Engineering & Computer Science
Syracuse University

CIS 657 – Principles of Operating Systems

Topic: Process – Policies (Scheduling)

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Acknowledgement

- Youjip Won (Hanyang University)
- OSTEP book – by Remzi and Andrea Arpaci-Dusseau (University of Wisconsin)

Process Scheduling

- Workload assumptions:
  1. Each job runs for the **same amount of time.**
  2. All jobs **arrive** at the same time.
  3. All jobs only use the **CPU** (i.e., they perform no I/O).
  4. The **run-time** of each job is known.

Process Scheduling

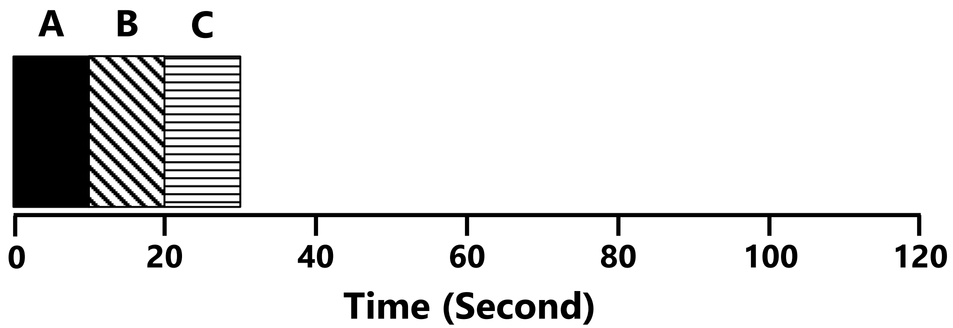
- Performance metric: Turnaround time
  - The time at which **the job completes** minus the time at which **the job arrived** in the system.

$$T_{turnaround} = T_{completion} - T_{arrival}$$

- Another metric is fairness.
  - Performance and fairness are often **at odds** in scheduling.

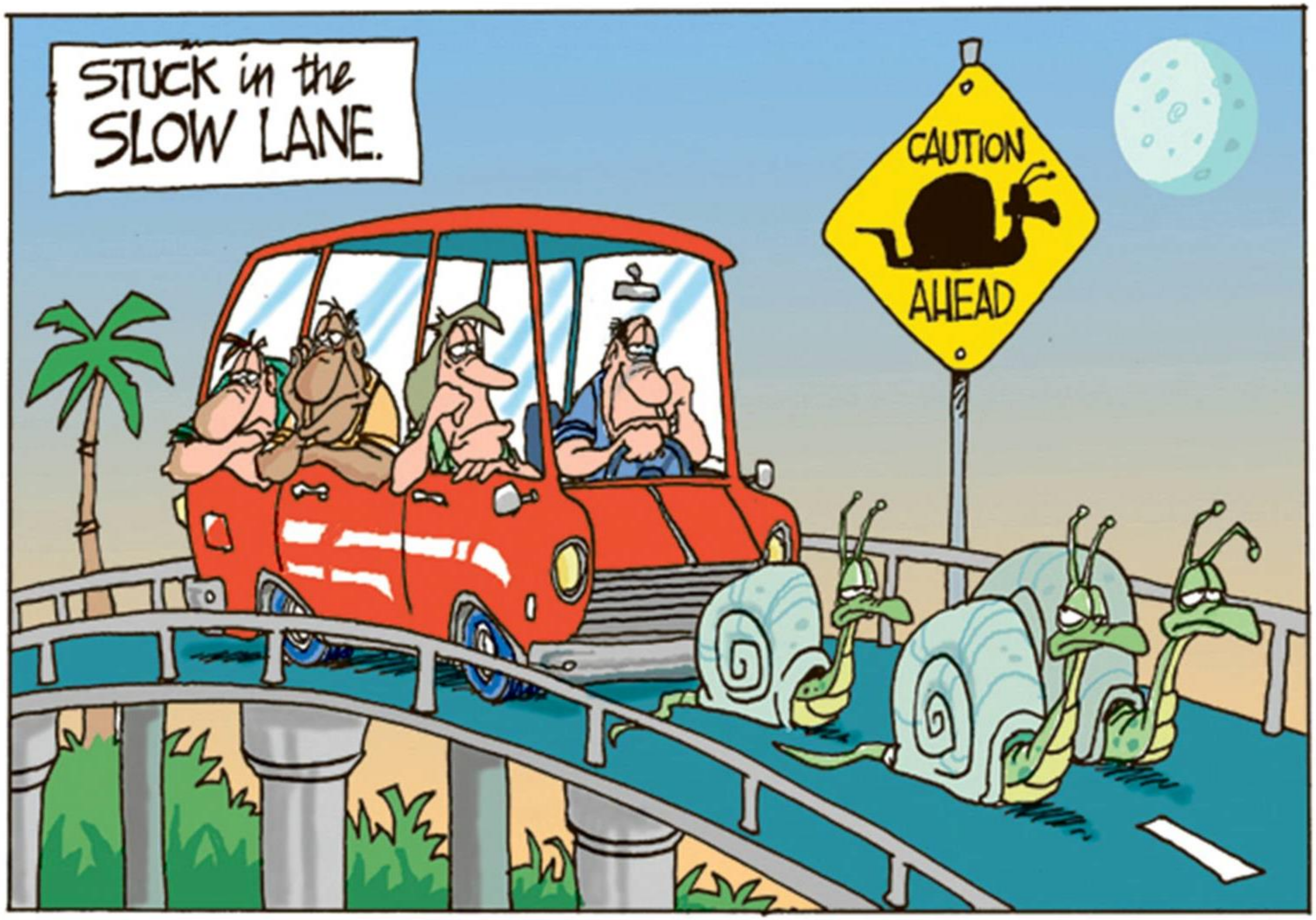
First in, First Out (FIFO)

- Also, known as First Come, First Served (**FCFS**)
  - Very simple and easy to implement
- Example:
  - A arrived just before B which arrived just before C.
  - Each job runs for 10 seconds.



$$\text{Average turnaround time} = \frac{10 + 20 + 30}{3} = 20\ sec$$

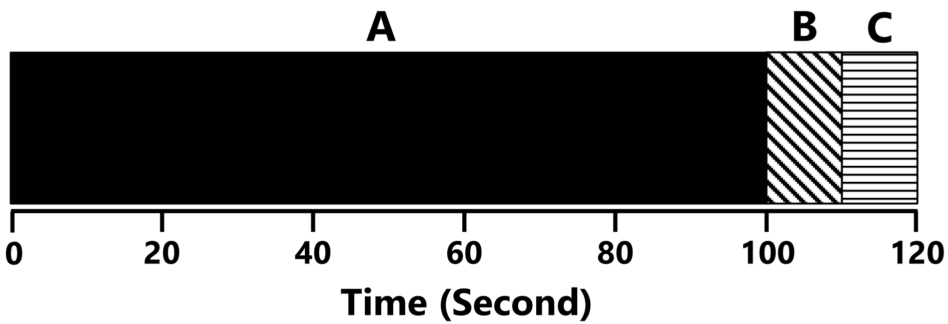
Why is FIFO not that great? – Convoy effect



src: https://www.moveoverslowdrivers.com/speed-up-slowpoke-or-get-a-ticket/

Why is FIFO not that great? – Convoy effect

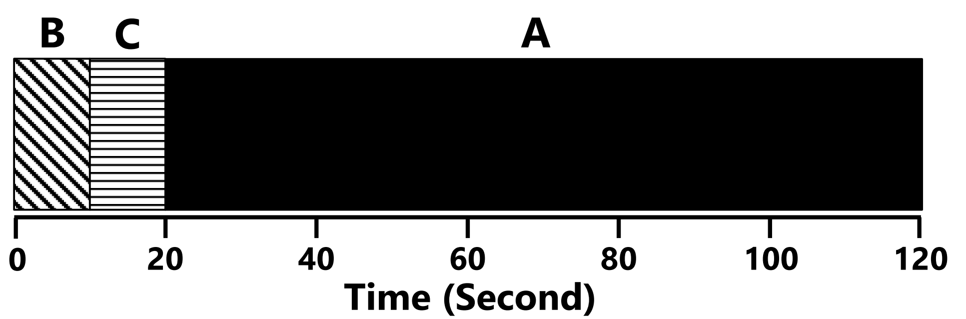
- Let’s relax assumption 1: Each job **no longer** runs for the same amount of time.
- Example:
  - A arrived just before B which arrived just before C.
  - A runs for 100 seconds, B and C run for 10 each.



$$Average\ turnaround\ time = \frac{100 + 110 + 120}{3} = 110\ sec$$

Shortest Job First (SJF)

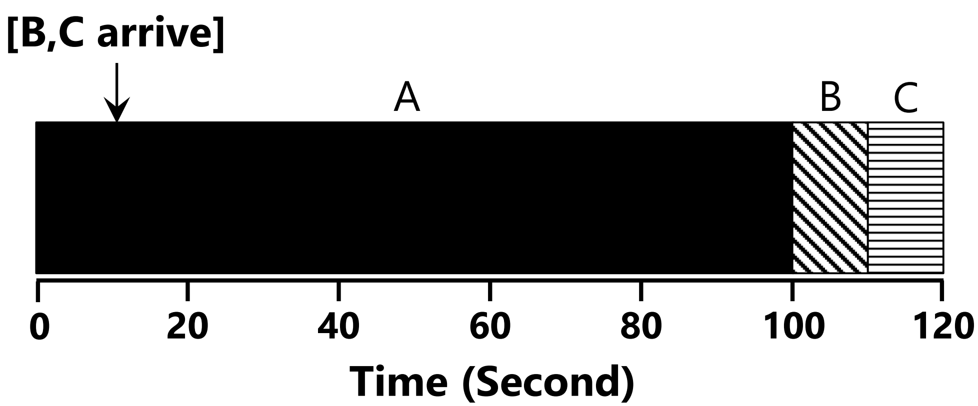
- Run the shortest job first, then the next shortest, and so on
  – Non-preemptive scheduler
- Example:
  – A arrived just before B which arrived just before C.
  – A runs for 100 seconds, B and C run for 10 each.



$$\mathit{Average\ turnaround\ time} = \frac{10 + 20 + 120}{3} = 50\ \mathit{sec}$$

SJF with Late Arrivals from B and C

- Let’s relax assumption 2: Jobs can arrive at any time.
- Example:
  - A arrives at t=0 and needs to run for 100 seconds.
  - B and C arrive at t=10 and each need to run for 10 seconds



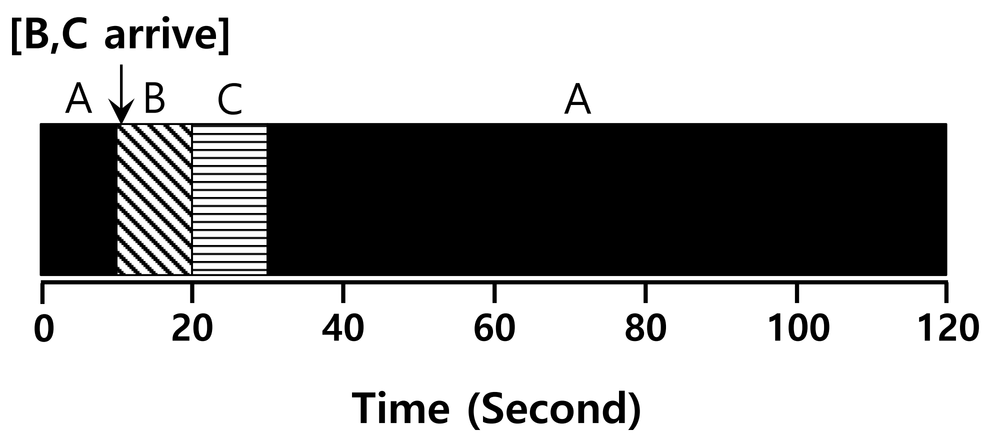
$$\textit{Average turnaround time} = \frac{100 + (110 - 10) + (120 - 10)}{3}$$
$$= 103.33\ sec$$

Shortest Time-to-Completion First (STCF)

- Add preemption to SJF
  - Also knows as Preemptive Shortest Job First (PSJF)
- A new job enters the system:
  - Determine of the remaining jobs and new job
  - Schedule the job which has the lowest time left (i.e., which requires the minimum time to finish)

Shortest Time-to-Completion First (STCF)

- Example:
  - A arrives at t=0 and needs to run for 100 seconds.
  - B and C arrive at t=10 and each need to run for 10 seconds



$$\text{Average turnaround time} = \frac{(120-0)+(20-10)+(30-10)}{3}$$
$$= 50\ sec$$

New Scheduling Metric: Response Time

- The time from **when the job arrives** to the **first time it is scheduled**.

$$T_{response} = T_{firstrun} - T_{arrival}$$

  - STCF and related disciplines are not particularly good for response time.

How can we build a scheduler that is **sensitive to response time**?

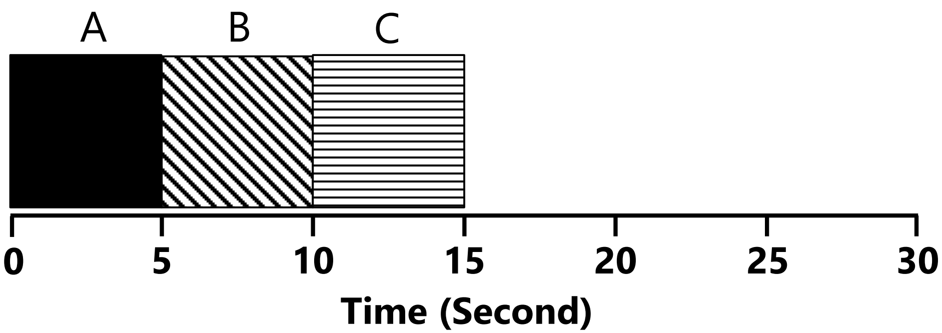
Round Robin (RR) Scheduling

- Time slicing Scheduling
  - Run a job for a time slice and then switch to the next job in the **run queue** until the jobs are finished.
    - Time slice is sometimes called a scheduling quantum.
  - It repeatedly does so until the jobs are finished.
  - The length of a time slice must be *a multiple of* the timer-interrupt period.

RR is fair, but performs poorly on metrics such as turnaround time

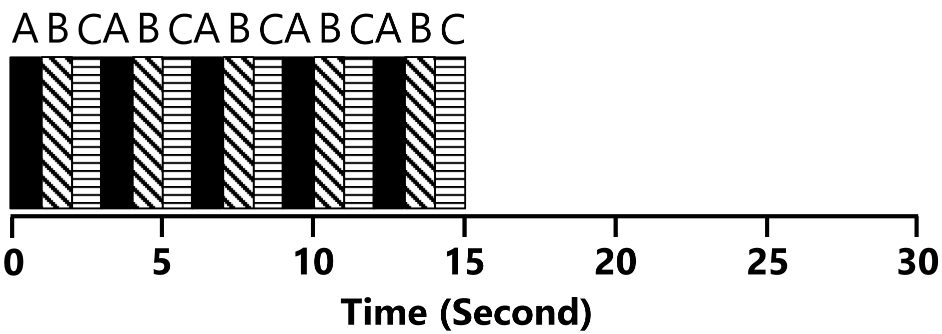
Round Robin (RR) Scheduling

- A, B and C arrive at the same time.
- They each wish to run for 5 seconds.



SJF (Bad for Response Time)

$$T_{average\ response} = \frac{0+5+10}{3} = \mathbf{5}\boldsymbol{sec}$$



RR with a time-slice of 1sec (Good for Response Time)

$$T_{average\ response} = \frac{0+1+2}{3} = \mathbf{1}\boldsymbol{sec}$$

The length of the time slice is critical

- The shorter time slice
  - Better response time
  - The cost of context switching will dominate overall performance.

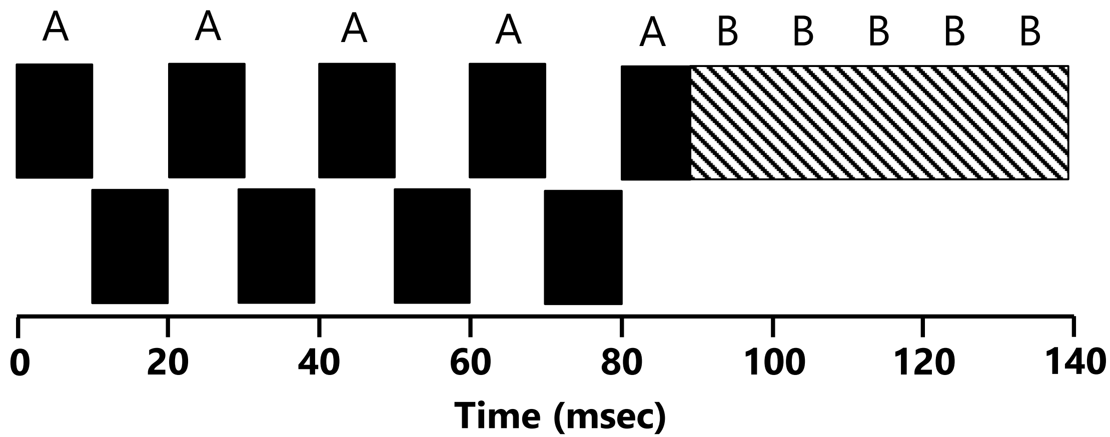
- The longer time slice
  - Amortize the cost of switching
  - Worse response time

Deciding on the length of the time slice presents a **trade-off** to a system designer

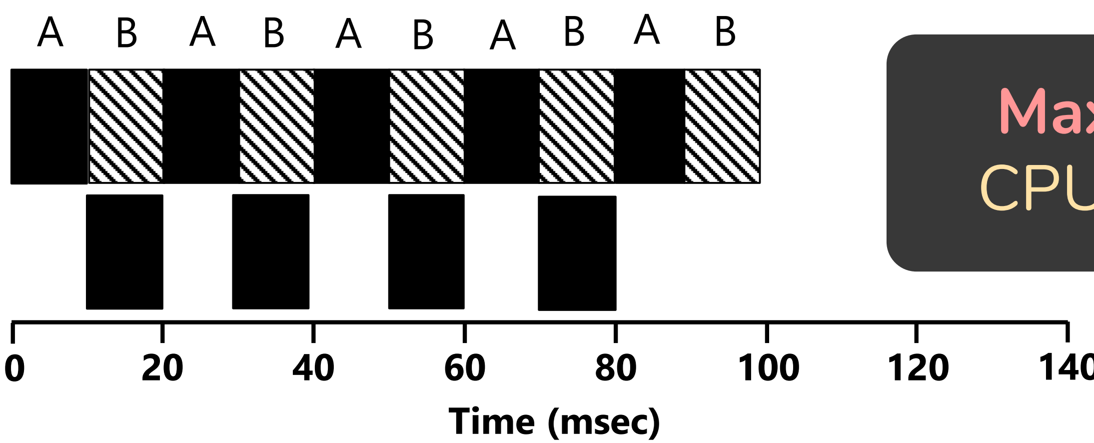
Incorporating I/O

- Let's relax assumption 3: All programs perform I/O
- Example:
  - A and B need 50ms of CPU time each.
  - A runs for 10ms and then issues an I/O request
    - I/Os each take 10ms
  - B simply uses the CPU for 50ms and performs no I/O
  - The scheduler runs A first, then B after

Incorporating I/O



Poor Use of Resources



Overlap Allows Better Use of Resources

Maximize the CPU utilization

Incorporating I/O

- When a job initiates an I/O request.
  - The job is blocked waiting for I/O completion.
  - The scheduler should schedule another job on the CPU.
- When the I/O completes
  - An interrupt is raised.
  - The OS moves the process from blocked back to the ready state.

Reading Material

- **Chapter 7** of OSTEP book – by Remzi and Andrea Arpaci-Dusseau (University of Wisconsin) http://pages.cs.wisc.edu/~remzi/OSTEP/cpu-sched.pdf

Questions?