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A Simulation of the Service Performance of a Supermarket: A Case Study

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ABSTRACT

Simulation of waiting lines has become a widely studied research area of many researchers. Supermarket waiting lines are foremost among those experienced daily by ordinary Sri Lankans. Waiting in queues wastes the time and it creates a bad reputation for any organization. The study analyzed the performance of a supermarket and presented relative measures and recommendations for improvements. The system was modeled using the student version of Rockwell ARENA 14.5. Data were collected through direct observations for three hours in one Saturday. The sample consisted of 100 observations for inter arrival times and service times at counters. Heavy crowd at the supermarket permitted the study to analyze only three counters. ARENA Input Analyzer recorded the probability distributions for each process. The model was run for a replication length of three hours. The performance of the existing system was measured by the number of customers served among the number arrived. This was recorded as 76.36 %. But the results showed higher customer waiting times in queues. Thus the authors decided to increase the resources used at each counter as a means of reducing the waiting time. The proposed model recorded the maximum performance with lower waiting times as expected. Accordingly the authors recommended employing two people at each counter to speed up the billing process. Further the layout of the supermarket could be rearranged allowing adequate space for the customers to walk around.

KEYWORDS: ARENA 14.5, Input Analyzer, Performance of a Supermarket, Simulation of Queuing Systems, Waiting Time

1 INTRODUCTION

Queuing is one of the main problems of the services that have affected the service quality. The scenario is same in suparmarkets as well. There have been instances when the customers involved in the queue are frustrated and leave because of their long waiting time in the queue.

The study aims a renowned supermarket in a selected area. The problem identified included the lack of employees, increasing arrival rate of customers, fault in the scanning machines that consumed extra time, time lapse or failures in scanning the bar code of the product purchased and tiredness from the side of the customer service personnel. Therefore managers and employee supervisors focus on analyzing the queues at the supermarket to optimize their service and to decrease the waiting times for customers.

Although the selected supermarket had many counters, the authors selected only three counters in the queuing system. The study used the student version of ARENA 14.5 software as the effective analysis tool for designing the model.

The study considered few assumptions:

- Customer arrival at each counter followed the same probability distribution,
- The servers were identical,
- No work shifts were allowed among the workers,
- No breaks were allowed for the workers during the time when the model was running,
- No customer left the queue until the service was completed,
- The capacity of each queue was infinite,

- The service discipline was First In First Out.

2 LITERATURE REVIEW

Ghaleb et al. (2015) studied on modeling and simulation of queuing systems using ARENA software for a student restaurant. The authors proposed the average waiting time in the system and the average number of students in queues as performance measures in the study. The system had faced a big pressure in the first hour, a slight pressure in the second hour and no pressure in the last hour of serving lunch. Several alternatives were tested to improve the efficiency of the system and to achieve better service quality during rush hours. The same scenario could be applied for supermarkets during rush hours.

Xian et al. (2016) improved queuing model in analyzing the service performance at UniMall. The main purpose of this model was to propose solutions for better service provision in improving customer satisfaction. Moreover, Suhadak et al. (2015) studied facility layout for SME food industry via value stream mapping and simulation. However, Ghaleba et al. (2015) published, modeling and simulation of queuing system using ARENA with the intention of improving the efficiency of systems to get better service quality during rush hours. Thus, ARENA simulation software was one of the best tools in simulating queuing systems.

3 METHODOLOGY

3.1 Data Collection

Inter arrival times and service times required for the study were collected via direct observations for three hours on a Saturday. The time period was 9.00 a.m. to 12.00 noon. The sample included 100 observations. The data collection was carried out at the time that the customer entered the queue, arrived to the counter and departed from the counter. Data were collected in seconds by observing the arrivals to the system and to the three counters.

Data Analysis

Inter arrival times were calculated by the difference of two consecutive arrivals. Also, service times were calculated by the difference of arrival time to the counter and leaving time from the counter.

The data were entered into ARENA Input Analyzer to identify the probability distributions given in each instance.

3.2 Model Development

ARENA model to illustrate the existing supermarket system was developed using the basic process panels and advance transfers. Three process modules denoted the three counters. A decide module was used to denote the customers' decision of selecting one of the three counters for payment. Further this probability was assumed to be equal.

Table 1: Data Distributions

Data	Distribution
Arrivals	NORM (193,70.5)
Counter 1	TRIA (47, 255,351)
Counter 2	TRIA (150, 231, 342)
Counter 3	NORM (267,75.4)

4 RESULTS AND DISCUSSION

Probability distributions were given by ARENA input Analyzer are summarized in Table 1. Then, the data distributions were introduced to ARENA modules to develop the model for the existing system demonstrated in Figure 1. This model was run for a replication length of 3 hours to find the performance measures of the existing system.

3.3 Proposed Model

Since the existing model recorded unexpected waiting times in queues and in the supermarket system, there came the need for developing a more accurate and optimal model for the system. Investigations revealed that the cause for higher waiting times was the excess time consumed by the cashiers in billing and parceling the goods. Thus, the authors recommended to employ another person for each counter for the parceling purpose. Thus, the resources that were used at each process module of the existing system was doubled and run for the same replication length. The proposed system gave more reliable results as expected. Table 2 comapares the results obtained by two models.

Figure 2: Animated ARENA model for the existing system

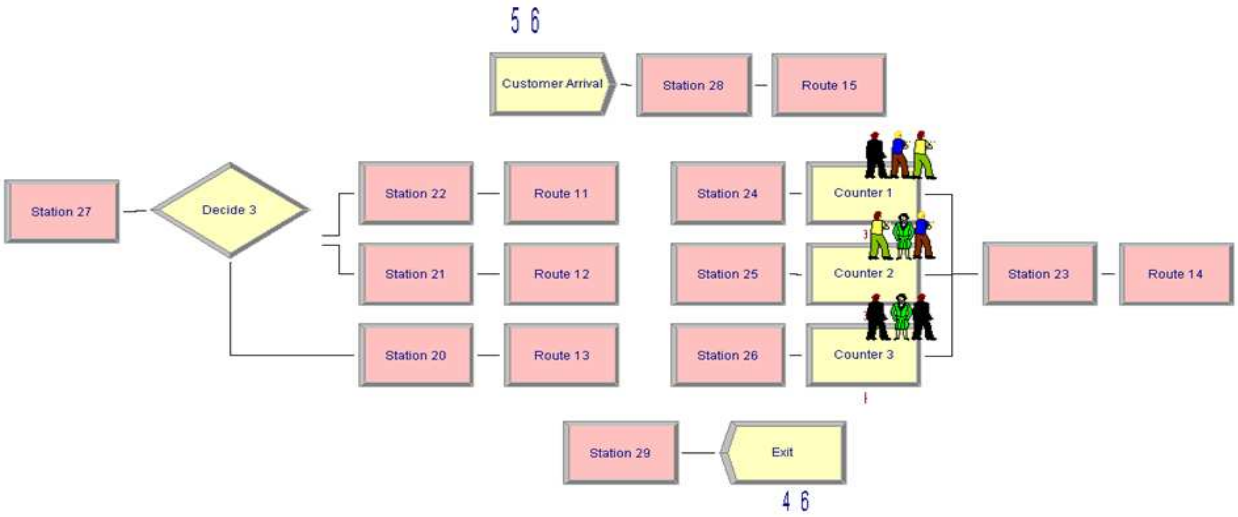

Figure 3: ARENA model for the existing system

5 CONCLUSIONS AND RECOMMENDATIONS

The study dealt with analyzing the performance measures of a supermarket. The study had several limitations;

- Only three counters of the supermarket were studied because of the complications in data collection.
- Observations were collected on weekends due to availability of rush hours throughout the day.
- Model was run for a replication length of three hours depicting the period of data collection.

ARENA simulation recorded that the performance of the current system was only 76.36% and customer waiting times at the queues were higher than expected. Consequently a more accurate model was proposed by doubling the resources which recorded the maximum performance with lower waiting times. Thus the need of two employees at each counter was confirmed. Further, the layout of the supermarket could be re arranged allowing adequate space for the customers to walk around. Moreover the study can be generalized by collecting data for each day in a week or by collecting data for the entire time period of service provision in a day.

Table 2: Results obtained from two models

			Existing System	Proposed System
Number In			55	51
Number Out			42	51
% Served			76.36	100
Waiting Time	In Queue (min)	Counter 1	16.77	0.02
		Counter 2	15.22	0.49
		Counter 3	15.10	0.22
	In System		19.52	4.59
Number Waiting	Counter 1		1.57	0.00
	Counter 2		1.69	0.04
	Counter 3		2.00	0.02

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