**Homework (Simulation) Wan Huzaifah bin Wan Azhar**

This program, scheduler.py, allows you to see how different schedulers perform under scheduling metrics such as response time, turnaround time, and total wait time. See the README for details.

**Answer:**

1. FIFO of length 200:
   * Job 0: Response: 0s. Turnaround: 30s. Wait 0s.
   * Job 1: Response: 30s. Turnaround: 121s. Wait 30s.
   * Job 3: Response: 121s. Turnaround: 276s. Wait 121s.
   * Average Turnaround = (30 + 121 + 246)/3 = 142.33s. Average Wait = 50.3s.

SJF of length 200:

* + Job 0: Response: 0s. Turnaround: 30s. Wait 0s.
  + Job 1: Response: 30s. Turnaround: 121s. Wait 30s.
  + Job 3: Response: 121s. Turnaround: 276s. Wait 121s.
  + Average Turnaround = (30 + 121 + 246)/3 = 142.33s. Average Wait = 50.3s.

1. FIFO Length 100:
   * Job 0: Response: 0s. Turnaround: 15s. Wait 0s.
   * Job 1: Response: 15s. Turnaround: 61s. Wait 15s.
   * Job 3: Response: 61s. Turnaround: 139s. Wait 61s.
   * Average Response = 15 + 61/3 = 25.33s
   * Average Turnaround = (15 + 61 +139)/3 = 71.67s.
   * Average Wait = 25.33s.

SJF Length 100:

* + Job 0: Response: 0s. Turnaround: 15s. Wait 0s.
  + Job 1: Response: 15s. Turnaround: 61s. Wait 15s.
  + Job 3: Response: 61s. Turnaround: 139s. Wait 61s.
  + Average Turnaround = (15 + 61 +139)/3 = 71.67s. Average Wait = 25.33s.

FIFO Length 300:

* + Job 0: Response: 0s. Turnaround: 44s. Wait 0s.
  + Job 1: Response: 44s. Turnaround: 181s. Wait 44s.
  + Job 3: Response: 181s. Turnaround: 413s. Wait 181s.
  + Average Turnaround = (44 + 181 +413)/3 = 212.67s. Average Wait = 75s.

SJF Length 300:

* + Job 0: Response: 0s. Turnaround: 44s. Wait 0s.
  + Job 1: Response: 44s. Turnaround: 181s. Wait 44s.
  + Job 3: Response: 181s. Turnaround: 413s. Wait 181s.
  + Average Turnaround = (44 + 181 +413)/3 = 212.67s. Average Wait = 75s.

If the jobs are given to FIFO from shortest to longest, then it matched the turnaround time of SJF (Since, SJF = shortest job FIFO)

1. Round Robin of time-slice 1s:

Length 100:

* + Job 0: Response: 0s. Turnaround: 43s. Wait 28s.
  + Job 1: Response: 1s. Turnaround: 107s. Wait 60s.
  + Job 3: Response: 2s. Turnaround: 139s. Wait 61s.
  + Average Response: (0+1+2)/3 = 1s.
  + Average Turnaround = 96.33s.
  + Average Wait = 49.67s.

Length 200:

* Job 0: Response: 0s. Turnaround: 88s. Wait 58s.
* Job 1: Response: 1s. Turnaround: 211s. Wait 120s.
* Job 3: Response: 2s. Turnaround: 276s. Wait 121s.
* Average Response: (0+1+2)/3 = 1s.
* Average Turnaround = 191.67s.
* Average Wait = 99.67s.

Length 300:

* Job 0: Response: 0s. Turnaround: 130s. Wait 86s.
* Job 1: Response: 1s. Turnaround: 317s. Wait 180s.
* Job 3: Response: 2s. Turnaround: 413s. Wait 181s.
* Average Response: (0+1+2)/3 = 1s.
* Average Turnaround = 286.67s.
* Average Wait = 149s.

1. For what types of workloads does SJF deliver the same turnaround times as

FIFO?

* That SJF will have same turnaround time as FIFO when the workload given from the shortest job to longest job, since FIFO is equal SJF in that case.
* Conversely, SJF will have same turnaround time as FIFO when the workload arrived is from longest job to shortest job in both algorithms. Since shortest job arrive late, B and C need to wait until A is finished first before they are able to finish.
* In general, FIFO and SJF is almost equal, except if the workload arrive at the same time, SJF would prioritize shortest job first, and thus better turnaround.

1. For what types of workloads and quantum lengths does SJF deliver the same response times as RR?
   * If the workload is in short burst, for example, A of length 1, B of length 1, C of length 3, then the response time at the beginning is almost the same of RR at time-slice 1.
   * Another scenario is when the all the job are given in length as time slice of RR, A,B,C, of length 1 means that average response time is the same of RR of time-slice 1.
2. What happens to response time with SJF as job lengths increase? Can you use the simulator to demonstrate the trend?
   * Response time will increase drastically.
   * This is because, despite been given the shortest job, it still needs to finish the job before other job can be run.
   * SJF does not have the ability to pre-emptively change jobs.
3. What happens to response time with RR as quantum lengths increase? Can you write an equation that gives the worst-case response time, given N jobs?
   * Response time increased as quantum lengths increase.
   * All three-job arrived at time 0. If a response time of A, B, C is 1, then average response time is 1. However, if response time of A, B, C is 10, then average response time is 10.
   * Simple calculation to calculate worst-case response time:
     1. Average response time is calculated as (Summation of response time of all n)/n
     2. As worst-case is upper bound of response time, so the equation need not to divide by N jobs.
     3. Therefore, the equation is (Summation of response time of all N jobs)
     4. Assuming all job of N = 4 arrived at time 0 and time-slice is 1. Worst case of response time is,
        1. Job A: 0s.
        2. Job B: 1s.
        3. Job C: 2s.
        4. Job D: 3s.
        5. Summation of all job is 6s, which is the worst-case response time.