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QUEUING THEORY IN FAST FOOD RESTAURANTS

Purvi Todi[1], Rahil Khunt[2] , Rashi Pareek[3] , Ria Gogri[4] , Rishab Kuckian[5]

[1]Purvi Todi (SYB.B.A Student, ASMSOC NMIMS University, Mumbai)
[2]Rahil Kunt (SYB.B.A Student, ASMSOC NMIMS University, Mumbai)
[3]Rashi Pareek (SYB.B.A Student, ASMSOC NMIMS University, Mumbai)
[4]Ria Gogri (SYB.B.A Student, ASMSOC NMIMS University, Mumbai)
[5]Rishab Kuckian (SYB.B.A Student, ASMSOC NMIMS University, Mumbai)

Abstract

Queuing at the cashier counter at any restaurant is a very common sight. This mainly occurs due to the difference in the time of the order placed and when the order is received. Longer queues could signify a number of things, but the main factors affecting the queues are the space of the place and the efficiency in management. Usually if a consumer were to see huge queues at the restaurant they would prefer going to other places rather than waiting in the queue, leading to a major loss for the management. This is where queuing theory comes into picture. Queuing theory helps to tackle the obstacles that the management faces, in terms of number of servers required, appropriate size of the restaurant, number of cooks required at the back end etc, which ultimately makes the queues move faster. This paper aims at analysing the queuing models like the Simulation model, Poisson distribution, Little's theorem etc., used in restaurants over the years to make the queues less monotonous and less time consuming for the customers. Hence, leading to attracting more customers thereby increasing profits. Management over the years have come up with innovative ways to decrease the wait time or make waiting more interesting for the customers for examples kiosks help in fast ordering, installing televisions at restaurants to pass time, and many more discussed in the paper ahead.

Keywords*: queuing theory, service, queuing models, customers, fast food, time.*

Introduction

Waiting in lines is something that can ruin anyone's day. Whenever the demand is greater than the serving capacity of the service provider, a queue becomes inevitable. Fast food chains advertise their sales during lunch hours by providing cheap package meals. Due to the popularity of these lunch specials, there are occasionally long lines and uncomfortable wait times. (Koh et al., 2014a)

The first Automat Restaurant opened in New York in 1912 and since then the history of fast-food restaurants started. A&W Root Beer, the second fast food establishment, launched in 1919, and White Castle followed in 1921. McDonald's got into QSR in 1948. These joints used to heavy congestion due to poor queuing models. (Koh et al., 2014b)

Fast food restaurants have the USP of quick service, if this is not fulfilled, there arises a problem. Copper (1981), Davis & Vollman (1990) and Molla (2017) proposed the use of queuing theory, a mathematical based technique for analyzing waiting line for service industry. Using conventional, manual methods, such a study is typically time- and resource-intensive, but modern computer simulation (or modelling) software solves both of these issues.(Church & Newman, 2000a)

The concept of queuing theory has been around for more than a century, but it only gained prominence after a Danish engineer introduced it to the telecom industry, where he primarily used the theory to deal with tele-traffic. The work on waiting line models was only expanded to other types of issues after World War II. The basic waiting line model is now accepted as accurately describing a wide range of seemingly disparate problem scenarios. Blue Meadow's Queuing Model, backed by tests for Poisson distribution and Chi-Square Goodness of Fit for the peak period, off period, decision rule, and exponential distribution, as well as FIFO, Single Channel, Multiple Channels, are some of the well-known models used over the years in the fast-food industries. (Gumus et al., 2017a)

Queuing theory is a subfield of mathematics that investigates the formation, operation, and causes of queues.(Basir & Chandrashekar, 2020a). Some of the analysis that can be derived using queuing theory include the expected waiting time in the queue, the average time in the system, the expected queue length, the expected number of customers served at one time, the probability of balking customers, as well as the probability of the system to be in certain states, such as empty or full. (Dharmawirya & Adi, n.d.) The findings are frequently used to make critical business decisions regarding the resources required to deliver quality service. For fast food businesses, this means increasing the number of serving counters and accelerating food preparation during busy times. In order to best match supply and demand, queuing systems are widely used in a variety of disciplines, including restaurants, computer architecture, transportation, and numerous industries. (Koh et al., 2014a)

When there are sudden requests the time in waiting is unavoidable. Hence more efficient staff is required which might result in higher costs. This is the premise from which the queuing theory starts in designing service systems. (Cernea et al., n.d.)

The issues mentioned above indicates a need for a research model that makes it easier for the fast-food restaurants to achieve its objective and keep its customers happy. For fast food restaurants, fast queuing time and short queuing line is important in attracting customers, besides inexpensive price, good worker attitude and superb food quality. (Koh et al., 2014)

Literature review

The study of queuing theory has been covered by an extensive body of literature. (Tamber et al., 2015) Queuing theory is the study of queues or waiting lines. Queueing systems are simplified mathematical models to explain congestion. (J, 2003). A good model of queuing should be easy to analyze and accurately depict a real-life system. These two requirements are frequently satisfied by a queuing model based on the Poisson process and its companion exponential probability distribution. (Koh et al., 2014b) A queuing system consists of three basic elements: customers, servers, and randomness. (Tamber et al., 2015)

Fast food is in higher demand than ever, particularly in societies where people are constantly working. The majority of the population that works spends far too little time at home, according to previous studies. Therefore, they are demanding a suitable product such as fast food that suits to their lifestyle. (Basir & Chandrashekar, 2020b)

Fast food chains essentially depend on Food preparation time, length of ques, and wait time. In this study, we want to examine the queueing system. During peak hours of lunch or dinner or any promotional events, these chains face long ques and wait times. Customers who cannot be treated right away must wait in line, frequently impatiently. Those who are unwilling to wait for long time may opt to leave. (Koh et al., 2014b)

Queueing management has been used quite successfully in a number of service-oriented businesses to reduce cycle time in a busy system, such as hospitals and restaurants, as well as to boost throughput and efficiency, many academics have previously used queuing theory to simulate the fast food operation and numerous service industries. (Gumus et al., 2017b)

There are a lot of different reasons as to why there are queues in fast food restaurants. One of them is very common but important reason being a significant chunk of customers (i.e., about 65% of family groupings) will first reserve a table by leaving one of the members of the party there or (less frequently) by putting their stuff there to avoid losing out on a place to sit after waiting in long queues. This behaviour is crucial because it reduces the number of tables available to customers who are leaving the counter with food, which adds to the wait time and crowding.(Church & Newman, 2000b)

Customers are always trying to get in shorter queues which is why many times multiple customers belonging to same party stand in multiple queues in order give the order faster, this is a drawback of multi waiting channel line. (Church & Newman, 2000b). To solve this problem most of wait time the management form one line of customers and send them one by one to the counters that free up, this is known as single waiting channel line.(Sherman, 2014)

The expected waiting time in the line, the average time spent in the system, the anticipated length of the line, the anticipated number of customers served at once, the likelihood that customers will baulk, and the likelihood that the system will be empty or full are some of the analyses that can be derived using the queuing theory.(Bhavani & Jayalalitha, 2021) .Hence, the main advantage of queuing theory is to identify these common issues in any type of queues and then find solutions for the same. (Cernea et al., n.d.)

By better understanding queuing theory, service managers can make decisions that increase the satisfaction of all relevant groups – customers, employees, and management. (Nosek & Wilson, n.d.)

Model creation and the direct application of these techniques in management decision-making are now taking precedence over the emphasis in the literature on the precise solution of queueing problems with sophisticated mathematical techniques. Since most real-world issues do not exactly match mathematical models, complicated computational analysis, imprecise solutions, sensitivity assessments, etc., are receiving more attention. The development of the practice of queueing theory must not be restricted by a lack of closed-form solutions. (Ismail & Shokor, 2016)

An essential theorem behind queueing theory, known as Little's Law, which is the fundamental principle of queuing theory describes the relationship between three critical limitations in a queuing system. (Eilon, 1969)The limitations are:- (i) the average waiting time W for a customer in the queue (ii) the average arrival rate λ of customers into the queue system and (iii) the average number of customers in a queue L (Little, 2011). Because of its straightforward theoretical foundation and vast range of practical applications, The Little's Theorem has gained widespread acceptance. (Bertisimas & Nakazato, 1992)The Little's Law has been utilized in a wide range of sectors like operation management and computer architecture. It is also used in the manufacturing and service sectors, and Whitt (Herbon & Khmelnitsky, 2010)and Wolff (Wolff, 2011) have written in-depth reviews on it. The quintessential Little's Law has been expanded to cover some new and additional applications. (Author et al., 2010). The expected number of cutomers in a line is equal to the product of the mean arrival rate and the average amount of time a customer waits in line under steady state conditions. The Little's Law theorem indicates that $L = \lambda W$, when L = expected number of customers in the line, = mean customer arrival rate, and W = average waiting time for a customer. (Koh et al., 2014c)

The findings are frequently used to make critical business decisions regarding the resources required to deliver quality service. For fast food businesses, this means increasing the number of serving counters and accelerating food preparation during busy times. In order to best match supply and demand, queuing systems are widely used in a variety of disciplines, including restaurants, computer architecture, transportation, and numerous industries. (Koh et al., 2014b)

When competing, small food joints face long lines during peak hours, they lack coping skills. However, few studies have looked at the revenue management techniques of small restaurants during peak hours. This study looks at how small restaurants in may enhance their profitability by adjusting their pricing hikes, table mix, and utilization rate equilibrium points. The rate of utilization and average time spent in waiting are also considered as having a trade-off connection in a queuing system. (Green, 2007) The findings provide light on how managers of small restaurants with long lines might devise effective revenue management techniques to handle peak hours. (Kim et al., 2020)

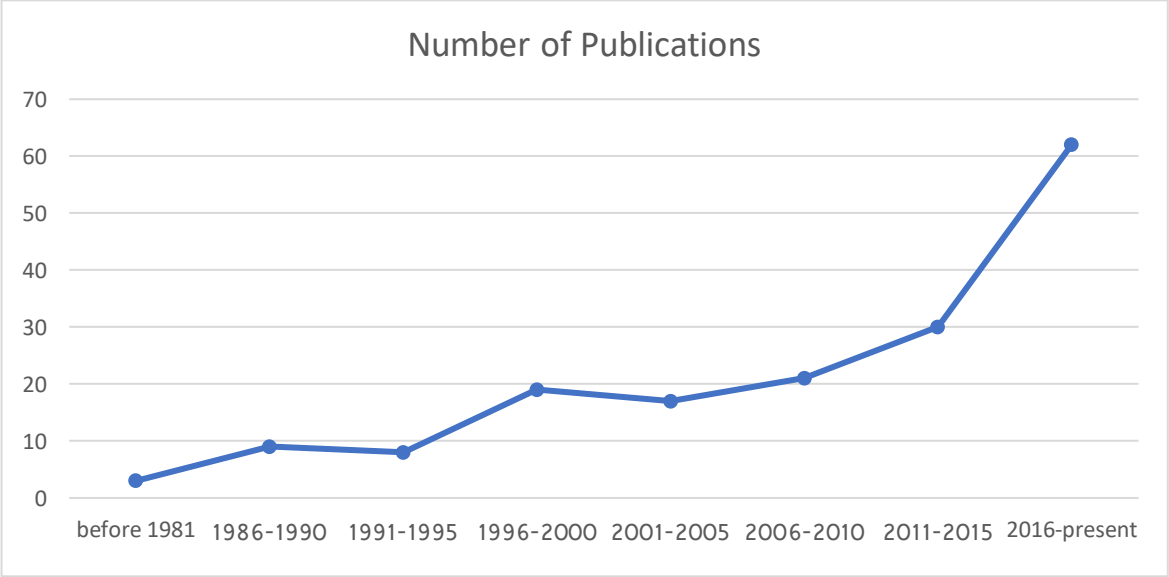
In food chains such as cafeterias, when the capacity of the servers is less than the demand of the clients, long lines are formed with long waiting periods. This predicament is exacerbated when demand varies, resulting in issues such as client loss, income decline, and poor service quality. As a result, it is critical to seek solutions to such

issues. Lean concepts combined with queuing theory may be an effective way to handle these issues. The approach is divided into three stages: current process analysis, arrival analysis, and improvement analysis. The development of activities in the cafeteria is improved by employing different tools and simulation scenarios in each stage and numerous tactics are devised to improve the system's behaviour. (“Techniques, Tools and Methodologies Applied to Quality Assurance in Manufacturing,” 2021)

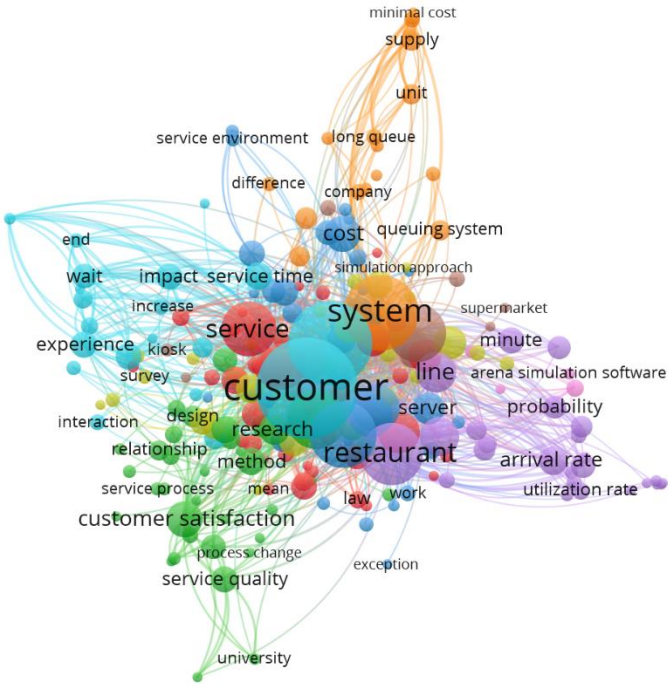
After reviewing different papers, we have analyzed that one thing is certain, queuing theory is being applied by all fast-food chains knowingly or unknowingly. There are many chains who are facing queuing issues, and using operations research queuing models to solve them, while others are unknowingly using methods and applications of queuing theory to help their day-to-day operations. Queuing theory is such a useful aspect that if it is applied and analyzed well it can be very fruitful for the restaurants.

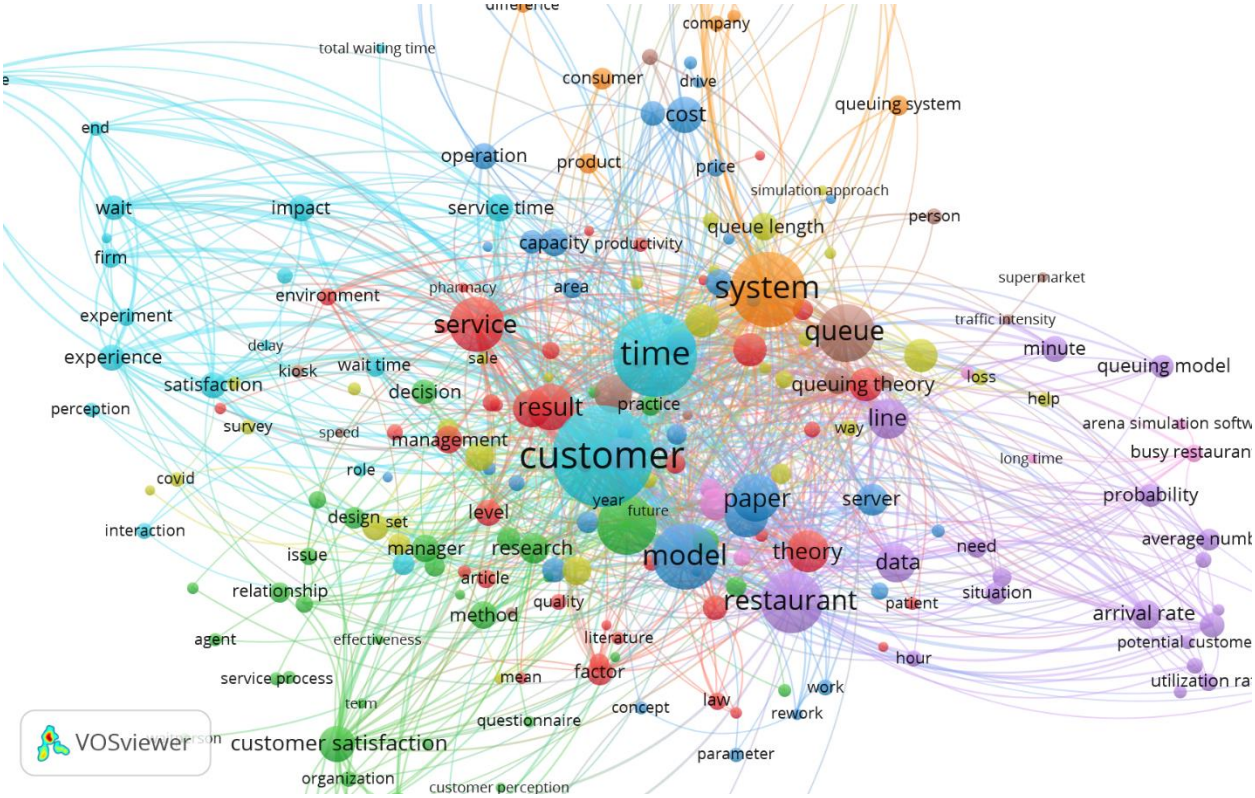
Research Methodology and Analysis

To conduct this research paper we have gathered data, material, methodologies, and solutions from the databases of ScienceDirect, Google Scholar, EBSCOHOST and SciHub.se which align our objective of the simple literature review. In order to extract relevant papers we made use of the following keywords; “Queueing theory” AND “Queuing Models” AND “Queuing Simulation” AND “Fast Food Restaurants” AND “Operations Research” AND “Wait time” AND “Efficiency”, and so on. Our main focus was directed towards reading more and more research papers, to have good citations in our research paper, but we have also gone through a few articles, books, chapter or conferences, etc. All of the papers were carefully screened to avoid bogus and unverified material. Abstract, introduction, databases, implications and conclusions were read thoroughly to make sure the same. We used a desktop application named “Mendeley” to upload all of the papers which helped us to formulate the RIS file. Thereafter, we uploaded the file on VosViewer to carry out further analysis of the studied papers. Further analysis comprised number of citations, year wise filtration, no. of authors, countries that have participated in similar studies and/or collaborated on such papers.

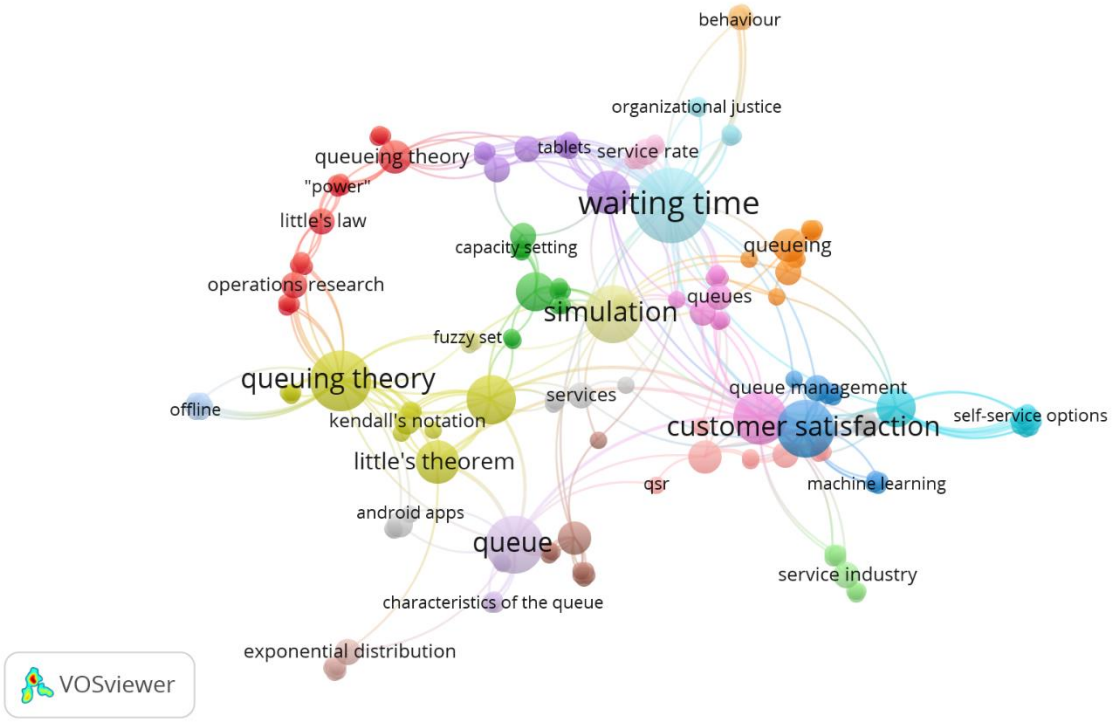


From a sample size of 172 papers, the bar graph represents a half-yearly distribution of research paper publications ranging from 1985- the present. It tracks the trajectory of involvement and interest shown in the area of "Queuing Theory". Fast food restaurants have started to gain popularity and momentum, as a result, we can see a sharp rise in the number of papers published in the past decade owing to the active interest people have been taking to study and solve the challenges that QSRs face in their queuing models. These papers guide them to enhance service efficiency and resolve long waiting lines for maximum customer satisfaction and higher revenue with quick inflow and outflow of traffic by using relevant Queuing Models.



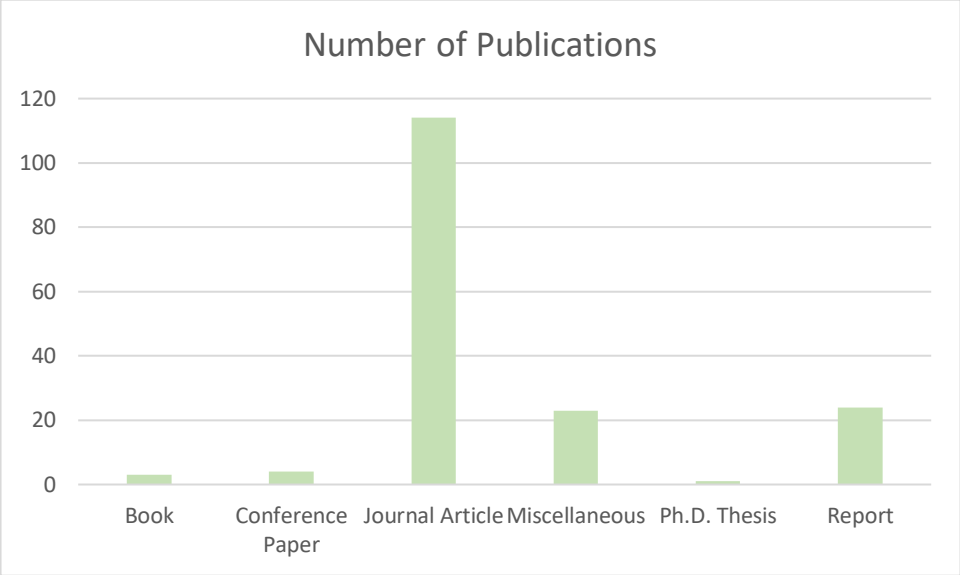


The map of clusters encapsulates a distribution of the words reiterated most number of times across the 200 papers that were reviewed. “Customer”, “Restaurant”, “Time” and “Queue” are one of the most extensively used words throughout the years. The crux of majority papers revolves around these keywords.

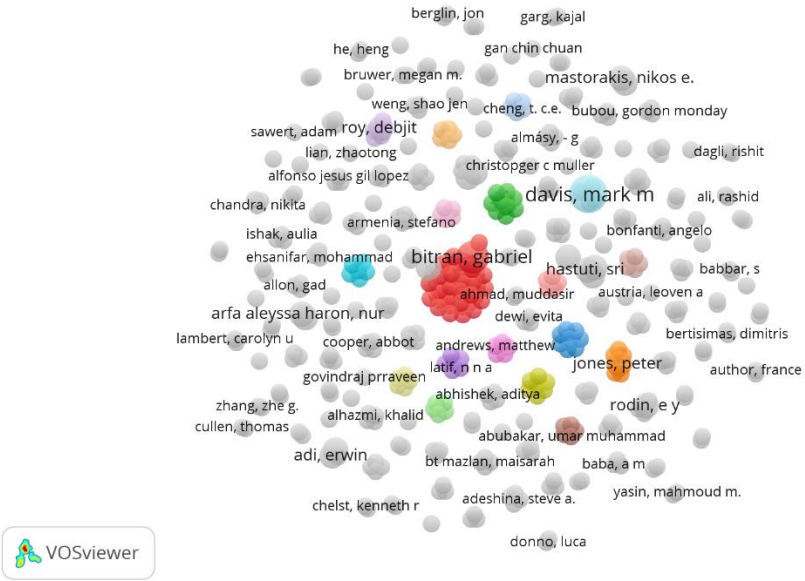


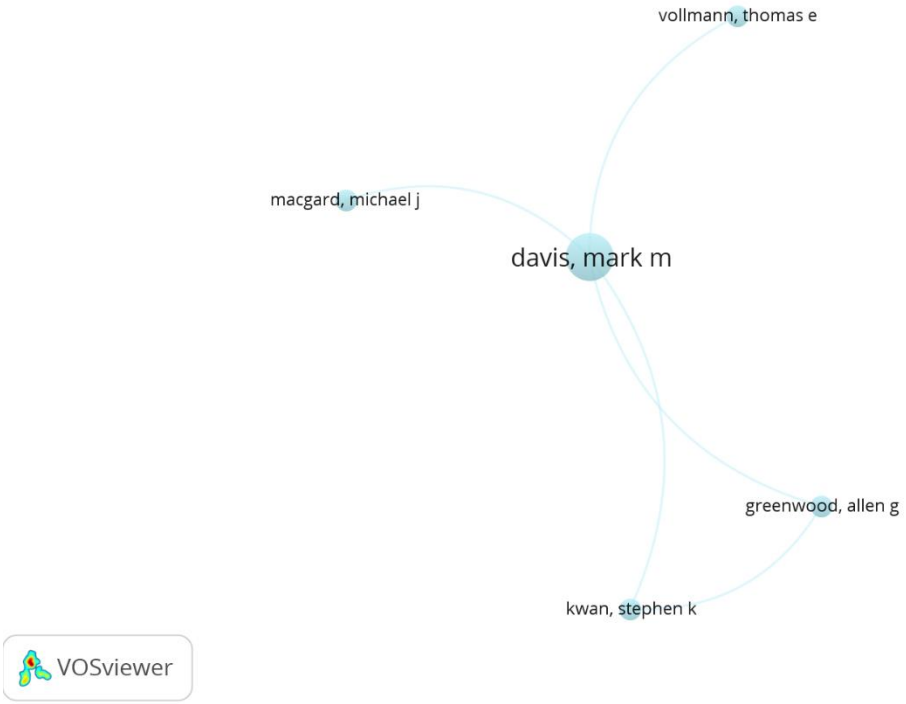
The majority of papers emphasize both client satisfaction and waiting times. Along with “Queuing Theory”, “Little’s theorem”, “Fishbein’s Model”, “Poisson distribution”, they also demonstrate extensive use of the “Simulation Model” with the help of computer software.

The simulation framework may be used to specify and parameterize the flexible queueing system. We use a simulation framework to analyse the data obtained from the real-world system. We examine measures like waiting time and server consumption in both single-server and multi-server queueing systems. Both customer satisfaction and wait times are heavily emphasized in the majority of publications. They use computer software to demonstrate how the "Simulation Model," together with the "Queuing Theory," the "Little Theorem," the "Fishbein's Model," and the "Poisson distribution," are extensively used. We pay close attention to how the quantity of servers influences wait times and server utilization. The studies show that flexible designs can lead to significant gains and that it is possible to increase server utilization while decreasing the number of servers without appreciably increasing wait times.



Our major focus was directed towards reviewing a lot of research papers as seen above. We also referred to a few books, conference papers, reports, PhD Thesis, etc. to delvc deeper into the topic to extract meaningful insights.





The publication of research articles on the queuing theory in fast food restaurants had a total of 314 writers. Four of them, written by Mark M. Davis of the Operations Management Department at Bentley College in Waltham, are primarily concerned with the queuing theory used in fast food outlets and restaurants. Michael J. Macgard, Vollmann, and Thomas E. from the University of Washington are his principal colleagues. There are 28 links in all.

Conclusion

There exists a wide range of literature on the subject of wait times and queuing in the food industry. Different models of queuing theory, like a combination of multi/single channel and multi/single phase, need to be applied to optimize wait time and result in higher efficiency in the food service industry. This paper discusses the need and applications of queuing theory in terms of simulations, mobile applications like "Que" and other such models to reduce queuing time, service time and waiting time of each customer. (Koh et al., 2014a). Other initiatives include the access of free Wi-fi and a television set is functional in strategic location to keep the customers' occupied while in queue. (Latif et al., 2019) However, issues with crowding and queuing at popular times continue to exist. By using simulation software, it is possible to take into account the majority, if not all, of the important variables, which may make it possible to carry out more optimization. (Church & Newman, 2000a)

The likelihood that the waiting area may in fact be constrained is an evident constraint. Another possibility is that the rate of arrival differs by state. When potential customers arrive, they can be discouraged from joining the queue

if it is long. Another practical restriction of this concept is that the arrival process is not stationary. The possibility exists that the gas station will encounter busy and slow times when the arrival rate is higher. (Spencer et al., 2014)

As our future works, we will do deep research on queuing theory at street food stalls by conducting a survey of 200-300 street food counters in Mumbai, India. Followed by a detailed analysis about how queuing theory and its various models are applicable in that sector, along with how it can help the street food vendors to improve efficiency and optimize their time. This paper helped us understand the various models and methodologies of queuing used over the past years, and developed a base for us to conduct a detailed analysis in the future.

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