A Framework for Balanced Service and Cross–Selling by Using Queuing Science

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Abstract:

Call centers are complex contact centers to handle large volume of inbound, outbound or both types of calls depending on the business purpose. Call centers assume the role of the primary contact medium for many companies from a wide range of industries with their customers or clients. Despite of being seen traditionally as adding cost to the companies' bottom lines, call centers are now viewed by many companies to turn a service request into an opportunity to sell additional products and services. This sales attempt is called cross-selling. The opportunity to generate profit from an existing customer-base is a key factor for a successful call center. This paper introduces a framework for balancing cross-selling and service activities in a call center setup from a queuing science point of view. The main goal of this study is to introduce a framework to maximize a call center's performance without degrading the service quality. Our framework is based on the usage of real-time queue characteristics, customer profile information and server-skill set information from a cross-sell point of view.

Keywords: call center; cross-selling; contact center; queuing theory; skill-based routing, call routing.

Submission Area: System Modeling and Simulation

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1. Introduction

Call centers also known as customer service centers are becoming more prevalent means to handle customer service request in a variety industries ranging from financial service to retail companies. Call center industry is expanding worldwide in rapid face in terms of workforce and economic. For example, it is estimated that 3% of workforce both in the UK and USA is employed by call center industry with 20% growth rate (Koole and Mandelbaum, (2001)). In addition, outsourcing activities in developed countries create significant amount of jobs in developing countries like India.

Queuing theory concerns with the mathematical explanations and analysis of stochastic systems from congestion point of view. On the other hand, as mentioned in Brown et al., (2005), queuing science deals with to validate and calibrate queuing-theoretic models by extensive statistical data analysis on real systems. Thus, queuing science can be considered as the empirical and practical answer to the operational and managerial problems in the call center industry. Nevertheless, many design decisions are made based on the theoretical results of the queuing theory.

Johnson and Seymour (1985) studied a retail bank before and after a cross-sell program initiated across its branches. Their study is the one of earliest analysis of cross-sell efforts in traditional business environment. Similar to the Johnson and Seymour (1985) study, Aksin and Harker (1999) studied identifying some of the effects of increased sales activities on customer service in phone centers. The primary goal in this particular study was to ascertain possible effects of cross-sell effort under different organizational scenarios. Aksin and Harker (1999) applied the framework proposed in their study to a retail bank call center. For a successful entering customer, the expected revenue is deterministic but dependent on the service type. They showed that appropriate managerial actions can ameliorate the congestive effects of cross-selling.

Gans et al., (2003) provides a tutorial to the operation and management issues in telephone centers. Koole and Mandelbaum (2001) also prepared a survey as an introduction to the queuing models of call centers. Güneş and Akşin and (2004) segmented customer base into high and low value customers and analyzed cross-selling attempts to one or both customer segments. Örmeci and Akşin (2005) modeled revenu generation and congestion in a call center as a dynamic framework. We model our cross-selling problem as a queuing system for optimal control.

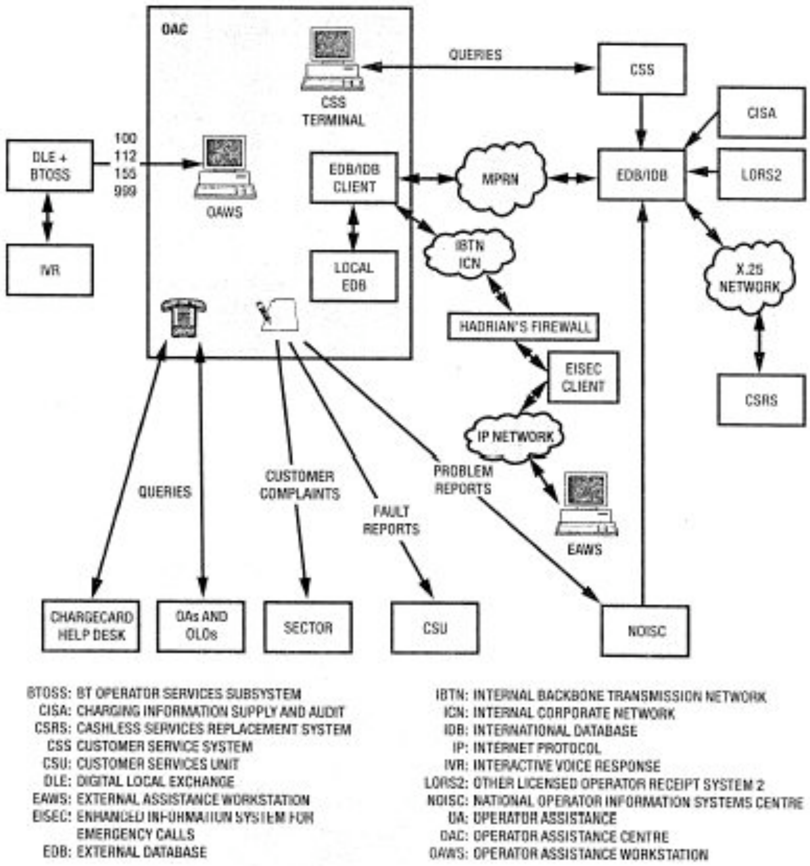

Figure 1. Call Center Technology (Adapted from Duxbury et al. (1999))

2. What is a Call Center?

Call centers are modern service networks in which customer service representatives (CSRs) provide services to customers via telephones and computers (see Figure 1). Call centers can be categorized according to their functionalities (help desk, emergency, tele-marketing, information providers, etc.), agent characteristics (low-skilled, high-skilled vs.), their sizes (number of agent seats) and more (Koole and Mandelbaum, (2001)). A main characteristic of a call center is whether it handles inbound or outbound traffic. Our focus here is on inbound (incoming) call centers.

Call **(contact)** centers are technology-intensive operations. However, 70% or more of their operating costs are devoted to human resources (Koole and Mandelbaum, (2001)). Well-run call centers maximize the expected operation profit without sacrificing the service quality. Successful call centers adhere to the agent efficiency through well balanced call routing based on queue characteristics (service quality) and customer profile information. Call centers can be viewed, naturally and usefully, as queuing systems see Figure 2. In a queuing model of a call center, the customers are callers, servers (resources) are telephone agents (operators) or communication equipment, and tele-queues consist of callers that await service by a system resource. Our model is based on a single line, multi-server and finite queuing model that works according to FCFS discipline.

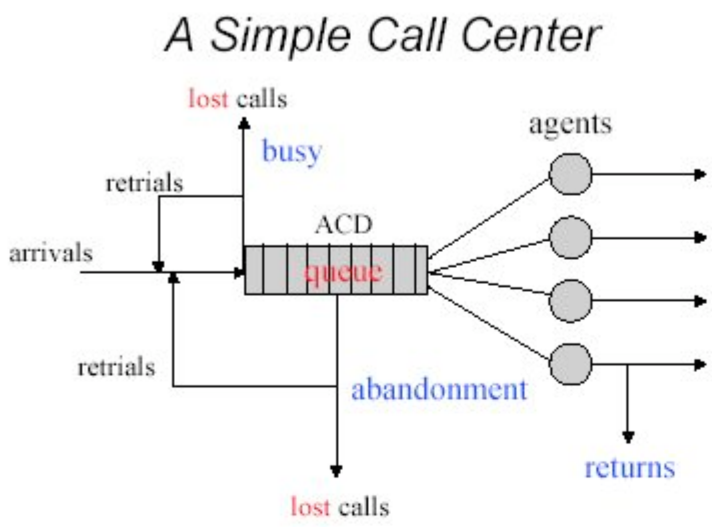

Figure 2. Operational scheme of a simple call center (Adapted from Koole and Mandelbaum, (2001))

Modern call center is often more complicated queuing networks. One of the early breakthroughs in call center technology is the PABX's (Private Automatic Branch Exchanges, or simply PBX), the telephone exchanges within companies. A PBX connects, the public telephone network to telephones within the call centers where are staffed by telephone agents, often called CSR (Customer Service Representatives). In between the PBX and the agents, there is the ACD (Automatic Call Distribution) switch, whose role is to distribute calls according to skill and idle among agents. ACD is also the archival collection of operational data, which is of first importance research for call center (Koole and Mandelbaum, (2001)).

Most call centers support Interactive Voice Response (IVR) units, or Voice Response Units (VRU's), which are the industrial versions of answering machines, including the possibilities of interactions. But more generally, a current trend is the extension of the call center into a contact center. Telephone service is enhanced by some additional multi-media customer-contact channels such as e-mail, fax, internet or chat (in that order of prevalence). The customer can be often automatically identified by the PBX, using Automatic Number identification (ANI). Computer Telephony Integration,
(CTI) is then used to search for customer's history file. CTI and ANI are together used to identify the potential customer, for example, cross-selling opportunities and, thus routing of the call to an appropriately skilled agent. IVR and CTI can be used for reporting purposes.

3. Call Centers from a Queuing Theory Perspective

Queues (or waiting lines) are an unavoidable component of modern life. We are required to stand physically in queues in grocery stores, banks, department stores, amusement parks, movie theaters etc. Although we do not necessarily like standing in a queue, we appreciate the fairness that it imposes. Typically, a queueing system consist of a stream of customers (humans, finished goods,messages) that arrive at a service facility, get served according a given service discipline, and then depart. In practice we are interseted in designing a queuing system, namely, its capacity, number of servers, service discipline, etc.

From a queuing theoretic point of view, call centers can simply be modeled as M/M/s/FCFS/K/∞. Assume that $\{X_K(t), t \geq 0\}$ is a birth and death process on $\{0, 1, ..., K\}$ with birth parameters $\lambda_i = \lambda$ for $0 \leq i \leq K-1$ and death parameters $\mu_i = \min(i,s)\mu$ for $0 \leq i \leq K$. Characteristics of M/M/s/FCFS/K/∞ queuing model then can be defined as follows Kulkarni, (1999).

$$\rho = \frac{\lambda}{s\mu}$$

$$\rho_i(K) = \rho_0(K)\rho_i \qquad i = 0,1,2,...,K,$$

$$\rho_i = \begin{cases} \dfrac{1}{i!}\left(\dfrac{\lambda}{\mu}\right)^i, & \text{if } 0 \leq i \leq s-1, \\ \dfrac{s^s}{s!}\rho^i, & \text{if } s \leq i \leq K, \end{cases}$$

Server idleness can be computed as

$$P_0(K) = \left[\sum_{i=0}^{s-1}\frac{1}{i!}\left(\frac{\lambda}{\mu}\right)^i + \frac{1}{s!}\left(\frac{\lambda}{\mu}\right)^s . \frac{1-\rho^{K-s+1}}{1-\rho}\right]^{-1}$$

Expected number of customers in the system is calculated by

$$L = 0.P_0 + 1.P_1 + 2.P_2 + ...$$

$$L = \sum_{n=0}^{K} nP_n = \sum_{n=0}^{K} iP_i(K)$$

Blocking probability for the finite

$$P_K(K) = P_0(K).\rho^K = P_0(K).\left(\frac{\lambda}{s\mu}\right)^K = P_0(K).\frac{s^s}{s!}\rho^K$$

For entering customers

$\prod_i^*(K) = 0$ for i ≥ K i.e. a customer cannot enter the system, if the system is full.

$\prod_i(K) = \dfrac{P_i(K)}{1-P_K(K)}$ for $0 \leq i \leq K-1$

Expected waiting time for the entering customers is computed as

$$W = \frac{L}{(\lambda(1 - P_K(K)))}$$, where $\lambda(1 - P_K(K))$ is arrival rate of entering customers.

In the next section, we explain the fundamental components of our approach based on the work of Byers and So, (2004).

4. Call Center Models

We used birth and death processes to analyze the operations of a call center system with the assumptions that arrival and service times follow certain distributions. Our framework shares some similar approaches as Byers and So, (2004). Following their notation we define that

$\lambda =$ Arrival rate
s= number of service agents(servers)
$\mu_1 =$ Service rate for bundling the regular service request with the cross-selling effort
$\mu_2 =$ Service rate for providing the regular service request only
h=Unit holding cost per successful sale
R= revenue for each successful sale
C_{ss}=Cross-sell skill of servers
$\rho_1 = \lambda / s\mu_1$
$\rho_2 = \lambda / s\mu_2$

We assume in this study that the service time distributions for both providing cross-selling with the regular service and only regular service as exponential, with rates μ_1 and μ_2 respectively. We also assume that $\mu_1 < \mu_2$ and $\rho_2 < 1$ throughout this study.

In Byers and So, (2004), the probability distribution of a successful cross-sell for existing customer base is uniformly distributed in $[q - \in, q + \in]$, where $0 \le q - \in \le q + \in \le 1$. In other words, q is the average probability that a random customer will make a purchase, and $\in$ is a measure of variability of successful cross-sell across the existent customer base.

The main goal of this study is to propose a framework to decide whether to cross-sell or not cross-sell by considering the system congestion information (queue length), customer profile information (likelihood to purchase) and cross-sell skill of server information. We consider cross-sell effort to an opportunity management for maximizing the expected operating profit in the system, which is equal to the expected revenue for successful cross-sell minus expected customer holding costs as used in general queuing theory.

We utilize queue characteristics such as the length, customer profile and server cross-sell skill information to control cross–sell opportunity to an individual customer. We initially separate all customers into two segment based on the estimated probability of a successful sale to customers as in Byers and So, (2004). The top $p\ (0 \le p \le 1)$ proportion of customers has the highest probability of successful cross-sell as high-value customers. The remaining customers belong to low value group. A threshold value is used for cross-sell to an individual customer if and only if the total number of customers in the system is less than or equal to some pre-determined threshold when that individual customer is being served. We assume $n_h \ge 0$ and $n_l \ge 0$ to denote the respective thresholds used for high-value and low-value customers Byers and So, (2004).

Under the exponential service times assumption, we use birth-death process to determine expected operating profit. All customers are assumed to be first-come first-served. Let S=

$\{ (i,n): 0 \le i; 0 \le n \le \max(i,s) \}$ denote the state space of underlying birth-death process, where i denotes the total number of customers in the system and n denotes the number of high-value customers currently by the servers. Let $\pi_{i,n}$ denote the steady-state probability at state (i, n). We define $\mu_h(i)$ and $\mu_l(i)$ as the service rates fort he high-value and low-value customers when there are i customers in the system, respectively.

$$\mu_h(i) = \mu_1, 0 \le i \le n_h$$
$$\mu_l(i) = \mu_{2,} i > n_h$$

$$\mu_l(i) = \mu_1, 0 \le i \le n_l$$
$$\mu_l(i) = \mu_{2,} i > n_l$$

$$\pi_{i,j} = 0, \qquad \text{for i < 0 or j < 0}$$

For $0 \le i < s$ and $0 \le n \le i$

$$\{\lambda + n_h \mu_h(i) + (i-n)\mu_l(i)\} = p\lambda\pi_{i-1,n-1} + (1-p)\lambda\pi_{i-1,n} + (i+1-n)\mu_l(i)\pi_{i+1,n} + (n+1)\mu_h(i)\pi_{i+1,n+1}$$

For $i \ge s$ and $0 \le n \le s$,

$$\{\lambda + n\mu_h(i) + (s-n)\mu_l(i)\}\pi_{i,n} = p\lambda\pi_{i-1,n-1} + (1-p)\lambda\pi_{i-1,n} + (s+1-n)\mu_l(i)\pi_{i+1,n} + (n+1)\mu_h(i)\pi_{i+1,n+1}$$

The probability distribution of a successful cross-sell of all customers is assumed to be uniform $[q-\in, q+\in]$ where 0 ≤ q ≤ 1. We also assume for this study that the probability cross-sell skill of the server (C_{ss}) is distributed uniform between 0 and 1. Hence, the probability distribution of successful cross-sell for high value customers is uniform $[q + (1-2p)\in, q+\in]$, which implies that the average probability of a successful cross-sell to any random high-value customer is equal to $C_{ss}[q + (1-p)\in]$. Arrival rate for high-value customers is equal to λp, the mean revenue per unit time because of cross-selling to high-value customers is equal to $C_{ss}R\lambda p[q + (1-p)\in]$. Similarly arrival rate of law value customers is equal to $\lambda(1-p)$ and the expected reward per unit time because of successful cross-sell to low–value customers is equal to $C_{ss}R\lambda(1-p)[q - p\in]$. Thus, the expected operating profit is equal to

$$F = C_{ss}\lambda Rp[q + (1-p)\in]\sum_{i=0}^{n_g-1}\sum_{n=0}^{\min(i,s}\pi_{i,n} + C_{ss}\lambda R(1-p)[q - p\in]\sum_{i=0}^{n_b-1}\sum_{n=0}^{\min(i,s)}\pi_{i,n} - h\sum_{i=1}^{\infty}\sum_{n=0}^{\min(i,s)} i,\pi_{i,n}.$$

5. Proposed Framework

Our framework (see Figure 3) differs from prior work in many ways. First of all, we consider adding information about agent cross-sell skills. Moreover, the centerpiece of our framework is a new product recommender system (Demiriz, (2004)) that works concurrently with an ACD. This new product recommender system is devised to optimize the cross-sell activities by considering the real-time queue characteristics, customer profile, contact history, and the cross-sell ability of agents.

In a call center environment, we might also consider adding individual sales targets of each agent into our framework. But this needs a careful consideration.

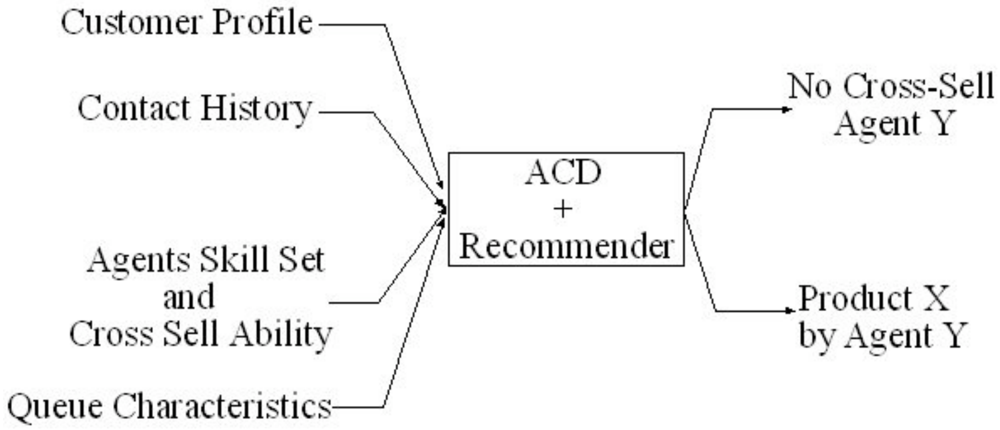

Figure 3. Proposed Framework

6. Conclusion

We proposed a new framework for cross-sell efforts in a call center from a queuing science point of view by considering agent skill set as well compared to previous work in the literature. We also propose a new recommender system that works with automatic call distribution systems to route the call to appropriate agent at real-time.

Once we show the steady-state formulas of our queuing model in a forthcoming paper, we will eventually apply our findings on real dataset mentioned in Koole and Mandelbaum, (2001). In addition, we will test different scenarios and policies under different arrival and service time distributions using discrete-event simulation.

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