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A SIMULATION STUDY ON THE OUTDOOR WAITING LINE OF A PRIVATE HOSPITAL USING THE ARENA SOFTWARE

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Abstract- *The Patients coming to medical outdoor service sector do not expect to wait for a long time to receive treatment. The waiting time for Patients to receive the service becomes one of the key quality characteristics of private medical service. However, waiting lines always exist in medical outdoor during peak hours. In this article, the queuing system in a private medical outdoor has been studied using a simulation tool, ARENA. The patients are served on first-come, first-serve basis. The article proposes an improved system with decreasing waiting time and total time in the system.*

Keywords: simulation, queuing system, waiting time, service time, probability distribution

1. INTRODUCTION

During the last two decades, the service sector has shown a remarkable growth in different aspects of both national and international economies. Service companies such as banking, hospitality, restaurants, health systems, telecommunication, transportation, and insurance industry play a major role in today's market. As a result, many engineering techniques, analytical methods, and software tools were developed to help designing service systems, solving problems in their operation, and optimizing their performance. In such context, simulation is a key engineering tool that is widely used for the analysis of service systems [1].

Waiting is now a major problem for many service sectors of the world so that many researches are going on this topic and papers and articles have been published to analyze the queuing system. In some studies, researchers have generated models that were able to make accurate predictions of quantities such as waiting time and patient care time. One of such model was developed in [2]. This model was used to test alternative ED attending physician staffing schedules and their impacts on patient flow and resource utilization. This reduces average length of stay for patients by up to 50 minutes.

The application of basic queuing principles and models to the hospital patient admitting process has been studied in [3] using the queuing modeling to analyze the impact of various admissions policies to ICU facilities. An investigation into the prevailing queuing system in the private practices of Dhaka city is studied in [4].

There seems to be a lack of research on using queuing theory and simulation of the patient flow and service process in the private hospital outdoor considering independent queuing system.

Simulation technique is an easy way to build up models to represent real life scenarios, to identify bottlenecks and to enhance system performance**.** Use of a valid simulation model may give several advantages in creating better process in order to improve the system performances. This study focuses on exploring the queuing system in a private medical outdoor and tries to provide necessary suggestions.

2. MATERIALS AND METHODOLOGY

There are several software's to create simulation models on computer, such as: Automod [5], Arena [6], AweSim [7] , Extend [8] etc. Among these we use Arena version 10 simulation tool (Academic version) as it is an available, flexible and powerful tool.

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2.1 Arena Overview

The ARENA modeling system from Systems Modeling Corporation is a flexible and powerful tool that allows analysts to create animated simulation models, that accurately represents virtually any system. First released in 1993, ARENA employs an object-oriented design for entirely graphical model development. Simulation analysts place graphical objects, called modules, on a layout in order to define system components such as machines, operators, and material handling devices. Arena is a commercially available discrete-event simulation program that provides a user-friendly windows-based interface while using SIMAN/Cinema simulation language. Arena automatically calculates the 95% confidence interval unless the user specifies otherwise. ARENA® provides a

modeling medium that is easy enough to suit the needs of the beginner, and powerful enough to satisfy the demands of the most advanced users. Another advantage of ARENA® is that it is open to interaction with many applications such as Microsoft Access and Excel with its built-in spreadsheet data interface.

ARENA Input Analyzer can be used to process and classify the obtained data for input in the developed model using ARENA. Appropriate probability distributions can be obtained to for being used in the models

ARENA Output Analyzer lets the user carry out statistical analysis on the results obtained. Finally, the Process Analyzer helps to examine the selected outcomes of several different alternatives dependent on selected controls on the system. The most attractive feature of a simulation study is the animation that accompanies the model.

2.2 Methodology

We analyze the outdoor service system of a medical which is situated in Sylhet city using the queuing theory and arena simulation tool. The outdoor of hospital consists of nine individual departments and two counters. 0ne for ticket and another for receiving cash. A patient arrived in medical, has to complete sequential processes. The service flow from the counter to the exit is shown in figure-1.

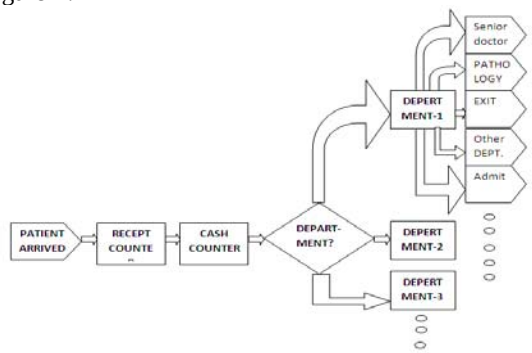


Fig.1: Service flow diagram of the existing system.

The flow chart of methodology followed to complete this research work is shown in figure-2.

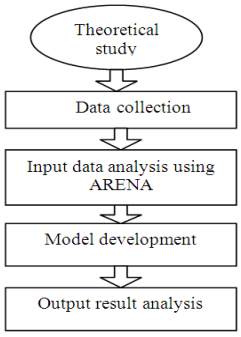


Fig. 2: Flow chart of methodology

Arrival and service time are collected from each counters and departments by using time study method [9].

Then the distribution function of these data is evaluated with the help of arena input analyzer. Both will be described in section 3.1.

Using this distribution, we build a simulation model for the existing system in the outdoor of a private medical. This model is explained in section 3.2.

After analyzing output, we find out the point of improvement. Then a model to improve the existing system is shown in section 3.3.

3. MODEL DEVELOPMENTS

3.1 Input Analysis

Hospital outdoor require data on customer arrival, availability of resources, service times, size of waiting rooms, and so on.

3.1.1 Data Collection

Arrival rates and service rates are essential to calculate system performance measures such as average waiting time, utilization, and average time in system. For each patient, we record the times of arrival, time of service start, and service end from each of nine departments and two counters for a single 5 hours working day.

From these data, Time between Arrivals (TBA) and service time (ST) are calculated.

3.1.2 Data Analysis

During the data collection period, data are obtained from each department using time study techniques. All data are evaluated by the Arena Input Analyzer software in order to determine distribution function. For example, evaluation of a service time distribution is found using the Arena input analyzer as shown in figure-3

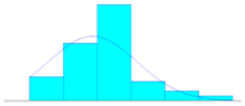
Distribution Summary
Distribution: Normal

Expression:
NORM (172, 78.4)

Square Error: 0.042552

Data Summary
N0. Of Data Points = 44
Min Data Value = 60
Max Data Value = 420
Sample Mean = 172
Sample Std Dev = 79.3

Histogram Summary
Histogram Range =60-420
Number of Intervals = 6



Chi Square Test
Number of intervals= 4
Degrees of freedom= 1
Test Statistic =7.94
Corresponding p-value
< 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.133
Corresponding p-value
> 0.15

Fig.3: Summary of input analyzer

Distribution of other activities found in ARENA input analyzer are shown in table-1

Table 1: Distribution types for each departments of hospital outdoor, unit: second.

Activities	**Distribution Type**	**EXPRESSION**
Patients arrival	Lognormal	-0.001+LOGN(23.7,36.4)
Receipt counter	Gamma	2.5+GAMM(4.81, 5.32)
Cash counter	Exponential	-0.001 + EXPO(32.1)
Medicine service time	normal	NORM(192, 134)
Physical medicine service time	normal	NORM(250, 89.5)
Skin service time	normal	NORM(257, 159)
ENT service time	Exponential	9 + EXPO(162)
EYE service time	Gamma	120+GAMM(366, 0.514)
Dental service time	Uniform	UNIF(63, 352)
Pediatrics service time	normal	NORM(172, 78.4)
Gynecology service time	Beta	32+791* BETA(0.725, 1.21)
Orthopedics service time	Beta	44 + 707 * BETA(0.924, 2.52)

3.2 Model of the Existing System

After completing the data analysis a simulation model is built using ARENA software. The model is shown in figure.4. System generally consists of five components [10]. The identified components of the existing system are shown in table-2. Model consists of several sub models while more than one server is used. The number of resource person utilized for each department and counters are given in table 3.

Table 2: Components of existing system.

Components	Service center system
1. Entities	Patients.
2. Attributes	Condition of patient, ticket no.
3. Activities	Treatment of patient. receipt cutting
4. resource	Doctor, Casher etc.
5. Events	Arrival & departure

Table 3: Number of resource person for each department

Operation	Number of resource person
Receipt counter	1
Cash counter	1
Medicine	4
Physical medicine	3
Skin	3
ENT	1
EYE	2
Dental	2
Pediatrics	2
Gynecology	2
Orthopedics	1

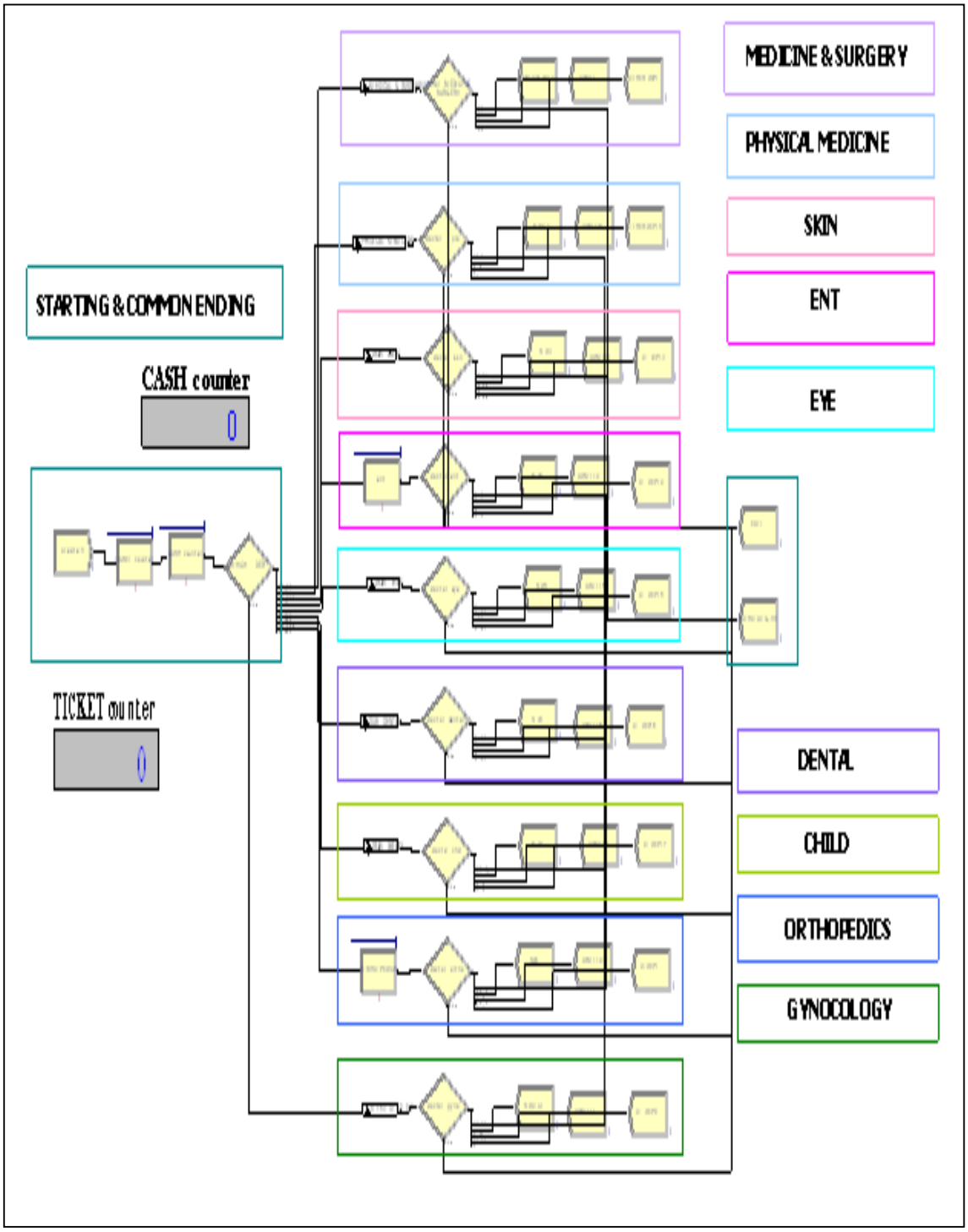


Fig.4: Model of existing system

3.3 Output Result and Analysis

Output results are summarized in the table-4. From our analysis we see that, waiting time and number of queue in different departments are satisfactory, but the waiting time in counter to take ticket and to pay cash is much more than expected. From results of the model we see that, on an average 27.28min a patient stay in the system. Of this time a patient has to wait 22.57min in counter and service queue. There by only for ticket collection and cash payment he/she has to wait maximum of total queue time.

Table 4: Output results of existing system

Department	Waiting time(min)		Utilization (%)	No. of queue		Value added time
	Maximum value	Average value		Average value	Maximum value	
Ticket counter	28.3340	11.5544	0.9985	30.4233	61.00	0.4717
Cash counter	19.3583	12.2909	0.9949	25.32	39.00	0.5515
Medicine1	7.4690	2.0881	0.5682	0.2958	2.00	4.0110
Medicine2	10.3341	2.4378	0.5585	0.4266	3.00	3.2248
Medicine3	3.4337	0.5623	0.1631	0.0468	1.00	1.9568
Medicine4	6.3196	1.1798	0.3206	0.1278	2.00	2.9952
Physical Medicine 1	1.7236	0.5745	0.1192	0.0143	1.00	4.7697
Physical Medicine 2	2.6883	0.4480	0.1926	0.0224	1.00	3.8522
Physical Medicine 3	0.00	0.00	0.1762	0.00	0.00	4.2277
Skin 1	2.1035	0.3520	0.3634	0.3519	1.00	3.6341
Skin 2	3.3979	0.6475	0.3598	0.6474	2.00	3.5904
Skin 3	13.6571	3.3416	0.4690	0.3898	3.00	4.2589
ENT	1.9391	0.1763	0.1217	0.1616	1.00	1.3281
Eye 1	1.74121	3.2540	0.3218	0.3254	2.00	6.4027
Eye 2	7.5950	1.2658	0.6174	0.1055	1.00	4.1408
Dental 1	0.00	0.00	0.0977	0.00	0.00	3.9081
Dental 2	2.7156	1.3578	0.06858	0.02630	1.00	4.1147
Child 1	8.6694	1.7613	0.6641	0.3816	3.00	3.0653
Child 2	1.3067	0.1633	0.2007	0.0108	1.00	3.0099
Orthopedic	6.9110	2.0087	0.3932	0.2009	2.00	3.9110
Gynecology 1	4.0242	1.224	0.3684	0.0814	2.00	3.2555
Gynecology 2	8.1744	1.8162	0.3703	0.1362	2.00	4.937

3.4 Model of the Proposed System

After analyzing existing system, we see that, though utilization of both counters (ticket and cash) are maximum, but a patient have to spent much more time in the counter compare to his/her total time in the system. So we have tried to reduce this waiting time. In the existing system receipt counter works for preparing the receipt and cash counter works for receiving cash. But in our proposed system both activities receipt preparation and cash payment are performed by each counter. One patient may use any one counter between this two. So one patient has to face a single queue rather than two separate. Explanations f service flow from the counter to the exit in the Proposed System are shown in figure-5.

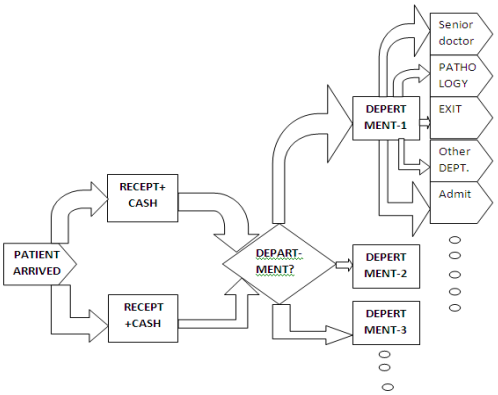


Fig.5: service flow diagram of the improved system

4. RESULTS AND DISCUSSION

After analysis both systems, a comparison between the output of the existing and proposed system are summarized in table-5.

Table 5: comparison between two systems

Differentiation based on	***Current system***	***Proposed system***	***Comment***
Average number out	209	220	Improved
VA time per person	4.6982 min	4.7309 min	Increase
Wait time per person	22.5746 min	15.1708 min	33% reduced
Total number of patient complete counter formalities	214	236	Increase
Counter 1 (ticket)	Give receipt	Give ticket & receive cash	Improve service
Counter 2 (cash)	Receive cash	Give ticket & receive cash	Improve service
Average time in system	27.2728min	19.9017min	27.02% reduced

From the results of the study, the management can decide to combine the task of receipt cutting and cash counter, such that the Patients waiting time can be reduced.

5. CONCLUSION

This paper presents the result of a modified simulation model to reduce waiting time and increase the number of served patients. In our current medical outdoor system, patient waiting times in the system and in the queue are 27.2728min and 22.5746 min while in proposed model this time reduced to 19.9017min and 15.1708 min. The improved model showed average 27.02% decrease in total time and 33% decrease in waiting time in system. Number of served patients also increased from 209 to 220 people. The study exposed significant differences in patient waiting time in the system and in the queue when the number of doctors is fixed in the existing system. From the results of the study, the management can decide to combine the task of receipt cutting and cash counter, and then patients waiting time can be reduced.

6. FUTURE WORK

Simulation study with more replication and using more data is going on to improve the whole system of the mentioned medical.

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