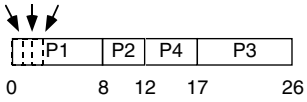
Shortest-Remaining-Time (SRT)

- SRT is a preemptive version of SJF
- Policy:
  - Choose the process that has the smallest next CPU burst, and run that process preemptively…
    - (until termination or blocking, or
    - until a process enters the ready queue (either a new process or a previously blocked process))
  - At that point, choose another process to run if one has a smaller expected CPU burst than what is left of the current process' CPU burst

SJF & SRT Example

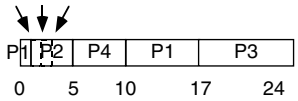
- SJF Example:

Process (Arrival Order)	P1	P2	P3	P4
Burst Time	8	4	9	5
Arrival Time	0	1	2	3



average waiting time = (0 + (8–1) + (12–3) + (17–2)) / 4 = 7.75

- Same Example, SRT Schedule:



average waiting time = ((0+(10–1) + (1–1) + (17–2) + (5–3)) / 4 = 6.5

SRT Evaluation

- Preemptive (at arrival of process into ready queue)
- Response time — good
  - Provably *optimal* — minimizes average waiting time for a given set of processes
- Throughput — high
- Fairness — penalizes long processes
  - Note that long processes eventually become short processes
- Starvation — possible for long processes
- Overhead — can be high (recording and estimating CPU burst times)

Priority Scheduling

- Policy:
  - Associate a priority with each process
    - Externally defined, based on importance, money, politics, etc.
    - Internally defined, based on memory requirements, file requirements, CPU requirements vs. I/O requirements, etc.
    - SJF is priority scheduling, where priority is inversely proportional to length of next CPU burst
  - Choose the process that has the highest priority, and run that process either:
    - preemptively, or
    - non-preemptively
- Evaluation
  - Starvation — possible for low-priority processes
    - Can avoid by *aging* processes: increase priority as they spend time in the system

Multilevel Queue Scheduling

- Policy:
  - Use several ready queues, and associate a different priority with each queue
  - Choose the process from the occupied queue that has the highest priority, and run that process either:
    - preemptively, or
    - non-preemptively
  - Assign new processes permanently to a particular queue
    - Foreground, background
    - System, interactive, editing, computing
  - Each queue can have a different scheduling policy
    - Example: preemptive, using timer
      - 80% of CPU time to foreground, using RR
      - 20% of CPU time to background, using FCFS

Multilevel Feedback Queue Scheduling

- Policy:
  - Use several ready queues, and associate a different priority with each queue
  - Choose the process from the occupied queue with the highest priority, and run that process either:
    - preemptively, or
    - non-preemptively
  - Each queue can have a different scheduling policy
  - Allow scheduler to move processes between queues
    - Start each process in a high-priority queue; as it finishes each CPU burst, move it to a lower-priority queue
    - Aging — move older processes to higher-priority queues
    - Feedback = use the past to predict the future — favor jobs that haven't used the CPU much in the past — close to SRT!

CPU Scheduling in UNIX using Multilevel Feedback Queue Scheduling

- Policy:
  - Multiple queues, each with a priority value (low value = high priority):
    - Kernel processes have negative values
      - Includes processes performing system calls, that just finished their I/O and haven't yet returned to user mode
    - User processes (doing computation) have positive values
  - Choose the process from the occupied queue with the highest priority, and run that process preemptively, using a timer (time slice typically around 100ms)
    - Round-robin scheduling in each queue
  - Move processes between queues
    - Keep track of clock ticks (60/second)
    - Once per second, add clock ticks to priority value
    - Also change priority based on whether or not process has used more than it's "fair share" of CPU time (compared to others)