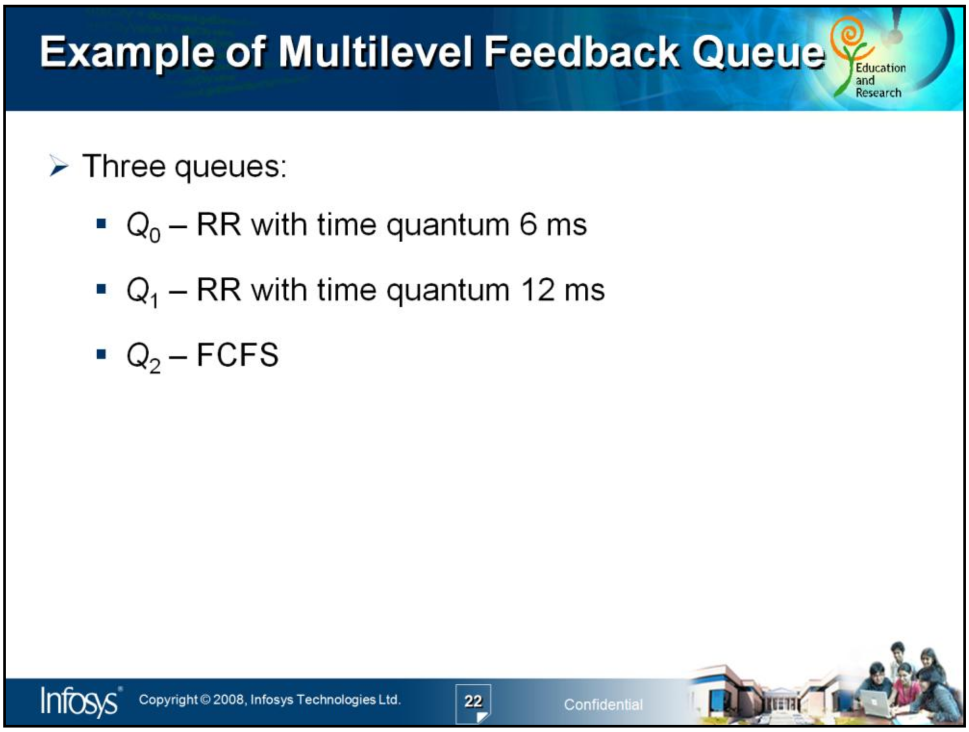


Multilevel Feedback Queue(MFQ)

Education and Research

- Multilevel Feedback Queue have more then one queues and a process can move between one queue to another queue
- Below mentioned parameters defines a Multilevel-Feedback-Queue scheduler
  - number of queues in MFQ
  - scheduling algorithms for each queue
  - method used to determine the following :
    - In which queue a process will enter
    - when to upgrade a process
    - when to demote a process

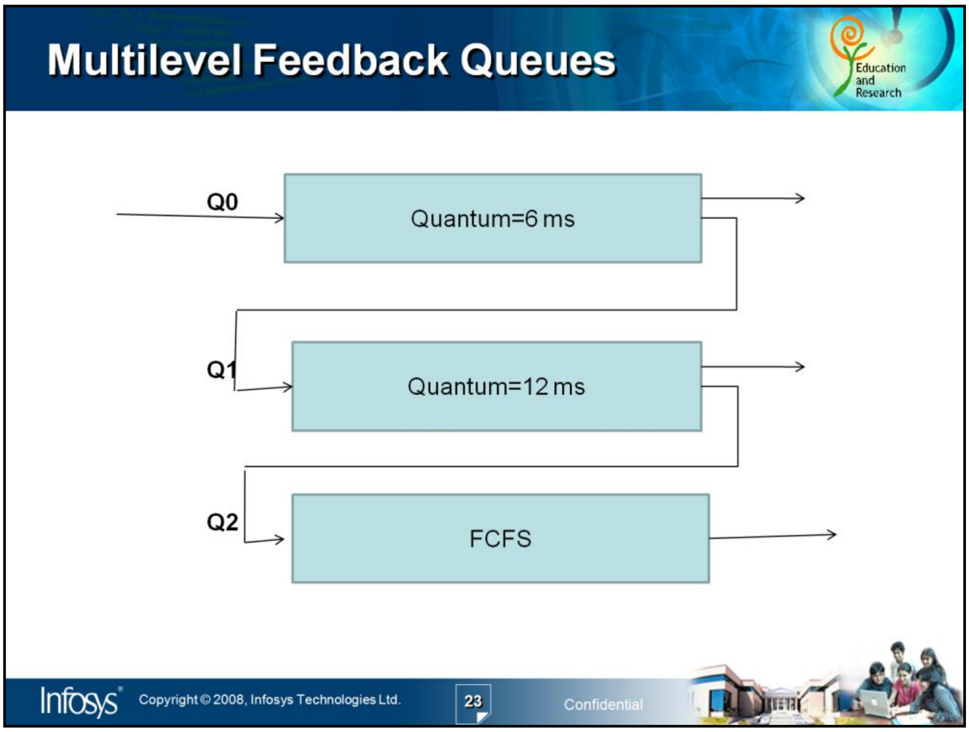
Aging can be achieved by moving the process from one queue to other.



Example of Multilevel Feedback Queue

Education and Research

- Three queues:
  - Q_0 – RR with time quantum 6 ms
  - Q_1 – RR with time quantum 12 ms
  - Q_2 – FCFS



Multilevel Feedback Queues

Q0

Quantum=6 ms

Q1

Quantum=12 ms

Q2

FCFS

Infosys

23

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A new process enters queue Q_0 .

In Q0 the algorithm is RR with time quantum of 6 ms. When the CPU will be allocated to Process it will be served for 6 ms.

If process will not be finished in 6 milliseconds it will be preempted and process will move to queue Q_1.

In Q_1 process will be served again using RR algorithm , with a time quantum of 12 ms.

If still, it will not complete, it will be preempted and moved to queue Q_2.

In Q2 process will be served using FCFS algorithm.