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SIMULATION MODELING FOR CALL CENTER MANAGEMENT: A CASE STUDY IN A PRIVATE BANK

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Recent technology advances and the faster pace of change in business environments have made call center management a rapidly growing industry. Flexibility in call center design and processes is now one of the basic requirements for improved performances. In this study two alternative call center management decisions, namely "introducing the call back" option and "increasing the agent size" options are evaluated by using simulation modeling on the IVR (interactive voice recognition) system of a private bank call center. It is shown that the simulation approach can be used to generate valuable managerial insights by setting the trade off between the increased costs and increased service levels in call center management. It is suggested that the simulation based decision support systems can be designed to increase the quality of decisions in call center management.

Key Words: Call center management, Simulation, Service level

ÇAĞRI MERKEZİ YÖNETİMİ İÇİN BENZETİM MODELLEME: ÖZEL BİR BANKADA VAKA ÇALIŞMASI

Yakın zamanda yaşanan teknolojik gelişmeler ve iş çevrelerindeki hızlı değişim çağrı merkezi yönetimini hızla büyüyen bir endüstri haline getirmektedir. Çağrı merkezi tasarımındaki ve süreçlerindeki esneklik artık performans gelişiminin en temel gereksinimidir. Bu çalışmada biri "geri arama opsiyonu" diğeri "operator sayısını arttırma" olmak üzere iki çağrı merkezi yönetim karar opsiyonu benzetim modelleme ile değerlendirilmekte ve özel bir bankanın. çağrı merkezinin IVR sisteminde bir çalışma yapılmaktadır. Benzetim yaklaşımının çağrı merkezlerinde artan maliyet ve yükselen servis seviyesi arasındaki ilişkiyi göstererek, değerli yönetimsel sezgiler geliştirmede kullanılabileceği gösterilmektedir. Çağrı merkezi yönetiminde verilen kararların kalitesini arttırmak için, benzetim tabanlı karar destek sistemlerinin tasarlanması önerilmektedir.

Anahtar Sözcükler: Çağrı merkezi yönetimi, Benzetim, Servis seviyesi

INTRODUCTION

A call center is a central place or network of places where telephone calls are handled by an enterprise. Typically, a call center has the ability to handle a considerable volume of calls, forward those to qualified agents and log them.

Call centers are used by many firms that operate in very different sectors, such as mail-order catalogue organizations, telemarketing companies, computer product help desks, banks and any large enterprises that use the telephone to sell or service products and services. In addition to answering incoming phone calls, they can make out calls, reply e-mail messages, and conduct marketing surveys such as questionnaires.

In call centers, the cost of providing trained agents accounts for over 50% of total operations costs. So, it is crucial to determine correct strategies for staffing and workforce scheduling that directly affects the profitability and the efficiency. On one hand overstaffing results in incorrect usage of resources and on the other hand, understaffing causes decreases in performance indicators, and of course, the customer satisfaction.

In this study, the standard processes and the related performance measures in a call center are analyzed by using simulation methodologies. The study is based on one of the leading call centers of a private bank in Turkey. The aim is to show that simulation based Decision Support Systems can be used efficiently in evaluating alternative designs in a call center. Such an approach will introduce the advances of using simulation in designing and managing complex systems.

Within the scope of the project, we two alternative designs are evaluated to improve the performance of the system. In the first alternative, we the call-back option is considered for the calls when the expected waiting times are greater than a threshold value. In the second alternative, hiring part-time agents for the peak hours is proposed and optimal staffing levels are found to meet the minimum service level requirements. Then the two alternatives are compared and the robustness of the operational costs is tested with respect to the deviations in the estimated input abandonment cost values.

In the next section, a brief literature survey on the studies for call center management is provided. In section 2, the current call center system is modelled and its performance is analyzed by using Arena Rockwell simulation software. In section 3, alternative models are developed to improve the system performance. In section 4, alternative models are compared by using the Output Analyzer of Arena. In the last section, a summary and critics of all the study are provided.

1. LITERATURE SURVEY

In this section, a brief literature is provided about the studies on call centers, workforce management systems and the role of simulation in call center management.

Studies on call centers are mostly related to work force management (WFM) issues which can be summarized under the four main headings: 1)Demand forecasting, 2) Labor staffing, 3) Shift scheduling and 4) Staff allocation to the shifts. Most researchers follow this general approach in different WFM analysis tools.

In the recent years, Green, Kolesar and Soares (2001) suggest an approach to determine the minimum staffing requirements in each period based on a stationary M/M/s queuing system which assumes stationary arrivals and service processes. Ingolfsson, Cabral and Wu (2002), Thompson (1997), Atlason, Epelman and Henderson (2004) propose some approaches to integrate steps 2 and 3 of WFM, where minimum agent requirements and shift schedules are determined simultaneously.

Ingolfsson et al. (2002) propose a method to find low cost employee shift schedules to guarantee that target service level is met or exceeded. As previously discussed, most approaches use a two-step procedure. First, determining the minimum employee requirements and then finding a minimum cost schedule that provides the required number of employees in every period. According to Ingolfsson et al. (2002), due to approximations used in the first step, the two-step approach usually results in infeasible or suboptimal solutions. Therefore, their method iterates between two components: a schedule evaluator and a schedule generator. Although the method does not guarantee optimality, it provides a lower bound on the minimum cost.

Thompson (1997) introduces two models of the labor staffing and scheduling problems that overcome the limitations of existing models. He distinguishes between the aggregate threshold service level (the overall level of service that management wishes to provide to customers) and the minimum acceptable service level (the lowest level of customer service that management considers acceptable in any planning period).

Atlason, et al. (2004) and Henderson and Mason (1998) propose a model to optimize the scheduling of agents in a single call type and single-skill call center, under service-level constraints. A linear (integer) model is generated to find the staffing levels, and this solution is used as an input for a simulation model to calculate the service level. If the service level is not satisfactory, new constraints are added to the linear program and reiterated.

Cezik and L'Ecuyer (2005) describe a generalization of the model developed by Atlason et al. (2004) for multi-skill call centers. Due to the complexity of multi-skill call centers, the computation time of the algorithm is relatively longer than single-skill call centers. Furthermore, Koole and Pot (2005) propose a two-step method to generate shifts in multi-skill call centers. In the first step, the optimal staffing levels for each skill group and each interval are determined. In the second step, shifts are composed such that the staffing level in each interval is met. Avramidis and L'Ecuyer (2005) and Mehrotra and Fama (2003) generate models for call center management that are based on simulation approaches.

Klungle (1999) discusses that with the improvements in technology and the changing business environment, call center sector has showed significant growth rates, so both technical issues, such as call routing strategies, and management issues should be addressed on a regular basis. Klungle's work covers how simulation is used to address some of these issues, and when it should be used. Moreover, strength and weaknesses of call center management software for forecasting, staffing, and scheduling are discussed.

Gedikoğlu (2006) develops a decision support system (DSS) design for workforce management in call centers. His study differs from the previous WFM models since an integrated optimization model and a computer simulation model are suggested. Most of the researchers use a stepwise approach by using various mathematical models but use of computer system simulation as a supportive model is not a common method in the literature. Erdem and Gedikoğlu (2006) suggest that simulation should be used as a supportive tool to solve shift scheduling and staff allocation problems.

2. SIMULATION OF CALL CENTER OPERATIONS

In this section, a simulation model is developed to analyze the operations in the call center of a private bank. Two alternative scenarios are generated to improve the service level performances and compared statistically.

Processes in a Call Center

When a customer makes a call to contact with a call center, an IVR system receives the call, prompts some announcements and serves a series of interactive menu. The customer can choose one of the choices in the interactive menu. According to the characteristic of the call, IVR system continues to interact with the call or transfers the call to an agent.

In this study the current IVR system of the call center is modeled by Arena 7.01 simulation software. Incoming call rates and operator service times are not publicly available and therefore, might differ from the actual values.

In the IVR system, the customer enters the queue of the selected option on FIFO basis and he is informed about the expected waiting time in the queue. At this point, the customer can either wait for an agent to become available or abandon from the system. A customer abandons the system if his expected waiting time is longer than his tolerance time, which will be referred to as the "reneging time" in this study. It is assumed that the "service time of an agent" is generated from the triangle distribution with the parameters of 90, 120 and 140 seconds respectively and the reneging (tolerance) time of a customer is exponentially distributed with mean value of 60 seconds. Here the expected waiting time of a customer, at any time in a period, EWT is approximated as follows:

EWT =
[number of calls waiting in the queue] *
[average service time] / [number of scheduled agents]

Call Arrivals

Without loss of generality, the call arrivals in any period are assumed to follow Poisson distribution, i.e., the mean arrival rate is fixed in intervals of 30 min. whereas the means are different in respective periods as seen in Figure 2.1. It should be noted that the mean arrival rates are hypothetically developed.

Agents

There are two sets of agents grouped according to their skills. The agents in the first set give services for all menu options in Turkish; agents in the second set give support in English. There are 66 agents in the first group and 9 agents in the second group. Each agent works on an 8 hr shift basis and the daily work schedules are given in Table 2.1.

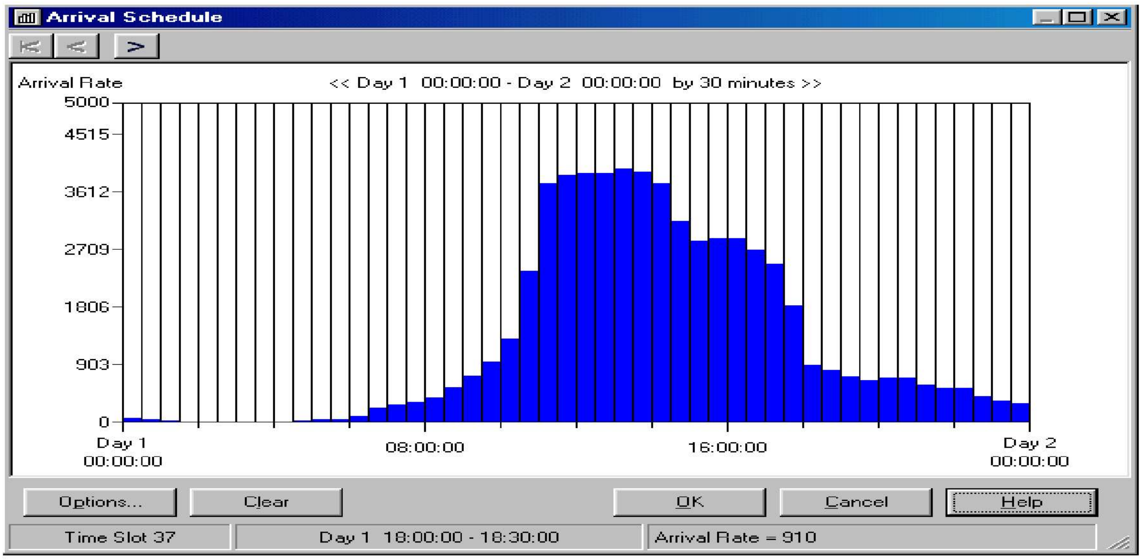

Figure 2.1 Mean arrival rate (#/hr) in periods of 30 min.

Table 2.1 – Working schedules of agents

Agents in the first set		Agents in the second set	
Shift Periods	Number of Agents	Shift Periods	Number of Agents
00:00a.m.-08:00a.m.	3	00:00a.m.-08:00a.m	3
08:00a.m-4:00p.m	15	08:00a.m-4:00p.m	3
10:00a.m–6:00p.m	48	4:00p.m–12:00p.m	3
4:00p.m–12:00p.m	15		

Performance Measures

A call center can measure its performance according to many different criteria. Performance measurements can vary usually depending on the function of the call center and the sector within which that center resides. These terms may be used in different forms but most commonly used terms are listed below:

- *Average Speed of Answer (ASA):* ASA is the average waiting time in the queue experienced by a customer for the first available agent who will serve him.
- *Service Level:* Service level can be defined as the percent of a specified time in which the service goal is reached. The 80/20 rule is generally accepted as the service goal, which means 80% of the incoming calls are to be handled within 20 seconds. Service level is crucial for the determination of accurate staffing levels.
- *Abandonment Rate:* Abandonment rate is the percentage of customers who end their calls after entering the IVR system but before being served by an agent.
- *Agent Utilization:* Utilization can be explained as the percent of the available time of agents that is spent actually for handling incoming calls. Utilization can be calculated as:

$$\text{Utilization} = \frac{\text{number of calls handled} * \text{average talk time}}{\text{time length of period} * \text{number of agents}}$$

where "average talk time" is the average value of time that an agent spends for a customer except the time spent for some works after the call is ended; "time length of period" represents length of the period during which the mean arrival rate is assumed to be stationary, which is 30 min. in this study; "number of agents" is the number of available agents in this period; and "number of calls handled" is the number of calls answered in a period.

Objective and Cost Structure

The basic objective of call center management is to decrease the costs, the abandonment rate, and ASA while increasing the service level with limited number of agents. The service level objective is to respond at least 80% of incoming calls within 20 seconds. For this purpose the performance measure "service level met periods" (SLMP) is defined, as the percentage of periods in a day during which the minimum service level of 80/20 is met.

The cost structure of the call center is analyzed in two parts: Fixed costs and operational costs. Fixed costs consist of agent payments which are not affected by operational performance. On the other hand, operational costs are directly affected by the operational performance. Duder and Rosenwein (2001) identify the components of the operational costs as follows:

- Inbound telecommunication cost incurred from total duration of IVR experience: In this study, this cost parameter is taken as 0.001$/sec.
- Information systems cost per IVR experience: These costs arise from an IVR system querying various databases in order to develop a customer profile. In this study, it is assumed to be 0.04$/call.
- Cost of erosion of the bank's customer base: A customer that has abandoned a call may judge the time required to reach an agent to be too long and hence, may view the call center as having provided inferior service. Some of these customers may even switch their bank preference. It is assumed that the probability of a customer switching to a competitor bank given inferior customer service is 0.001. Although estimating the exact price is impossible, each customer has a value for companies. So, customers that switch their bank preference incur a cost, which is initially taken as $100 per customer in the model. The sensitivity of the performance measures to this hypothetical parameter is also analyzed in the next steps.

Then the total costs are formulated as follows:

Total cost/day = operational costs/day + fixed costs/day where,

Operational costs = [total system time (sec/day)*inbound telecommunication cost/sec] +

+[total number of calls (calls/day) * information systems cost / call] +

+[total number of abandoned calls (calls/day)* probability of changing banking preference for a customer given inferior service * cost of erosion / call]

Fixed costs = salary/day/agent * total number of agents

Simulation Results

Initially the existing system (base model) is simulated by using Arena 7.01 for 1 day (48 periods) and 30 replications. We obtain the following performance outputs:

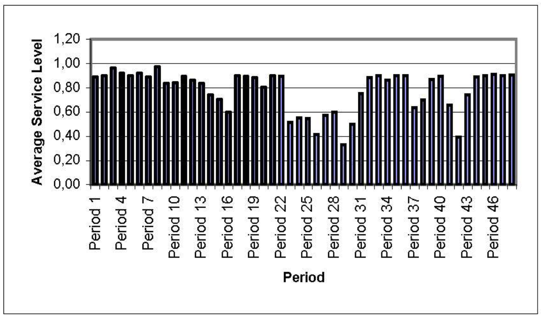

Figure 2.2 – Average service level in base model

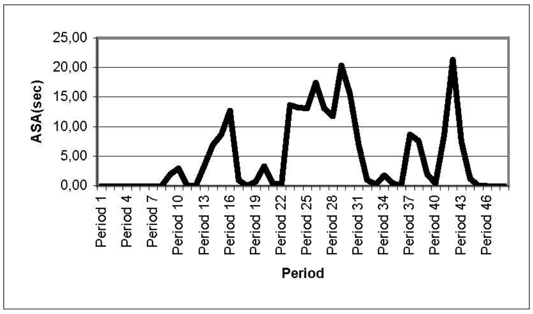

Figure 2.3 – Average speed of answer in base model

As seen in the above Figure 2.2, the call center has difficulty in meeting the required minimum service level of 80% during the peak hours in periods 22-32, i.e., between 11:00 a.m.- 4:00 p.m. The service level drops to the minimum value 33% in period 29. Moreover, we see that in some periods outside the peak hours, i.e., before 08:00 a.m. (period 16) and after 4:00 p.m. (period 32) the minimum service level is not met because of agent scarcity.

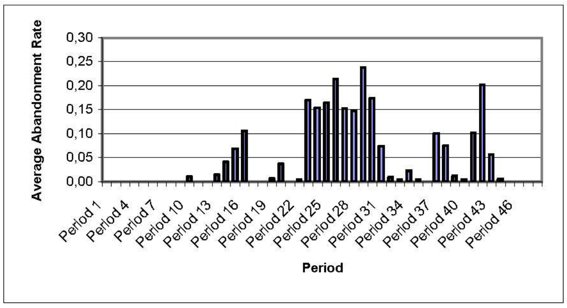

Figure 2.4 – Average abandonment rates in base model

Table 2.2 – Daily costs and SLMP in base model

	95% CI for Average Costs and SLMP
Agent Cost	992($/day) ± 0
Operational Cost	5301($/day) ± 15
Total Cost	6293($/day) ± 15
SLMP %	0,6000 ± 0,01

As it is seen in Figure 2.3, ASA times are high at the periods where service levels are low. During the peak times, the ASA rises up to levels above 20 sec. As ASA increases, customers are bored of waiting in the queue and some of them abandon the system. As seen in Figure 2.4, in the lower service level periods, higher abandonment rates are realized.

Total costs associated in the current system are tabulated in Table 2.2. It can be seen that, in almost 60% of the periods 80/20 service level is reached.

3. DEVELOPMENT OF ALTERNATIVE MODELS

In this section, alternative models are developed and analyzed for the Call Center system simulated in section 2.

3.1. Introducing the call-back option

In this model, a new IVR design is provided that offers the customers the option of "call back". For those customers, whose expected waiting times in the queue are more than 45 seconds, the IVR system prompts a call-back option. In this option, customers are asked to be called back by the IVR system outside the peak hours, specifically between 12:00 a.m - 4:00 p.m. and these customers are given high priority over normal calls when they are reached later. It should be noted that the customer can still wait for the operator by standing long waiting times, if he does not want to be called back.

In the alternative model, a new shift period is created with 6 agents (3 agents are shifted from third shift, and 3 agents are shifted from fourth shift) to handle call backs. If there are not any call backs, these agents can serve the usual calls. It is assumed that the probability of customers who choose the call-back option is 0.7 as suggested by Duder and Rosenwein (2001).

Results

It can be seen in Figure 3.1 that service levels in all periods increase considerably in the call-back option. It follows from Figure 3.2 that ASA times decrease in all periods. There are slight increases in some periods because of the changes in work schedules of some agents. As can be followed from Figure 3.3 and Table 3.1, in the call-back option, the abandonment rates decrease considerably in each period whereas the daily total cost increases. The reasoning lies behind the fact that call-back option increases the total IVR time since the abandonment rate is decreased and more calls are handled by the IVR system. However the increase in the percentage of periods in which the 80/20 service level is reached, namely SLMP does not increase significantly. If more agents are hired, the increase in SLMP will obviously be more significant. Actually the basic effect of call back option is to decrease the deviation in the service levels during a day.

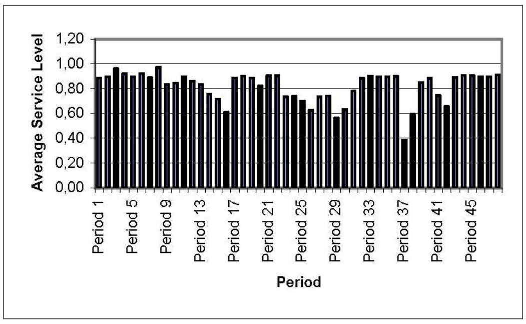

Figure 3.1 – Average service level in call-back model

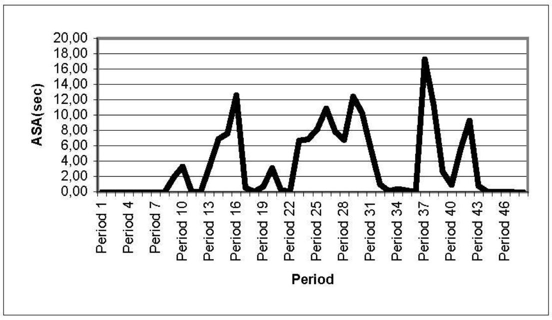

Figure 3.2 – Average speed of answer (sec) in call-back model

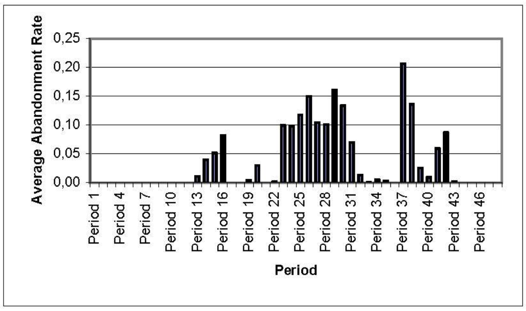

Figure 3.3 – Average abandonment rates in call-back model

Table 3.1 – Daily costs and SLMP in call-back model

	95% CI for Average Costs and SLMP
Agent Cost	992($/day) ± 0
Operational Cost	5348($/day) ± 11,21
Total Cost	6340($/day) ± 11,21
SLMP	0,6111 ± 0,01

3.2. Increasing the agent capacity

A second alternative is to hire new agents to improve the system performance. In this model, "Optquest" module of Arena 7.01 is used to find the optimal number of agents required to meet the minimum service level of 80/20 in each half-hour period. According to Optquest report, 3 new agents should be added to the first shift period (0:00 a.m.-8:00 a.m.), 9 to the second shift (8:00 a.m.-4:00 p.m.), 8 to the third shift (10:00 a.m. – 6:00 p.m.), and 9 to the fourth shift (4:00p.m–12:00p.m).

Results

In the second alternative, there is a remarkable increase in the service levels and the minimum requirement of 80/20 is reached in all periods as seen in Figure 3.4.

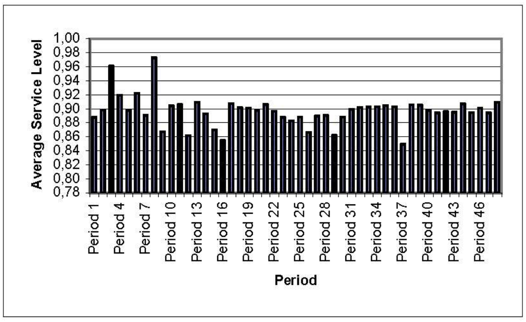

Figure 3.4 – Average service level in the increased agent capacity model

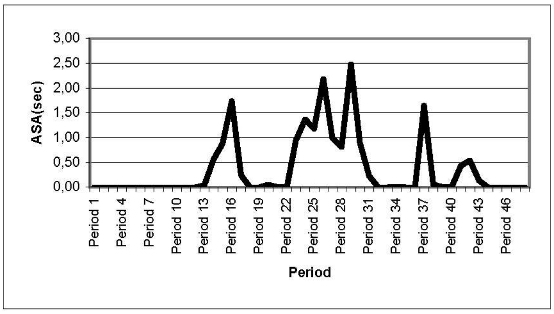

Figure 3.5 – Average speed of answer (sec) in the increased agent capacity model

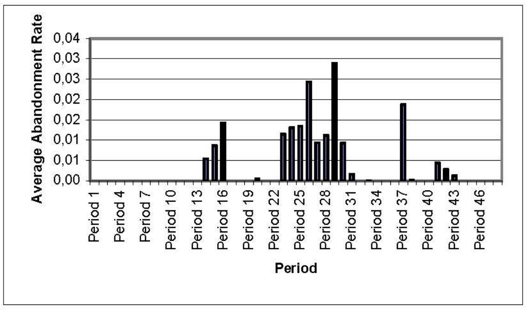

Figure 3.6 – Average abandonment rates in increased agent capacity model

Table 3.2 – Daily costs and SLMP in increased agent capacity model

	95% CI for Average Costs and SLMP
Agent Cost	1330 ($/day) ± 0
Operational Cost	5233 ($/day) ± 12,47
Total Cost	6563 ($/day) ± 12,47
SLMP %	0,9458 ± 0,01

As a direct consequence, there is a sharp fall in ASA times in every period as seen in Figure 3.5. It should be noted that maximum ASA time is 2.5 seconds at period 29 and furthermore, hired agents decrease abandonment rates considerably as seen in Figure 3.6. Comparison of Table 2.2 and Table 3.2 shows that when new agents are hired, agent costs increase but operational costs decrease due to better service levels. However the total costs are still higher.

4. COMPARISON OF THE MODELS

In this section, the base model is compared with alternative models by statistical hypothesis tests in the Output Analyzer of Arena 7.01. Each model is run for 30 times and confidence interval estimations are provided at 5% significance level for the daily costs and SLMP as seen below in Table 4.1.

Table 4.1 – Comparison of Models

Model	95% CI for Total Costs	95% CI for for SLMP
Base Model (Cost of erosion = $100)	$6293 ± $15	0.6000 ± 0,01
Base Model (Cost of erosion = $1000)	$6560.35 ± $46,36	0.6000 ± 0,01
Call-Back Model (Cost of erosion = $100)	$6340 ± $11,21	0.6111 ± 0,01
Call-Back Model (Cost of erosion = $1000)	$6282.44 ± $26.45	0.6111 ± 0,01
Increasing Agent Capacity (cost of erosion = $100)	$6563 ± $12.47	0.9458 ± 0,01

4.1. Comparison of Base Model with Call-Back Model

According to the results of the hypothesis tests with the Output Analyzer in Table 4.1, total costs in the call-back option is higher than the base model at 0.05 significance level, if the cost of erosion is $100 per customer. The reasoning lies behind the fact that the outbound telecommunication costs of calls are increased in the call back option. That is, while there are cost savings from abandoned calls in the alternative model, there is also an increase in the operational costs because of the extra service times of these call backs.

Nevertheless, the above result can not be generalized for all values of the cost of erosion. When the cost of erosion per customer is $1000 instead of $100, the total cost in Call-Back Model is less than the base model at 0.05 significance level. Therefore, while evaluating the models, the cost of erosion should be estimated with high precision noting that the performance of the system is highly sensitive to the changes in this input value.

In the base model, a customer whose expected waiting time is greater than the reneging time abandons the system; whereas in the alternative system, this customer has the option of "call-back later". Thus in the alternative system, the abandonment rates are decreased and service levels are increased. However for more significant increases in the service levels, new agents should be hired for call back option, rather than switching agents from other shifts.

4.2. Comparison of Base Model with Increased Agent Capacity Model

Here, the changes in the daily costs and system performance of the base case model are analyzed when new agents are introduced to the model. According to the results of Output Analyzer as seen in Table 4.1, the daily costs of the model with additional agents are significantly higher than the base model at 0.05 significance level when the cost of erosion is $100. However, the hired agents improve the system performance by increasing the service levels and decreasing the abandonment rates.

The arguments mentioned in section 4.1 are also applicable here. That is, the daily costs are strongly affected by cost of erosion which is usually intangible. As the cost of a lost customer increases, the decrease in the cost of abandonments is higher than the cost of additional agents, thus resulting in lower costs in the alternative model.

Finally, by increasing the agent capacity, the service levels are increased significantly as expected. As seen in Table 4.1, SLMP increases from 60% to approximately 95% by the increased number of agents.

CONCLUSION

Recent technology advances and the faster pace of change in business environments have made call center management a rapidly growing industry. Flexibility in call center design and processing is now one of the basic requirements for improved performances.

In this study, a simulation based DSS is proposed for a call center where the standard processes and the related performance measures are analyzed by using simulation methodologies. It is shown that, call-back option decreases the high variation in the system performance by significantly increasing the service levels and decreasing the abandonment rates during the peak times. However, the change in the resulting costs is highly dependent on the choice of the cost of erosion.

Service levels can also be improved by hiring new agents. This option is more costly; however the increase in the service levels is drastic. The simulation model can be used to generate a good managerial insight by setting the trade off between the increased costs and increased service levels for each additional agent.

As a future improvement, these simulation models can be integrated with the database of WFM systems and user-interfaces modules to form a DSS for call center management. It is suggested that the simulation based DSSs can be designed to increase the quality of the decision making process in call centers.

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