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 queue of financial products	0.7563		[0.7203,0.7924]		0.0476
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