

Cairo University

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DS331

System Modeling and Simulation

Simulation Project

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Prepared by

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Problem I: Multi-Channel Queue

Formulation:

- The checkout area contains two cashiers, one for express customers who have 12 items or less and regular customers who have more than 12 items. They come to the supermarket with a percentage of 40% regular customers and 60% for express customers.
- When a regular customer arrives, he enters the regular cashier.
- When an express customer arrives, he enters the express cashier only if the length of the express cashier's queue is less than 1.5 times the regular cashier's queue length.
- Both cashiers have the same efficiency and unlimited queue length.

The Cumulative Probability of Inter-arrival Time of Customers:

Inter-arrival Time	Probability	Cumulative Prob
0	0.16	0.16
1	0.23	0.39
2	0.30	0.69
3	0.21	0.9
4	0.1	1

The Cumulative Probability of Service Time of Express Customers

Service Time	Probability	Cumulative Prob
1	0.30	0.30
2	0.40	0.70
3	0.30	1

Cumulative Probability of Service time of Regular Customer

Service Time	Probability	Cumulative Prob
3	0.20	0.20
5	0.50	0.70
7	0.30	1

Objectives:

- Efficiently manage customer queues.
- Optimize the utilization of both express and regular cashiers.
- Minimize waiting times for customers.
- Ensure fair distribution of customers between the express and regular cashiers.

System Components:

- Checkout area.
- Express Cashier
- Regular Cashier
- Two queues for each cashier
- Customer

Tables of Simulation:

All Customers Table

ID	Type	Inter-arrival Time	Arrival Time	Service Time	Waiting Time	Completion Time
1	Express	2	2	3	0	5
2	Regular	2	2	3	0	5
3	Regular	1	3	5	2	10
4	Express	3	5	1	0	6
5	Express	3	8	2	0	10
6	Regular	2	5	5	5	15
7	Express	2	10	2	0	12
8	Express	0	10	1	2	13
9	Express	2	12	2	1	15
10	Express	4	16	1	0	17

Express Customers Table

ID	Type	Inter-arrival Time	Arrival Time	Service Time	Waiting Time	Completion Time
1	Express	2	2	3	0	5
4	Express	3	5	1	0	6
5	Express	3	8	2	0	10
7	Express	2	10	2	0	12
8	Express	0	10	1	2	13
9	Express	2	12	2	1	15
10	Express	4	16	1	0	17

Regular Customers Table

ID	Type	Inter-arrival Time	Arrival Time	Service Time	Waiting Time	Completion Time
2	Regular	2	2	3	0	5
3	Regular	1	3	5	2	10
6	Regular	2	5	5	5	15

Difference between theoretical and experimental averages:

The theoretical average of inter-arrival time = $(0*0.16) + (1*0.23) + (2*0.3) + (3*0.21) + (4*0.1) = 1.86$

The theoretical average of service time of express customer = $(1*0.3) + (2*0.4) + (3*0.3) = 2$

The theoretical average of service time of regular customer = $(3*0.2) + (5*0.5) + (7*0.3) = 5.2$

The experimental averages: we run the simulation five times on ten customers to get the average of each run and computing the average of theses averages:

# of Runs	Average inter-arrival time	Average express service time	Average regular service time
1	1.7	1.5	4
2	1.7	2	4.33
3	2.1	2	5.33
4	1.6	2.17	4.25
5	1.7	2.33	4.5
Average	1.65	2	4.482

The theoretical average of inter-arrival time and service time of regular customers does not match the experimental average. But the experimental average of service time of express customers matches the theoretical one.

Note: As the number of runs increases, the percentage of convergence between the averages (experimental and theoretical) increases.