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Waiting Time Before Justice in the Law Sector: A QUEUEING Theory

Etaga Harrison Oghenekevwe[1], Chikwendu Peace[1], Awopeju Kabiru Abidemi[1], Aforka Kenechukwu Florence[1], Etaga Njideka Cecilia[2]

[1]Department of Statistics, Faculty of Physical Sciences, Nnamdi Azikiwe University, Awka, Nigeria

[2]Department of Educational Foundations, Faculty of Education, Nnamdi Azikiwe University, Awka, Nigeria

Email address:
ho.etaga@unizik.edu.ng (H. O. Etaga)
*Corresponding author

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Abstract: The legal system in Nigeria is be-deviled with delayed justice which has become a source of concern to many person. This is very much peculiar to those who feel that the judiciary is too slow in resolving legal issues in Nigeria. In Nigeria, there abound court cases especially those of criminal dimensions that have ongoing for years now without reaching a conclusive conclusion. The study is aimed at modelling the queuing system in the magistrate courts in Onitsha Magisterial districts. The specific objectives include: to apply the M/M/2 and M/M/3 models with identical and parallel queues to criminal cases in the Magistrate court and to compare the efficiency of the two models and in either cases to determine time to justice in criminal cases in the Magisterial District. The results of the study show that M/M/2 model with 2 identical and parallel queues have an expected number of cases in the system as 39 with 50% idle time while the M/M/3 model with 3 identical and parallel queues have an expected number of cases in the system as 23 cases with 64.88% idle time. The comparison of the two models shows M/M/2 with 2-identical and parallel queues is more efficient as it has more number of cases to attend to and less idle time. The study therefore concludes that the delays in the disposal of cases especially those with criminal nature may not be attributable to the queuing systems in place. Even though lesser number of servers is seen to be efficient, this may not be advised. Increasing the number of servers though will increase speed of disposal of cases, may also lead to increased idle time of servers. As more courts being set up may result in waste of resources, manpower and time as the 2-server system is efficient in speeding up justice delivery in the magisterial division.

Keywords: Queuing, Waiting Time, Justice, Models, Legal

1. Introduction

The issue of "justice delayed is justice denied" has become a household word used daily across the globe. This is mostly used in cased where legal redress is not forthcoming within a specified period of time or not having a redress at all. The experts argue that great injustice is done to a plaintiff if he or she has to put up with the wrongdoing of a defendant for a long time, with no end seemingly in sight.

The legal system in Nigeria is be-deviled with delayed justice which has become a source of concern to many person. This is very much peculiar to those who feel that the judiciary is too slow in resolving legal issues in Nigeria. In Nigeria, there abound court cases especially those of criminal dimensions that have ongoing for years now without reaching a conclusive conclusion.

Application of queuing theory to the judicial system is almost non existence. Except for the work of Mukherjee and Whalen [16]. They worked on queuing behavior of time lapse between the period a case enters a court's docket and period the case disposed of.

Queuing theory can be defined as a mathematical study of the waiting lines. It involves the construction of a queuing model so that queue lengths and waiting times can be predicted (Sundarapandian [26]. Queuing has been a subject of debate for many years now and there is no known society that is not confronted with the problem of queuing. Wherever there is competition for limited resource queuing is likely to occur.

Sathiyabalan and Vidhya [23] defines queue as a file or line of persons. According to the authors, Queue means to form a line while waiting for something or a waiting line. It involves arriving items that wait to be served at the facility that provides the service they seek. Queuing theory is the mathematical theory of waiting lines. However, waiting in line is just a part of the overall queuing system. A queuing system (also known as a processing system) can be characterized by four main elements: the arrival, the queue discipline, the service mechanism, and the cost structure. A queuing model of a system is an abstract representation whose purpose is to isolate those factors that relate to the system's ability to meet service demands whose occurrences and durations are random.

Badane [5] posits that queuing theory tries to answer questions like the mean waiting time in the queue, the mean system response time (waiting time in the queue plus service times), mean utilization of the service facility, distribution of the number of customers in the queue, distribution of the number of customers in the system and so forth.

1.1. Components of a Queuing System

In general, a queuing system comprise of two components, the queue and the service facility. Sathiyabalan and Vidhya [23] while analyzing a queuing system identified some basic elements of it. Namely.

1.1.1. Input Process

If the occurrence of arrivals and the offer of service are strictly according to schedule, a queue can be avoided. But in practice this does not happen. In most cases the arrivals are the product of external factors.

1.1.2. Service Mechanism

The uncertainties involved in the service mechanism are the number of servers, the number of customers getting served at any time, and the duration and mode of service. Networks of queues consist of more than one servers arranged in series and/or parallel.

1.1.3. System Capacity

At most how many customers can wait at a time in a queueing system is a significant factor for consideration. If the waiting room is large, one can assume that for all practical purposes, it is infinite.

1.1.4. Service Discipline

All other factors regarding the rules of conduct of the queue can be pooled under this heading. One of these is the rule followed by the server in accepting customers for service. In this context, the rules such as First-Come, First-Served (FCFS), Last-Come, First-Served (LCFS), and Random Selection for Service (RS) are self explanatory.

Ozigbo [19] Argues that the basic components of queuing system are arrival, servers and waiting lines while

The analysis of queue is based on building a mathematical model representing the process of arrival of Item who joins the queue, the rules by which they are allowed into service, and the time it takes to service.

1.2. Characteristics of a Queuing Model

According to Jo et al [11] a queuing model is characterized by the following:

1.2.1. The Arrival Process of Customers

Usually it is assume that the inter-arrival times are independent and have a common distribution. In many practical situations customers arrive according to a Poisson stream (i.e. exponential inter-arrival times). Customers may arrive one by one, or in batches. An example of batch arrivals is the customs office at the border where travel documents of bus passengers have to be checked.

1.2.2. The Behaviour of Customers

Customers may be patient and willing to wait (for a long time). Or customers maybe impatient and leave after a while. For example, in call centers, customers will hang up when they have to wait too long before an operator is available, and they possibly try again after a while.

1.2.3. The Service Times

Usually it is assume that the service times are independent and identically distributed, and that they are independent of the inter-arrival times. For example, the service times can be deterministic or exponentially distributed. It can also occur that service times are dependent of the queue length. For example, the processing rates of the machines in a production system can be increased once the number of jobs waiting to be processed becomes too large.

1.2.4. The Service Discipline

Customers can be served one by one or in batches. We have many possibilities for the order in which they enter service. It include: first come-first served, i.e. in order of arrival; random order; last come first served; priorities (e.g. rush orders first, shortest processing time first); processor sharing (in computers that equally divide their processing power overall jobs in the system).

1.2.5. The Service Capacity

There may be a single server or a group of servers helping the customers.

1.2.6. The Waiting Room

There can be limitations with respect to the number of customers in the system. For example, in a data communication network, only finitely many cells can be buffered in a switch. The determination of good buffer sizes is an important issue in the design of these networks.

1.3. Assumptions of the Queuing Theory

Ozigbo [19] enumerated the following as the assumption of queuing theory:

i. Arrivals are served on a first in, first out basis

ii. Every arrival waits to be served regardless of the length of line

iii. Arrivals are independent of preceding arrivals, but the average number of arrivals does not change over time.

iv. Service times also vary from one customer to the other and are independent of one another, but their average rate is known.

v. Service times occur according to the negative exponential probability distribution.

vi. The average rate is greater than the average arrival rate.

This study therefore models the queueing system in the Nigerian magistrate court in other to effectively manage the time of dispensation of justice in the study area.

This study is to model the queuing system in the magistrate courts in Onitsha Magisterial districts.

2. Literature

Several studies have been conducted in the area of queueing theory and waiting time in particular. Some of such studies are reviewed.

Fomunfam and Hermann [9] surveyed the contributions and applications of queuing theory in the field of healthcare.

Sheikh et al [24] Converted the M/M/Z/∞:FCFS model into M/M/1/∞: FCFS in an attempt to determine the most efficient. Anokye et al [3] used queuing model to investigate the vehicular traffic flow and explore how vehicular traffic could be minimized using queuing theory. The results showed a traffic intensity, $\rho<1$ for all sessions. Osahenvemwen [18] use queuing models to worked on effective utilization of mobile call center which was done for effective utilization (management) of queue in service delivery in mobile communication network call center and other relative public infrastructures. Mukherjee and Whalen [5] using date from a hospital constructed, developed and applied an Approach to Modeling Technique which is cumulative in nature. The approach track the Analytical result of phenomenon of waiting in lines using representative measures of performance, such as average queue length, and average waiting time in queue. Paul et al [20] using questionnaire data, modelled service delivery in Federal Polytechnic Nasarawa with the sole aim of improving it. It is found that, lack of full online registration of the system can result to long queues. Yakubu and Najim [28] used queuing theory to determine optimal service level for a case ATM base on a customer-defined criterion of wait time not exceeding eight (8) minutes. They developed a queuing theory based decision support system which was applied in improving on the existing system. Yusuf et al [29] investigated and explore the general background into queuing theory, its associated performance, and it relationship to customer satisfaction in banking sector. They argued that for better understanding of queuing theory, service managers can make decisions that increase the satisfaction of all relevant groups-customers, employees, and management. Odior [17] using data from five petrol stations in an area, show that queues exist in each of the five petrol stations. It was also observed that the waiting time in the queue and service time at the five petrol filling stations decrease with increase in the number of servers. Sallam and Zobu [22] using simulation data on a queuing model with sequential two stations (stages) and all other conditions well defined, concluded that the simulation results approximated the theoretical results. So many authors have used queuing models in one way or the other among whom are Qureshi et al [21], Srinivas et al [25], Famule[8], Keaogile et al[13] ,Gumus et al [10], Kembe et al [14], Aradhye and Kallurkar [4], Cho et al [6] , Maedeh et al [15], Adan[1], Conte et al [7], Ugwuishiwu et al [27] ,Afrane and Appah [2] , Kama and Mankilik [12], Mukherjee and Whalen [16], Jo et al [11].

3. Materials and Method

This study employs the M/M/Z/∞ queuing Model. This model treats the condition in which there are several service stations in parallel and each customer in the waiting queue can be served by more than one station channel. This is the real case of judicial system in which there are several Z-court (servers) and just one queue (criminal cases lined up in the court registry). Here we consider a general M/M/z model and restricts it to only three functional court in Onitsha metropolitan city.

3.1. Definition of Model Parameters

P_n= Probability of exactly n customers in the system.

N= Number of customers in the system.

Ls= Expected number of customers in the system

Lq= Expected number of customers in the queue.

Ws= Waiting time of customers in the system

Wq= Waiting time of customers in the queue.

λn= The mean arrival rate (expected number of arrivals per unit time) of new customers are in systems.

μ_n= The mean service rate for overall systems (expected number of customers completing service per unit time) when n customers are in systems

3.2. The M/M/z Queuing Model

Consider an M/M/z queue with arrival rate λ, service rate μ and z servers. The traffic intensity is defined usually by the ratio. Consider an M/M/z queue with arrival rate λ, service rate μ and z servers.

The queuing systems in practice in the magistrate court are multiple queuing systems with identical servers in parallel and it is assumed that the arrivals follow a

Poisson distribution pattern with arrival rate of "λ" cases per unit of time. It is also assumed that they are served on a first-come, first-served basis by any of the servers. The service time are distributed exponentially ,with an average of "μ" cases per unit of time. Queue parameters are found using Little's laws, which states that the long term average number of customers in a stable system is equal to the long term average effective arrival rate multiplied by the average time a customer spend in the system. The utilization factor is the proportion of the system's resources that is used by the traffic which arrives at it. It should be strictly less than one for the system to be functioning effectively.

3.3. Traffic Intensity

The traffic intensity is defined as the ratio$\rho_z = \frac{\rho}{z} = \frac{\lambda}{z\mu}$

The steady distribution of queuing system is given as following:

$\rho_n = P(N = n), n = 0,1,2, ...$is the probabilitydistribution of the queue length *N,* as the system is in steady state, when the number of system servers is Z, then we have λn = λ, n=0,1,2,…

If there are n customers in the queuing system at any point in time, then the following two cases may arise:

1. If n<Z, (number of customers in the system is less than the number of servers), then there will be no queue. However, (Z–n) number of servers will not be busy. The combined service rate will then be μn=nμ; n<Z.
2. If n≥Z, (number of customers in the system is more than or equal to the number of servers) then all servers will be busy and the maximum number of customers in the queue will be (n – Z).The combined service rate will be μn = zμ; n≥Z.

From the model Utilization factor i.e. the fraction of time servers are busy$\rho_z = \frac{\lambda}{z\mu}$

$$P_0 = \left[\sum_{n=0}^{z-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n + \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^z \frac{z\mu}{z\mu - \lambda}\right]^{-1}$$

$$P_n = \begin{cases} (\rho^n/n!)P_0 \; n \le z \\ \rho^n/(z!\,z^{n-z})\, P_0 \; n > z \end{cases}$$

When n≥Z, it is that the number of customers in the system is not smaller than the number of servers, the next customers must wait, that is:

$$C(z,\rho) = \sum_{n=z}^{\infty} P_n = \frac{\rho^z}{z!(1-\rho_z)} P_0$$

Where $\rho_z = \rho/z = \lambda/(zu)$

3.4. Expected Number of the Customers Waiting on the Queue

$$L_q = \left[\frac{1}{(z-1)!}\left(\frac{\lambda}{\mu}\right)^z \frac{\mu\lambda}{(z\mu - \lambda)^2}\right] P_0$$

3.5. Expected Number of customers in the System

$$L_s = L_q + \frac{\lambda}{\mu}$$

3.6. Expected Waiting Time of Customers in the Queue

$$W_q = \frac{L_q}{\lambda}$$

3.7. Expected Time a Customer Spends in the System

$$W_s = \frac{L_s}{\lambda}$$

3.8. The M/M/3 Queuing Model

Consider an M/M/3 queue with arrival rate λ, service rate μ and z (=3) servers. The queuing parameters are then computed as follows:

4. Results

This section presents the data used in this study. The data was sourced from the court Registry of the Onitsha Magisterial District of Anambra State Judiciary. The time of filing a case in the court registry and the time it was eventually disposed of was of interest. Cases without full judgment were not considered.

Table 1. *Arrival and Service Rates for Courts.*

		Total Arrival	CI	CII	C III	C I	C II	C III	Total Service
S/N	Date of arrival	λ	λ_I	λ_{II}	λ_{III}	μ_I	μ_{II}	μ_{III}	μ
1	Jan 2007 to Dec 2007	278	92	102	84	74	72	75	220
2	Jan 2008 to Dec 2008	323	107	119	97	86	83	88	256
3	Jan 2009 to Dec 2009	251	83	92	75	66	65	68	199
4	Jan 2010 to Dec 2010	236	78	87	71	62	61	64	187
5	Jan2011 to Dec 2011	347	115	128	105	92	82	94	268
6	Jan 2012 to Dec 2012	387	128	142	116	102	89	67	258
7	Jan2013 to Dec 2013	269	89	99	81	71	69	73	213
8	Jan2014 to Dec 2014	335	111	123	101	89	86	91	266
9	Jan2015 to Dec 2015	397	147	163	87	118	68	72	258
10	Jan2016 to Dec 2016	356	118	131	107	94	92	80	266
TOTAL	10 YEARS	3179	1068	1186	924	854	767	772	2392

Source: Admin Court Onitsha Registry (2020)

Table 1 presents the data obtained from the court registry in the Onitsha magisterial district. The data contains the dates of arrival and disposal of criminal cases, the number of cases that arrived in each year, the service rates of the various courts and the total service rates. The data covers a period of 10 years.

4.1. General Queue Characteristics

The queue system in the Onitsha magisterial district is a three server queue system of M/M/3 case and the queue parameters are obtained as follows:

Consider an M/M/3 queue with arrival rate λ, service rate μ and z (=3 servers). The queuing parameters are then computed as follows:

Mean Arrival Rates, λ = 3179/10 = 317.9 Cases Per Year

Mean Service Rate of Customers = 2392/10 = 239.2

4.2. 3-Parallel Queue- 3-Server Model Parameter Estimates

The mean arrival rates for the 3 servers is 317.9/3 = 106 per year.

4.2.1. Traffic Intensity for 3-Parallel Queue- 3-Server Model

$\rho_n = P(N = 3)$, is the probabilitydistribution of the queue length *N,* as the system is unsteady state.

The traffic intensity is defined as the ratio$\rho_3 = \frac{\rho}{3} = \frac{\lambda}{3\mu} = \frac{106}{3(239.2)} = 0.1477$

The traffic intensity is converted to weeks for simplicity by multiplying with 52 weeks; hence we have 7.7, approximately 8 cases per week

4.2.2. Probability of Having no Customer in the System for the 3-Parallel Queue- 3-Server Model is

$$P_0 = \left[\sum_{n=0}^{3-1}\frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n + \frac{1}{z!}\left(\frac{\lambda}{\mu}\right)^3\frac{3\mu}{3\mu-\lambda}\right]^{-1} = \left[\left(\frac{1}{0!}\left(\frac{106}{239.2}\right)^0 + \frac{1}{1!}\left(\frac{106}{239.2}\right)^1 + \frac{1}{2!}\left(\frac{106}{239.2}\right)^2\right) + \frac{1}{3!}\left(\frac{106}{239.2}\right)^3\frac{3(239.2)}{3(239.2)-106}\right]^{-1} = (1.5412)^{-1} = 0.6488$$

This means that the servers (courts) are idle 64.88% of the time.

4.2.3. Expected Number of Cases Waiting on the Queue for the 3-Parallel Queue- 3-Server Model

$$L_q = \left[\frac{1}{(3-1)!}\left(\frac{\lambda}{\mu}\right)^z\frac{\mu\lambda}{(3\mu-\lambda)^2}\right]P_0 = \left[\frac{1}{2!}\left(\frac{106}{239.2}\right)^3\frac{106(239.2)}{(3(239.2)-106)^2}\right]0.6488 = 0.001913\ (0.01/\text{week})$$

4.2.4. Expected Number of Cases in the System for the 3-Parallel Queue- 3-Server Model

$$L_s = L_q + \frac{\lambda}{\mu} = 0.001913 + \frac{106}{239.2} = 0.4451$$

4.2.5. Expected Waiting Time of Customers in the Queue for the 3-Parallel Queue- 3-Server Model

$$W_q = \frac{0.001913}{106} = 0.000018\ (0.000936\ \text{weeks})$$

4.3. 2-Parallel Queue-2-Server Model Parameter Estimates

Mean Arrival Time for the 2-Parallel Queue-2-Server

The steady distribution of queuing system is given as following:

$\rho_n = P(N = 2)$, is the probabilitydistribution of the queue length *N,* as the system is in steady state, when the number of system servers is 2. **λ**= **λ**/2= $\frac{317.9}{2}$ =158.95 ≈159.

4.3.1. Traffic Intensity for the 2-Parallel Queue-2-Server

The traffic intensity is defined as the ratio

$$\rho_3 = \frac{\rho}{3} = \frac{\lambda}{2\mu} = \frac{159}{2(239.2)} = 0.3323\ (17\ \text{cases per week}).$$

4.3.2. Probability of Having no Customer in the System for the 2-Parallel Queue-2-Server is

$$P_0 = \left[\sum_{n=0}^{2-1}\frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n + \frac{1}{z!}\left(\frac{\lambda}{\mu}\right)^3\frac{2\mu}{2\mu-\lambda}\right]^{-1} = \left[\left(\frac{1}{0!}\left(\frac{159}{239.2}\right)^0 + \frac{1}{1!}\left(\frac{159}{239.2}\right)^1\right) + \frac{1}{2!}\left(\frac{159}{239.2}\right)^2\frac{2(239.2)}{2(239.2)-159}\right]^{-1} = (2)^{-1} = 0.5$$

This means that the courts will be idle 50% of the time when this 2-server 2-identical queuing system is followed

4.3.3. Expected Number of Cases Waiting on the Queue for the 2-Parallel Queue-2-Server

$$L_q = \left[\frac{1}{(2-1)!}\left(\frac{\lambda}{\mu}\right)^2\frac{\mu\lambda}{(2\mu-\lambda)^2}\right]P_0 = \left[\frac{1}{1!}\left(\frac{159}{239.2}\right)^2\frac{159(239.2)}{(2(239.2)-159)^2}\right]0.5 = 0.0824\ (\text{YEAR})$$

4.3.4. Expected Number of Cases in the System for the 2-Parallel Queue-2-Server

$$L_s = L_q + \frac{\lambda}{\mu} = 0.0824 + \frac{159}{239.2} = 0.7471\ (38.85\ \text{cases per week})$$

This result implies that approximately 39 cases has to be attended to every week is this queuing system is observed.

4.3.5. Expected Waiting Time of Customers in the Queue for the 2-Parallel Queue-2-Server

$$W_q = \frac{0.7471}{159} = 0.0047 \text{ (0.2444 week)}$$

Table 2. *Summary of Results and Parameter Estimates.*

QUEUE PARAMETERS	NOTATION	M/M/2	M/M/3
Mean Arrival Rate	λ	159	106
Mean Service Rate	μ	239.3	239.2
Traffic Intensity	ρ=λ/zμ	0.2215	0.1477
Expected number of cases waiting on the queue	Lq	0.0824	0.001913
Expected number of cases in the system:	Ls	0.7471	0.4451
Expected waiting time of customers in the queue	Wq	0.0047	0.000018
Probability of having no case in the system		0.6488	0.5

Table 2 Presents an overview of the results from both queuing models for easy comparison and referencing.

5. Discussion of Findings

The results of the two queuing models have been presented in the previous sections. The results show that the mean arrival rate of cases in the Judiciary Registry is 317.9 approximately 318 cases per year. The mean service rates of the Magistrate courts studied is 239.2 cases per year.

The 3-Server, 3-Parallel Queue system was the first queue model studied. The traffic intensity under this model was seen at 0.14477 case per year which when converted gives approximately 8 cases per week. Expected waiting time of cases in the queue is 0.0943 per year (0.491 per week). The probability of having no customer in the system otherwise known as idle time is 0.6488. This means that the system will be 1ddle 64.88% of the time. The expected number of cases in the system under this model is 0.4451 per year approximately 23 cases per week. The waiting time for customers is estimated at 0.000934 per year (or 0.0486)

The 2-Server, 2-Parallel Queue system was the second model considered. The mean arrival rate under this model is 158.95 approximately 159 cases per year. The traffic intensity is given as 0.3327 per year which is approximately 17 cases per week. Under this model, the idle time which is the probability of having no case in the system is 0.5. This means that the system will be idle 50% of the time. Expected number of cases in the system is given as 0.7471 case per year which is approximately 39 cases per week. The expected waiting time of cases in the queue is 0.0047 per year approximately 0.2444 cases per week.

Two queuing models were used to analyze the queuing system in the magistrate courts under the Onitsha Magisterial Jurisdiction. The models are M/M/2 with 2 identical and parallel queues; and M/M/3 with 3-identical and parallel queues. The objectives were to estimate the models parameters and compare their result so as to determine the best model that optimizes the time to justice and idle times of the courts. The following are the findings:

1. M/M/2 model with 2 identical and parallel queues have an expected number of cases in the system as 39cases with 50% idle time.
2. M/M/3 model with 3 identical and parallel queues have an expected number of cases in the system as 23 cases with 64.88% idle time.
3. The comparison of the two models shows M/M/2 with 2-identical and parallel queues is more efficient as it has more number of cases to attend to and less idle time.

6. Conclusion

The results and summary of findings have been presented in previous sections. The results show that the expected time to justice in the various courts is very small. It brings to the fore that the delays caused in the disposal of cases especially those with criminal nature may not be attributable to the queuing systems in place. Even though lesser number of servers is seen to be efficient, this may not be advised. Increasing the number of servers though will increase speed of disposal of cases, may also lead to increased idle time of servers. As more courts being set up may result in waste of resources, manpower and time as the 2-server system is efficient in speeding up justice delivery in the magisterial division.

Based on the finding in this study the following recommendations are proffered.

1. Since the study has shown that the expected time for justice delivery in criminal cases is to small, it then means that the delay may be attributable to the internal mechanism of the judicial system. Government should therefore strive to strengthen the internal process of the judicial system for efficient and speedy service delivery.
2. The study has shown that the 2-server system is efficient in handling the number of cases, specialized criminal courts especially at magistrate level may however be set up specifically for criminal cases so as to speed up criminal justice delivery.
3. This study did not put into consideration the nature of disjointed (adjournments) and parallel (processing several cases at the same time, say day, month etc) case processing observed in the court of law, as this may be far above the level of this study. Further studies to consider this scenarios may be required.

References

[1] Adan, I and Resing, J (2015). Queueing Systems. Department of Mathematics and Computing Science, Eindhoven University of Technology.

[2] Afrane, S. and Appah, A. (2014). Queuing theory and the management of Waiting-time in Hospitals: The case of Anglo Gold Ashanti Hospital in Ghana. International Journal of Academic Research in Business and Social Sciences Vol. 4 (2).

[3] Anokye, M., Abdul-Aziz, A. R., Annin, A. and Oduro, F. T (2013). Application of Queuing Theory to Vehicular Traffic at Signalized Intersection in Kumasi-Ashanti Region, Ghana. *American International Journal of Contemporary Research Vol. 3 (7).*

[4] Aradhye, A and Kallurkar, S. (2014). Application of Queuing Theory to Reduce Waiting Period of Pilgrim. International Journal of Innovative Research in Science, Engineering and Technology Vol. 3 (10).

[5] Bedane, I. (2017). Modeling Hospital Triage Queuing System. Global Journal of Researches in Engineering: Industrial Engineering Vol. 17 (1).

[6] Cho, K. W., Kim, S. M, Chae, Y. M. and Song, Y. U (2017). Application of Queuing Theory to Analysis of Changes in Outpatients' Waiting Times in Hospitals, Introducing EMR. Health Inform Res. 23 (1).

[7] Conte, A. and Scarsini, M. and Sürücü, O (2016). The impact of time limitation: Insights from a queueing experiment. Judgement and Decision making Vol. 11 (3).

[8] Famule, F. D. (2010). Analysis of M/M/1 Queueing Model with Applications To Waiting Time Of Customers In Banks. Global Journal of Computer Science and Technology. Vol. 10 (13).

[9] Fomundam, S., and Herrmann, J (2007). A Survey Of Queuing Theory Applications In Healthcare. The Institute for Systems Research (ISR), Technical Report 2007-24.

[10] Gumus, S., Bubou, G. M Oladeinde, M. H (2017). Application Of Queuing Theory To A Fast Food Outfit: A Study Of Blue Meadows Restaurant. Independent Journal of Management & Production. Vol. 8.

[11] Jo H. H, Pan RK, Kaski K. (2012) Time-varying priority queuing models for human dynamics. Phys Rev E (2012) 85: 066101. doi: 10.1103/PhysRevE.85.066101.

[12] Kama, H. N and Mankilik, I. M (2015). Application Of Queuing Theory In Cadet Mess Administration: A Case Study Of Nigerian Defence Academy, Kaduna Nigeria. Academy Journal of Science and Engineering 9 (1).

[13] Keaogile, T., Adewole, A. F. and Ramasamy, S (2015). Geo (λ)/ Geo (μ) +G/2 Queues with Heterogeneous Servers Operating under FCFS Queue Discipline. *American Journal of Applied Mathematics and Statistics, 2015, Vol. (2), 54-58.*

[14] Kembe, M. M., Gbenimak, C. J., Onoja A. A. (2017). Application of Queueing Theory to Customers Purchasing Premium Motor Spirit (PMS) at a Filling Station. Res Rev J Statistics Math Sci | Vol. 3 (1).

[15] Maedeh Chaleshigar Kordasiabi, Hadi Gholizadeh, Hamed Fazlollahtabar and Nikbakhsh Javadian (2020) Analysis of cost model with queuing system under uncertainty. Journal of Industrial and Production Engineering 37 (1): 1-13.

[16] Mukherjee S and Whalen R (2018). Priority Queuing on the Docket: Universality of Judicial Dispute Resolution Timing. Front. Phys. 6:1. doi: 10.3389/fphy.2018.00001.

[17] Odior, A. O. (2013). Application of Queuing Theory to Petrol Stations In Benin-City Area Of Edo State, Nigeria. *Nigerian Journal of Technology Vol. 32 (2).*

[18] Osahenvemwen O. A. and Odiase O. F. (2016). Effective Utilization of Mobile Call Center Using Queuing Models. International Journal of Engineering and Technology, Vol. 8 (2).

[19] Ozigbo (2000). *Quantitative Analysis for Management*. Enugu: Precision printer Publishers, 1st Edition. p. 161-167.

[20] Paul, G. D., Abdullah, A. M. and Halilu, R. (2015). The Application Of Queueing Model/Waiting Lines in Improving Service Delivering in Nigeria's Higher Institutions. International Journal of Economics, Commerce and Management United Kingdom Vol. III (1).

[21] Qureshi, M. I., Bhatti, M., Khan, A and Zaman, K (2014). Measuring queuing system and time standards: a case study of student affairs in universities Muhammad. African Journal of Business Management. Vol. 8 (2).

[22] Sallam, V. and Zobu, M. (2013). A Two-Stage Model Queueing with No Waiting Line between Channels. Mathematical Problems in Engineering, Vol. 2013.

[23] Sathiyabalan, P. and Vidhya, V (2015). Queuing Theory And It's Impact On Various Applications - A Review. *Sathiyabalan,* 2 (6).

[24] Sheikh, T., Singh, S. K. and Kashyap, A. K. (2013). Application of Queuing Theory for The Improvement Of Bank Service. International Journal of Advanced Computational Engineering and Networking, ISSN: 2320-2106 Vol. 1 (4).

[25] Srinivas R. Chakravarthy, Shruti, Rakhee Kulstrestha (2020) A queuing Model with Server breakdowns, repairs, vacations and backup server. Journal of Operation Research Perspectives. Volume 7.

[26] Sundarapandian, V. (2009). 7. Queueing Theory: Probability, Statistics and Queueing Theory. PHI Learning.

[27] Ugwuishiwu, C. H, Okoronkwo, M. C., and Asogwa, C. N. (2017). Performance evaluation of law enforcement agency on crime information management using queuing network model. International Journal of Physical Sciences. Vol. 12 (4).

[28] Yakubu, A. W. and Najim, U (2014). An Application of Queuing Theory to ATM Service Optimization: A Case Study. Mathematical Theory and Modeling Vol. 4 (6).

[29] Yusuf, M. O. Nwaiwu, B. and Kazeem, A. O (2015). Queuing Theory and Customer Satisfaction: A Review of Performance, Trends and Application in Banking Practice (A Study of First Bank Plc Gwagwalada, Abuja Branch). European Journal of Business and Management, Vol. 7 (35).