An Asymptotic Analysis of a Queuing Model for a Call Center

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Abstract

This article deals with the simplest abandonment model in which the customer’s patience is exponentially distributed and the capacity of the system is unlimited. Sze (1984, 229-249) has designed a queuing model for the telephone operating system without abandonment. The most common model which supports the workforce management of the telephone centre is M/M/N/B and some special cases can be analyzed as M/M/N with Erlang distribution C which models out busy signals and M/M/N/N queuing model with Erlang B distribution disallow the waiting concept. Many queuing models lack the feature that impatient customers might decide to leave, before the service begins. In this article, the simplest abandonment model is considered is M/M/N+M which includes abandonment and this model can be used to analyse, provide information which is important for the call center managers. Based on the numerical calculations and graphical representations this model can be considered as an appropriate queuing model to manage a large call center in heavy traffic with abandonment.

Keywords: abandonment; customer’s potential waiting time; staffing level; telephone trunks

Introduction

Modeling a Call Centre
A schematic representation of a call center is shown in Figure 1. A single queue from which the calls received has to wait for service from one of the “N” statistically identical agents. Automatic call distributor (ACD) is provided so that K+N telephone trunks are being connected, which manages the queue and connects the customer to the available agents. A busy signal (Red) is provided so that all the trunks are occupied even though the customer arrivals are there from different places. Customers try for calls by the two concepts such as retrial queues and lost demand. When all the agents are busy, or in other words there are at least N customers but fewer than K
+ N customers within the call centre, then they will be placed on the queue.

After waiting for a long time the customer may be impatient before the service begins which leads to the concept of abandonment. After abandonment, customers might try calling again and again. The number of trunks available is given by K + N and the number of agents available is denoted by N. If waiting customers run out of patience before their service begins, they hand up (“abandon”). After abandoning, customers might try calling again later. The cost of trunk lines is trivial compared to personnel costs. In this article, the staffing decisions are being focused by assuming K = ∞ for modeling purpose. The queuing model M/M/N is a Erlang-C model in which abandonment is not included. Thus, busy signals are absent in the previous models, which has to be considered in this queuing model.

**Square Root Rule for Safety Staffing with Abandonment**

Consider the queuing model M/M/N inclusive of abandonment. Let ρ = λ / μ be defined as the average load offered, λ be the average call arrival rate, 1/μ be the mean call duration and R be the duration per unit time. For moderate to large values of R, the staffing level is given by:

\[ N = R + \beta \sqrt{R} \]  

(1)

where β is a positive constant that depends on the desired level of service. Now β\sqrt{R} is described as the excess capacity needed beyond the nominal requirements to achieve the target service level in the face of stochastic variability, which is defined as the statistical economies of scale. Equation (1) is defined as the required excess capacity which grows less than proportionality with the load of calls to be handled, and this is defined as “Statistical economics of scale.”

Square root rule has been already discussed and derived by Whitt (1992). The variables characterizing different callers are independent and identically distributed with mean θ and they are independent of all other model elements, where the positive quantity is considered as the abandonment rate. Baccelli and Hebuterne (1981) have discussed the queues with impatient customers (pp.159-179). Garnett (1998) has designed a telephone call center with impatient customers. But in this model the square root
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