Efficiently Serving Customers at a Call Center

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Agenda

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Introduction

• A company needs to continuously provide services that satisfy customers [1,2]. For uninterrupted support, call centers are required to serve numerous customers [3-5]. Through a call center system, customers can contact operators (servers) through phone lines or Internet calls. Customers can contact operators through the call center's computer system and inquire about their after-sales service, maintenance support, and value-add services [2,6-8]. For example, credit-card users can reserve seats on shuttle buses to/from the airport by contacting the call center of a bank [2]. Thus, after a product is sold, the call center provides a channel of communication between the consumers and the company.
Introduction

• Obviously, more operators can serve more customers. However, their salaries must be carefully thought out, because salary cost is a company’s largest expenditure. Therefore, it is not advisable for a company to hire too many operators [5,9,10]. Generally, a company provides its customers with a toll-free number on which to contact the call center. However, all inbound calls are charged to the company. Waiting costs are generated when a customer calls the call center and is placed on hold by the call-center computer system before speaking with an operator. The more inbound calls queued, the greater the waiting costs generated. On average, the potential waiting cost is $0.33 US dollars/minute in Taiwan [11]. In summary, it is important to discuss the opportunity costs involved, namely, the blocking and waiting costs. Customer contributions are keys to covering these costs and providing equivalent service.
Introduction

- Each customer contributes a specific value to the company. In the fiercely-competitive service industry, when users making significant contributions unsubscribe to services, the potential loss is huge [8,15,16].

Each customer contributes revenues ranging from $7.9 US dollars/month (regular users) to $60 US dollars/month (important users) [12-14]
Introduction

• However, a few studies mention the provision of different services to important and regular customers at a fair price/cost. Choi [10] derived a refined queueing model for the approximate cost estimation of a call center. However, the study does not consider the abovementioned business requirements for running a call center. Providing different customers with satisfactory service at affordable costs is a major concern for managers. If all the lines are busy, the regular users must wait to be attended to. Naturally, some users who have been made to wait for an unacceptable amount of time will hang up the phone. Although a company can reserve as many operators as possible to satisfy the few important customers, this will leave many regular users unsatisfied. Allocating adequate resources to serve different users is important for call centers. This study discusses the optimal number of call center operators to be reserved for important customers.
Model of Call Center

- Let $\lambda_r$ and $\lambda_v$ be the average arrival rate of regular customers and VIPs which are associated with exponential distributions, respectively. On the basis of section 2, this study assumes that there are $K$ lines (operators) in the call center, where $1 < K < \infty$. The line transmission time is exponentially distributed and its service rate of both types of customers is $\mu$. 
Model of Call Center

- When there are $N$ ($1 \leq N \leq K$) or more lines that are busy, the regular user’s inbound calls are blocked and these calls enter the queue and wait for answering. The computer system in the call center attempts to re-send the blocking regular calls from the queue ($\emptyset$) after a retrial time, which is exponentially distributed at rate $\alpha$. This study assumes that the capacity of the queue ($\emptyset$) is finite. Let $P_v$ be the blocking probability of VIP calls (do not receive service). Let $P_r$ be the blocking probability of that regular calls receive no answer on the first attempt. Moreover, let $H_0$ be the probability of the blocking regular calls enter the waiting queue. Then, $1 - H_0$ is the probability that the blocking regular calls leave the call center. Let $H_1$ be the probability that regular calls in the waiting queue return to the waiting queue after an unsuccessful retrial. Then, $1 - H_1$ is the probability that the regular calls in the queue leave the call center after an unsuccessful retrial. The average number of regular calls in the queue is $G$. 
Model of Call Center

- This study is to provide optimal call center service based on the reservation of operators. For a company, the optimal service means the costs must be consumed as few as possible. That is, to minimize the total expected cost by setting the threshold $N$ when the total $K$ lines must be discussed. This study derives a total expected opportunity cost function (per unit time) for the $N$-signal $M/M/K$ queueing system, where $N$ is the decision variable. Based on the description of the call center, the total expected opportunity cost function (per unit time) can be expressed as

$$OC(N, K) = C_w G + C_r P_r + C_v P_v, \quad (1)$$

where $C_w$ is the holding cost per unit time for each call in the queue, $C_r$ is the cost of the regular calls that are failing to be served, and $C_v$ is the cost of the VIP calls that are failing to be served.
Model of Call Center

- Let $X_1(t)$ be the random variable that represents the number of blocked regular calls in the waiting queue at time $t$. Let $X_2(t)$ be the random variable that represents the number of calls under transmission (in service) at time $t$, including regular calls and VIP calls. Then, $X_1(t)$ and $X_2(t)$ can be modeled as a 2-dimensional Markov chain, whose $Q$-matrix can be given by

\[
q((i,j), (i',j')) = \begin{cases} 
\lambda_r + \lambda_v & \text{if } i' = i, j' = j + 1, 0 \leq i \leq Q, 0 \leq j \leq N - 1 \\
\lambda_v & \text{if } i' = i, j' = j + 1, 0 \leq i \leq Q, N \leq j \leq K \\
i\alpha & \text{if } i' = i - 1, j' = j + 1, 1 \leq i \leq Q, 0 \leq j \leq N - 1 \\
\lambda_r H_0 & \text{if } i' = i - 1, j' = j, 1 \leq i \leq Q, N \leq j \leq K \\
j\mu & \text{if } i' = i + 1, j' = j, 0 \leq i \leq Q, N \leq j \leq K \\
0 & \text{if } i' = i, j' = j - 1, 0 \leq i \leq Q, 1 \leq j \leq K \\
otherwise & 
\end{cases}
\]
Model of Call Center

• Let $P(i, j)$ be the stationary probability at state $(i, j)$. Then, the balance equation can be derived as follows:

$$\sum_{i=0}^{Q} \sum_{j=0}^{K} P(i, j) q((i, j), (i', j')) = 0. \quad (3)$$

• From equation 3, this study obtains the stationary probability $P(i, j)$. Therefore, performance measures of this queuing system can be determined as follows:

$$G = \sum_{i=1}^{Q} \sum_{j=0}^{K} iP(i, j). \quad (4) \text{ The average number of regular calls in the queue}$$

$$P_r = \sum_{i=0}^{Q} \sum_{j=N}^{K} P(i, j). \quad (5) \text{ The probability that regular calls cannot be caught up on the first attempt}$$

$$P_v = \sum_{i=0}^{Q} P(i, K). \quad (6) \text{ The probability that VIP calls cannot be caught up on the first attempt}$$
Analytical Results

- From the survey of the sample call center, the frequency of unanswered regular calls being queued for retrial is unknown. This study assumes the following parameters to see the changes in the retrial rate of unanswered regular calls: $\alpha = 1, 30, \text{and } 120$ ($\alpha = 1$ implies that the computer system queues an unanswered regular call for retrial every 60 s to give the operators a chance to take the call; $\alpha = 30$ implies 2 s; and $\alpha = 120$ implies 0.5 s).

- This study also analyses the initial changes in the important performance measures of the derived queueing model $G$. On the basis of the opportunity cost function $OC$ in (1), Figures 1–2 illustrate three performance measures of the sample call center at peak hours. Figure 1 shows the average number of regular calls in the queue ($Q$) along with the increase in $N$. Figures 2 and 3 show the blocking probabilities of regular calls and VIP calls with a service rate of 0.16 at peak hours. The high retrial rate causes the high blocking probability of regular calls.
Analytical Results

Figure 1. $G_{\text{peak}}$, service rate = 0.16

Figure 2. $P_{\text{r,peak}}$, service rate = 0.16

Figure 3. $P_{\text{v,peak}}$, service rate = 0.16

* Figure 1 shows that a large $\alpha$ implies a small $G$ at peak hours. Along with an increase in $N$, $P_r$ and $P_v$ have different shapes: $P_r$ decreases when $N \geq 69$ ($\alpha = 30$ and 120) and $N \geq 65$ ($\alpha = 1$) (Figure 2), and $P_v$ increases when $N \geq 68$ ($\alpha = 30$ and 120) and $N \geq 64$ ($\alpha = 1$) (Figure 3).
Analytical Results

- Because $P_v$ represents the blocking probability of VIP calls, a small $P_v$ means a low probability of losing VIPs and therefore, lowers costs. Along with an increase in $N$, it is possible for $P_v$ to be larger, because of the reduced number of operators ($K-N$) reserved to serve VIPs. Additionally, because $P_r$ represents the blocking probability of regular calls, a small $P_r$ means a low probability of losing regular users and therefore, lowers costs. Along with an increase in $N$, it is possible for $P_r$ to be smaller, because of the reduced number of operators reserved to serve VIPs.
Conclusion

• This study proposes a queueing model for measuring the opportunity costs of a call center. To achieve the results, it applies the proposed cost functions to a sample call center with 70 operators. The analysis reveals that when the number of operators is fixed, providing different services at low costs is possible with the reservation of operators. The results show that at peak hours, spending 6.25 minutes per call, the optimum numbers of reserved operators (minimum opportunity costs) are 6 (retrial rate is 1 time/minute; opportunity cost is 58.51), 2 (retrial rate is 1 time/2 seconds; opportunity cost is 72.74), and 1 (retrial rate is 1 time/0.5 seconds; opportunity cost is 74.23). Therefore, increasing the retrial rate of queued calls or the size of the queue is pointless. Only an improvement in the service rate can reduce opportunity costs.
Q&A

Thank you for your attention