IE 306
Systems Simulation

Spring 2020

Homework 1
Call Center Simulation

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1 Introduction

In this project we simulate a call center with two operators and an automated answering system which directs callers to these operators with respectively 0.3 and 0.7 probabilities. Calls arrive at exponentially distributed random times with a mean of 6 minutes. The automated answering system has a capacity of 100 callers and collects the information of the caller in exponentially distributed random time with a mean of 5 minutes. The first operator serves the caller in LogNormally distributed random time with mean 12 minutes and standard deviation 6 minutes.The operators take 3 minute breaks a random times distributed according to poisson distribution with a mean of 8 times throughout their shifts. The shifts are 8 hours long and when the shift is over, the operator changes without any delay. When a caller is directed to an operator, if the operator is serving someone else, or if the operator is on a break, the caller enters an FCFS queue. If the caller waits 10 minutes before getting served the hang up. We ran our simulation 10 times for 1000 answered calls with different random seeds and then, we ran the simulation again 10 times for 5000 answered calls using the same seeds. And we collected statistics.

Statistics to be Collected

- Utilization of the answering system.
- Utilization of the operators.
- Average Total Waiting Time.
- Maximum Total Waiting Time to Total System Time Ratio.
- Average number of people waiting to be served by each operator.
- Average number of customers leaving the system unsatisfied.

2 Event Definitions

- A new call arrives:
- Caller drops if the answering machine is at capacity
- The collection of the callers details
- Directing a caller to an operator
- Miss direction of a caller
- The caller waits at the queue of the operator
- The caller reneging after 10 minutes
- The caller arrives an operator
- The operator serves a caller
- The operator takes a break if scan
- After 8 hour shift, operator changes
- After last call is processed, simulation ends

3 Simulation Logic

First, the 10 random seeds are created. The resources for the operator queues are created which have 1 capacity each. The resource for the answering machine is created with 100 capacity and its queueing system is disabled so that the callers which arrive when the system at capacity are dropped. Customer generator is initiated. The calls are sent to the answering machine with interarrival times exponentially distributed with a mean of 6 minutes. Answering machine collects the data for a random time distributed exponentially with a mean of 5 minutes. The caller is directed to the two operators with %30 and % 70 probabilities respectively. The caller is directed to the wrong operator with %10 probability. If the caller is directed to the wrong operator, the caller immediately hangs up. Otherwise, the caller enters the queue for the certain operator. If the caller waits 10 minutes in the queue, the caller hangs up immediately. When the caller arrives at the front of the queue, the operator starts serving the customer. The duration of the serving depends on the operator. The first operator takes a random time distributed lognormally. The mean and the standard deviation of the underlying normal distrubition for the lognormal distribution are respectively 12 and 6. The second operator takes a random time distributed uniformly between 1 and 7 minutes. Each operator takes a number of breaks in their shift. The number of breaks an operator takes is randomly distributed with Poisson distribution with a mean of 8 breaks per shift. A single break takes 3 minutes. These breaks are distributed with Poisson distribution troughout the shift. An operator may take a break if only their queue is empty and if their break time has arrived. When an operator break time arrives, the operator checks if their queue is empty. If their queue is empty, they will pause serving for three minutes. Otherwise if the queue is not empty, the operator postpones their break until everyone currently in the queue is served. At every 8 hours a shift change occurs. When a shift change occurs, each operator is immediately replaced with a new one. When new operators come, their breaks are calculated the same way as before. When the predefined number of calls are processed, the simulation is terminated.

4 Simulation Outputs

Table Glossary

- **Seed:** Random seed that is used.
- **UAns:** Utilization of the answering system.
- **UOp1:** Utilization of the operator 1.
- **UOp2:** Utilization of the operator 2.
- **AvgW:** Average Total Waiting Time.
- **M/T:** Maximum Total Waiting Time to Total System Time Ratio.
- **AvgW Op1:** Average number of people waiting to be served by operator 1.
- **AvgW Op2:** Average number of people waiting to be served by operator 2.
- **L:** Number of customers leaving the system unsatisfied.

Tables

Simulation With 1000 Customers								
Seed	UAns	UOp1	UOp2	AvgW	M/T	AvgW Op1	AvgW Op2	L
0	0.008	0.477	0.389	1.843	0.152	0.145	0.155	153
194	0.016	0.446	0.419	1.790	0.148	0.137	0.155	142
482	0.024	0.453	0.410	1.705	0.144	0.140	0.144	146
241	0.032	0.452	0.386	1.846	0.149	0.157	0.141	148
832	0.042	0.418	0.404	1.788	0.152	0.117	0.183	171
997	0.049	0.450	0.393	2.003	0.161	0.168	0.156	166
352	0.055	0.460	0.379	1.693	0.140	0.139	0.127	162
153	0.068	0.431	0.416	1.973	0.164	0.137	0.197	171
56	0.074	0.445	0.417	1.991	0.162	0.164	0.162	157
569	0.086	0.448	0.421	1.614	0.138	0.116	0.161	148

Average customers that are leaving the system unsatisfied 156.4

Simulation With 5000 Customers								
Seed	UAns	UOp1	UOp2	AvgW	M/T	AvgW Op1	AvgW Op2	AvgL
0	0.025	0.460	0.414	1.798	0.150	0.137	0.166	792
194	0.033	0.458	0.419	1.890	0.157	0.149	0.169	790
482	0.041	0.454	0.415	1.780	0.149	0.132	0.165	758
241	0.050	0.447	0.415	1.796	0.148	0.135	0.164	786
832	0.058	0.438	0.415	1.857	0.155	0.141	0.170	802
997	0.067	0.452	0.419	1.971	0.162	0.155	0.177	782
352	0.073	0.454	0.403	1.752	0.145	0.132	0.154	760
153	0.083	0.450	0.406	1.767	0.148	0.137	0.156	836
56	0.091	0.446	0.403	1.741	0.147	0.141	0.147	832
569	0.101	0.446	0.419	1.878	0.157	0.148	0.171	796

Average customers that are leaving the system unsatisfied 793.4

5 Observation ans Interpretation of The Results

Simulation With 1000 Customers							
	UAns	UOp1	UOp2	AvgW	M/T	AvgW Op1	AvgW Op2
mean	0.045	0.448	0.403	1.824	0.151	0.142	0.158
variance	0.001	0.000	0.000	0.016	7.459	0.000	0.000

Simulation With 5000 Customers							
	UAns	UOp1	UOp2	AvgW	M/T	AvgW Op1	AvgW Op2
mean	0.062	0.451	0.413	1.823	0.152	0.141	0.164
variance	0.001	0.000	0.000	0.004	2.639	5.299	7.299

As we can see that, AvgW and M/T variances tends to decrease or remain same. This tendency caused by increase in the number of customers. On the other hand, an increase can be observed in this case AvgW Op1 and AvgW Op2 expected to increase. variances. Because there are more custo mers in the system and it makes the queues more crowded. The other variances almost remains the same. In order to get accurate results for the AvgW and M/T variances, we should use greater numbers of customers; however, in this case AvgW Op1 and AvgW Op2 expected to increase.

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