GROCERY CHECKOUT MODEL

a. Questions

1- The average waiting time for a customer:

$$\text{Average waiting time (minutes)} = \frac{total\ time\ customers\ wait\ in\ queue\ (minutes)}{total\ numbers\ of\ customers}$$

$$\frac{124}{100} = 1.24 \text{ minutes}$$

2- The probability that a customer has to wait in the queue is:

$$\text{Probability (wait)} = \frac{numbers\ of\ customers\ who\ wait}{total\ numbers\ of\ customers}$$

$$\frac{29}{100} = 0.29$$

3- The server is idle about 24% of the time:

$$\text{Probability of idle server} = \frac{total\ idle\ time\ of\ server\ (minutes)}{total\ run\ time\ of\ simulation\ (minutes)}$$

total run time of simulation = (1/service utilization) x total service time

= 1/0.76 x 328 = 432

total idle time of server = 432(total run time) – 328(total service time) = 104

$$\frac{104}{432} = 0.24$$

4- The average service time is:

$$\text{Average service time (minutes)} = \frac{total\ service\ time\ (minutes)}{total\ numbers\ of\ customers}$$

$$\frac{328}{100} = 3.28 \text{ minutes}$$

Expected service time = 1(0.1) + 2(0.2) + 3(0.3) + 4(0.25) + 5(0.1) + 6(0.05)

= 3.2 minutes

5- The average time between arrivals is:

$$\text{Average time between arrivals (minutes)} = \frac{sum\ of\ all\ times\ between\ arrivals}{number\ of\ arrivals - 1}$$

6- The average waiting time of those who wait is:

$$\text{Average waiting time of those who wait (minutes)} = \frac{total\ time\ customers\ wait\ in\ queue\ (minutes)}{total\ number\ of\ customers\ who\ wait}$$

$$\frac{124}{29} = 4.28 \text{ minutes}$$

7- The average time a customer spends in the system is:

$$\text{Average time customer spends in the system (minutes)} = \frac{total\ time\ customers\ spend\ in\ the\ system\ (minutes)}{total\ numbers\ of\ customers}$$

$$\frac{452}{100} = 4.52 \text{ minutes}$$

b. Performance Measures

Alternative Scenario's Values:

- Arrival is Uniform Distribution: [0,10] (Equal probability for each value.)
- Service time distribution:
  1: 0.1
  2: 0.15
  3: 0.05
  4: 0.15
  5: 0.05
  6: 0.15
  7: 0.15
  8: 0.20

1- Customer's average waiting time:

Original: 124/100 = 1.24 minutes

Alternative: 314/100 = 3.14 minutes

2- The proportion of time that the server is idle:

Original: 104/432 = 24%

Alternative: 91/569 = 16%

c. Comparison and Discussion

	Original Model	Alternative Model
Total time in queue	124	314
Total time spend in the system	452	792
Service utilization	0.76	0.84
Total service time	328	478
Number of customers who wait	29	55

In the original model, number of customers who wait in the queue is 29 and average waiting time is 1.24 minutes. However, number of customers who wait in the queue is 55 and average waiting time is 3.14 minutes in the alternative model. The reason of these differences is about distribution of service times mostly. In alternative model, larger service times have more probability to occur than original model. For example, probability of 8 minutes service time is 0.20 in alternative model, but maximum service time is 6 minutes in original model. System spends more time in service process in alternative model, so customer's average waiting time and number of customers who wait in the queue increase.

Another thing that I want to mention about is service utilization. In alternative model, service process is so busy because there are customers in the queue usually. System always works. This property provides more service utilization in the alternative model. Service utilization in alternative model is 0.84, and service utilization in original model is 0.76. These bring one more thing to compare: Total time spend in the system. In alternative model, total time spend in the system is 792 minutes, but in the original model, total time spend in the system is 452.

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