



Applications of discrete event simulation: A literature review

Dr.M.Parthiban¹, Ram Kumar P²

¹Assistant Professor (Sl.Gr.), Dept. of Mechanical Engineering, PSG College of Technology, Peelamedu, Coimbatore, India.

²PG Scholar, Dept. of Mechanical Engineering, PSG College of Technology, Peelamedu, Coimbatore, India.

ramkumarp699@gmail.com²

Abstract

This review article presents how various authors have used discrete event simulation to improve an existing system with least financial involvement and no down times to conduct the study. The simulation process has proven to be efficient in most of the cases and was able to identify the system bottlenecks critical areas and suggest necessary improvements which could be implemented in real life. Further use of simulation software Such as ARENA has proven how diverse its use has been it could be used anywhere from a critical emergency ward to a local store to check the system performance find out where its lacking, workout various alternate scenarios, put it into test and implement it all this without disturbing the actual system.

Keywords: Discrete event, Simulation, ARENA, System performance.

1.Introduction

Simulation is the representation of a real world model in a computer using programming techniques in order to run the model virtually and obtain an idea of how it works and identify various problems present in the existing system and be able to modify them virtually without having to disturb the actual system. Over the years researchers have incorporated simulation study into various real word systems to demonstrate its working and check if there is any scope for improvement. Since simulation can be performed on various software packages there is no operational cost involved and no down time in the real sysytem.this article will enable readers to get a better understanding of past studies from the year 1999-2020 and see the diverse usage of simulation.

2. Literature review

José A. Sepulveda et al., 1999 [1]in this particular journal a cancer treatment centre model was built and simulated to study patient inflow and

understand the impact of alternative layouts to ensure optimum utilization of resources and patient movement requirements in the event of a new construction. Simulation model paved way for existing facility relocation and alternative scheduling procedures that resulted in a significant increase in patient throughput utilising existing resources. Also insufficient spacing issues were highlighted in the new simulation model analysis.

John Fontanesi et al., 2001 [2]system simulated models are used by eminent medical establishments to survive existing market conditions but the same cannot be performed in small or regional centres where the capital is less. Hence the authors have explained the creation of allow cost, generic, discrete event simulation model using excel spreadsheet that can be completed by the existing man power allowing extensive customization. Focus is on vaccine delivery systems for children and also to make this system available for similar health institutions.

Edward J. Williams et al., 2002[3]have presented the use of discrete event simulation in a retail store

to improve its overall efficiency. Positive results were obtained that have enabled efficient store management and have prevented overcrowding of customers in the cash checkout lines at any particular point of time.

Hamid Khan et al., 2003 [4] in this particular study customer waiting times in a drive through section of a fast-food restaurant was taken up for simulation study. Arrival time at the drive through, ordering and service times formed the basis of data collection and a simulation model was built using The GPSS/H simulation software package based on the models performance adequate changes were made to obtain an efficient queue handling system to optimize the service time involved.

Christine Duguay et al., 2007 [5] in this journal arena software was used to build a patient waiting time simulation model and design alterations were suggested based on resource availability. The results were contradictory and showed that was no direct relationship between waiting time and the number of test rooms without adequate staff presence. Suggestions made are qualitative and may find its application in similar setups.

Jorge A. Alvarado et al., 2008 [6] have used promodel software in this particular journal where a case study has been conducted in a Colombian supermarket. Varying register time and the number of staff involved in billing and bagging of items proved to be successful in finding an optimal schedule but it was not satisfactory enough to meet all service requirements because of varying queue lengths actual interview with staff was suggestive of increasing bagging staff for every increase in staff.

Tao Wang, Alain Guinet et al., 2009 [7] IDS Scheer ARIS and Rockwell Arena software was used to design a simulation model that represented patients arriving at a particular emergency care centre. Process bottlenecks could be identified, and optimal allocation of resources and staff was possible without disturbing the actual system. In order to reduce waiting time in emergency conditions doctor's efficiency improvement and rapid pass process are proposed and tested as the alternative solutions. Further these software were able to predict pros and cons of the existing model and also shortcomings that could be faced by future models.

Shufeng Jiao 2010 [8] In this paper supermarket waiting lines were simulated using Matlab/Simulink 7.0 based on the Monte Carlo Theory, customers' arrival at random and the number of cashier's had to be correlated with the customers waiting and also the cost required to keep the market running in order to achieve any process efficiency.

Alinda Kokkinou et al., 2012 [9] in this paper the authors have discussed how self-service measures in a service delivery system could lower the service waiting time and enhance satisfaction. This study further shows that time spent in the queue and level of service in a hotel reception were affected by various resource options customers are presented with, the total end users who receive service, rate at which request is processed and facility rate of non-fulfilment. It was concluded that prolonged time taken to process an application and excessive levels of dereliction were the causes of overlong waiting times. Hence the authors have suggested that that service providers should design and monitor this tech effectively and from time to time.

Kembe et al., 2012 [10] the time required to access a healthcare facility has been a major hindrance to the quality of service provided because of long queues. Increasing the service levels leads to excessive operating costs at the same time reducing them could deny service to one who is in most need of it and also waiting costs involved. In this study, a Multi-server queuing Model was used as a base study to achieve an optimal Waiting cost and service level in a specialist clinic. Data for this study was collected for over a month based on constant monitoring, discussion and questionnaire usage. TORA optimization Software was used to analyse the data it was concluded that average queue length, patient waiting time as well as doctor scheduling were optimised without involving higher operating cost and taking into account the waiting and service costs. Policy makers can use this model to solve other Multi-server queuing problems.

J. A. Lopez et al., 2013 [11] in this journal Arena simulation model has been developed to optimize surgery scheduling time to offer better response to varying demand. Waiting line models have been analysed to determine how the existing system capacity can be improved. A time study conducted

in a gynaecological clinic serves as the basis for this study.

Najmeh Madadi et al., 2013 [12] in any service organization, managers are mostly concerned about customer waiting time to receive a service. Banks go an extra length to provide customer satisfaction in order to stay in focus among rival banking establishments. The length of a queue and waiting time to receive a particular service are two significant factors which play a vital role in how a customer feels about the service quality offered in banks. Hence bank managers must put in more thought to provide an optimal service configuration that can satisfy both customers and service providers. Simulation has yet again proven its worth in order to monitor, model and evaluate such a problem. In this study a system based simulation model that has been aimed at reducing the customer waiting time in a bank in Malaysia has been carried out to achieve the most efficient configuration. Results are more focussed on how the new model has been able to reach an edge over the previous one in terms of efficient counter utilization and how the queue length can be reduced to lower the waiting time.

Md. Manjurul Ahsan et al., 2014 [13] The ability of a restaurant to survive in the current market conditions depends on their customer satisfaction feedback. One main issue is the amount of time a customer waits in a queue to be served. Other primary factors are taste, cleanliness and the restaurant setup overall. Waiting time in service lines can make or break a restaurant business. In this journal the authors have used Arena software and queuing theory to model the customer waiting line system in a fast food restaurant to increase its efficiency and throughput. The total time involved in service, time idle and the total time spent in the billing counter is measured in order to simulate the model.

Manuel D. Rossetti et al., 2015 [14] conducted a simulation study in a retail store checkout counter. The model was split into two halves first which took in to effect the end users reason of choice when entering a billing line and the second considered his choice of payment which was separated from the item scanning line. The results however showed that checkout line selection had nothing to do with the time involved in a checkout. But a significant

drop in average waiting time is observed when payment and checkout area was separated.

Edward Williams 2015 [15] has described how the discrete event simulation study has proven to be the saviour for a conventional grocery store which is facing heavy competition from a bigger establishment. One of the solutions brought up were a good investment in a self-checkout system in addition to the checkouts with staff employment. It was found that self-service systems were able to achieve improved customer service without long waiting times.

Sara Djokovic et al., 2015 [16] The main aim of inventory management is to provide adequate goods in the warehouse so that user requirements can be fulfilled at any particular point of time. Due to the randomness of demands inventory management has become very difficult, various factors such as time of delivery, cost of holding, ordering and lack of inventories can be taken into consideration for effective inventory management. The data of 57 items held in the warehouse of 3PL provider were processed analysed via simulation for a period of one year to determine demand by applying few inventory management strategies.

Mageed A. Ghaleb et al., 2015 [17] have built a simulation model for a university restaurant setup using arena simulation software. Multiple performance measures need to be considered and evaluated such as waiting time to be served, the total number of students standing in queues. There is a huge inflow during lunch which decreases gradually over time and there is no students during class hours. "What if" analysis was used to generate other options and their ability to provide better results in terms of crowd handling and quality of service are checked. Based on process analysis the best alternative was shortlisted and suggested to the restaurant also the authors have suggested future improvement works that can be done using this study as a base.

Janar Dehantoro et al., 2016 [18] conducted a research on the queuing system in a vehicle service workshop to check the performance measure of each service station. Arena software was used to build and obtain a simulation model to process the data. The queue process starts from the time a customer enters into a service facility, waiting time in the queue if the server was busy until service

completion time. Data was collected from registration, service, final inspection and billing service stations.

Muhammad Abdus Samad et al., 2016 [19] In order to minimise handling costs, stock run-outs and meet demand volatility, efficient inventory management is very critical. The lack of proper inventory management is cited in the maintenance warehouse as the explanation for high costs. There was often no stock of lamp stock available because of the additional capital involved in order to satisfy an urgent order. This analysis was therefore carried out to establish an optimum amount of inventory for a lamp in order to reduce costs and stock and satisfy the fluctuating demands of the different departments that occur unexpectedly during the year.

Jessica Dorismond 2016 [20] study purely focusses on developing an optimal simulation model for a shopping centre layout keeping in mind its profitability and stimulation driven sales factor. In a majority of the shopping centres items do not reach maximum sales levels because they cannot be located by customers easily. Customers are drawn to products with certain visual appeal. Designing a layout that increases stimulus based sales requires exceptional skill and effort. In addition to increasing the shopping path length, customers must encounter several products that may lead to stimulus based sales, without making the whole shopping process tedious for them. Here a simulation based software model which targets the quality of various layouts in a shopping centre has been put into use with an aim to build a replica model of customer movement and shopping behaviour. The model was also able to achieve its deputed function flawlessly. Future personnel in managerial positions may use this model as a reference for optimally allocating various products.

Seifedine Kadry et al., 2017 [21] In this research paper, the existing staff schedule in a hotel has been reworked, to reduce excessive waiting time and offer an implicit client service by obtaining the most appropriate employee allocation that doesn't incur additional cost on hiring new staff. This objective has been met by developing an ARENA simulation model where areas of focus are employee allocation in various areas such as

reception and hospitality during peak season to reduce visitor waiting time at the entrance.

Jorge A Alvarado et al., 2017 in this study discrete-event simulation was used to develop a model based on consumer reaction in locations where extensive queues are formed to obtain a service. The model developed took into consideration various rational parameters and professional choices on the evaluation of waiting and its further impact on customer satisfaction and the firm's profitability. This model is a conclusive tool for start-ups that want to figure out the losses incurred due to formation of queues in critical locations that leads to customer dissatisfaction and loss of customers.

Chantal Barila et al., 2019 [23] paper deals with the duration of stay of patients in an emergency department of a particular hospital. In order to identify the factors affecting the emergency ward performance, average duration of stay for ambulatory patients, design of experiments and discrete-event simulation techniques were used. Research results show that giving more responsibility to staff nurses reduces average stay duration thus preventing overcrowding with less financial burden than increasing the number of doctors. Thus allowing them to focus only on patients who require critical care.

Tomasz Antczaka et al., 2020 [24] have built a realistic agent-based simulation model on customers' choice of billing lines in a supermarket. The model is calibrated to actual point of sale (POS) data from three supermarkets of Europe's major retail chains and is implemented using Net Logo simulation platform. The model generated provides insight on how individual customer choice of picking lines impacts the overall efficiency of the checkout process. It is shown that when customers choose a line with minimal waiting time, it is a win-win situation for the customers, as it leads to shorter queues and waiting times, and also for the supermarket management, since it paves way shorter cashier working hours.

Soori Sasanfar et al., 2020 [25] the aim of this research is to identify an improved resource allocation in various wards of an emergency department, in order to improve patients and staff workflow. The hospital's emergency department is taken up for a new layout design which can reduce

waiting time of patients and optimize staff allocation. Arena simulation technique was used and recommendations for designing a new layout were proposed and the authors were able to achieve a considerable waiting time reduction for the emergency ward patients and the surgical ward patients.

Conclusions

We can see how simulation study has evolved over the years ,the various software available to perform the same and the areas which need to focused on more while performing a study especially in case of waiting line models. We see how ARENA software has been used in rearranging departments and effective scheduling of resources within an establishment. The authors have also mentioned the scope for improvement in future which aids researchers to carry on their work from where they left. This review article is a comprehensive, simple and straightforward package which has brought forward and combined all simulation studies from leading journals over the last 20 years into a single package from a researcher's point of view. This article can also give beginners a basic idea of what simulation study is and its area of application.

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