COMPUTER UNIVERSITY(MANDALAY)

FINAL YEAR PROJECT REPORT
ON

SIMULATION OF QUEUE BASED SYSTEM FOR DENTAL CLINIC

Bachelor of Computer Science

(B.C.Sc.)

Presented by Group(2)

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Book Submission					

Abstract

A queue is a line of people or things to be handled in a sequential order. Simulation means to assume the appearance of the characteristics of reality. This project aims to simulate, queuing based system for Dental Clinic. This system estimates the patient's waiting time, server's waiting time and queue length. The imperfect matching between the patients and service facilities can cause waiting time. To simulate Dental Clinic system, we made assumptions or approximations , both logical and mathematical about how it work. This project is implemented by VB.NET.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Simulation technique can be used to assist management decision-making. Queuing is a common phenomenon in our daily lives. It is impossible to avoid queuing as long as the number of people arrived is greater than the capacity of the service facility. In designing queuing systems need to aim for a balance between service to customers. It is always assumed that there is just a single queue (waiting line) and customers move from this single queue to the servers. This project use Monte Carlo Simulation Technique to simulate the Dental Clinic and depended on historical data. This system is the simulation process for Dental Clinic. User gives the arrival time and the random number as input. The system decide to give services as process. The waiting time and idle time are displayed depend on these services.

1.2 Objectives of The Project

- To study how Monte Carlo Simulation work for Dental Clinic
- To know how imitation of the operation of a real-world process or system over time
- To know how long the patients need to wait for the next appointment

1.3 Project Requirements

1.3.1 Hardware Requirements

- A computer or laptop
- A memory stick
- Core I3

1.3.2 Software Requirements

- Microsoft Visual Studio 2010
- Microsoft Office Access 2007

CHAPTER 2

THEORY BACKGROUND

2.1 Queuing

Typically business problems where simulation could be used to aid management decision-making are inventory control and queuing problems [3]. Queuing theory is the mathematical study of waiting lines or queue [2]. Queuing theory can be used to analyze simple queuing systems and more complex queuing systems are typically analyzed using simulation. In queuing theory, a model is constructed so that queue length and waiting time can be predicted. Queuing and waiting time analysis is particularly important in service system. Complex queuing systems are almost always analysed using simulation. Queuing theory is important when we study scheduling.

A queuing system consists of three basic components. These are

Arrivals : Customers arrive according to some arrival pattern.

Waiting : Arriving customers may have to wait in one or more queues for service.

Service : Customers receive service and leave the system.

2.2 Simulation

A collection of historical data was necessary to create the experimental environment which the simulation would be run [1]. A simulation is the imitation of the operation of a real-world process or system over time. From the simulation, data are collected as if a real system were being observed. Monte Carlo Simulation calculates results over and over each time using a different set of random values from the probability function. Monte Carlo Simulation lets all the possible outcomes of your decisions and assess the impact of risk, allowing for better decision making under uncertainty. A typical Monte Carlo simulation calculates the model hundreds or thousands of times each time using different randomly-selected value [5]. Monte Carlo Simulation can be a valuable tool when forecasting an unknown future. Simulation involves the generation of an artificial history of a system. This simulation-generated data are used to estimate the measures of performances of the system. The behavior of a system as it evolves over time is studied by developing a simulation model [4]. From the simulation, data are collected as if a real system were being observed. Many real-world systems are so complex that models of these systems are virtually impossible to solve mathematically. Most simulation outputs are essentially random variable.

2.3 Applications of Simulation

There is a wide range of applications of computer based simulation models because it is an approach rather than application of specific techniques. The major use of computer based Monte-Carlo simulation model has been in the solution of complex queuing problems.

A number of job shop simulation programmes have been developed involving deterministic times for the individual operations of a given order. Due to different processing times for similar operations and different order operations sequences, it is difficult to predict the waiting time for a particular job at any given work centre. For better scheduling , orders must be scheduled with a provision of waiting at the various work centres they will pass through. Simulation can help in estimating accurately such waiting times.

A number of network simulation models have also been developed. For example, with a randomly selected activity times the critical path can be evaluated. Repeating this process many times , the probability distribution of project completion time can be obtained as well as the probability that each given activity is on the critical path.

A variety of other problems which could be solved by simulation include:

(i) Military studies of logistics , support planning and weapon systems effectiveness.

(ii) Studies of individual and group behavior.

(iii) Financial studies involving risky investments.

(iv) Testing of decision rules for hospital admission and operating policies.

2.4 *Advantages Of Simulation*

1. Simulation is suitable to analyse large and complex real life problems which cannot be solved by usual quantitative methods.
2. Simulation allows the decision maker to study the interactive system variables and the reflect on changes in these variables on the system performance in order to determine the desired one.
3. Simulation experiments are done with the model , not on the system itself . It also allows to include additional information during analysis that most quantitative models do not permit.
4. Simulation can be used as a pre-service test to try out new policies and decision rules for operating a system before running the risk of experimentation in the real system.

2.5 Monte Carlo Simulation

Monte Carlo simulation is a computerized mathematical technique that allows people to account for risk in quantitative analysis and decision making. The technique is used by professionals in such widely disparate fields as finance, project management, energy, manufacturing, engineering, research and development, insurance, oil and gas, transportation, and the environment.

Monte Carlo simulation furnishes the decision-maker with a range of possible outcomes and the probabilities they will occur for any choice of action. It shows the extreme possibilities-the outcomes of going for broke and for the most conservative decision-along with all possible consequences for middle- of –the-road decisions.

The technique was first used by scientists working on the atom bomb; it was named for Monte Carlo, the Monaco resort town renowned for its casinos. Since its introduction in World War II, Monte Carlo simulation has been used to model a variety of physical and conceptual systems.

2.6 Queuing Theory Can Also Be Used In Other Application

Queuing theory deals with problems which involve queuing (or waiting). Typical examples might be:

- Banks/supermarkets –waiting for service
- Computers – waiting for a response
- Failure situations – waiting for a failure to occur e.g. in a piece of machinery
- Public transport – waiting for a train or a bus

2.7 Queue Characteristics

How, from the set of customers waiting for service, do we choose the one to be served next (e.g. FIFO (first- in first – out) also known as FCFS (first-come first served); LIFO (last – in first – out); randomly) (this is often called the queue discipline).

- Do we have:
- Balking (customers deciding not to join the queue if it is too long)
- Reneging (customers leave the queue if they have waited too long for service)
- Jockeying (customers switch between queues if they think they will get served faster by so doing)
- A queue of finite capacity or (effectively) of infinite capacity

Changing the queue discipline (the rule by which we select the next customer to be served) can often reduce congestion. Often the queue discipline "choose the customer with lowest service time" results in the smallest value for the time (on average) a customer spends queuing.

2.8 Random Number Generation

Monte Carlo simulation requires the generation of a sequence of random numbers that is an integral part of the simulation model. This sequence of random numbers help in choosing random observations from the probability distribution.

A random number is a number in a sequence of integer numbers between 0 to 9 whose probability of occurrence is same as that of any other number in the sequence . Any decision variable of a simulation model can be represented as a random variable and assumed to follow some theoretical probability distribution such as normal, Poisson, exponential, etc. or an empirical distribution.

Random numbers can be generated both by simple arithmetic computation and computer generator based on some known probability distribution.

2.9 Steps Of Monte Carlo Simulation

The steps of Monte Carlo Simulation are as follows:

1. Setting up a probability distribution for variables to be analyzed.
2. Building a cumulative probability distribution for each random variable.
3. Assign an appropriate set of random numbers to represent value or range (interval) of values for each random variable.
4. Conduct the simulation experiment by means of random sampling.
5. Repeat Step 4 until the required number of simulation run has been generated.
6. Design and implement a course of action and maintain control.

2.10 Random Number Generation (by using Multiplicative Congruential Method)

If simulation is used, random numbers are generated. The formula of random number generation is as follow:

$$r_n \equiv p r_{n-1} \ (modulo\ \ m)$$

m= prime number

p= nearly value of square root of m.

r_0= choose between 1 and m.(r_0> 1 & r_0<m)

Assume m=87, p=9, r_0 =72

- r_1 = pr_0 (modulo m)

  = (9* 72) % 87

  = 39

- r_2 = pr_1 (modulo m)

  = (9*39) % 87

  = 03

- r_3 = pr_2 (modulo m)

  = (9*03) % 87

  = 27

- r_4 = pr_3 (modulo m)

  = (9*27) % 87

  = 69

- r_5= pr_4 (modulo m)

  = (9*69) % 87

  = 12

- r_6= pr_5 (modulo m)

  = (9*12) % 87

  = 21

- $r_7 = pr_6$ (modulo m)

  $= (9*21)$ % 87

  $= 15$

- $r_8 = pr_7$ (modulo m)

  $= (9*15)$ % 87

  $= 48$

- $r_9 = pr_8$(modulo m)

  $= (9*48)$ % 87

  $= 84$

2.11 Calculation of Probability

For the available of cumulative probability, the system need to calculate the probability.

Categories/day	:	Filling	Crown	Cleaning	Extraction	Checkup
Frequency	:	3	10	5	10	3
Total Frequency	:	31				
Probability	:	(Frequency/ Total Frequency)				
		0.10	0.32	0.16	0.32	0.10

2.12 Simulation Can Also Be Used In Other Application

Simulation in general is to pretend that one deals with a real thing while really working with an imitation. In operations research the imitation is a computer model of the simulated reality. A flight simulator on a PC is also a computer model of some aspects of the flight: it shows on the screen the controls and what the "pilot" (youngster who operates it) is supposed to see from the "cockpit".

Simulation is a useful tool for any systems that change with time, such as a gas station where cars come and go and involve randomness. Nobody can guess at exactly which time the next car should arrive at the station, are good candidates for simulation. Modeling complex dynamic systems theoretically need too many simplifying assumptions, making it the only too even in absence of randomness.

2.13 Steps Of Simulation Process

The process of simulating a system consists of following steps:

Step 1: Identify the problem

Step 2: (a) Identify the decision variables

(b) Decide the performance criterion (objective) and decision rules

Step 3: Construct a numerical model so that it can be analysed on the computer. Sometimes the model is written in a particular simulation language which is suited for the problem under analysis.

Step 4: Validate the model to ensure whether it is truly representing the system being analysed and the results will be reliable.

Step 5: Design the experiments to be conducted with the simulation model by listing specific values of variables to be tested at each trial.

Step 6: Run the simulation model on the computer to get the results in the form of operating characteristics.

Step 7: Examine the results in terms of problem solution as well as their reliability and correctness. If the simulation process is complete, then select the best course of action otherwise make desired changes in model decision variables, parameters or design, and return to Step 3.

CHAPTER 3

DESIGN AND IMPLEMENTATION

3.1 System Flow Diagram

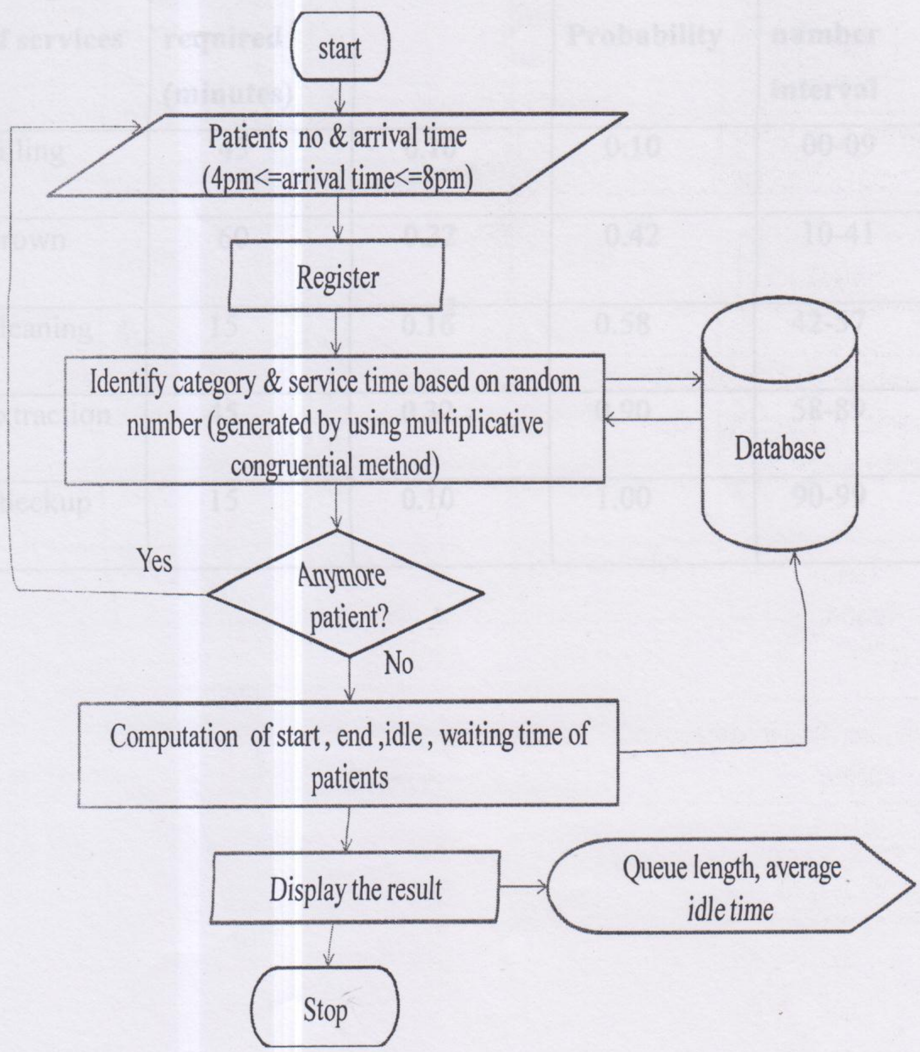


Figure 3.1: System Flow Diagram For Dental Clinic

3.2 Simulate the Dentist's Clinic for Four Hours Starting at 4:00 PM to 8:00 PM

Table 3.1 The Cumulative Probability Distribution and Random Number Interval for Service Time Table

Category of services	Service time required (minutes)	Probability	Cumulative Probability	Random number interval
Filling	45	0.10	0.10	00-09
Crown	60	0.32	0.42	10-41
Cleaning	15	0.16	0.58	42-57
Extraction	45	0.32	0.90	58-89
Checkup	15	0.10	1.00	90-99

Table 3.2 Arrival Pattern and Nature of Service Table

Patient number	Arrival time	Random number	Category of service	Service time(minutes)
1	4:00	39	Crown	60
2	4:30	03	Filling	45
3	5:00	27	Crown	60
4	5:30	69	Extraction	45
5	6:00	12	Crown	60
6	6:30	21	Crown	60
7	7:00	15	Crown	60
8	7:30	48	Cleaning	15
9	8:00	84	Extraction	45

Table 3.3 Computation of Start , End , Idle and Waiting Time of Patients Table

Patient number	Arrival time	Waiting Patient number	Service time	Start time	End time	Idle time	Waiting time (minutes)
1	4:00	-	60	4:00	5:00	-	-
2	4:30	2	45	5:00	5:45	-	30
3	5:00	3	60	5:45	6:45	-	45
4	5:30	3,4	45	6:45	7:30	-	75
5	6:00	4,5	60	7:30	8:30	-	90
6	6:30	4,5,6	60	8:30	9:30	-	120
7	7:00	5,6,7	60	9:30	10:30	-	150
8	7:30	6,7,8	15	10:30	10:45	-	180
9	8:00	6,7,8,9	45	10:45	11:30	-	165

From the above table,

Queue length=8

Average idle time=0/9=0min

3.3 Main Page

This figure shows total execution of system.

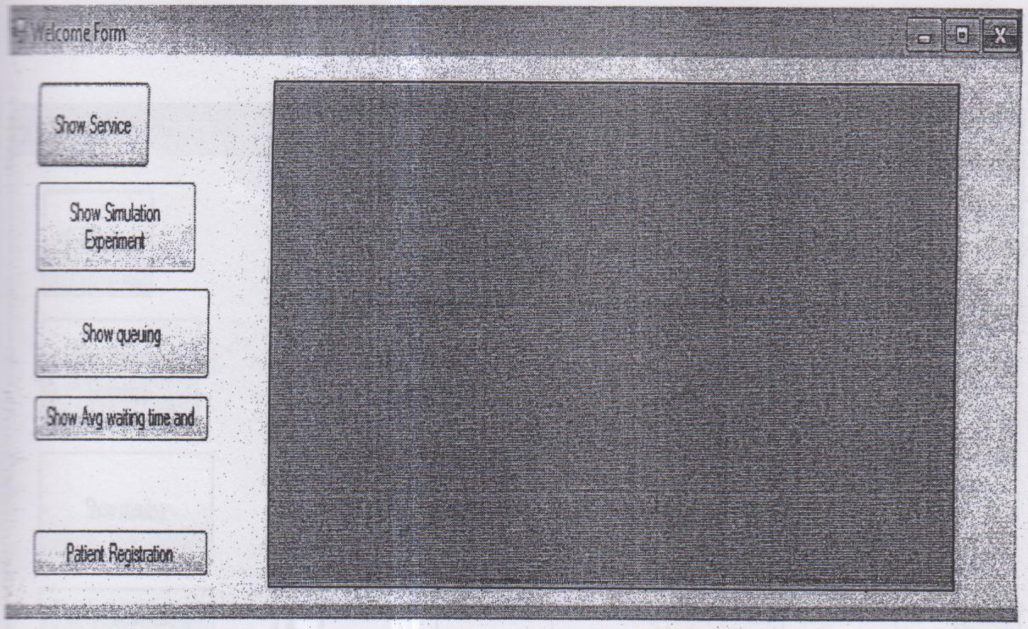
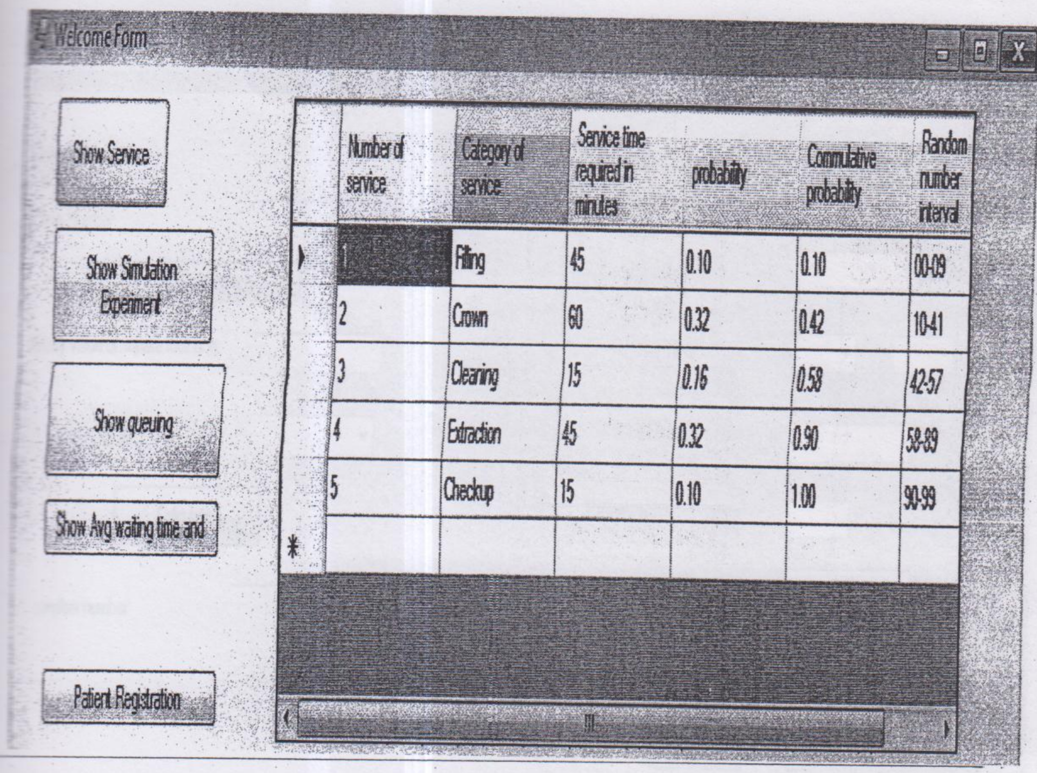


Figure 3.2: Main Page

3.3.1 Show Service

If the patients view services, they must click show service button as shown in figure (3.3).



Number of service	Category of service	Service time required in minutes	probability	Commulative probability	Random number interval
1	Filling	45	0.10	0.10	00-09
2	Crown	60	0.32	0.42	10-41
3	Cleaning	15	0.16	0.58	42-57
4	Extraction	45	0.32	0.90	58-89
5	Checkup	15	0.10	1.00	90-99

Figure 3.3: Show Service

3.3.2 Registration Form

Patient will fill register form as shown in figure (3.4). Patient will fill prime number, values for r0, patient name, sex and arrival time.

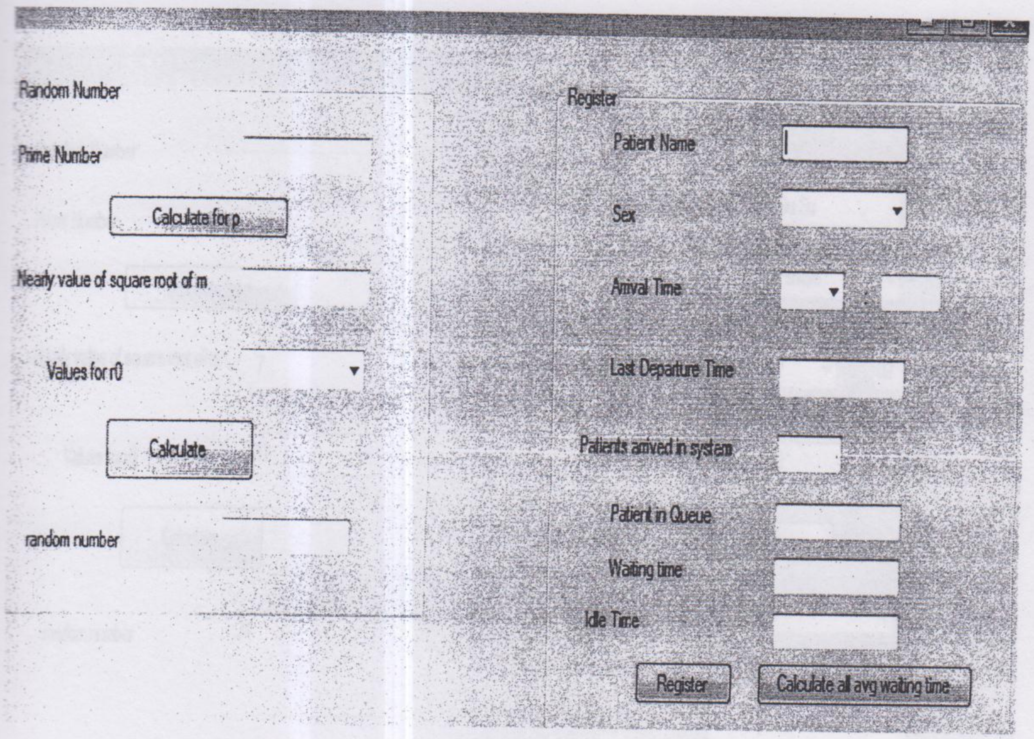


Figure 3.4: Registration Form

3.3.2.1 Filling The Register Form

If the patient has filled prime number, click calculate button then the value of p will available and choose values for r0 then click calculate button, the value of random number will available. If patient clicked register button, register form is completed as shown in figure (3.5).

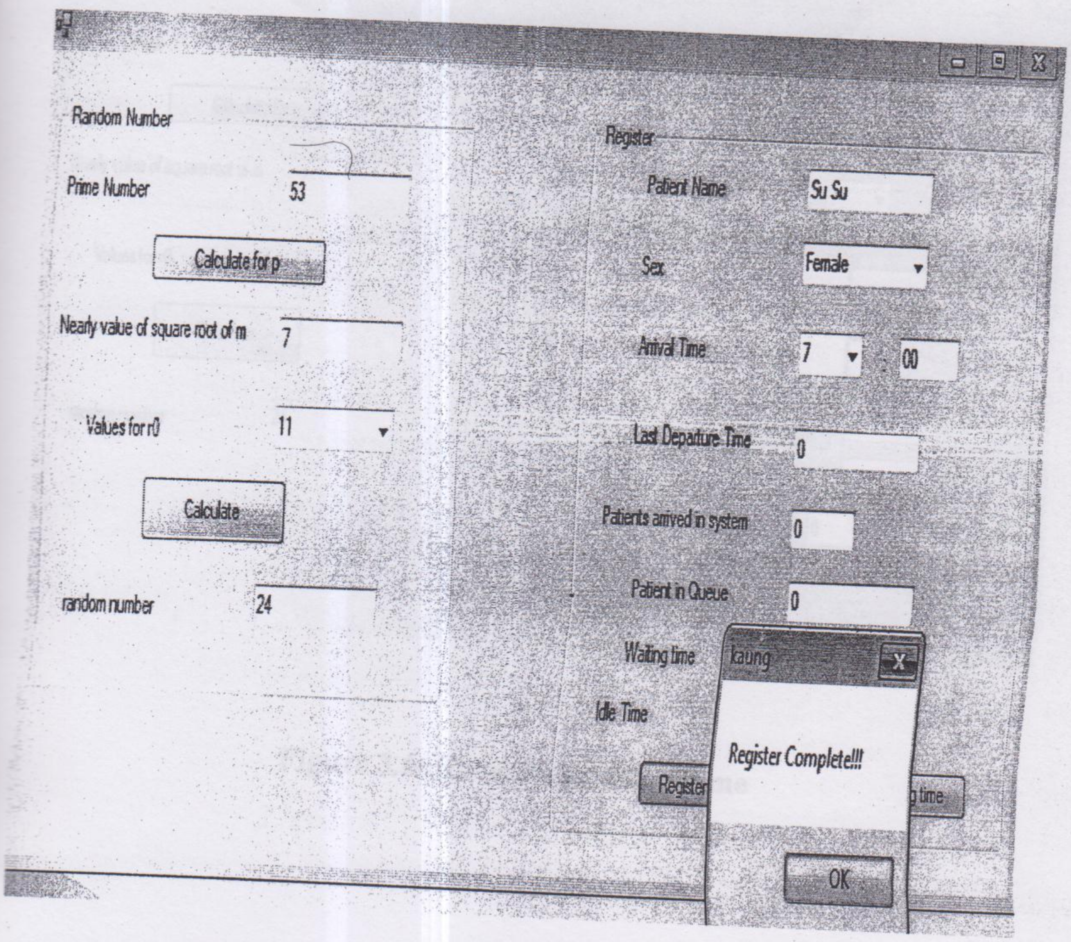


Figure 3.5: Filling The Register Form

3.3.2.2 Show Departure Time

System shows patient's service finish time as departure time as shown in figure(3.6).

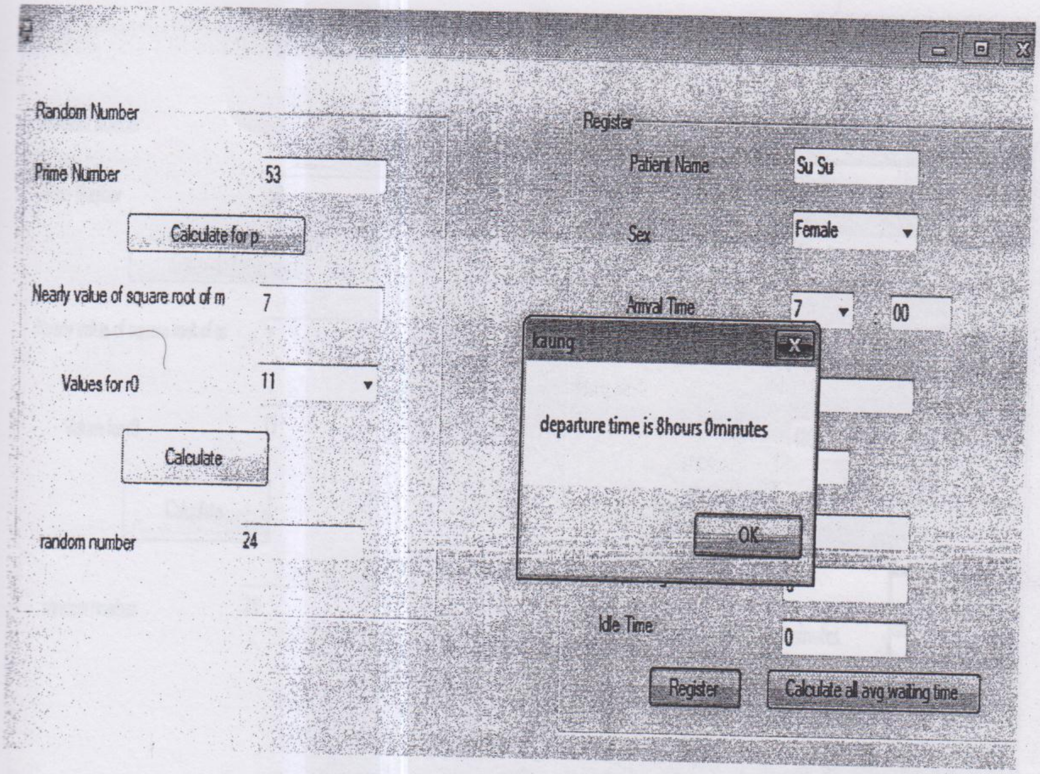


Figure 3.6: Show Departure Time

3.3.2.3 Show Idle Time

For waiting patient, idle times are presented in the system as shown in figure (3.7).

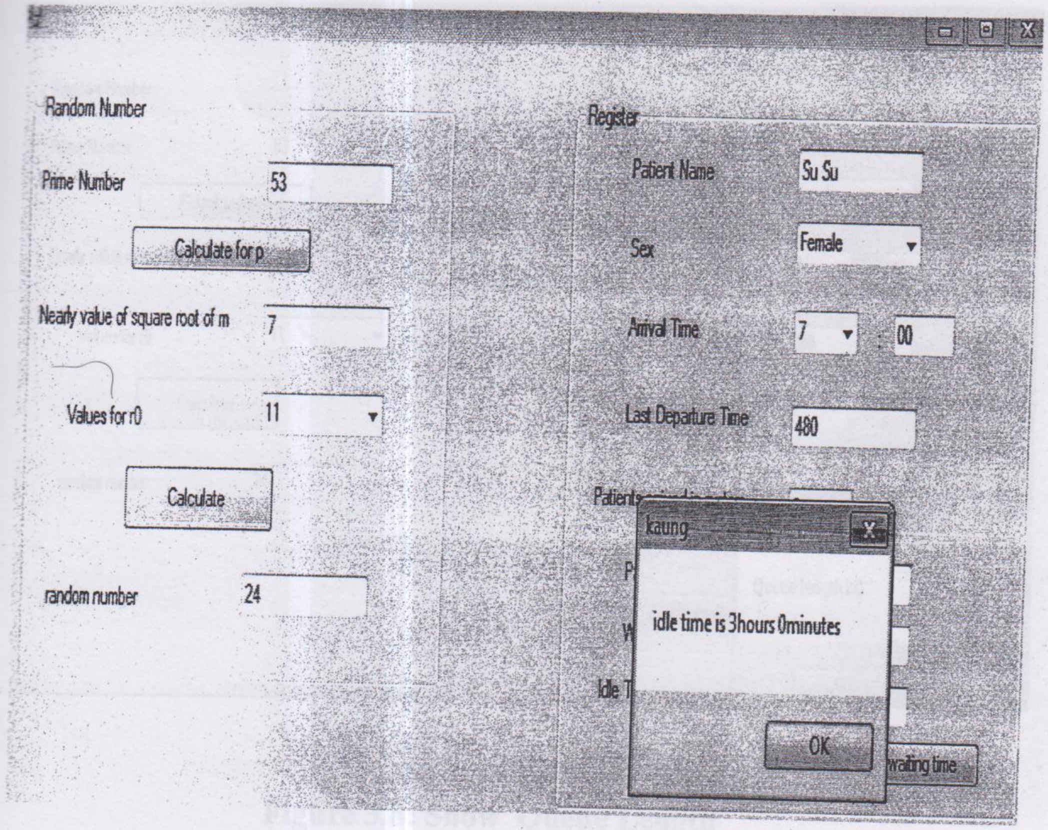


Figure 3.7: Show Idle Time

3.3.2.4 Show Queue Length

For the first patient, queue length is zero means no waiting patient number as shown in figure (3.8).

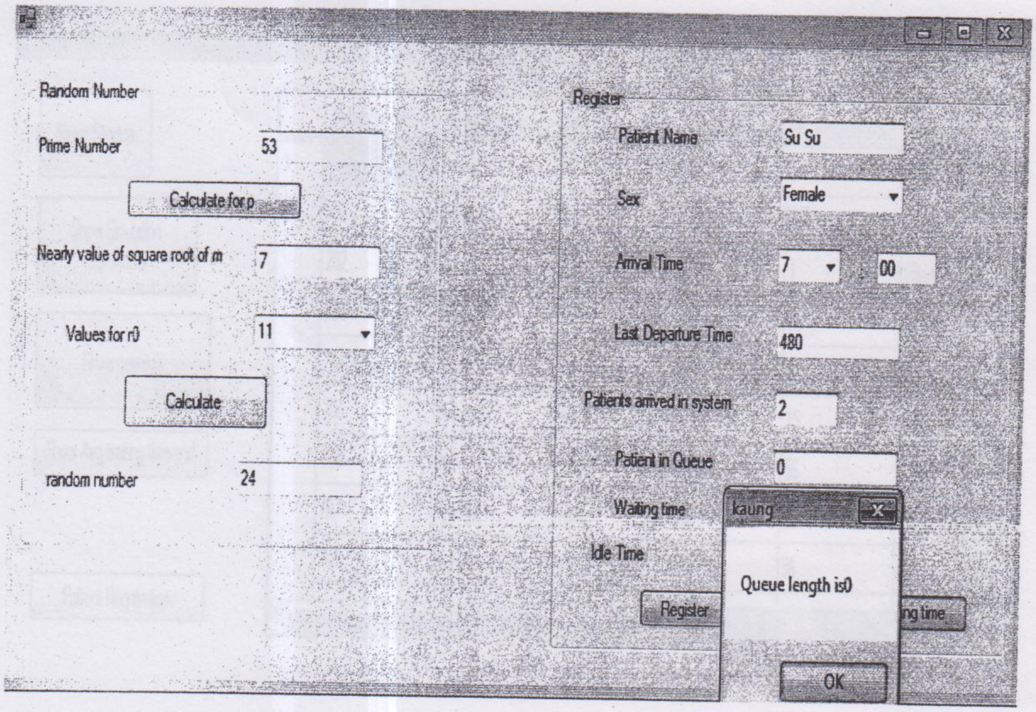


Figure 3.8: Show Queue Length

3.3.3 Show Simulation Experiment

If system wanted to view simulation experiment, click show simulation experiment button as seen in figure (3.9).

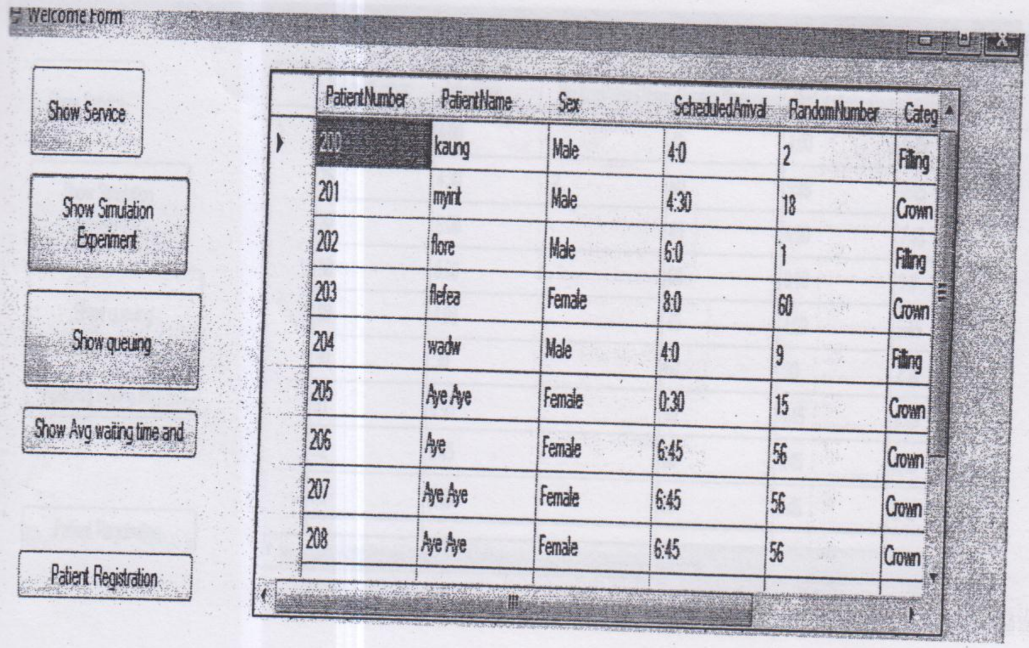
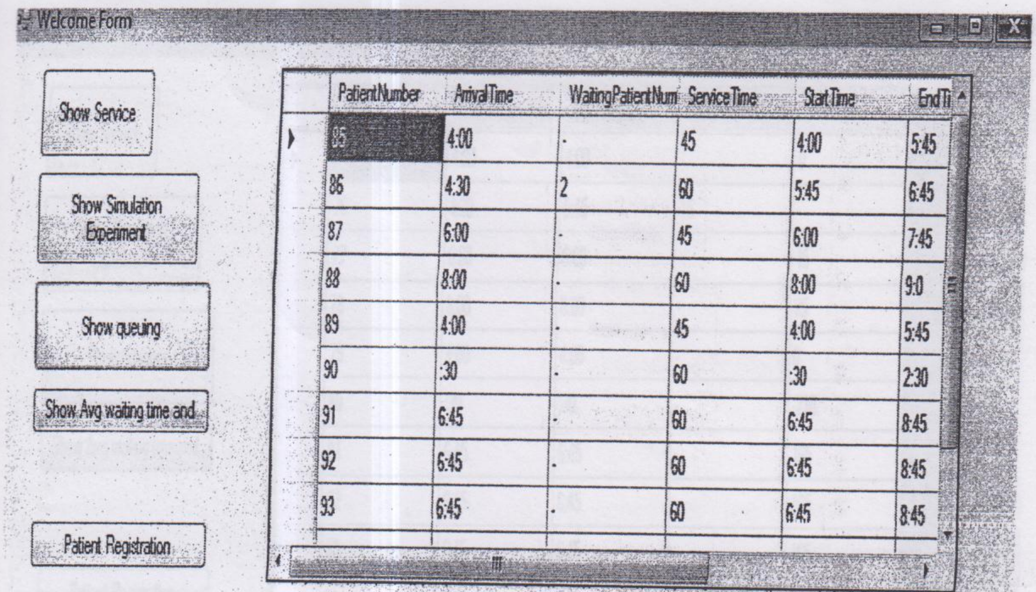


Figure 3.9: Show Simulation Experiment

3.3.4 Show Queue Length

If the patients waited for service time, the patients must enter queue, so queue length was available as seen in figure (3.10).

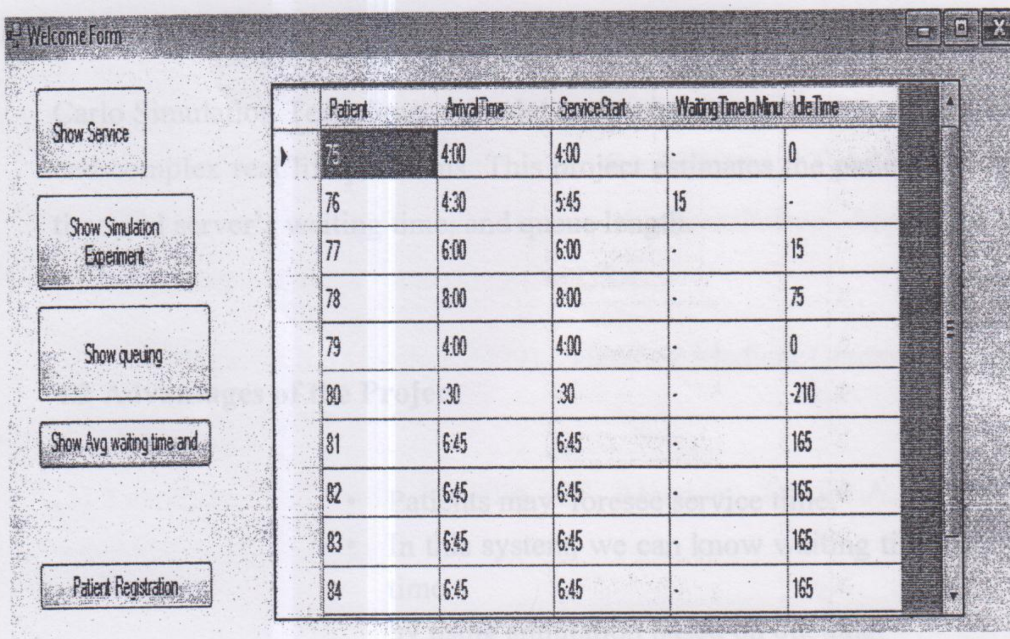


PatientNumber	ArivalTime	WaitingPatientNum	ServiceTime	StartTime	EndTi
85	4:00	.	45	4:00	5:45
86	4:30	2	60	5:45	6:45
87	6:00	.	45	6:00	7:45
88	8:00	.	60	8:00	9:0
89	4:00	.	45	4:00	5:45
90	:30	.	60	:30	2:30
91	6:45	.	60	6:45	8:45
92	6:45	.	60	6:45	8:45
93	6:45	.	60	6:45	8:45

Figure 3.10: Show Queue Length

3.3.5 Show Average Idle Time

In welcome form, the system retrieve the idle time for each patient as seen in figure (3.11).



Patient	ArrivalTime	ServiceStart	WaitingTimeInMinut	IdleTime
75	4:00	4:00	-	0
76	4:30	5:45	15	-
77	6:00	6:00	-	15
78	8:00	8:00	-	75
79	4:00	4:00	-	0
80	:30	:30	-	-210
81	6:45	6:45	-	165
82	6:45	6:45	-	165
83	6:45	6:45	-	165
84	6:45	6:45	-	165

Figure 3.11: Show Average Idle Time

CHAPTER 4

CONCLUSION

4.1 Conclusion

Dental Clinic system based on queue is simulated using Monte Carlo Simulation Technique. Simulation is experimented on analysing large and complex real life problems. This project estimates the patient's waiting time and server's waiting time, and queue length.

4.2 Advantages of the Project

- Patients may foresee service time.
- In this system, we can know waiting time and idle time
  by using simulation based on queuing.

4.3 Limitations and Further Extensions

- Patients can be available the given categories of services.
- Queue can be used in the other application area such as waiting vehicles at toll stations.
- This system may execute one or more servers.

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