BITS, PILANI – K. K. BIRLA GOA CAMPUS

Operating Systems

(CS C372 & IS C362)

by

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OPERATING SYSTEMS
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LECTURE 14: CPU SCHEDULING

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.
- Uses preemption based on a clock.
- If there are $\boldsymbol{n}$ processes in the ready queue and the time quantum is $\boldsymbol{q}$, then each process gets $1/\boldsymbol{n}$ of the CPU time in chunks of at most $\boldsymbol{q}$ time units at once. No process waits more than $(\boldsymbol{n}-1)\boldsymbol{q}$ time units.

Round Robin (RR)

- Clock interrupt is generated at periodic intervals
- When an interrupt occurs, the currently running process is placed in the read queue
  - Next ready job is selected
- Known as time slicing
- Performance
  - $\boldsymbol{q}$ large $\Rightarrow$ FIFO
  - $\boldsymbol{q}$ small $\Rightarrow$ $\boldsymbol{q}$ must be large with respect to context switch, otherwise overhead is too high

Example of RR with Time Quantum = 4

<u>Process</u>	<u>Burst Time</u>
$\boldsymbol{P_1}$	24
$\boldsymbol{P_2}$	3
$\boldsymbol{P_3}$	3

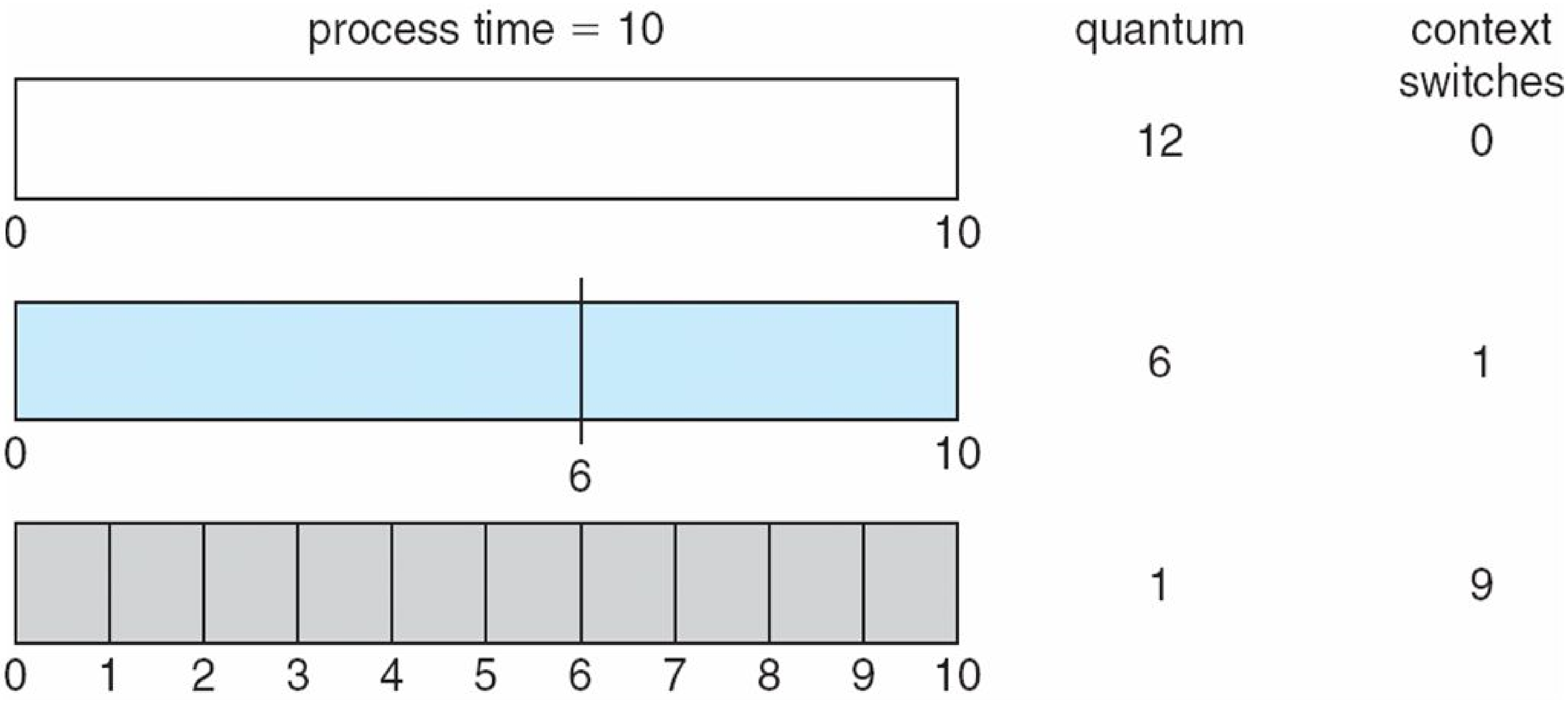
- The Gantt chart is:

P_1	P_2	P_3	P_1	P_1	P_1	P_1	P_1

0 4 7 10 14 18 22 26 30

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

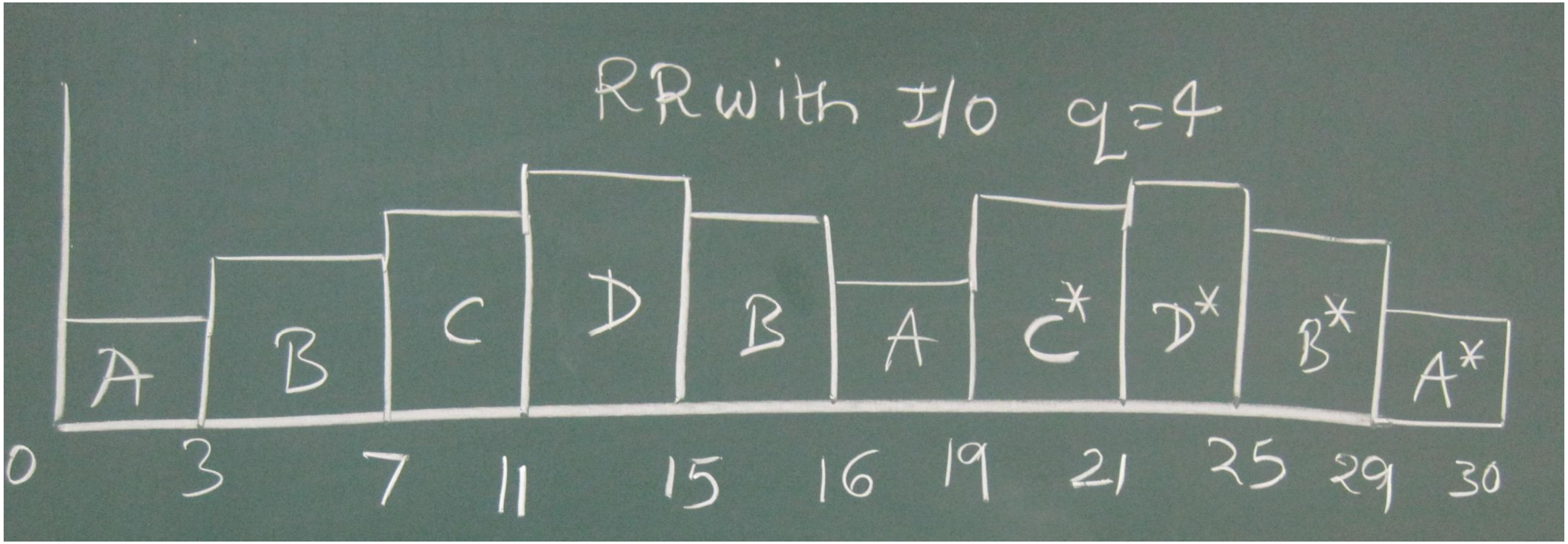
Time Quantum and Context Switch Time



RR with I/O, Time Quantum = 4

Process	Arrival Time	Execution Time
A	0	7
B	2	9
C	4	6
D	6	8

- Assume process A goes for I/O for 5 units of time after every 3 unit execution in CPU
- Assume B goes for I/O for 2 units after 5 units of execution in CPU
- Process C is a CPU bound process with no I/O
- Process D goes for I/O for 1 unit after 4 units of execution in CPU.



RR with I/O q=4
A
B
C
D
B
A
C*
D*
B*
A*
0
3
7
11
15
16
19
21
25
29
30

Virtual Round Robin

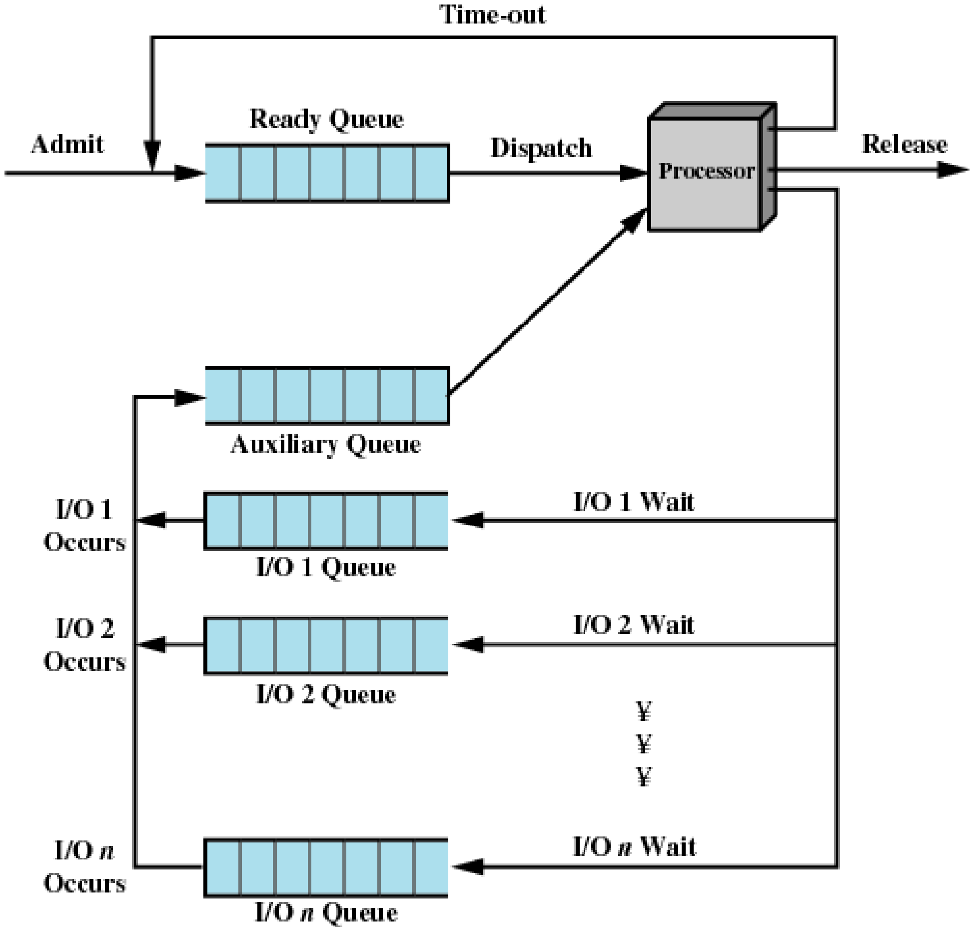
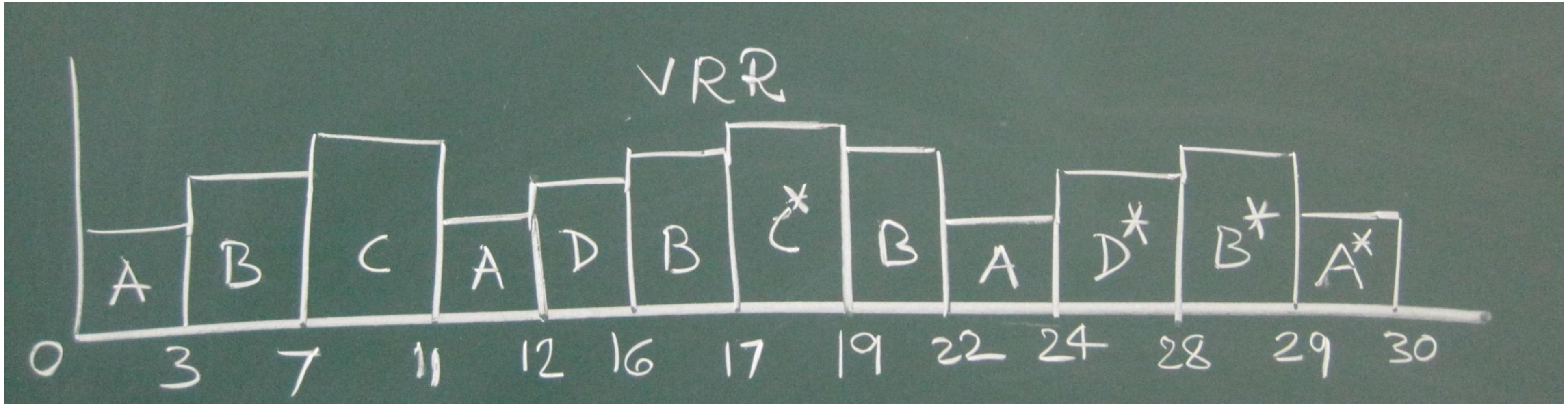


Figure 9.7 Queuing Diagram for Virtual Round-Robin Scheduler

VRR with I/O, Time Quantum = 4

Process	Arrival Time	Execution Time
A	0	7
B	2	9
C	4	6
D	6	8

- Assume process A goes for I/O for 5 units of time after every 3 unit execution in CPU
- Assume B goes for I/O for 2 units after 5 units of execution in CPU
- Process C is a CPU bound process with no I/O
- Process D goes for I/O for 1 unit after 4 units of execution in CPU.

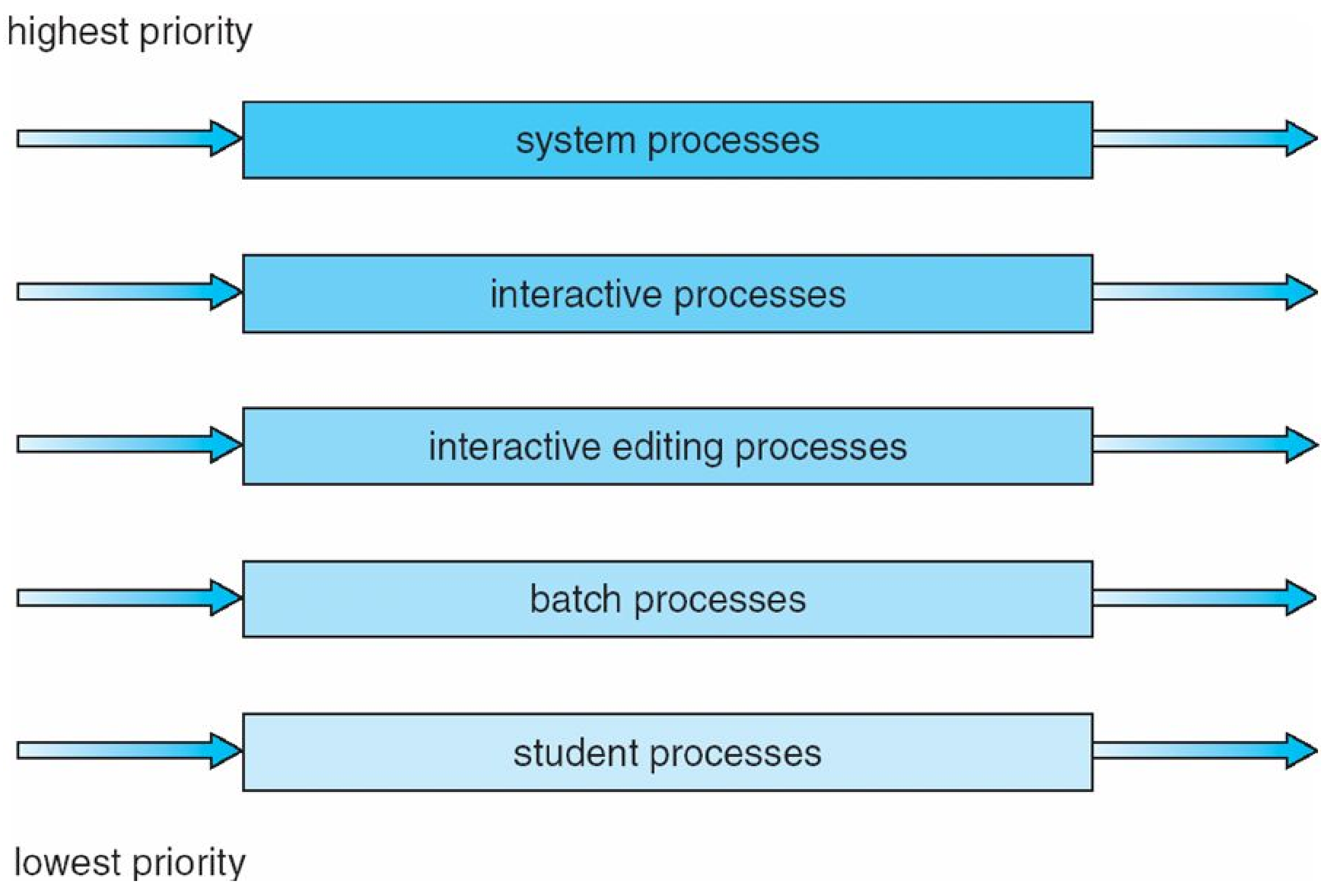

VRR
A
B
C
A
D
B
C*
B
A
D*
B*
A*
0
3
7
11
12
16
17
19
22
24
28
29
30

Multilevel Queue

- Ready queue is partitioned into separate queues:
  foreground (interactive)
  background (batch)

- Each queue has its own scheduling algorithm
  - foreground – RR
  - background – FCFS

Multilevel Queue Scheduling



Multilevel Queue

- 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 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

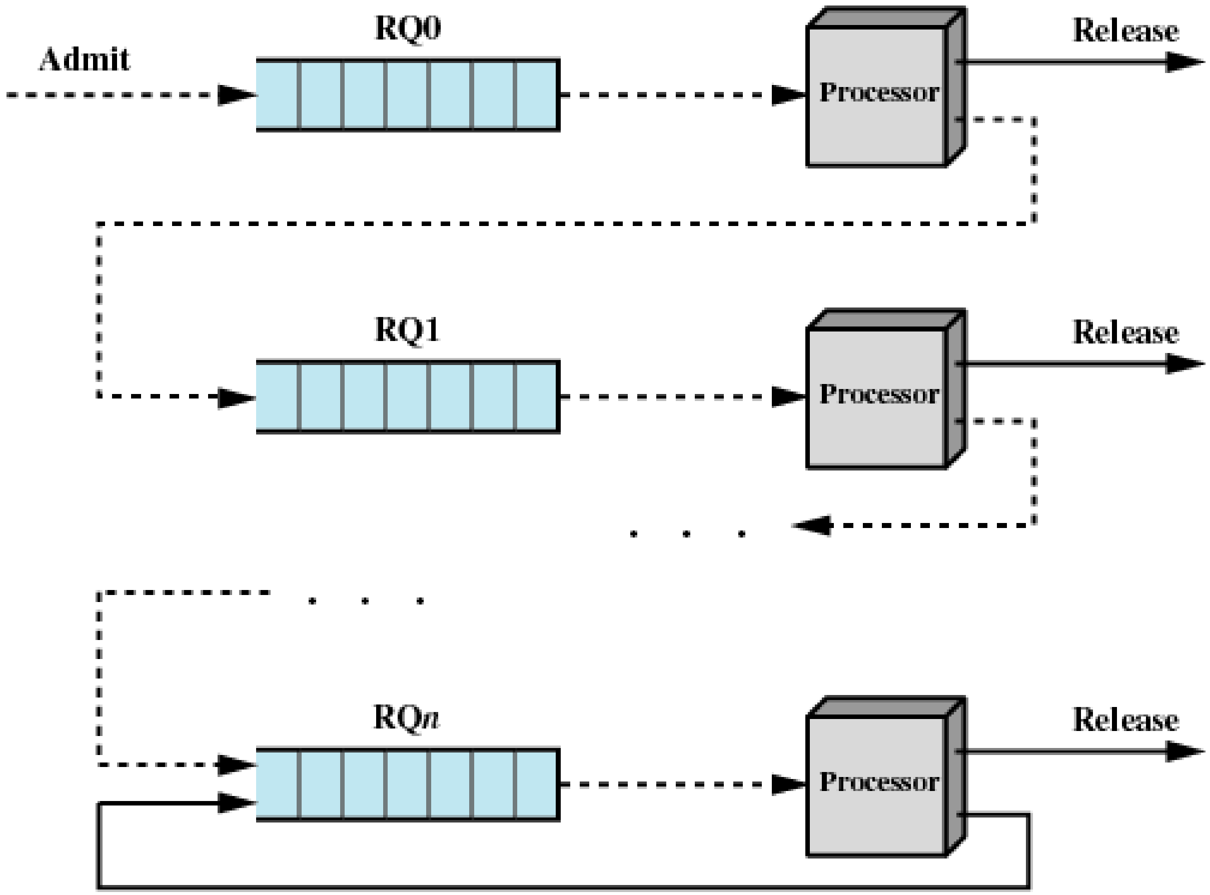
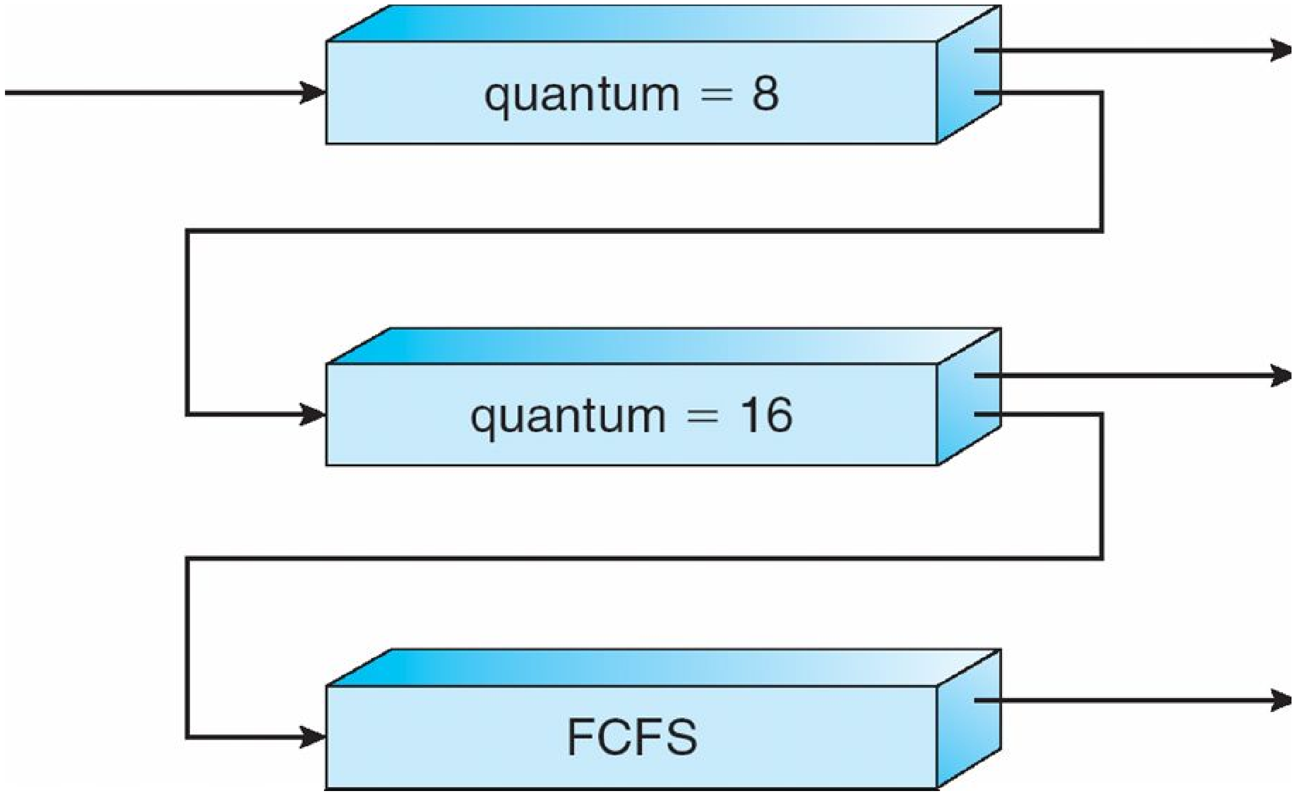


Figure 9.10 Feedback Scheduling

Example of Multilevel Feedback Queues



Example of Multilevel Feedback Queue

- Three queues:
  - $\boldsymbol{Q}_0$ – RR with time quantum 8 milliseconds
  - $\boldsymbol{Q}_1$ – RR time quantum 16 milliseconds
  - $\boldsymbol{Q}_2$ – FCFS
- Scheduling
  - A new job enters queue $\boldsymbol{Q}_{\boldsymbol{0}}$ 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 $\boldsymbol{Q}_1$.
  - At $\boldsymbol{Q}_1$ job is again served FCFS and receives 16 additional milliseconds. If it still does not complete, it is preempted and moved to queue $\boldsymbol{Q}_2$.

Table 9.3 Characteristics of Various Scheduling Policies

	Selection Function	Decision Mode	Throughput	Response Time	Overhead	Effect on Processes	Starvation
FCFS	max[w]	Nonpreemptive	Not emphasized	May be high, especially if there is a large variance in process execution times	Minimum	Penalizes short processes; penalizes I/O bound processes	No
Round Robin	constant	Preemptive (at time quantum)	May be low if quantum is too small	Provides good response time for short processes	Minimum	Fair treatment	No
SPN	min[s]	Nonpreemptive	High	Provides good response time for short processes	Can be high	Penalizes long processes	Possible
SRT	min[$s - e$]	Preemptive (at arrival)	High	Provides good response time	Can be high	Penalizes long processes	Possible
HRRN	$\max\left(\frac{w+s}{s}\right)$	Nonpreemptive	High	Provides good response time	Can be high	Good balance	No
Feedback	(see text)	Preemptive (at time quantum)	Not emphasized	Not emphasized	Can be high	May favor I/O bound processes	Possible

w = time spent waiting
e = time spent in execution so far
s = total service time required by the process, including e

Table 9.5 A Comparison of Scheduling Policies

	Process	A	B	C	D	E	
	Arrival Time	0	2	4	6	8	
	Service Time (T_s)	3	6	4	5	2	Mean
FCFS	Finish Time	3	9	13	18	20	
	Turnaround Time (T_r)	3	7	9	12	12	8.60
	T_r/T_s	1.00	1.17	2.25	2.40	6.00	2.56
RR $q = 1$	Finish Time	4	18	17	20	15	
	Turnaround Time (T_r)	4	16	13	14	7	10.80
	T_r/T_s	1.33	2.67	3.25	2.80	3.50	2.71
RR $q = 4$	Finish Time	3	17	11	20	19	
	Turnaround Time (T_r)	3	15	7	14	11	10.00
	T_r/T_s	1.00	2.5	1.75	2.80	5.50	2.71
SPN	Finish Time	3	9	15	20	11	
	Turnaround Time (T_r)	3	7	11	14	3	7.60
	T_r/T_s	1.00	1.17	2.75	2.80	1.50	1.84
SRT	Finish Time	3	15	8	20	10	
	Turnaround Time (T_r)	3	13	4	14	2	7.20
	T_r/T_s	1.00	2.17	1.00	2.80	1.00	1.59
HRRN	Finish Time	3	9	13	20	15	
	Turnaround Time (T_r)	3	7	9	14	7	8.00
	T_r/T_s	1.00	1.17	2.25	2.80	3.5	2.14
FB $q = 1$	Finish Time	4	20	16	19	11	
	Turnaround Time (T_r)	4	18	12	13	3	10.00
	T_r/T_s	1.33	3.00	3.00	2.60	1.5	2.29
FB $q = 2^i$	Finish Time	4	17	18	20	14	
	Turnaround Time (T_r)	4	15	14	14	6	10.60
	T_r/T_s	1.33	2.50	3.50	2.80	3.00	2.63