Application of queuing theory to a financial institution in the public service sector in the city of Manaus

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Abstract

This paper aims to apply queuing theory to a banking service system. Financial institutions are known to attract large audiences on a daily basis, generating long and lengthy queues. Based on empirical knowledge, it is common to use seasonality to explain the increase and decrease in the flow of people in the agencies, either because it is the payment week of a wallet, the workers' lunchtime. This paper aims to apply the theory in a system, with the objective of increasing the company's competitiveness, so that it is remembered as the customer's first choice.

Keywords: Service; Queue Theory; Decision Making; Banking.

1. Introduction

Queue theory is a well-known subject, but this study aims to broaden knowledge by explaining how and why queues are created. In addition to applying such knowledge in a banking sector in order to reduce the formation of large queues.

Much of a bank's ways of making money depend on the client who goes to the agency, whether it's loans, checking, financing, and so on. That is, customer dissatisfaction may lead them to seek out the competitor directly affecting profit. Therefore, good queue management is required in order to build customer loyalty. According to [1], the idleness of the attendants or the very large number of customers always waiting for attendance can mean the inadequate system sizing.

Every year there is a significant increase in the opening of current accounts, according to [2], in 2017 there was a 171% increase in the opening of digital accounts compared to 2016, large parts of transactions can be executed by Internet banking, but there are still situations where the customer needs to look for a branch, which means a significant increase in account holders going to banks.

To develop the work, a bank branch of Manaus was chosen to analyze a service sector seeking to identify the main causes of the cluster. Subsequently, propose improvements to meet customer expectations, as well as use efficient service as a competitive factor for the company.

2. THEORETICAL REVIEW

This topic will cover the bibliographic material that underlies the research, its relationship to operational research, and the use of queuing theory. Thus, the theoretical foundation focuses on providing the scientific information necessary for a good understanding of queuing theory and where it fits within the study.

2.1. Queue Theory

According to [3], queue management may be related to manufacturing, however, rather than product inventory, it is a customer inventory that seeks to reduce its total cost by assessing the balance between maintenance and procurement costs. [6], the realization of the balance between costs as expressed in a U curve, relating the increase in operating capacity with the reduction in the number of customers waiting in queues.

For [4] queues are inevitable and often impossible to program. Each company should put queues under control as they follow. The layout may change, the number of attendants may increase or decrease, among other factors contributing to queue management.

According to [13], even with their distinctions, four elements can be considered common during queuing, which are: queued customers, priority rule utilization, customer generating input population in potential, service facilities, which may be the means, structure and persons necessary to perform the service.

The author [5] describes a queue as a state of clients waiting for service. These queues can be defined as finite or infinite:

According to [6] some of the queue structure models are:

• With a single channel and single phase: there is a queue and a server between the arrival and departure period;

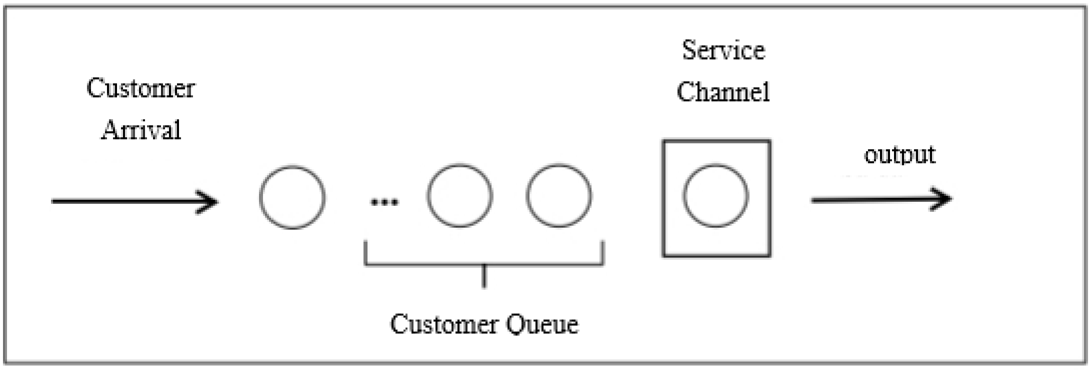

Figure 1: Single Queue and Single Channel System

Source: Adapted from [1]

With single channel and multiple phases: where the individual expects to be served by one server and later served by another;

Multiple Channels and Single Phase: A queue that provides access to different servers;

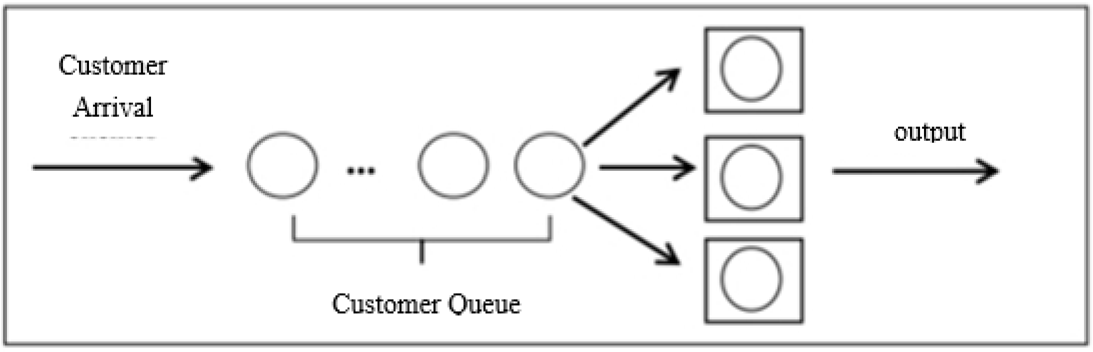

Figure 2: Model with one row and multiple channels.

Source: Adapted from [1]

• Multiple channels and multiple phases: a single queue and more than one answering channel, later passed to other channels;

• Mixed: Multiple queues for single channels and alternate path structure.

The queue model with infinite population and multiple service channel is one with more than one attendant and with discipline of PEPS service, where the values of λ and μ will not always be constant. According to [5], the M / M / k model is based on the hypothesis that all times between calls are distributed identically following an exponential distribution according to another exponential distribution and that the number of attendants is k (any integer). positive). Thus, using the nomenclature of [12], we have the following equations:

Table 1: List of Equations

Indicators	Equations
Sector occupancy rate Eq. 1	**$\rho=\lambda / c * \mu \rightarrow \rho= 0,257$**
Fraction of time a server is empty Eq. 2 and 3	$P_o=\frac{1}{\sum_{i=0}^{S-1}\frac{(s\rho)^i}{i!}+\frac{(s\rho)^s}{s!(1-\rho)}}=$ $Pj=\frac{(s\rho)^j P_o}{j!}=$
Expected number of customers at the bank and likelihood that attendants or one of the service channels will be busy Eq. 4	$P(j\geq S)=\frac{(s\rho)^s P_o}{s!(1-\rho)}=$
The average number of clients in the queue and system Eq. 5 and 6	$Lq=\frac{P(j\geq s)\ \rho}{(1-\rho)}=$ $L=Lq+\frac{\lambda}{\mu}=$
The average wait time of a customer in bank Eq. 7	$W=\frac{L}{\lambda}=$

Source: Author

For the system to be considered stable it is necessary that:

$$\rho = \frac{\lambda}{k\mu} < 1$$

(Eq. 7)

Where λ is the average arrival rate of customers; μ: is the rate of service of a single channel, in this case, it assumes that all μ are equal; ρ: is the system utilization factor; K: is the number of service channels.

2.2. Decision making

The decision-making process is common in every individual's daily life, and this also applies to managers whose goal of their choice is to solve a present problem or situation. According to [8], one way to understand how institutions work is to focus on their hierarchical flow, work materials, information and decision-making processes.

For [9], the process of reaching a decision is affected by elements such as the nature of the problem, its organizational context, the basic characteristics of decision makers, and the cognitive limitations of human beings. In order to make a good decision one must keep in mind all the viable options to the problem in question, using analysis procedures as a decision support system.

According to [10], there are some steps that must be put into practice that configure the role of decision maker, which are:

• Identify the problem: Problems are not always clear and well defined. At this stage it is important to identify which systems interact with the system where the problem in question occurs. It is very important to have a multidisciplinary team so that the problem can be seen from different points to have the best solution.

• Formulate objectives: Here you define the objectives to be achieved by solving the problem. These may be quantitative objectives, which involve profits and costs, as qualitative which in turn may refer to customer satisfaction. In some situations there may be a conflict between them.

• Analyze limitations: after defining the objectives it should be pointed out which limitations will be applied to the proposed solutions. These restrictions may relate to budget, deadlines, demand, technologies, and other points.

• Evaluate alternatives: With the alternatives in hand, the decision maker will choose the best solution to apply, he should use tools and procedures to support his decision. In this process the person responsible may use a quantitative or qualitative approach. The qualitative approach applies to common everyday problems that have little impact on this treatment should take into account the experience of past situations. Since the quantitative approach is more used in less frequent, more complex problems, here it is recommended to use scientific optics and available to obtain the best solution.

3. Methodology

The survey was conducted at a bank branch located in the city of Manaus. The agency sectors can be divided into four groups, management sector, cash sector, miscellaneous service sector, and legal sector. The chosen object of study of this work was the service sector diverse because it is the biggest bottleneck of the company. This sector serves credit, account, and other faster customer support services. The site consists of four terminals, three of them for employees to perform the service and the fourth for an

independent broker. That is, for answering by password, it is considered three terminals.
Data collection was performed in the defined sector, at first the researcher did not intervene in the activities in order to analyze and identify possible problems in the care system. The collection took place through tables where the employee wrote down the customer's password number, the time of entry, the time it was answered and finally the service time.
The article had outlined the results of sizing calculations and service performance measurements.

4. Application of Study

The sector studied has the highest concentration of agency staff, being affected by seasonality in various periods, several factors that contribute to this were observed, namely: trade lunch time, INSS retirees pay week, and pay periods of monthly bills.
Data were collected between April and June 2019, from 9:00 am to 3:00 pm. The data were organized in Excel spreadsheet, for later calculations.
Thus, the time used for answering is 6 hours and the number of 3 answering channels without limit of attendance capacity and PEPS type order.
Bank arrival rate (λ): 13.80 calls / hour
Call rate (μ): 18.23 calls / hour
The data collected can be seen in the table below.

Table 2: Data from consultations collected between April and June 2019

Service Day	Number of calls	Service Time (h)
1	102	5,35
2	90	4,37
3	57	3,4
4	99	5,45
5	72	4,48
Total	420	23,05

Source: Author

5. Results and Discussions

In the city where this study was conducted, there are laws in place [11] that set the time the consumer can spend waiting for care, 15 minutes on normal flow days; 20 minutes on eve or after holidays and 25 minutes on paydays from public servants. According to the calculations and data collected, it is possible to observe how the customer flow happened during the monitored period. Below in table 3 are the results obtained:

Table 3: Results obtained through the calculation of the collected data.

VARIÁVEL	VALUE (APPROXIMATE)
Customer Arrival Rate (λ)	13.80 clients / hour

Service Rate (μ)	18.23 calls / hour
Fraction of time a server is empty (probability) (P_o)	45%
Customer Waiting Probability (Pj)	34%
Queued Customer Probability (P (J≥S))	9%
Average Number of Customers Queued (Lq)	0.03 client / hour
Average number of clients in the system (L)	0.79 customer / hour
Average customer wait time (W)	0.057 hour or 3.42 minutes

Source: Author

From the results obtained it can be observed that the average time that a customer waits in line is 3.189 minutes which is at acceptable levels of the company regarding the waiting time for customer service.

It can also be noted that despite the continuous flow of customer arrivals at the company this does not prevent customer service and waiting times from remaining within acceptable business and customer satisfactory standards.

Looking at the tables, it can be seen that the total number of clients were served before 1/3 of the maximum waiting time, leaving employees with idle time in about 45% of their work routine.

As previously mentioned, the analyzed sector has three attendants to the public. A new analysis was made this time removing one of the attendants, relocating it to another sector. With this we get the results represented in the table below:

Table 4: Results considering the removal of one of the attendants

VARIABLE	VALUE (APPROXIMATE)
Customer Arrival Rate (ʎ)	14 clients / hour
Service Rate (μ)	13.48 calls / hour
Fraction of time a server is empty (probability) ()	32%
Customer Waiting Probability (Pj)	32%
Queued Client Probability ($P(J \geq S)$)	34%
Expected Average Number of Customers Awaiting Service (Lq)	0.35 customer
Average number of clients in the system (L)	1.39 customer
Average customer wait time (W)	0.099 hour or 5.95 minutes

Source: Author

According to the results obtained, reducing the number of attendants, the customer's waiting time was from 0.057 hours or 3.42 minutes to 0.099 hours or 5.95 minutes, which remains slack within the required standard. By reducing to two attendants the system remained stable, which allowed the manager to allocate his employees more efficiently, allowing him to solve pending activities due to lack of manpower. In addition to reducing the cost with staff, because previously there was the idea of hiring another professional to support the activities as mentioned above. That is, the changes meet the needs of clients and the institution.

6. Final Considerations

Queue theory allows you to analyze the efficiency of a system. Through it one can analyze the management of the customer and the service. By gathering information, it is possible to improve the functioning of the process. This is why it is very useful to apply it to a bank service system.

With the results obtained, it was found that there is the possibility of optimizing the analyzed care process. To study the system, a sample of attendances was collected using as one of the methods the timing of the time that the customer spent in the system. Aiming to collect data to optimize the provision of services to customers, as well as assist in the decision making of managers.

In the first data collection it was found that the customer's waiting time was within the standard required by municipal laws. As it was identified that employees were about 45% of their work routine idle. For this reason, to reduce this time it is indicated to change the system from three channels to two channels. Such modification obeys the client's needs, as the waiting time remains below the limit, besides offering the manager options to optimize processes in other sectors of the institution.

If they chose to remove two of the three employees, the waiting time would remain within the limit, but it is not advisable due to unforeseen issues that could lead to industry congestion and customer overload, which would have consequences for the institution and would cause dissatisfaction. of the customer.

Service is an important factor for the customer when deciding which banking institution to choose. Which makes it a competitive factor to provide fast and efficient service. These improvement actions combined with entrepreneurial skills are important steps to ensure the success of the venture.

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