

Simulation of Service Queue for Dental Doctor Patients at Kindergarten Hospital. IV 01.07.02 Binjai Using the Exponential Method

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Abstract

One of the systems that can be simulated is a queue. The queuing system consists of a collection of customer servers, a queue that regulates service to customers. The utilization of queuing simulations is to optimize services by designing service resources so that services can be effective and efficient. In the queuing system there are several problems that often occur, for example queuing queues, the number of queues will cause problems such as bored customers, and discomfort will make customers dissatisfied with the service. The Application of the Exponential Method in the Dentist Patient Service Queuing System There are 28 general populations in this study, namely all consumers at the Kesrem Binjai Hospital, while the target population is the population that is actually used as a data source for patients who queue at the Kesrem Binjai Hospital to get the best service. is the target population in this study.

Keywords: Queuing System, Exponential, Dentist, Kesrem Binjai Hospital

1. Introduction

Queues are events that we can encounter in various places that provide services to the community, such as hospitals, banks, toll roads and others. The process of queuing is tedious for the public due to various reasons, including the long queuing process, the space in which to wait in line is less comfortable and the queuing system is unable to provide queue management for the public. The problem that occurs at the Kesrem Binjai Hospital is that there are a lot of queues that occur due to the need for services exceeding the capacity of the service or service facilities, so that facility users who arrive do not immediately get services due to the busyness of the service because the number of servers is unable to accommodate the large number of patients queuing at the Kesrem Hospital binjai [1], [2].

2. The Exponential Method

The Exponential Method is very useful for analyzing the form of queue length, average service time, average waiting time. The problem currently occurring is that many goods delivery service companies are experiencing an increase in demand for goods delivery services, which has resulted in queues for customer service. This customer service queue problem can certainly result in inconvenience for customers in using their delivery services. The research conducted by Kresna Ramanda and Yunita aims to solve customer queue service problems that occur, for this reason the Exponential method is applied to evaluate better service at goods delivery service companies. The results of the analysis from applying the Exponential method in research conducted by Kresna Ramanda and Yunita resulted in the possibility that the system could serve 2 units of time [3], [4].

The principle of the exponential method is a mathematical approach used in various fields to describe growth or decline that occurs exponentially. This method is based on the exponential function, where the value of a variable grows with a growth rate proportional to its current value. Scholars have studied and applied exponential methods in various contexts. In economics, exponential methods are often used to analyze time data and forecast economic growth trends. Economists utilize exponential models to identify growth rates of gross domestic product (GDP), unemployment, and inflation. This method allows them to make more accurate predictions regarding how these variables will change over time [5].

3. Research Methodology

Research methods are defined as scientific ways to obtain data with specific purposes and uses. The research method used is [6], [7]:

1. Field study method, namely a data collection method by calculating how many patients come and the service time.
2. Literature study which is a review of the literature. This data collection technique involves conducting a review study of literature books, notes and reports that are related to the problem to be solved.

The research method used in this research is the observation method. According to Wibowo, the observation method is a way of collecting data by directly observing the research object.

3.1. Research Population

Population is a generalized area consisting of objects or subjects that have certain qualities and characteristics determined by researchers to be studied and then conclusions drawn. In accordance with the opinion above, as a basis the researcher determined the population in this study. The population in a study is divided into two, namely the general population and the target population. The general population is the entire object being studied, so the 28 general population in this study are all consumers at the Binjai Kesrem Army Hospital, while the target population is the population that is properly used as a data source for patients waiting in line. Research [8].

In this research there are several data collection methods, namely Primary data, According to Sugiyono, primary data is data obtained directly from the source. Primary data can be sourced from 30 individual respondents, focus groups, the internet if using the internet to distribute questionnaires. In research, primary data is collected by researchers conducting interviews and direct observations in the field. The primary data referred to in this research is observing and counting the number of customers who come per hour and recording the results according to events during the research. After that, calculate the average number of customer arrivals, average service level and conduct interviews with the head supervisor where the research took place. This research was carried out directly in the field by observing consumer arrivals for 2 days and 6 working hours in one day with a time interval of 60 minutes [9].

3.2. Research sample

Put forward by (Ajjjah, et al., 2021) who stated that the sample is part of the number of characteristics possessed by the population. Therefore, the sample taken must be truly representative. In this research, the sampling method was non-probability sampling with a purposive sampling technique. Purposive sampling is a technique for determining a sample by considering certain criteria that are strongly suspected to be related to a previously known population. In this study, researchers took samples with the following criteria:

1. Patients at the Kesrem Binjai Army Hospital who come to queue to have their health checked at the Kesrem Binjai Army Hospital on 19-June-2023 to 23-June-2023 at 08.00-15.00.
2. The time taken for this research was 5 days for 7 hours/day, starting from 08.00-15.00 because these times are busy times such as in the morning when the whole community is preparing for treatment and in the afternoon when they go home. Work.

3.2. Data and data collection method

Data collection methods are methods or techniques used by researchers to obtain and collect data to obtain the information needed by researchers in order to achieve research objectives. In this research there are several data collection methods, namely:

1. Primary data; Primary data according to Sugiyono is data obtained directly from the source. Primary data can be sourced from 30 individual respondents, focus groups, the internet when using the internet to distribute questionnaires. In research, primary data is collected by researchers conducting interviews and direct observations in the field. The primary data referred to in this research is observing and counting the number of customers who come per hour and recording the results according to events during the research. After that, calculate the average number of customer arrivals, the average level of service and conduct interviews with the head supervisor where the research took place. This research was carried out directly in the field by observing customer arrivals for 2 days and for 6 working hours in one day with a time interval of 60 minute.
2. Secondary data; Secondary data according to Sugiyono is data obtained indirectly from data collectors. Secondary data is data that is to support primary data needs such as books, literature and reading related to research. Secondary data in this research was obtained by reading official social media sites which are managed directly by officers to provide information in the form of history and matters related to research.

3.3. Operational variables

The service system is the patient arriving and waiting to receive dental health services when the health service facility or server is busy, then leaving the service system after receiving the desired service. The length of the queue and the length of time patients at Kesrem Binjai Hospital wait to receive services and be served by the operators of Kesrem Binjai Hospital to obtain dentist services is sometimes a measure of the service of a health center. Therefore, to optimize the service, you can estimate the service time and determine the queue line and number of services used. Kesrem Binjai Hospital applies a Multi Channel – Single Phase (M/M/S) queuing model, which means it has 2 or more lines of service facilities available to handle incoming and outgoing customers.

The service system only has one phase to complete transactions. The queuing discipline used by Binjai Kesrem Hospital to obtain dentist services is FIFO (First In First Out) where consumers Come and queue first at the Kesrem Binjai Hospital to get Dentist services, you will be served first.

3.4. System analysis

Systems Analysis is the process of understanding and studying existing systems, be they information technology systems, businesses, organizations, or a combination of these. The purpose of systems analysis is to identify needs, problems, and opportunities in existing systems, as well as develop recommendations for improvements or changes that can improve system performance. Systems analysis involves collecting and analyzing data about the system being studied, including business processes, organizational structure, data flows, user needs, and technology requirements. Methods commonly used in systems analysis include interviews with users and stakeholders, direct observation, collection of documents and system artifacts, as well as analysis techniques such as data flow diagrams, use case diagrams, and business process modeling.

3.5. Analysis of Running System Weaknesses

In the current system, the queuing system at the Kesrem Binjai Hospital is still done manually. Patient identification is carried out by the staff directly by registering the patient using a manual system, such as asking for name, address, date of birth and so on, then the staff checks the patient's condition in general, such as checking blood pressure, asking for complaints and so on, then immediately writing it down. on the form provided by the officer

3.6. New system requirements analysis

This research aims to design a queuing system that can display the results of serving the average patient at Kesrem Binjai Hospital. using the Exponential method using desktop-based Visual Basic programming tools. Following are some of the requirements that must be met, namely as follows:

- a. The hardware used to manufacture this system is a computer or laptop.
- b. The software used to build this system is Visual Basic for the text editor, MySQL for the database, and ASP.Net for the programming language.
- c. The information requirement for this new system is how many patients are served at one time if using the Exponential Method which will be replaced by this system design. Single-Server Queue (Model M/M/1) is one of the most commonly used Exponential methods in analyzing queuing systems with one server. In this model, M refers to the distribution of arrivals (arrival distribution) and also the distribution of service time (service time distribution), while the number 1 indicates that there is only one server serving the queue.

4. Results and discussion

The following are the steps in implementing the M/M/1 Model in a dentist patient service queuing system:

Arrival 1:

Random = 0
Intervalarrival time = 0
Arrival time = 0

Arrival 2:

Revive $U = U(0,1) = 0.7154$
• Arrival time interval =
- $1 \cdot \text{Log}(0.7154) = 0.0291$
5
 $x = \text{Arrival time interval} \cdot 3600 = 105$
Minutes $= x / 60 = 1.74 = 1 \text{ minute}$
Seconds $= x \text{ mod } 60 = 45 = 45 \text{ seconds}$
• Arrival time = $0 + 0.0291 = 0.0291$
 $X = \text{Arrival time} \cdot 3600 = 105$
Minutes $= x / 60 = 1.74 = 1 \text{ minute}$
Seconds $= x \text{ mod } 60 = 45 = 45 \text{ seconds}$

Arrival 3:

Awaken $U = U(0,1) = 0.4240$
• Arrival time interval =
- $1 \cdot \text{Log}(0.4240) = 0.0745$
5
 $x = \text{Arrival time interval} \cdot 3600 = 268$
Minutes $= x / 60 = 4.46 = 4 \text{ minutes}$
Seconds $= x \text{ mod } 60 = 28 = 28 \text{ seconds}$

• Arrival time = $0.0291 + 0.0745 = 0.1036$
 $X = \text{Arrival time} \cdot 3600 = 372$
Minutes $= x / 60 = 6.2 = 6 \text{ minutes}$
Seconds $= x \text{ mod } 60 = 12 = 12 \text{ seconds}$

Arrival 4:

Revive $U = U(0,1) = 0.3929$

- Arrival time interval =
 $-1 \cdot \text{Log}(0.3929) = 0.0811$

$x = \text{Arrival time interval} \cdot 3600 = 291$

Minutes = $x / 60 = 4.85 = 4$ minutes

Seconds = $x \bmod 60 = 51 = 51$ seconds

- Arrival time = $0.0745 + 0.0811 = 0.01848$

$X = \text{Arrival time} \cdot 3600 = 670$

Minutes = $x / 60 = 11.16 = 11$ minutes

Seconds = $x \bmod 60 = 15 = 15$ seconds

Arrival 5:

Generate $U = U(0,1) = 0.4750$

- Arrival time interval =
 $-1 \cdot \text{Log}(0.4750) = 0.0647$

5

$x = \text{Arrival time interval} \cdot 3600 = 232$

Minutes = $x / 60 = 3.86 = 3$ minutes

Seconds = $x \bmod 60 = 52 = 52$ seconds

- Arrival time = $0.0745 + 0.0811 = 0.2494$

$X = \text{Arrival time} \cdot 3600 = 897$

Minutes = $x / 60 = 14.95 = 14$ minutes

Seconds = $x \bmod 60 = 57 = 57$ seconds

For minutes rounding downwards, the remainder of the decimal goes into seconds. Thus the arrival to $-n$ is calculated by the same formula. Counter = Total time interval to arrival. If the counter \geq duration then it is over, if the counter \leq duration then awakened to the next arrival.

Table 1: Customer Arrival Table

Customer Arrivals	random rand ()	Arrival Time Interval	Arrival Time
1	0	0	0
2	0,7154	0,0291	0,0291
3	0,4240	0,0745	0,01036
4	0,3929	0,0811	0,01848
5	0,4750	0,0647	0,2494

The table above shows that the results of the simulation are still decimal units, for that we have to convert the unit into a unit of time, for that the formula is used.

Table 2: Arrival Table

Coming	Random Rand ()	Time Interval Coming	Time Coming
1	0	00:00	00:00
2	0,7154	01:45	01:45
3	0,4240	04:28	06:12
4	0,3929	04:51	11:15
5	0,4750	03:52	14:57

Table 3: Customer Table

No	Customer Name
1	A
2	B
3	C
4	D
5	E

After previously obtaining the total arrivals, it is continued to generate the service time using exponential distribution with: $-1/\mu \text{Log}(U)$, for example the total arrivals $\lambda = 5$ and $\mu = 10$.

Customer 1 (A):

Start time = arrival time = 0

Generate $U = U(0,1) = 0.2938$

Service time = $-1/10 \log(0.2938) = 0.0532$

Service completed = $0 + 0.0532 = 0.0532$

Queue wait time = 0

System timeout = 0.0532

Customer 2 (B)

If arrival time \leq finished customer service beforehand :Start time = finished customer service before
 If arrival time $>$ finished customer service beforehand :Start time = arrival time

Arrival time = 0.0291 $<$ 0.0532, then start time = 0.0532

Raise $U = U(0.1) = 0.0100$

Service time = $-1/10 \cdot \log(0.0100) = 0.2000$

Service completed = 0.0532 + 0.2000 = 0.2532

$x = \text{Service completed} \cdot 3600 = 912$

minutes = $x / 60 = 15.2 = 15$ minutes

Seconds = $x \bmod 60 = 12 = 12$ seconds

Queue wait time = 0.0532 – 0.0291 = 0.0241

$X = \text{queue wait time} \cdot 3600 = 87$

Minutes = $x / 60 = 1.45 = 1$ minute

Seconds = $x \bmod 60 = 27 = 27$ seconds

System wait time = 0.2532 – 0.0291 = 0.2241

$X = \text{queue wait time} \cdot 3600 = 807$

Minutes = $x / 60 = 13.45 = 13$ minutes

Seconds = $x \bmod 60 = 27 = 27$ seconds

Customer 3(C)

If the arrival time \leq completed previous customer service:

Start time = previous customer service finish

If the arrival time $>$ completed the previous customer service:

Start time = arrival time

Arrival time = 0.1036 $<$ 0.2532, then start time = 0.2532

Generate $U = U(0.1) = 0.6490$

Service Time = $-1/10 \cdot \log(0.6490) = 0.0188$

Service completed = 0.2720 + 0.0188 = 0.2720

$X = \text{Service completed} \cdot 3600 = 979$

Minutes = $x / 60 = 16.31 = 16$ minutes

Seconds = $x \bmod 60 = 19 = 19$ seconds

Queue wait time = 0.2532 – 0.1036 = 0.1684]

$X = \text{queue wait time} \cdot 3600 = 538$

Minutes = $x / 60 = 8.96 = 8$ minutes

Seconds = $x \bmod 60 = 58 = 58$ seconds

System timeout = 0.2720 – 0.1036 = 0.1684

$X = \text{queue wait time} \cdot 3600 = 606$

Minutes = $x / 60 = 10.1 = 10$ minutes

Seconds = $x \bmod 60 = 6 = 6$ seconds

Customer 4 (D)

If the arrival time \leq completed previous customer service:

Start time = previous customer service finish

If the arrival time $>$ completed the previous customer service:

Start time = arrival time

Arrival time = 0.1848 $<$ 0.2720, then start time = 0.2720

Generate $U = U(0.1) = 0.4225$

Service Time = $-1/10 \cdot \log(0.4225) = 0.0374$

Serv $X = \text{Service completed} \cdot 3600 = 1094$

Minutes = $x / 60 = 18.23 = 18$ minutes

Seconds = $x \bmod 60 = 14 = 14$ seconds

• Queue wait time = 0.2027 – 0.1848 = 0.1246

$X = \text{queue wait time} \cdot 3600 = 314$

Minutes = $x / 60 = 5.23 = 5$ minutes

Seconds = $x \bmod 60 = 14 = 14$ s

• System timeout = 0.3094 – 0.1848 = 0.1246

$X = \text{queue wait time} \cdot 3600 = 449$

Minutes = $x / 60 = 7.48 = 7$ minutes

Seconds = $x \bmod 60 = 29 = 29$ seconds

Customer 5(E)

If the arrival time \leq completed previous customer service:

Start time = previous customer service finish

If the arrival time $>$ completed the previous customer service:

Start time = arrival time

Arrival time = 0.2494 $<$ 0.3094, then start time = 0.3094

Generate $U = U(0.1) = 0.1020$

Service Time = $-1/10 \cdot \log(0.1020) = 0.0991$

Service completed = 0.3094 + 0.0991 = 0.4085

$X = \text{Service completed} \cdot 3600 = 1471$

Minutes = $x / 60 = 24.51 = 24$ minutes
 Seconds = $x \text{ mod } 60 = 31 = 31$ seconds
 Queue wait time = $0.3094 - 0.2494 = 0.1591$
 $X = \text{queue wait time} * 3600 = 216$
 Minutes = $x / 60 = 3.6 = 3$ minutes
 Seconds = $x \text{ mod } 60 = 36 = 36$ seconds
 • System wait time = $0.4085 - 0.2494 = 0.1591$
 $X = \text{queue wait time} * 3600 = 573$
 Minutes = $x / 60 = 9.55 = 9$ minutes
 Seconds = $x \text{ mod } 60 = 33 = 33$ seconds

Table 4: Service Table

Customer	Arrival Time	Start time	Random	Service Hours	Queue Waiting Time Service Completed	Queue Wait Time	System Waiting Time
1	0	0	0,2938	0,0532	0,0532	0,0000	0,0532
2	0,0291	0,0532	0,0100	0,2000	0,2532	0,0241	0,2241
3	0,1036	0,2532	0,6490	0,0188	0,2720	0,1496	0,1684
4	0,1848	0,2720	0,4225	0,0374	0,3094	0,0872	0,1246
5	0,2494	0,3094	0,1020	0,0991	0,4085	0,0600	0,1591

Table 5: Ministry Table in Units of Time

Customer	Arrival Time (mm: dd)	Start Time (mm:dd)	Random	Service Time (mm:dd)	Finished Service (mm:dd)	Waiting time (dd:mm)	TimeStandby System
1	00:00	00:00	0,2938	03:12	03:12	00:00	03:12
2	01:45	03:12	0,0100	12:00	15:12	01:27	13:27
3	06:13	15:12	0,6490	01:08	16:19	08:58	10:06
4	11:15	16:19	0,4225	02:15	18:14	05:14	07:29
5	14:58	18:44	0,1020	05:57	24:31	03:36	09:33

Table 6: Table of Simulation Results

Simulation Results	Wq ($\sum \text{TimeWait} / 5$)	Ws ($\sum \text{TimeWait Sys} / 5$)	Lq ($\sum \text{WaTimeWait} / 60$)	Ls ($\sum \text{TimeWaitSys} / 60$)	P
	0,0642	0,1464	0,0263	0,0122	0,0146

From the conclusion using $\lambda = 5$ and $\mu = 10$, the simulation results in table 3.7 are obtained with the conclusion

• $P = 0.0148 \times 100\% = 1.48\%$
 $Wq = 0.0642$
 $X = Wq * 3600 = 231.12$
 Minutes = $x / 60 = 3.852 = 3$ Minutes
 Seconds = $x \text{ Mod } 60 = 51.12 = 51$ Seconds
 • $Ws = 0.1464$
 $X = Wq * 3600 = 527.04$
 Minutes = $x / 60 = 8.784 = 8$ Minutes
 Seconds = $x \text{ Mod } 60 = 47.04 = 47$ Seconds

It can be seen that the probability of a busy server is 1.48% with an average wait time in a queue of 0.0642 or 3 minutes 51 seconds and an average wait time in the system of 0.1464 or 8 minutes 47 seconds.

The conclusion is that one server is still biased to serve all customers well, because the probability of the server is not too busy because the probability value has not passed the value of 1 and the average waiting time is not too long and is still biased to be overcome by one server.

5. Conclusion

From the results of research conducted at the Kesrem Hospital in the Binjai area, it greatly increases knowledge and insight, by collecting data related to optimizing customer registration queues, the following conclusions can be drawn:

1. Simulation of the Customer Registration Queue at the Public Health Hospital in the Binjai area can be built using the Visual Basic 2010 and SQL Server 2008 programming languages.
2. The service system built will be effective if the number of servers is 2, then the average busy server is 0.00523, the average waiting time (wq) is 0.05 minutes, the average waiting time in the system (ws) is 0.136 minutes, (Lq) = 0.0037, (Ls) = 0.5460.

6. Suggestion

Based on the conclusions above, several suggestions can be put forward which are expected to be input for the progress of the next queue simulation. Some suggestions from the author are as follows:

1. Research needs to be carried out using methods other than Exponential with different algorithms or by combining them with other methods so that a better comparison of methods can be used.
2. Further research is expected to be able to apply different methods and produce better queue simulations as a basis for comparing accurate results and using different applications other than using Visual Basic 2010 and SQL Server 2008 programming.

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