IEMS 435 Fall 2018

Project: Call Center Staffing
Project due: Thursday, December 13, 2018

Software Made Personal (SMP) customizes software products in two areas: financial tracking and contact management. They currently have a customer support call center that handles technical questions for owners of their software from the hours of 8 AM to 4 PM Eastern Time. Calls in progress or on hold at 4 PM are completed.

When a customer calls 888-555-4SMP, they listen to a recording that asks them to select among the three product lines (historically 59% financial products and 41% contact management products). The number of customers who can be connected at any one time is essentially unlimited. Each product line has its own agents. If an appropriate agent is available then the call is routed to the agent; if an appropriate agent is not available, then the caller is placed in a hold queue (and listens to a combination of music and ads). SMP has observed that 6% of callers who are placed on hold hang up immediately.

SMP is hoping to reduce the total number of operators they need by cross-training operators so that they can answer calls for any product line. Since the operators will not be experts across all products, this is expected to increase the time to process a call by about 10%. The question that SMP has asked you to answer is how many cross-trained operators are needed to provide service at the same level as the current system.

Incoming calls can be modeled as a Poisson arrival process with a rate of 60 per hour. The mean time required for an agent to answer a question is 5 minutes, with the actual time being Erlang2 for financial calls, and Erlang-3 for contact management calls. The current assignment of operators is as follows:

	Current Number of Agents
Financial	4
Contact Management	3

Simulate the system to find out how many operators are needed to deliver the *same level of service in the cross-trained system as in the current system*. Here are some guidelines:

1. You must use `PythonSim` for your programming. In particular, the Classes `Entity`, `EventCalendar`, `FIFOQueue` and `Resource` must be used (you may of course modify them).

2. Estimate the expected (mean) daily average number in each hold queue and the daily expected (mean) time spent in each hold queue (this is time in queue, not including

service time). Also look at the mean daily number of callers lost (hang up because they will be put on hold). Put 95% confidence intervals around your estimates.

3. Determine a number of replications so that the relative error on each estimate is no more than 5% (relative error = half width of the confidence interval divided by the sample mean). Use the sequential stopping rule.

4. Report:
    - Turn in a brief report (3 pages or less, including all tables and figures, 12 point font size). The report should clearly state your conclusions **and support them using numerical results (including confidence intervals and relative errors) summarized in tables**. State clearly how many replications you used and how you represented service times in the cross-trained system. **You will be graded on how clearly the report presents the results.**

    - Along with your report, turn in a print out of your simulation program for the current system. Turn in the `PythonSim` program for both systems on Canvas.

Stochastic simulation report

Sha Chen

Simulation results

Table 1

(a) Two-queue system (number of agents for financial product and contact management being 4 and 3, number of replications n=547)

Average waiting time in hold queue of financial products	1.2876	Confidence intervals	[1.2307,1.3445]	Relative errors	0.0442
Average waiting time in hold queue of contact management products	1.3429		[1.2813,1.4044]		0.0458
Average number of customers in hold	0.7563		[0.7203,0.7924]		0.0476

queue of financial products					
Average waiting time in hold queue of contact management products	0.5494		[0.5219,0.5768]		0.04999
Average number of callers lost	12.8629		[12.5217,13.2040]		0.0265

(b) Cross-training (one-queue) system (number of agents being 7, number of replications n=524)

Average waiting time in hold queue	0.8494	Confidence intervals	[0.8093,0.8894]	Relative errors	0.04713
Average number of customers in hold queue	0.8463		[0.8040,0.8886]		0.04999
Average number of callers lost	11.3492		[11.0033,11.6952]		0.0305

Representation of service times in cross-training system

The conditional distribution of service time given a customer type follows a Erlang distribution. The type of a customer, associated with the kind of software products, follows a Bernoulli distribution, with probability p=0.59 being financial and probability 0.41 being contact management. The steps to simulate service time is summarized as:

1. Generate a uniform random variable U on [0,1].
2. If U<p, generate service time from Erlang-2 distribution, otherwise, generate service time from Erlang-3 distribution.

The number of replications is given by determined by sequential stopping rule roughly lies in the range of 400 to 600 for both systems. I start with the initial replications being 50 and end up with replications of 547 and 524 in the above simulation cases respectively.

Discussions

Performance comparison between two systems

By comparing the corresponding performances in Table1 (a) and (b), we can conclude that under the same level of service (same number of agents), average waiting time of both two type customers, average number of customers in hold queues, and the average number of callers lost are smaller than those in two-queue system. This suggests that pooling resource helps improve waiting experience of customers. So the company should prefer cross-training system over the current system where the service is provided separately. If the company decrease the number of agents by 1, the performance is worse than the original system with seven agents, so the company cannot decrease staffing cost while maintaining the same level of service in the current market.

Table 2 performance of cross-training system under different number of agents

Number of agents	Average waiting time in hold queue	Average number of customers in hold queue	Average number of callers lost
6	2.9093	2.8435	18.9076
7	0.8511	0.8467	11.2977
8	0.3311	0.3323	6.3526

Impact of ratios of two types of customers on average waiting time

There could be other factors impacting performance of two systems in terms of customers' experience, like the ratio of two type customers. Next, we examine the average waiting time performances of two systems under different ratios of two type of customers. We fix the number of agents in both systems as 7. For a two-queue system, we record the minimal average waiting time under the optimal combination of number of agents assigned to each type given the total 7. From the table 3, we can see that the average waiting time of two-queue system is worse than that in a cross-training system. However, when the ratio of customers is 1:1, customers of financial products in a two-queue system have less waiting time than they do in a mixed queue. Customers of contact management also have such case when the ratio is 9:1. This is mainly because in a mixed queue, the average waiting time of either type of customers become mutually dependent on the other type of customers. As a result, customers with shorter waiting time in a

predesignated queue may experience longer waiting time in a mixed queue. So it is unfavorable to them to have the company operate a two-queue system.

Table 3 average waiting time under different ratios of customers in two-queue system to that in one-queue system, total number of agents 7

Average waiting time		Ratios of customers of financial products	3:7	1:1	7:3	9:1
	Two-queue system	Number of agents assigned to financial versus contact management	2:5	3:4	5:2	6:1
		Total customers	1.2442	1.9777	1.4541	0.9677
		Customers of financial products	1.0755	3.3567	0.7567	0.7808
		Customers of contact management	1.2864	0.5987	3.0814	2.6492
	One-queue system	Total customers	0.8989	0.8673	0.8925	0.8923