Uniprocessor Scheduling

Chapter 9

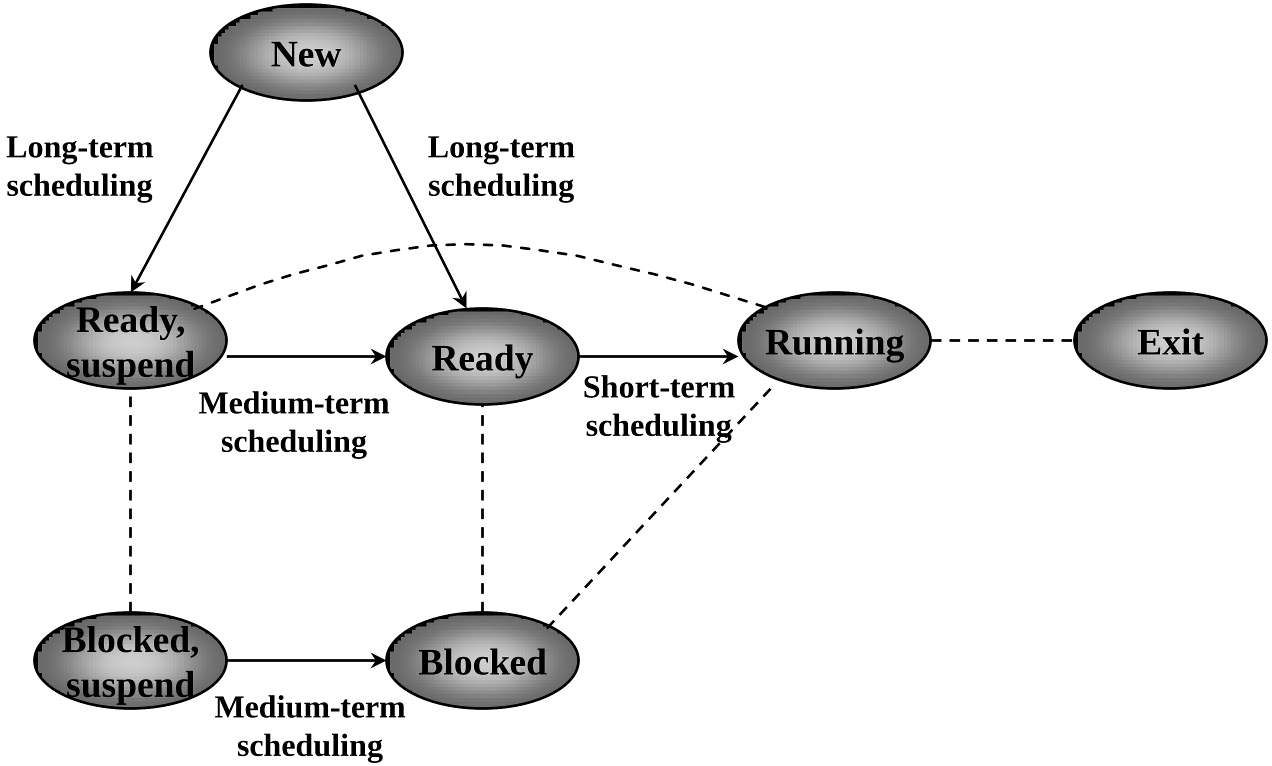
Goals of Scheduling

- ✓ Quick response time
- ✓ Fast throughput
- ✓ Processor efficiency

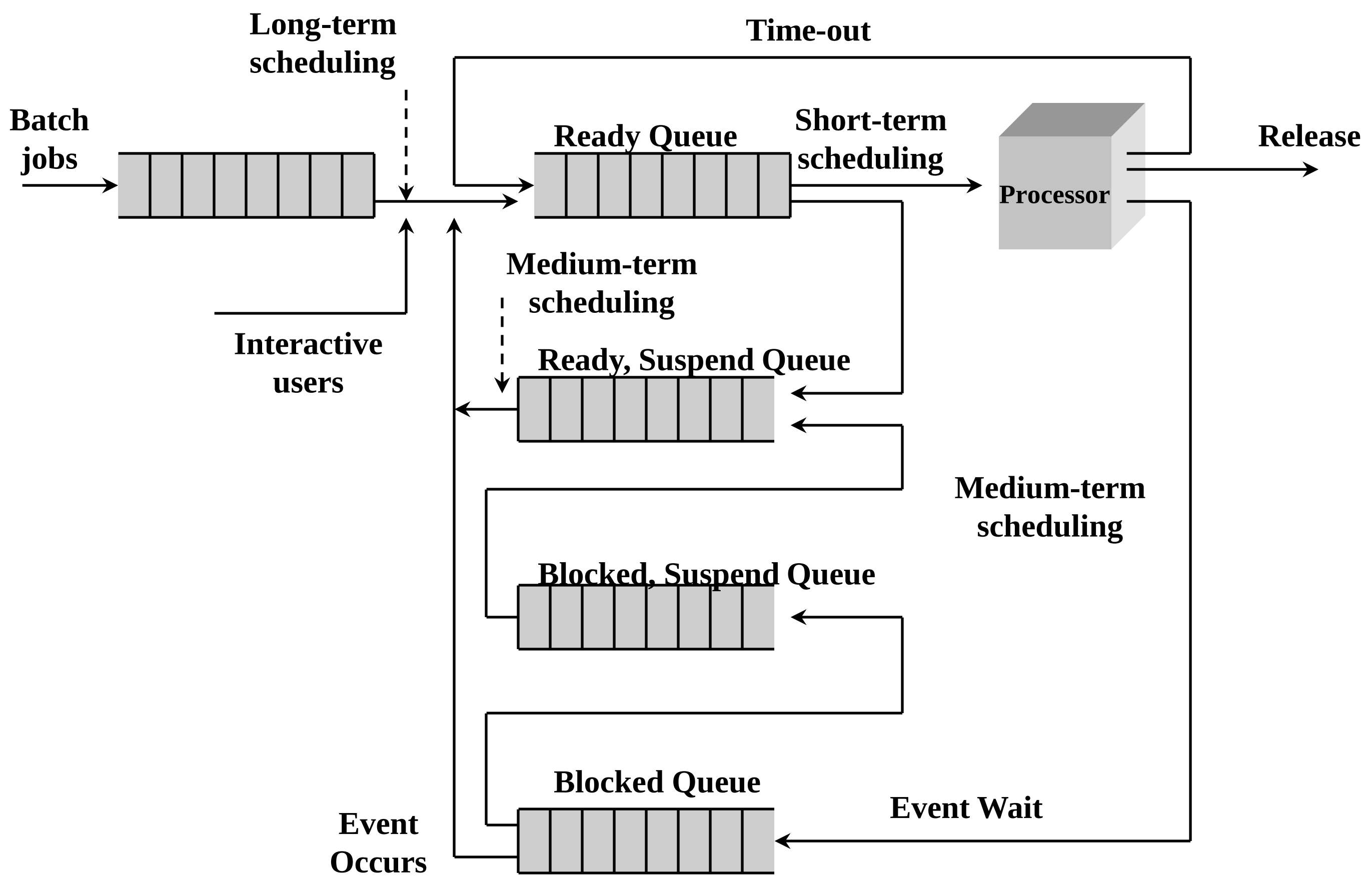
Type of Scheduling

- *Long-term*
  - performed when new process is created
- *Medium-term*
  - swapping
- *Short-term*
  - decision as to which ready process will be executed by the processor
- *I/O*
  - decision as to which process's pending I/O request shall be handled by available I/O device

Scheduling and Process State Transition



Queuing Diagram for Scheduling



Long-Term Scheduling

- Determines which programs are admitted to the system for processing
- Controls the degree of multiprogramming
- More processes, smaller percentage of time each process is executed

Medium-Term Scheduling

- ✓ Swapping
- ✓ Based on the need to manage multiprogramming (it is hard to foresee the CPU and memory requirements of processes in the long-term scheduling phase).

Short-Term Scheduling

- Performed by the *dispatcher*
- Invoked when an event occurs, e.g.
  - clock interrupt
  - I/O interrupt
  - operating system call
  - signal (e.g., when software events occur)

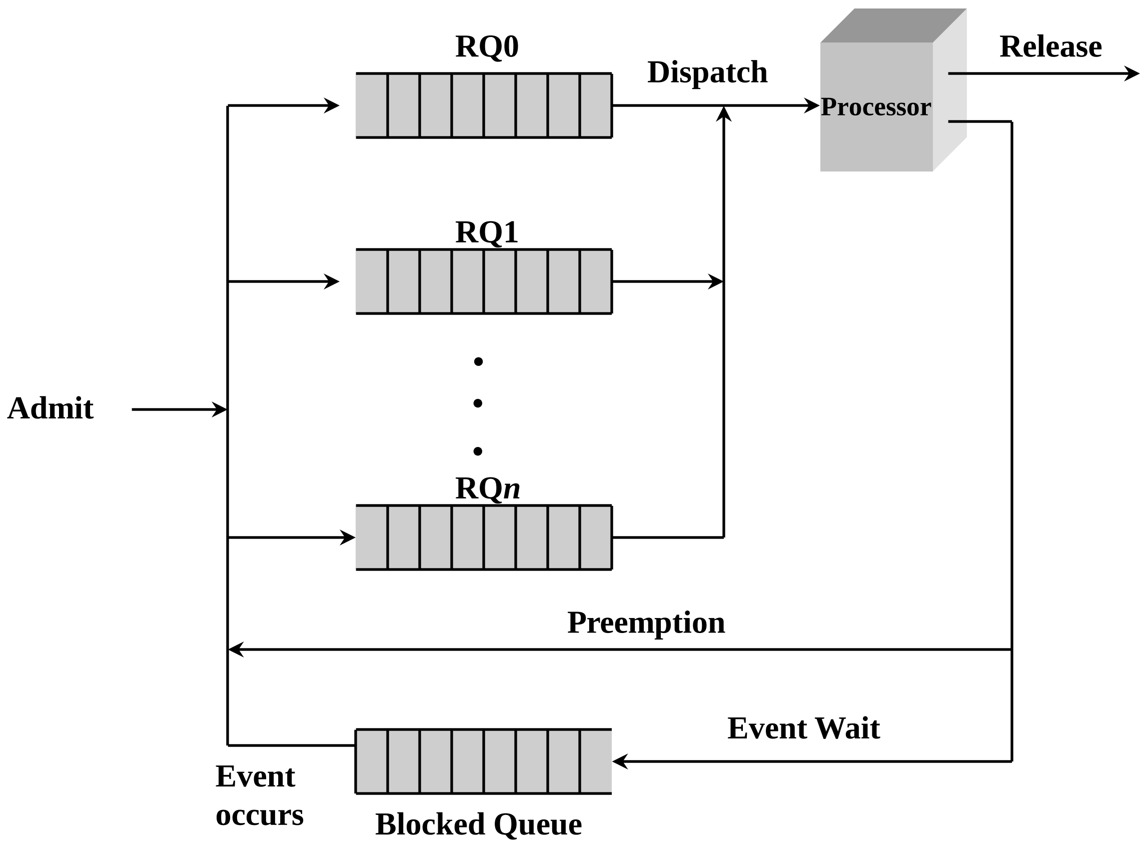
Short-Tem Scheduling Criteria

- User-oriented
  - Response Time
    - Elapsed time between the submission of a request until there is output.
- System-oriented
  - effective and efficient utilization of the processor
- Performance-related
  - response time and throughput
- Not performance related
  - predictability (e.g., fairness, no starvation)

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

Priority Queuing



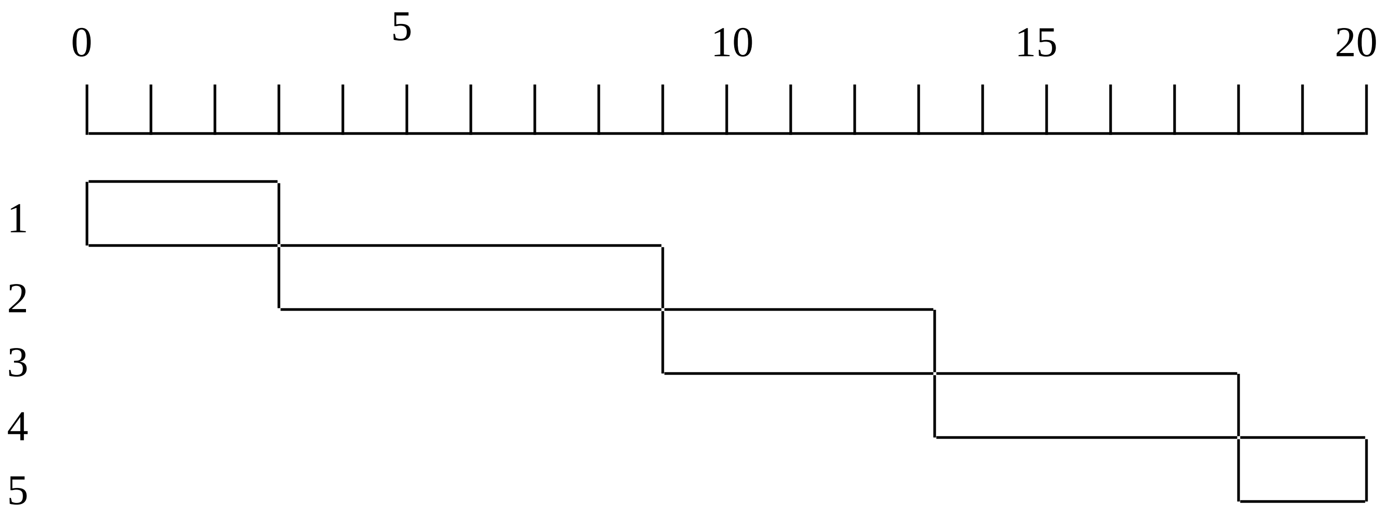
Decision Mode

- ✓ *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 no process can monopolize the processor for very long

An Example

Process	Arrival Time	Service Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2

First-Come-First-Served (FCFS)

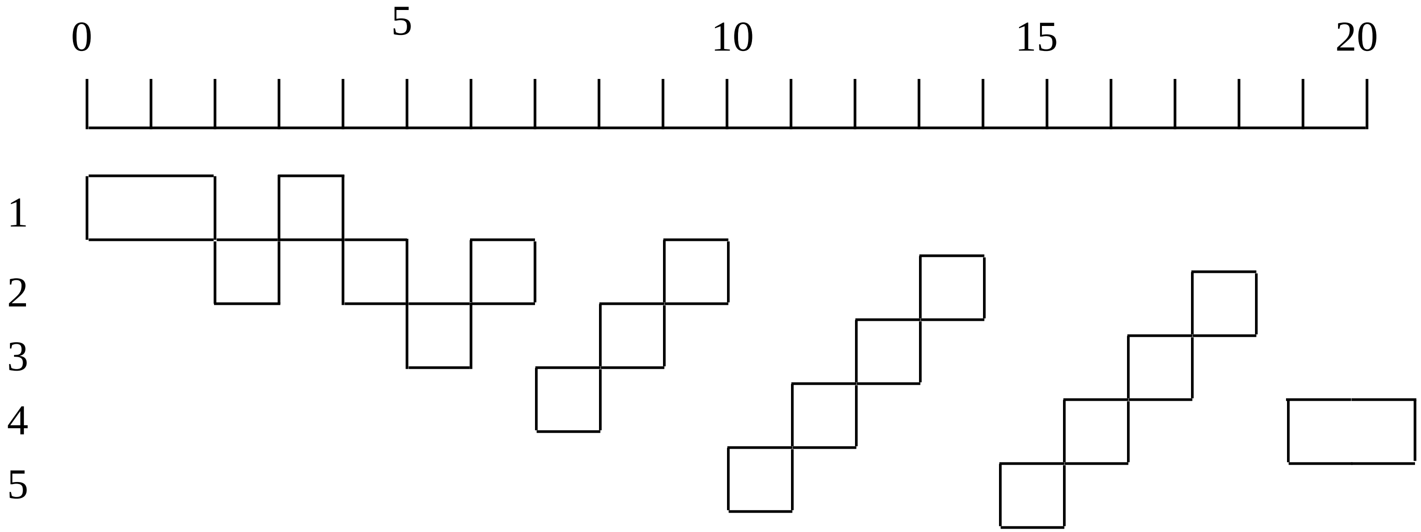


- Each process joins the Ready queue
- When the current process ceases to execute, the oldest process in the Ready queue is selected

First-Come-First-Served (FCFS)

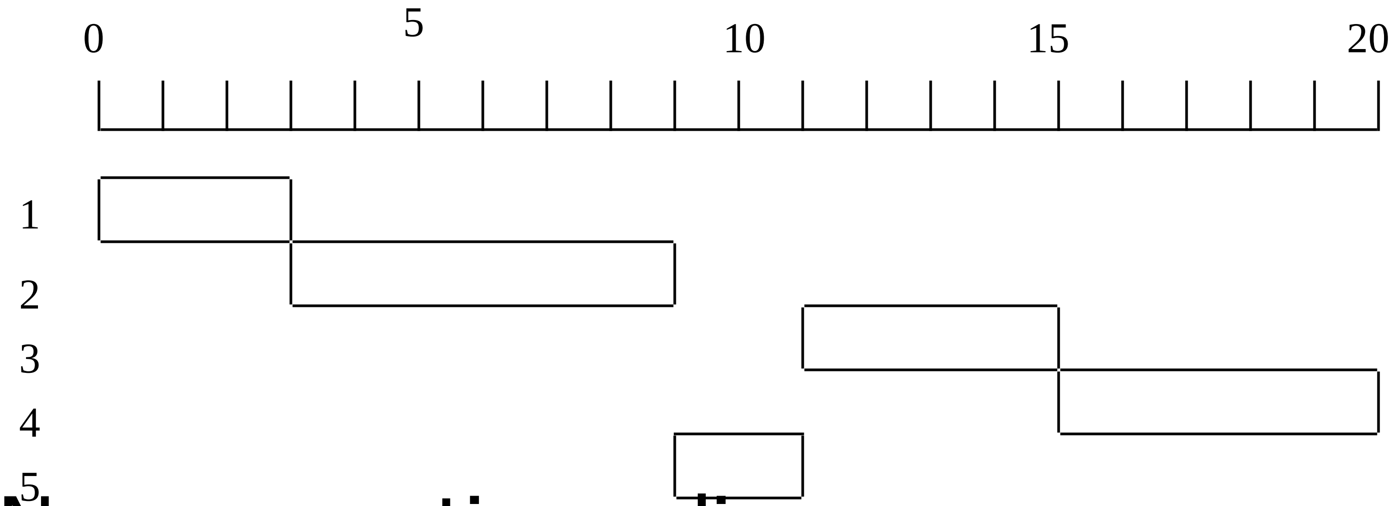
- A short process may have to wait a very long time before it can execute
- Favors CPU-bound processes
  - I/O processes have to wait until CPU-bound process completes

Round-Robin



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

Shortest Process Next

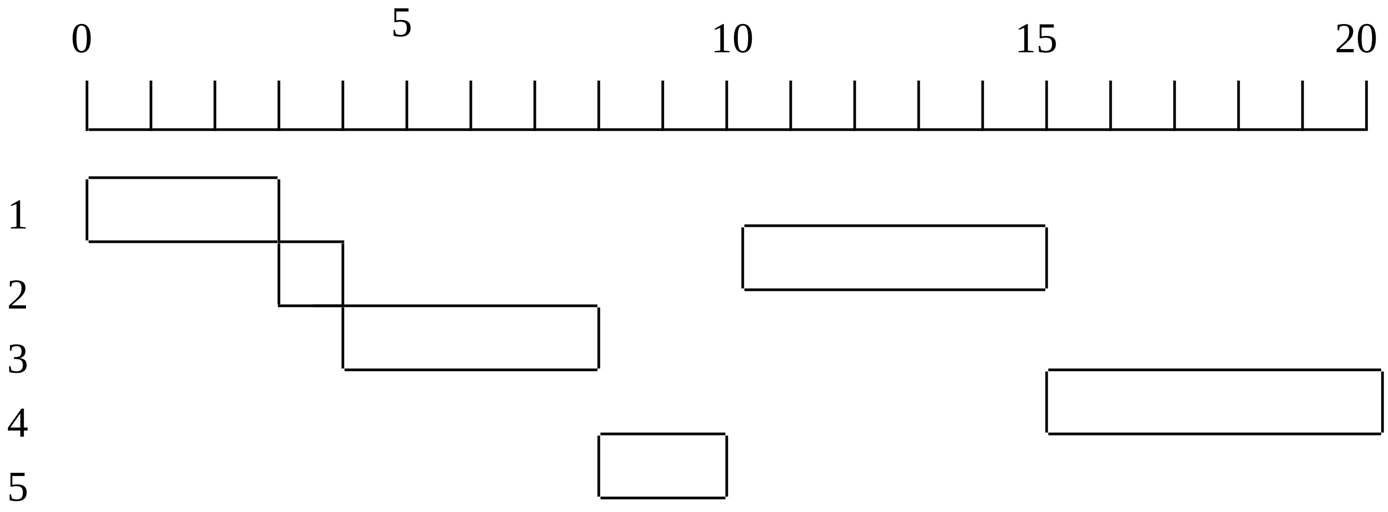


- Nonpreemptive policy
- Process with shortest expected processing time is selected next
- Short process jumps ahead of longer processes

Shortest Process Next

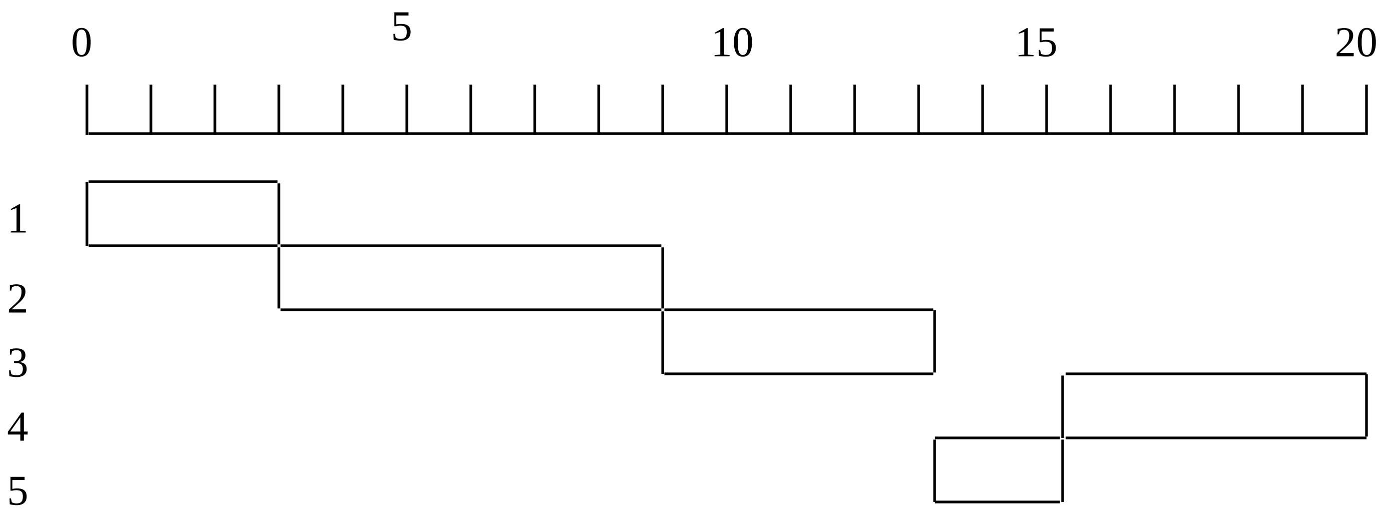
- Predictability of longer processes is reduced
- If estimated time for process not correct, the operating system may abort it
- Possibility of starvation for longer processes

Shortest Remaining Time



- Preemptive version of shortest process next policy
- Must be able to estimate remaining processing time

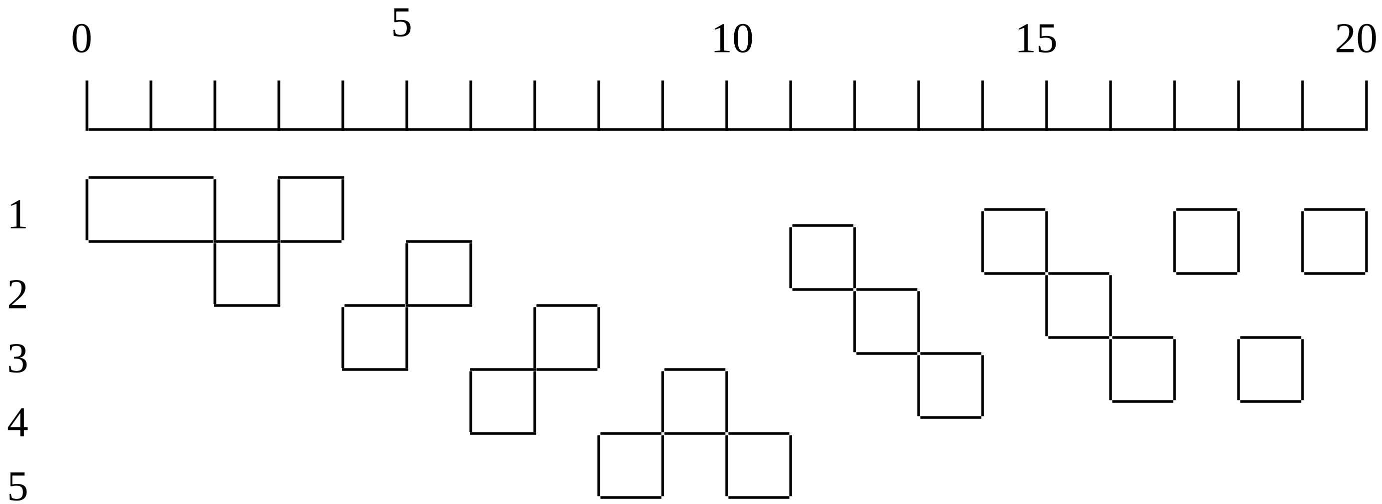
Highest Response Ratio Next (HRRN)



- Choose next process with the highest ratio of:

$$\frac{\textbf{time spent waiting + expected service time}}{\textbf{expected service time}}$$

Feedback



- Penalize jobs that have been running longer
- Can be used when we don’t know the remaining time a process needs to execute
- Implemented in UNIX (see later)

Fair-Share Scheduling

- ✓ User's application runs as a collection of processes (threads)
- ✓ User is concerned about the performance of the application
- ✓ Need to make scheduling decisions based on groups of processes
- ✓ For each process, there must be an a priori upper limit on the waiting time

UNIX Scheduling

- ✓ Priorities are recomputed once per second
- ✓ Base priority divides all threads into fixed bands of priority levels
- ✓ Adjustment factor used to keep process in its assigned band

  P(i) = Base + CPU(i)/2 + nice

  - i – i-th interval
  - CPU(i) – CPU utilization by the thread thus far
  - nice – user controllable factor (rare)
  - P – priority: lower values mean higher priority

Feedback

- ✓ Process is demoted to the next lower-priority queue each time it returns to the ready queue
- ✓ Longer processes drift downward
- ✓ To avoid starvation, CPU time slices for lower-priority processes are longer