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A STUDY ON STOCHASTIC PROCESSES IN QUEUING SYSTEMS

* Anjali

**Dr. Rishikant Agnihotri

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Corresponding Author: Anjali; doi:10.46360/cosmos.et.620212017

Abstract

In modelling and analysing queuing systems, stochastic processes are crucial. Queuing systems examine how individuals (commonly referred to as "customers") come at a location where services are provided, wait in a line if necessary, and then receive assistance from one or more servers. These systems have a wide range of applications in many industries, including manufacturing, transportation, computer networks, and telecommunications. The unpredictable demand for a finite supply of resources is always the cause of lines and wait times. It is common practise to refer to "customers" as being "served" by an abstraction. The average number of clients waiting in queue and the amount of time that should be expected to pass before being allowed entry to the service facility are two examples of typical performance metrics.

Keywords: Queuing, Stochastic, Service.

Introduction

Unpredictability can be most accurately articulated through statistical language, and stochastic modelling will play a pivotal role in this conversation. The level of sophistication of the model determines whether qualitative or quantitative findings may be obtained through mathematical analysis. Simulation is unavoidable if analytical methods are unable to provide the desired insight into the relevant performance numbers. This document delves into both analytical methods and simulation methodologies, providing an in-depth look at each. Only single-queue systems are being considered here for the sake of simplicity. For purposes of exemplification and illustration in analytical work, the M/M/1 model is utilised. As a result of the manageability of mathematics, essential concepts and ideas can be presented in a manner that is unambiguous. These ideas can be applied to a wider variety of contexts, including those in which the outcomes are frequently obscured by the complexity of the relevant mathematics. In this study, simulation is explored within the context of a G/G/1 queuing model, which is more broad. It is essential to be conscious of the fact that the tractability of the M/M/1 system is a result of simplifying assumptions. We point out the aspects of the model that make it tractable, as well as the aspects of the model that, in more complicated models, will often destroy the tractability. In addition, utilising the findings from the study of the M/M/1 queue, we describe some key expansions that can be applied to more complicated systems. It is important to keep in mind that concerns with simulation are limited to the experimental design, sampling strategies, and output analysis.

Literature Review

(2017); Ghimire [2]; consumers in line are served by one or more servers that are part of the queuing system. These servers offer a variety of services to the consumers as they wait in line. The majority of people have, at some point in their lives, endured the aggravating sensation of waiting in line for one of the many activities that make up daily life. It is logical to believe that the person who enters first in the line should be given the opportunity to get the service first. On the other hand, this rule might not always be applicable. Sometimes the person who comes in at the very end of the line or the client with the highest priority gets service before the person who has been waiting in line for a very long period. In the theory of queueing, each of these qualities represents an attractive subject for further investigation. In this paper, we describe some of the earlier works that have been done by a variety of researchers along with brief explanations of their findings. After that, we put into action a few of the mathematical equations that, collectively, reflect the various queuing behaviors. These kinds of queuing behaviors are investigated using mathematical simulations in practically every piece of published research on the subject. In light of the work done by other researchers in the past, our particular area of interest is to investigate the finite capacity queueing frameworks along with the batch queueing models. The finite capacity queueing frameworks involve a limited number of customers getting served through a single as well as multiple number of servers, while the batch queueing models involve arrival or service as well as both occurring in bulk. In addition, we offer several performance measure equations of various queuing type models along with essential

*Research Scholar, Kalinga University, Naya Raipur, Chhattisgarh, India.
** Supervisor, Kalinga University, Naya Raipur, Chhattisgarh, India.

components that are utilized in queueing theory. In conclusion, we discuss several applications of queuing mechanisms for supply chain management and bring out certain fields of research that need to be further developed.

2014, published by Vasiliadis [3]; the M/M/k/N/N queue is represented via a continuous-time homogeneous Markov system having finite state size capacity (HMS/cs) in this article. The capacity of each state is finite. A continuous-time homogeneous Markov system (HMS) with two states is utilized in this study so that the behavior of the queue may be analyzed. The state that matches the source in this HMS is the first one, and the state that corresponds to the servers in this HMS is the second one. The capacity of the second state is limited, and it is directly proportional to the total number of servers. The members on the system that are unable to progress to the second stage because of the latter's limited capacity progress to the buffer state, which is the queue for the system. Formulas for the factorial & mixed factorial moments of the state sizes are generated in matrix form in order to facilitate the investigation into the variable nature of the state sizes. As a direct result of this, the pmf of every state size may be calculated for any value of t within the range R+. An example with numbers is used to explain the outcomes of the theoretical analysis.

Study on Queuing Systems

An analysis of customer desertion behaviour in multi-queue systems can benefit from the application of probability theory. Customers have the option to exit the system if the wait time exceeds their threshold for acceptable wait times. It is essential to have a solid understanding of the probability of client abandonment in order to effectively manage customer happiness and system performance.

Customer desertion, also known as customer abandonment or reneging, is a phenomena that takes place in multiple queuing systems when customers leave the wait before being serviced. Other names for this phenomenon include customer desertion, customer abandonment, and customer reneging. It arises when customers get unsatisfied with the waiting time or perceive the service as being overly slow, forcing them to depart the queue and maybe seek treatment elsewhere. This can happen for a variety of reasons. Aspects Crucial to the Loss of Customers in Queuing Systems with Multiple Lines

1. Patience Threshold: The maximum amount of waiting time or level of service delay that a customer is willing to take is referred to as a customer's patience threshold. A customer's patience threshold typically plays a role in whether or not a customer would abandon a service. If the consumer has been waiting for longer than this allotted amount of time, they are more likely to leave the queue.

2. The length of the queue that customers have to wait in and the amount of time it takes for them to be served both have an impact on the possibility that customers would abandon their place in queue. The likelihood of people leaving a queue or waiting area increases when the wait time is longer and the pace of service is slower.

3. Real-Time Dynamics: The abandonment of an order by a customer can take place at any stage of the waiting process. It is a dynamic and unpredictable behaviour that is impacted by the fluctuating lengths of the lines and the wait times.

4. Impact on the Performance of the Service: The abandonment of a queue by a customer can have an adverse effect on the performance of the service by lowering its efficiency. This is because consumers who leave the wait before being served are not served, which can result in the underutilization of resources.

5. Load balancing, service differentiation, and managing client expectations are some of the tactics that can be used to cut down on the amount of customers who abandon a company. Reducing the length of time that people have to wait and giving clear and accurate information are both things that can assist reduce dropout rates.

The implications of customers abandoning their queues in multiple queue systems are as follows:

- Satisfaction of Customers: The loss of a customer can have a detrimental effect on customer satisfaction. Dissatisfaction and a decrease in client loyalty can be the result of prolonged wait times and high rates of customer abandonment.

- Utilisation of Resources: Deserted customers are a representation of underused resources. Strategies for load balancing and service management strive to maximise resource utilisation while simultaneously lowering the number of unused resources.

- Performance of the System: High rates of customer abandonment might have a negative impact on the overall performance of the multiple queue system. It is possible for this to result in inefficiencies as well as potential imbalances in the distribution of resources.

- Service Level Agreements (SLAs): Understanding the behaviour of customers who abandon their subscriptions can help in the process of defining appropriate SLAs that line with customer expectations and lower the risk of customers abandoning their subscriptions.

- Design of the Line and Layout: The design of the line and the physical layout can both have an impact on how quickly customers leave. It is possible to cut down on the amount of time that customers think they have been waiting by having effective queue management, signage, and customer flow.

The abandonment of customers is an important factor to take into account in multiple queuing systems. Organisations are able to execute strategies to reduce rates of customer defection, raise levels of customer satisfaction, and maximise the use of available resources if they have an understanding of the elements that drive consumer behaviour. Multi-queue systems have the potential to improve overall system performance as well as the quality of the customer experience they provide by effectively managing waiting times and ensuring that service levels are in line with the expectations of the customer.

Conclusion

A multi-queue system's queues and servers can be organised in a number of different ways, which can lead to a variety of network topologies. Tandem queues, also known as series queues, and parallel queues, sometimes known as parallel lines, are both examples of common topologies. When referring to a multiple queue system, the term "network topology" describes the configuration of the system's queues and servers as well as their connections to one another. It outlines the structure as well as the flow of entities (such as customers and tasks) as they make their way through the interconnected queues in order to get service. The multiple queue system's effectiveness, performance, and general behaviour are largely dependent on the network architecture, which plays an essential part in the decision-making process. The following are some of the most important aspects of network topology in multiple queue systems:

1. Tandem Queues: Tandem queues are a straightforward network structure in which individual queues are connected to one another in a sequential fashion. The entities go in a linear fashion from one queue to the next until they have finished their respective service processes in their entirety. When entities require many phases of service, a tandem queue is typically the most effective solution.

2. Queues can be said to be parallel if they function independently of one another while at the same time interacting with one another. Entities have the option of selecting one of several parallel queues to participate in depending on various criteria or personal preferences. When there are different service alternatives available or when entities have distinct requirements, it is helpful to segregate them using parallel queues.

3. Fork-Join Networks: Fork-Join networks combine characteristics of tandem queues with those of parallel queues. After beginning at a single queue (fork), entities branch off into a number of parallel queues in order to receive service. The entities, having received service from the parallel queues, then converge back into a single queue in order to finish their service process. This action is denoted by the verb "join."

4. Closed Networks and Open Networks: In closed networks, entities remain within the system and do not exit after getting service. Open networks, on the other hand, allow users to come and go as they want. On the other hand, open networks are characterised by the fact that entities join them from outside sources and then leave the system after their services are finished. Open networks frequently model situations that involve the ongoing entrance of new entities.

5. Feedback Loops: Certain multiple queue systems have feedback loops, in which entities may return to a previous queue based on certain conditions. This allows for greater flexibility in the system's operation. The analysis of the system is made more difficult by the presence of feedback loops, which introduce dynamic behaviour.

The underneath is some of the implications of network topology in multiple queue systems:

- Performance of the System: The selection of network topology has a considerable impact on the overall performance and effectiveness of the multiple queue system. A well-designed network can improve resource utilisation, lower congestion levels, and increase overall throughput if it is designed correctly.

- Allocation of Resources Resource allocation is impacted by the network topology since the queue configuration and flow of entities determines the number of servers and how they are distributed across the network.

- Management of Queues: Managing the interactions and dependencies between queues is vital for increasing the efficiency with which entities move across a network. Strategies for load balancing and queue management ought to take the topology of the network into consideration.

- Analysis of Performance The difficulty of the network topology has an effect on the analytical models that are used to investigate the operation of the system and its performance. Analysis of some types of network topologies, such as those with feedback loops or complex queue interactions, may call for more advanced mathematical methods.

Topology of the network is an essential component in the process of building and analysing multiple queue systems. It is crucial to select the suitable network topology in order to achieve optimal utilisation of resources, manage interactions with queues, and provide a seamless and customer-centric experience. Stakeholders may optimise the performance and overall efficiency of the multiple queue system by first gaining a grasp of the implications of network topology. This will allow them to achieve both the service objectives and the expectations of customers.

Conflict of Interest

There is no conflict of interest by the authors in this manuscript.

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