

## TASK 1 - Job shop simulation

Simulation runtime - 30 simulations each having 8-hour run-time.

### *Input*

5                      #number of stations(n)  
3 2 4 3 1            #number of machines in each station (ni)  
0.25                  #inter-arrival time for jobs (t)  
3                      #number of job types (k)  
0.3 0.5 0.2          #job probabilities (pi)  
4 3 5                #number of stations for each task (si)

Routing and mean service time of the jobs,

Job - 1 : 3 1 2 5  
          0.50 0.60 0.85 0.50  
Job - 2: 4 1 3  
          1.10 0.80 0.75  
Job - 3: 2 5 1 4 3  
          1.20 0.25 0.70 0.90 1.00

Expected average total delay in queue (exclusive of service times) for each job type

JOB	Avg total delay in queue
1	0.29274
2	0.62196
3	0.32185

Average number of jobs: 14.877179

Overall avg delay: 0.463171

Expected average number and delay in queue of each workstation

Work Station	Avg delay in queue	Avg number in queue
1	0.48589	0.0728
2	0.39521	0.14404
3	0.42422	0.3208
4	0.80318	1.03928
5	0.12697	0.00372

We can see that station 4 has a larger average delay than the others. So a new machine should be bought for this station

## Task-2: Cafeteria Simulation

This document reports the following measures of system performance:

1. The average and maximum delays in queue for hot food, specialty sandwiches, and cashiers (regardless of which cashier)
2. The time-average and maximum number in queue for hot food and specialty sandwiches (separately), and the time-average and maximum total number in all cashier queues
3. The average and maximum total delay in all the queues for each of the three types of customers (separately)
4. The overall average total delay for all customers, found by weighting their individual average total delays by their respective probabilities of occurrence
5. The time-average and maximum total number of customers in the entire system

*Base case (1,1,2) - 1 hot food employee, 1 sandwich employee, 2 cashiers*

Average and maximum delays in queue at each counter		
Counter	Avg (in minutes)	Maximum (in minutes)
Hot Food	37.17846	73.784046
Specialty sandwich	20.36548	37.80243
Drinks	Has no delay since it has self service	
Cashier	0.00000	0.0

Average and maximum total delay in all the queues for each of the three types of customers (separately)		
Customer type	Avg delay(in minutes)	Maximum delay(in minutes)
Hot Food customer	8.23329	73.784046
Specialty sandwich customer	13.09209	37.80243
Drinks customer	0.0	0.0

Time-average and maximum number in queue for hot food and specialty sandwiches (separately), and the time-average and maximum total number in all cashier queues		
Counter	Avg	Max
Hot Food	51.20850	230
Specialty sandwich	1.784427	25
Drinks	Has no queue since it has self service	
Cashier	0.0	0

Overall avg delay : 8.550448

Avg customer in system : 195.2371062264858

Total served: 120

*Special Case: - k [ #hot food employees, #sandwich employees, cashiers ]*

- 5 employees
  - k = [1, 1, 3]
    - Overall delay : 8.550448
    - Avg customer in system : 195.237106
    - Total served: 120
  - k = [2, 1, 2]
    - Overall delay : 10.792927
    - Avg customer in system : 177.634987
    - Total served: 125
  - k = [1, 2, 2]
    - Overall delay : 6.546082
    - Avg customer in system: 179.708116
    - Total served: 129
- 6 employees
  - k = [2, 2, 2]
    - Overall delay : 8.542393
    - Avg customer in system: 166.090222
    - Total served: 170
  - k = [2, 1, 3]
    - Overall delay : 11.053650
    - Avg customer in system: 173.597147
    - Total served: 182

- $k = [1, 2, 3]$ 
  - Overall delay : 6.546082
  - Avg customer in system: 179.70811
  - Total served: 129
- 7 employees
  - $k = [2, 2, 3]$ 
    - Overall delay : 9.543293
    - Avg customer in system: 174.747523
    - Total served: 197

Maximum served in the combination  $[2, 2, 3]$ : 197 customers.

The lowest overall average delay in the combination  $[1, 2, 2]$  and  $[1, 2, 3]$ : 6.546082 minutes.

So in terms of maximum customers served, deployment of 7 employees is the best and in terms of lowest avg delay the other option is the best.