Global Journal of Management and Business Research: G
Interdisciplinary
Volume 18 Issue 3 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4588 & Print ISSN: 0975-5853

Analysis of ATM Service Performance by using ARENA Simulation: The Case of Commercial Bank of Ethiopia, Sabyan Branch

By Dinku Manaye & Amare Worku
Dire Dawa University

Abstract- ATMs are among the most important service facilities in the banking industry. The main objective of ATM for bank is to keep away the customers from coming to bank and make the process easy for them to avoid the basic procedure they have to do in the bank. But ATMs themselves have as a result become subjects of large service demands which directly translate to queues for services when these demands cannot be quickly satisfied specially during weekend periods and month endings (salary times) where the demand for cash is high. In this study Arena simulation model was developed for the ATM service found in the commercial bank of Ethiopia, Sabyan branch to analyse its service performance. In the ATM center the customer inter arrival time of the customers followed the exponential distribution with a mean of 29 seconds and the service time is a Poisson distribution with a mean of 44.3 seconds. From the Arena simulation run results, we can conclude that the service is not efficient in the ATM Centre as there is excessive waste of time in the ATM center (71.3 seconds) and higher number of customers waiting in the queue (4 customers). To improve the ATM service efficiency of the case company and to keep satisfaction of the customers, we recommend the company to follow the following ways. To improve the ATM service efficiency of the case company and to keep satisfaction of the customers, we recommend the company the following ways. One way can be increasing the ATM facility number from two to three and another way can be increasing the service time of the available ATM services by improving the speed of the system.

Keywords: arena simulation model, ATM service center, customers, queue, service performance.

GJMBR-G Classification: *JEL Code: G29*

Analysis of ATM Service Performance by using ARENA Simulation: The Case of Commercial Bank of Ethiopia, Sabyan Branch

Dinku Manaye [α] & Amare Worku [σ]

Abstract- ATMs are among the most important service facilities in the banking industry. The main objective of ATM for bank is to keep away the customers from coming to bank and make the process easy for them to avoid the basic procedure they have to do in the bank. But ATMs themselves have as a result become subjects of large service demands which directly translate to queues for services when these demands cannot be quickly satisfied specially during weekend periods and month endings (salary times) where the demand for cash is high. In this study Arena simulation model was developed for the ATM service found in the commercial bank of Ethiopia, Sabyan branch to analyse its service performance. In the ATM center the customer inter arrival time of the customers followed the exponential distribution with a mean of 29 seconds and the service time is a Poisson distribution with a mean of 44.3 seconds. From the Arena simulation run results, we can conclude that the service is not efficient in the ATM Centre as there is excessive waste of time in the ATM center (71.3 seconds) and higher number of customers waiting in the queue (4 customers). To improve the ATM service efficiency of the case company and to keep satisfaction of the customers, we recommend the company to follow the following ways. To improve the ATM service efficiency of the case company and to keep satisfaction of the customers, we recommend the company the following ways. One way can be increasing the ATM facility number from two to three and another way can be increasing the service time of the available ATM services by improving the speed of the system. Both ways can be taken as good options since the operating cost of the new mechanisms is minimal compared with cost of losing customers due to low quality of service.

Keywords: arena simulation model, ATM service center, customers, queue, service performance.

I. Introduction

Improving the performance of service industries when arrival and service time are random and performed by human employee is a complex decision environment [1, 2]. This scenario was best expressed in the banking industry. The development of information technology in bank sectors is Automatic Teller Machine (ATM). ATMs are among the most important service facilities in the banking industry [3]. The main objective of ATM for bank is to keep away the customers from coming to bank and make the process easy for them to avoid the basic procedure they have to do in the bank. ATMs themselves have as a result become subjects of large service demands which directly translate to queues for services when these demands cannot be quickly satisfied. This situation becomes more evident during weekend periods and month endings (salary times) where the demand for cash is high. Simulation has become one of the most widely used tool in such system analysis due to availability of the many software's having large computing capabilities [2]. The simulation model is developed and run with particular inputs and model characteristics. In this study, two ATM services found in the commercial bank of Ethiopia, Sabyan branch has been considered. Simulation software ARENA is used to develop a simulation model and Performance analysis will be carried out.

Author α σ: Textile Engineering Department, DDIT, Dire Dawa, Ethiopia. e-mails: dinkumanaye22@gmail.com, dearmom2005@gmail.com

II. Literature Review

Simulation modeling is fast becoming an important aid in achieving higher levels of efficiency and productivity. Historically, the most frequent uses of simulation modeling have been directed to the improvement of manufacturing operations. More recently, simulation has come into its own as a powerful tool for improvement of operations within the services sector [4]. Simulation is one of the most powerful tools available to decision-makers responsible for the design and operation of complex processes and systems. It makes possible the study, analysis and evaluation of situations that would not be otherwise possible. In an increasingly competitive world, simulation has become an indispensable problem solving methodology for engineers, designers and managers [5].

Simulation can be defined as "the imitation of the operation of a real-world process or system over time" [6]. The process of interest is usually called a system. When building a simulation model of a real-life system under investigation, one does not simulate the whole system. Rather, one simulates those sub-systems which are related to the problems at hand. This involves modeling parts of the system at various levels of detail. In order to study the system, we make a set of assumptions about it. These assumptions constitute a model. Assumptions are expressed in mathematical or logical relationship. If the model is simple enough, it may be solved by mathematical methods such as calculus, algebra or probability theory. However, many real world problems are too complex. Models of these systems are almost impossible to solve analytically. In a simulation, we use a computer to evaluate a model numerically and data are gathered in order to estimate the desired characteristics of the model [7].

A simulation model is a representation that incorporates time and the changes that occur over time. Simulation models can be classified by many ways, but one useful way is along these dimensions [8]:

(1) *Continuous vs. Discrete:* It is convenient to distinguish between continuous and discrete simulations. In a continuous simulation the underlying space-time structure as well as the set of possible states of the system is assumed to be continuous [7], thus the state of the system can change continuously over time; an example would be the level of water flows in a tank. In discrete simulations, changes can occur only at separated points in time such as customer arrivals to a bank.

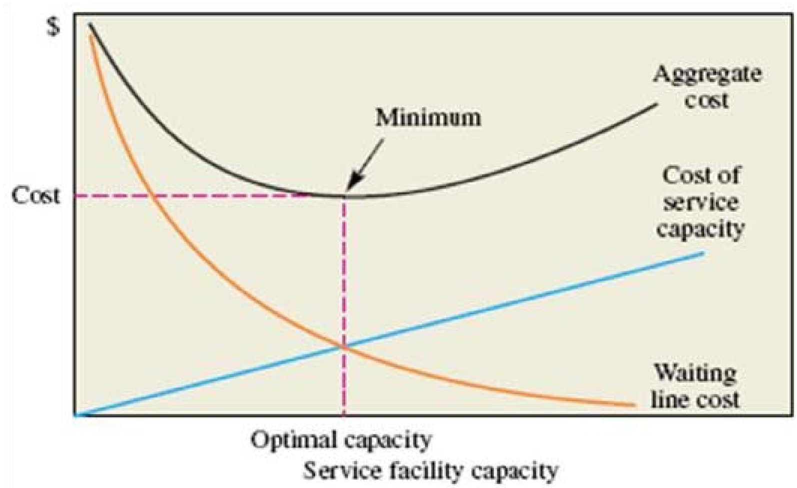
(2) *Static vs. Dynamic:* Simulation models can be classified as static or dynamic. A static simulation model is a representation of a system at a particular point in time. Static simulation is usually referred as a Monte Carlo simulation. A dynamic simulation model is a representation of a system as it evolves over time.

(3) *Deterministic vs. Stochastic:* A deterministic simulation model is one that contains no random inputs; a stochastic simulation model contains one or more random input variables like a bank with randomly arriving customers requiring varying service times. A model can have both deterministic and random inputs in different components. It is often a must to allow for random inputs in order to make the model a valid representation of reality. Random inputs can be generated through specifying probability distributions from which observations are sampled.

Simulation has a number of advantages that allow the identification of problems, bottlenecks and design shortfalls before building or modifying a system. It allows comparison of many alternative designs [9] and let us experiment with new and unfamiliar situations as to answer "what if" questions [5]. Evaluation and comparisons can take place before committing resources and investment to a project. Simulation allows study of the dynamics of a system, how it changes over time and how subsystems and components interact [9]. On the other hand, often simulations are time consuming, data is not available or costly to obtain, and the time available before decisions must be made is not sufficient for a reliable study [9].

Simulation modeling is an art that requires specialized training and therefore high skills of the modelers [5]. If two models of the same system are constructed by two competent individuals, they may have similarities, but it is highly unlikely that they will be the same. Despite its tremendous benefits, simulation is not a perfect technology. It is a decision support tool that may help in simplifying the decision making process. As such, simulation output must be carefully analyzed. Most simulation models have random inputs such as equipment reliability, variable demand or loss, which cause the simulation output to be random too [8]. Therefore, running a simulation once is like performing a random physical experiment once and the results will probably be different each time. So it is highly recommended to run simulation models many times before concluding results. Simulation modeling is used in a multitude of applications. Many researchers attempted to classify and categorize the simulation applications. Simulation modeling is often used for modeling and designing many applications including hospitals, military operations, traffic, airports, services industries, computer systems, tele-communication networks and manufacturing systems like factories, flexible manufacturing systems, assembly lines, warehouses, and supply chains [8].

Service industry has been developing rapidly and receiving more attention in the recent years by system modelers. Customer satisfaction is a growing concern in service industry settings such as banks, hospitals, and call centers. High variability in demand is prevalent in the service industry, and customers still expect to be served promptly when they arrive [10]. Therefore, there is a need for efficient staff utilization with minimal possible cost, taking into account varying demand levels for the day of the week, or even for the time of the day. Improving customer satisfaction and service levels usually requires extra investments. To decide whether or not to invest, it is important to know the effect of the investment on the waiting time, and service cost. Usually managers and decision makers seek to balance between the service and waiting time cost to offer the best service with minimal cost [11]. Figure (1) shows the relation between these costs and how to obtain the minimum aggregate cost and optimal capacity.



Source: (Chase, 2007)

Figure 1: Waiting line versus service capacity level trade-off

The service system is characterized by the number of waiting lines, the number of servers, the arrangement of the servers, the arrival and service patterns, and the service priority rules [12]. Some waiting line and service problems that seem simple on first impression turn out to be extremely difficult or maybe impossible to solve. Waiting lines that occur in series and parallel (such as in assembly lines and job shops) usually cannot be solved mathematically [9]. Therefore, simulation modeling is necessary to explore and analyze alternative designs to obtain the optimal solution.

Commercial simulation modeling packages enable modelers to develop simulation models and also provide facilities to carry out simulation optimization as to help modelers optimize performance parameters that are of critical importance in the design of the systems under study. Most simulation modeling packages provide statistical reports (mean, minimum value, maximum value) to simplify analysis for performance measures (e.g., wait times, inventory on hand, utilization … etc.). There are many different simulation modeling packages in the market and each has its strengths and weaknesses. The best packages allow the user to combine easy-to-use constructs with more flexibility [13]. Some of the most popular simulation modeling packages include Arena, Auto Mod, Pro Model, Simul8, and Witness.

Arena is a simulation software developed by Rockwell Automation. It uses the SIMAN simulation language. Arena is extensively used to simulate a company's process or system to analyze its current performance as well as possible changes that could be made. By accurately simulating a process or system, a company can see the outcomes of changes without implementing them in real-time, thus saving valuable time and resources.

In Arena, the user builds an experiment model by placing modules (boxes of different shapes) that represent processes or logic. Connector lines are used to join these modules together and specify the flow of entities. While modules have specific actions relative to entities, flow, and timing, the precise representation of each module and entity relative to real-life objects is subject to the modeler. When planning a new system or making significant changes to an existing one, simulation modeling is a key tool for predicting and validating system performance. Simulation modeling is not a perfect technology. It is a decision support tool that aids in decision making process and it is not a decision-maker. Simulation software tools like Arena are used to describe and analyze the behavior of a system, answer questions about proposed changes to the system, and help designing new systems. Statistical data, such as waiting time and resource utilization, can be recorded and outputted to reports as to simplify analysis. So in this study we have used the Arena simulation software to model and analyze the performance of the ATM service system.

III. Methodology

Various scholars have studied ATM service performance by using queuing theory [14, 15, 16]. But in this study we want to use computer simulation of ARENA instead of queuing theory to study the case ATM service system with ease. So different materials and methods are used to achieve the goal of this study as shown below in detail.

a) Research Design

Depending on research questions and orientation of the researcher, a choice is made in setting out the research plan. There is experimental design, longitudinal design, cross-sectional design and case study design. These designs are divided into fixed and flexible research designs [17]. Others have referred to this distinction as quantitative research designs and qualitative research designs respectively.

The case study design is applied appropriately in this paper. Case study as an empirical inquiry is chosen because it allows focus to be placed on the queue phenomenon within its real-life context. A case study design was chosen also because the topical issue was customer queuing at ATMs; this could not be considered more perceptively without the context, the banking environment and more specifically the settings created by the ATM-customer interaction. It was in these settings that data was gathered and utilized. Moreover, it allowed us to cover contextual conditions relevant to the phenomenon under study. The design here is particularly a single case where we considered the two ATMs of the commercial bank of Ethiopia, Sabyan branch. This appropriately provides us the needed environment to collect required data for analysis.

The researchers have provided the example of the application of discrete event simulation in evaluating performance of service line in the case company. A simulation model provides a visual animation of the service delivery process. The data was collected from the two ATM facilities of the commercial bank of Ethiopia, Sabyan branch so that modeling and simulation will be done by using arena software. An ARENA® simulation model was developed, verified, and validated to determine the performance of the ATM services.

b) Data collection, sampling procedure and data analysis

i. *Data Collection*

In this paper, two types of data were collected and used. These are primary data and secondary data. Secondary data was obtained through an intensive review of relevant literature on the ARENA simulation from journal articles, textbooks and many usable electronic sources and review of the ATMs transaction history. Primary data was collected in two weeks period via observation which involves recording of the three key required quantities (customer arrival time, customer service start time and customer service end time) as customers reach at and leave the ATM terminal.

ii. *Sampling Procedure and Population*

Participants for the time studies were ATM users who arrived at the ATM terminal between the hours of 7:00 AM and 7:00 PM. In each of the study period several repeat customers might have been captured in the time studies, but we didn't believe this will affect the analysis.

To simplify the study, the study period was divided into two groups that means peak hours of a day where there are more customers coming to the ATM terminal and normal hours of a day where there are less customers coming to the ATM terminal. Peak hours of a day includes early morning (7:00 AM to 9:30 AM) and late afternoon (4:30 PM to 7:00 PM) whereas the normal hours includes the hours which are not included in the peak hours of the day. But in the normal hours there are minimum number of customers coming to the ATM service. So we can represent a particular day customer arrival rate and service rate by the peak hour range. Then by taking a one hour interval observation we can obtain customer arrival rate and service rate.

iii. *Data Analysis*

The collected data through direct observation was analyzed. Fitting input distribution through the input analyzer of Arena is used to identify fitted statistical distribution. It is used to evaluate the distribution's parameter and calculates a number of measures of the data. To select which type of distribution to use, we have compared the square error of each distribution. Larger square error value means the further away of the fitted distribution is from the actual data [18]. So we have selected the distribution with the smallest square error value. The data was analyzed by using real recorded time from the case ATM system. These data supported the analysis of validation of the model [19].

The other thing we will analyze was the customer waiting time. There are two types of customer waiting times; the time a customer spends in the queue and the total time a customer spends in the system. Since we are dealing with human beings, we are specifically concerned with customer waiting time in queue. It is waiting in queue that is dissatisfactory to customers and affects greatly their service experience. The following performance measures of the system would be generated from the simulation model:

- ρ: Utilization; the probability that the ATMs are busy at random time (t) within the interval.
- Wq: Average customer waiting time in the queue, in second.
- W: Average time spent at the ATM service, including the waiting time in queue, in second.
- Number in: of customers arrived per day
- Number out: of customers served per day
- Lq: Average number of customer in the queue per time period.

Based on the values of this measures, we can give the analysis of the performance of the case ATM service system.

c) Model Development

The conceptual model for the ATM service can be represented as shown below. Customers arrive at the service system at random points in time to seek service also in a random manner. The service system operates in such a manner that for each arrival, if both ATMs are busy then the customer enters a queue; else the arriving customer immediately enters service. As customers depart, one or both ATMs becomes idle, else a customer is selected from the queue to enter service. This will be modelled by using computer simulation of Arena.

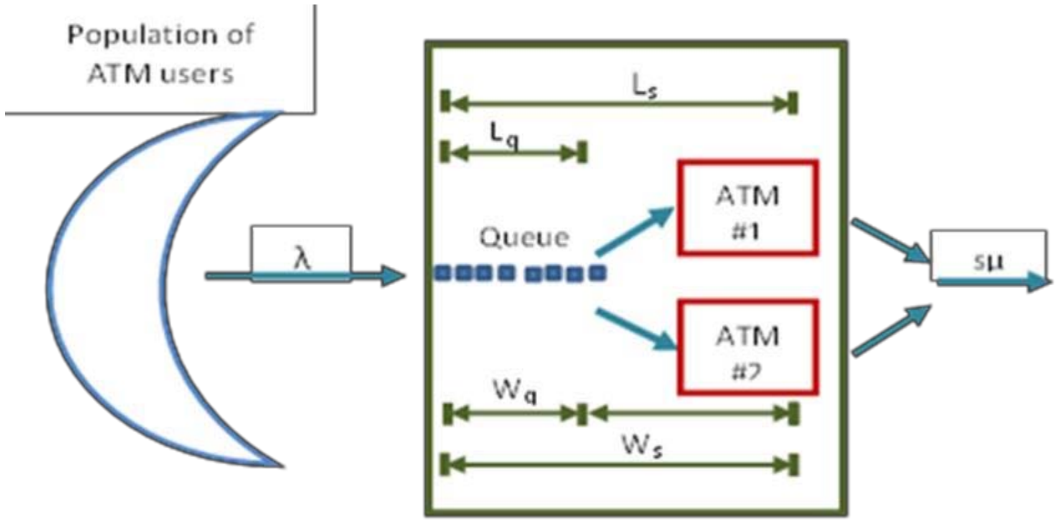


Figure 2: A Conceptual Model of the Case ATM queuing system

i. *Model Assumptions*

The model above is implemented with the following assumption implemented.

- Identical service facilities (since same kind of transactions are performed on both ATM).
- No customer leaved the queue without being served.
- A queue with unlimited waiting space that feeds into s identical servers.
- Customers are served on FCFS (First Come, First Serve) basis.
- Customers arrive randomly and the service time i.e. the time customer takes to do transaction in ATM, is also random.

ii. *Model Verification and Validation*

To verify the model, the Arena developed model should run in different running conditions to know whether the outputs are logical or not.

Validation activities are necessary to the construction of reliable models. Validation means to check whether the real world model and model made in simulated world is the same. The standard approach is to collect data (parameter values, performance metrics, etc.) from the system under study, and compare them to their model counter parts. These parameters will prove the validity of the data and simulation.

d) *Number of Replication Estimation*

In particular, minimizing the number of replications and their length is necessary to obtain reliable statistics. In order to decide the number of replication the model must run some initial set of replication so that sample average, standard deviation and confidence interval are computed.

IV. Result and Discussion

Based on recorded arrival times, the inter arrival time and service time are found out. Using the input analyzer module of the software, the probability distribution for inter-arrival time and service time are found out. The inter arrival time of the customers followed the exponentially distribution (Square Error: 0.009100 and corresponding p-value = 0.329) with a mean of 29 seconds. The service time is a Poisson distribution (Square Error: 0.049503 and corresponding p-value = 0.263) with a mean of 44.3 seconds.

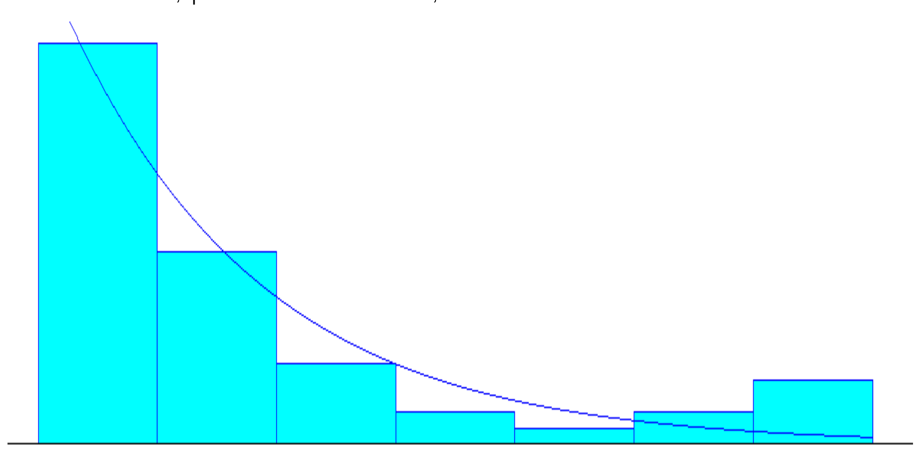


Figure 3: Customer inter arrival time distribution histogram

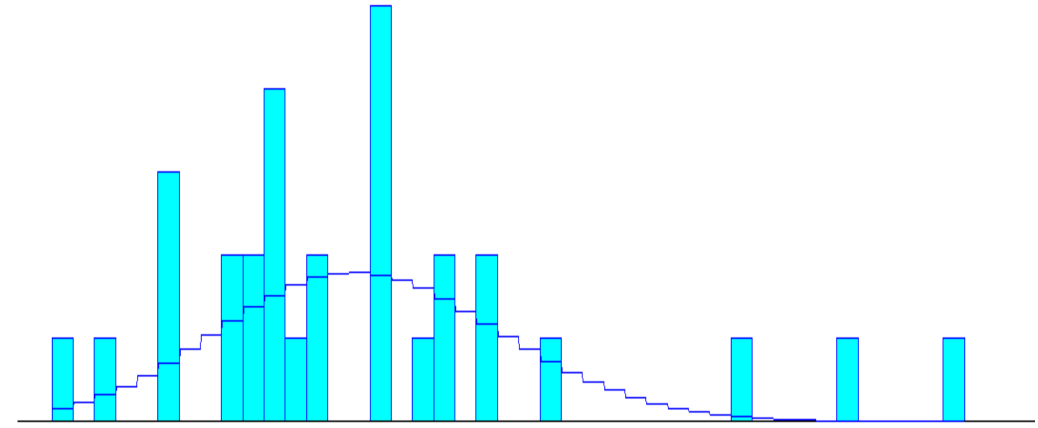


Figure 4: ATM service time distribution histogram

In the Arena simulation model, one create module, one assign module, one decide module, two process modules and one dispose module were used. Figure 3 is the snapshot of the simulation model in Arena.

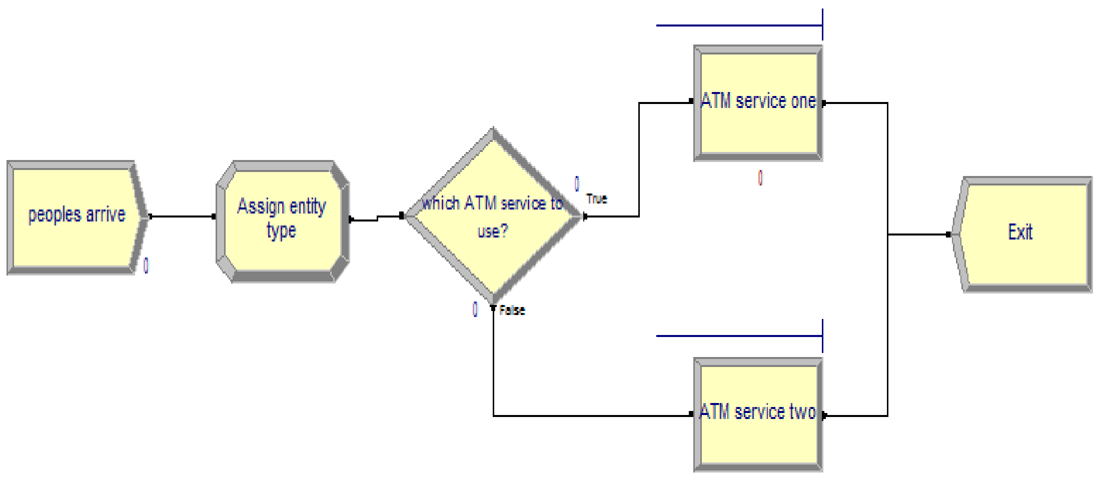


Figure 5: Arena simulation model of the ATM service

In order to decide the number of replication the model must run some initial set of replication so that sample average, standard deviation and confidence interval are computed. Through this mechanism the model replication number was set 30 with replication length of 8 hours (considering 8 hours of working in a day).

To verify the model, the Arena developed model was tested in different running conditions to know whether the outputs are logical and consistent or not. Through this mechanism the model was verified.

Validation of the model was performed by comparing the actual customers being served by the ATM service in a day which is 1000 in average (found from the bank personnel's data) and the Arena simulation run result (number out) which is 986. The data comparison shows that the difference is minimal which shows the developed model is valid.

Table 1: Arena simulation run results

Parameter	LqW	Wq	ρ		Number	Number
			ATM service1	ATM services 2	in	out
Value	4115.55	71.2996	0.7553	0.7616	990	986

The above Arena simulation model run results indicate that:

- The average utilization of ATM service one and ATM service two was found 75.53% and 76.16% respectively.
- The average number of customers coming to the ATM service were 990 and out of which 986 were served.
- The average number of customers waiting in the queue was 4.

- The average waiting time for a customer in the queue was whereas the service time was 44.3 seconds.
- The total waiting time for a customer in the ATM service was 115.6 seconds.

From these it was clear that the waiting time of a customer in the queue (71.3 seconds) is higher amount even as we can compare it with the service time (44.3 seconds) and higher number of customers waiting in the queue (4 customers) which indicates inefficient system.

V. Conclusion and Recommendation

The main purpose of this study is analysis of the performance of the ATM service found in the commercial bank of Ethiopia, Sabyan branch by developing Arena simulation model for the ATM service center. That means the simulation run was used to collect the service performance measures like the number of customers waiting in the queue and the waiting time in the queue. With all the above results, we can conclude that the service is not efficient in the ATM Centre as there is excessive waste of time in the ATM center (71.3 seconds) and higher number of customers waiting in the queue (4 customers). So efforts has to be taken to reduce the waiting line even though it cannot be totally eliminated as going for total elimination would lead to excessive service cost.

To improve the ATM service efficiency of the case company and to keep satisfaction of the customers, we recommend the company the following ways. One way can be increasing the ATM facility number from two to three (it can be increased further up to optimum service cost). Another way can be increasing the service time of the available ATM services by improving the speed of the system (for example by increasing the internet speed and removing fluctuation of electric power). Both ways can be taken as good options since the operating cost of the new mechanisms is minimal compared with cost of losing customers due to low quality of service.

References Références Referencias

1. Azmat, N. (2007). Queuing Theory and its Application: Analysis of the Sales Checkout Operation in ICA Supermarket. Dalana: University of Dalarna, Department of Economics & Society.
2. Ullah, A., Khalid, I., Xiao-dong, Z. and Muhammad, A. (2014), Sub-optimization of Bank Queuing System by Qualitative and Quantitative Analysis, 978-1-4799-3134-7/14/$31.00©2014 IEEE.
3. Aldajani, M. A., and Alfares, H. K. (2009), Location of banking automatic teller machines based on convolution. Systems Engineering Department, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia.
4. Zottolo, M., Williams, E. and Ülgen, O. (2007), 'Simulation Implements Demand-Driven Workforce Scheduler for Service Industry', Proceedings of the 2007 Winter Simulation Conference, USA.
5. Shannon, R. (1998), 'Introduction to the Art and Science of Simulation', Proceedings of the 1998 Winter Simulation Conference, USA.
6. Banks, J. (2000), 'Introduction to Simulation', Proceedings of the 2000 Winter Simulation Conference, USA.
7. Hartmann, S. (2005), 'The World as a Process: Simulations in the Natural and Social Sciences', PhilSci Archive, University of Pittsburgh, retrieved on 13 April 2008 from website: http://philsci-archive.pitt.edu/archive/00002412/01/Simulations.pdf
8. Kelton, D., Sadowski, R. and Sturrock, D. (2004), 'Simulation with Arena', Third Edition, Publisher: McGraw Hill Inc., New York.
9. Carson II, J. (2005), 'Introduction into Modeling and Simulation', Proceedings of the 2005 Winter Simulation Conference, USA.
10. Chandra, W. and Conner, W. (2006), 'Determining Bank Teller Scheduling using Simulation with Changing Arrival Rates', Research project, College of engineering, Pennsylvania State University, USA, retrieved on 13 November 2007 from website: http://www.personal.psu.edu/wxc202/cv/Determining%20Bank%20Teller%20Scheduling_Wenny%20Chandra_Whitney%20Conner.pdf
11. Chase, R. (2007), 'Operations Management', Second Edition, Publisher: McGraw Hill Inc.
12. Reid, R. and Sanders, N. (2005), 'Operations Management', Third Edition, Wiley Publishers.
13. Miller, S. and Pegden, D. (2000), 'Introduction to Manufacturing Simulation', Proceedings of the 2000 Winter Simulation Conference, USA.
14. Bhavin P. and Bhathawala P. (2013), M/M/1 Queuing Model for Bank ATM System. Mathematical Sciences International Research Journal. Vol. 2(2), pp. 120-126.
15. Srinivasan S. and Sundari M. S. (2012). Analysis of M/M/I Queueing Model for ATM Facility. Global Journal of Theoretical and Applied Mathematics Sciences. Vol. 2(1), pp. 41-46.
16. Dhar S. K and Rahman T. (May. - Jun. 2013), Case Study for Bank ATM Queuing Model. IOSR Journal of Mathematics (IOSR-JM). Vol. 7(1), pp. 01-05.
17. Robson, C. (1993), Real-world research: A resource for social scientists and practitioner-researchers. Malden: Blackwell Publishing.
18. Phillips DT, James JS (1987) Operations Research: Principles and Practice (2nd edn.) John Wiley & Sons.
19. Paul B, Bennett LF, Linus ES (1986). A Guide to Simulation. (2nd edn.) Springer-Verlag, New York, Berlin, Heidelberg, London, Paris, Tokyo.