Priorities

- Scheduler will always choose a process of higher priority over one of lower priority
- Have multiple ready queues to represent each level of priority
- Lower-priority may suffer starvation
  - Allow a process to change its priority based on its age or execution history

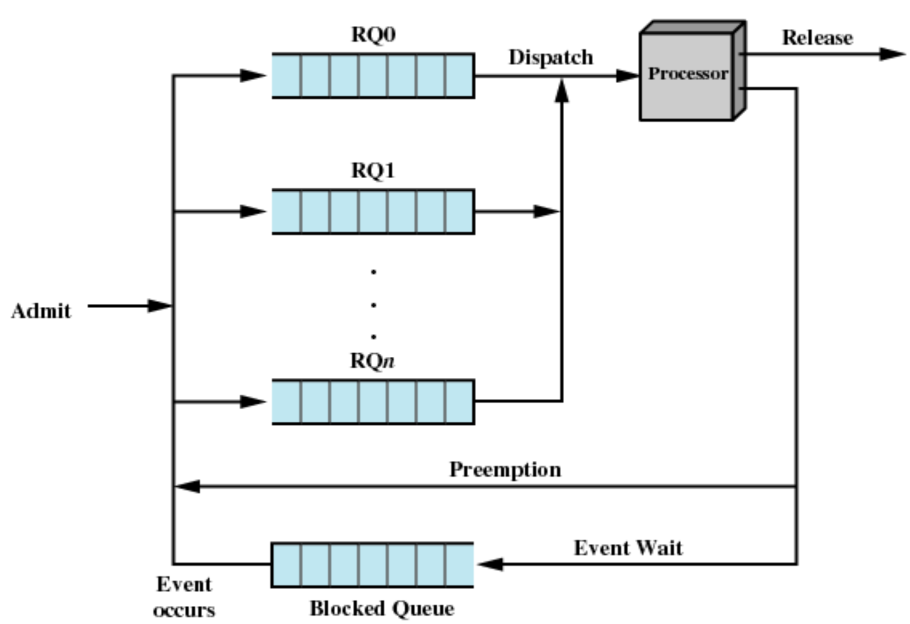

Figure 9.4 Priority Queuing

Decision Mode

- Nonpreemptive
  - Once a process is in the running state, it will continue until it terminates or blocks itself for I/O
- Preemptive
  - Currently running process may be interrupted and moved to the Ready state by the operating system
  - Allows for better service since any one process cannot monopolize the processor for very long

Process Scheduling Example

Table 9.4 Process Scheduling Example

Process	Arrival Time	Service Time
A	0	3
B	2	6
C	4	4
D	6	5
E	8	2

First-Come-First-Served (FCFS)

Table 9.4 Process Scheduling Example

Process	Arrival Time	Service Time
A	0	3
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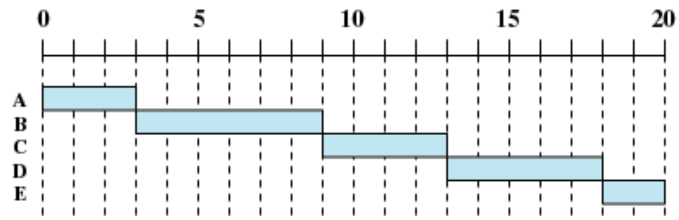
First-Come-First Served (FCFS)



- Each process joins the Ready queue
- When the current process ceases to execute, the oldest process in the Ready queue is selected

First-Come-First-Served (FCFS)

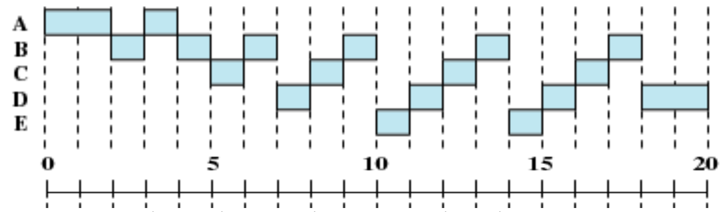
- Also called FIFO
- Performs much better for long processes
  - A short process may have to wait a very long time before it can execute
- Favors CPU-bound processes
  - I/O processes have to wait until CPU-bound process completes

Round-Robin

Table 9.4 Process Scheduling Example

Process	Arrival Time	Service Time
A	0	3
B	2	6
C	4	4
D	6	5
E	8	2

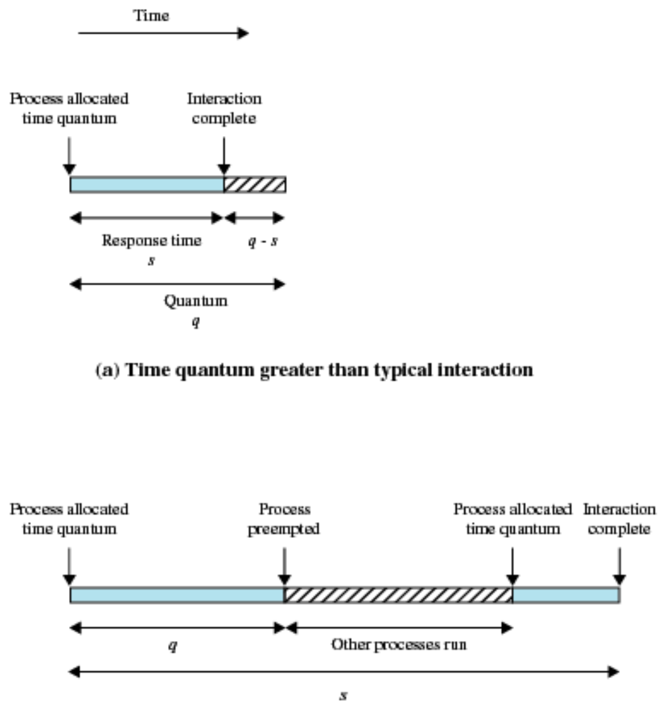
Round-Robin (RR), $q = 1$



- Uses preemption based on a clock
  - quantum *q*
- An amount of time is determined that allows each process to use the processor for that length of time

Round-Robin

- 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*



(a) Time quantum greater than typical interaction

(b) Time quantum less than typical interaction

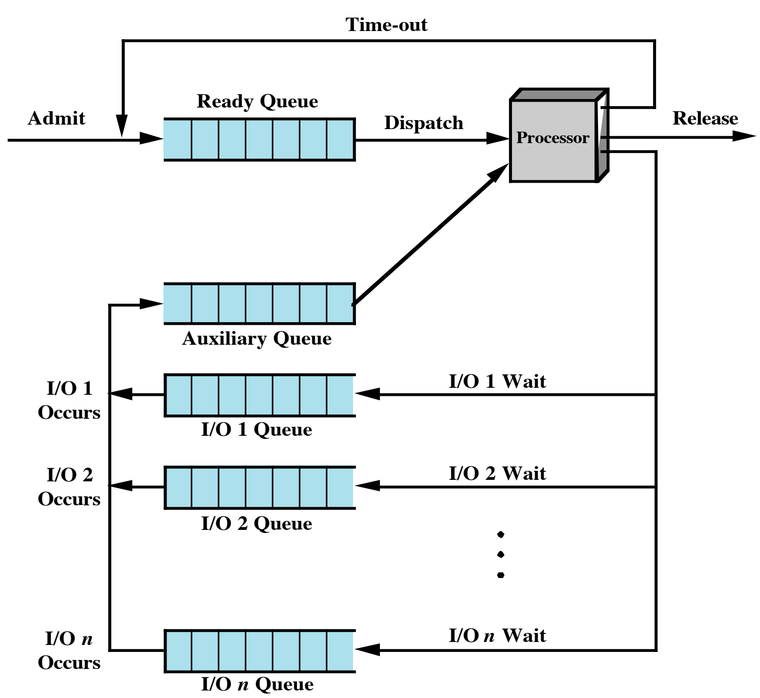


Figure 9.7 Queuing Diagram for Virtual Round-Robin Scheduler

Shortest Process Next

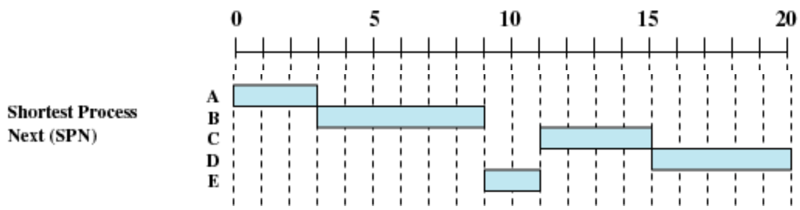


Table 9.4 Process Scheduling Example

Process	Arrival Time	Service Time
A	0	3
B	2	6
C	4	4
D	6	5
E	8	2

- Nonpreemptive policy
- Process with shortest expected processing time is selected next
- Short process jumps ahead of longer processes

Shortest Process Next

- Need to predict (or estimate) run time
- If estimated time for process not correct, the operating system may abort it
- Possibility of starvation for longer processes

Shortest Process Next

- Predictions (using simplest calculations)
  - T_i time for *i*-th instance of process
  - S_i predicted execution time for *i*-th instance
  - Simplest scenario, e.g. batch processing in burst mode

$$S_{n+1} = \frac{1}{n}\sum_{i=1}^{n} T_i$$

  - Avoiding recalculating entire sum

$$S_{n+1} = \frac{1}{n}T_n + \frac{n-1}{n}S_n$$

Shortest Process Next

- Previous calculations assumed equal weight
  - typically give higher weight to recent instances
  - exponential averaging: α a constant weight factor (0 < α < 1)

$$S_{n+1} = \alpha T_n + (1-\alpha)S_n$$

$$S_{n+1} = \alpha T_n + (1-\alpha)\alpha T_{n-1} + \ldots$$
$$+(1-\alpha)^i \alpha T_{n-i} + \ldots + (1-\alpha)^n S_1$$

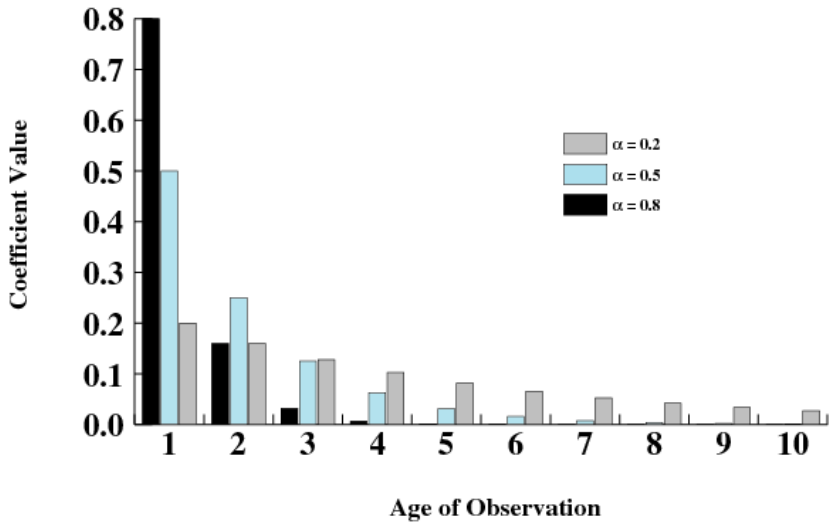


Figure 9.8 Exponential Smoothing Coefficients

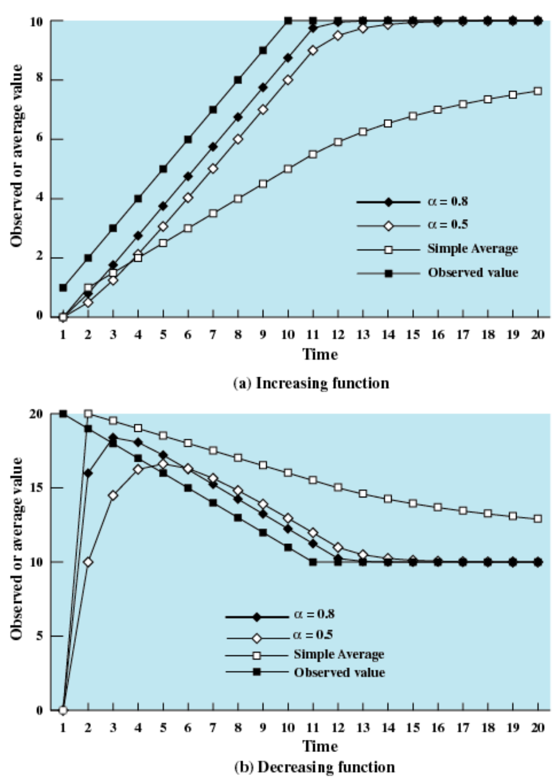


Figure 9.9 Use of Exponential Averaging