IJASCSE, Volume 2, Issue 5, 2013

Queue Management Systems for Congestion Control: Case study of First Bank, Nigeria

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Abstract-This paper is centred on the single-channel waiting line systems with Poisson arrivals and exponential service times in First Bank, Nigeria. They represent stages of customer flow management processes. Waiting systems are stochastic mathematical models and they represent the describing base of the waiting phenomena, service processes, and prioritization among others. Mathematical models of queuing theory present interest in modelling, designing and analysing information networks. The expanded networks of First Bank and years of establishment/service should bring about modern technologies of attending to customers in banking halls across the globe thereby increasing their turn out and efficiency of carrying out business. This paper presents the single-channel waiting line model in First Bank, Nigeria.

Keywords: *customer flow, queuing theory, waiting system, waiting line, efficiency.*

I. INTRODUCTION

First Bank, Nigeria (FBN) was founded in 1894, called First Bank of Nigeria Plc (FirstBank) which happens to be the first premier bank in West Africa and the leading financial services solutions provider in Nigeria (source). The Bank's contribution to the economic growth and development of Nigeria over the last 116 years has been driven by commitment to the provision of excellent banking services [12].

At inception, the Bank was incorporated as a limited liability company under the name Bank of British West Africa (BBWA), with the head office originally in Liverpool. The bank has witnessed lots of metamorphosis, few amongst them are: repackaging of the brand name in 1957 from Bank of British West Africa (BBWA) to Bank of West Africa (BWA); the merger of 1966 brought about a new name called Standard Bank of West Africa Limited and in 1969 they were incorporated locally as the Standard Bank of Nigeria Limited in line with the Companies Decree of 1968. The repackaging of names continued which was a symbol of commitments as they witnessed another one 1979 and 1991 to First Bank of Nigeria Limited and First Bank of Nigeria Plc, respectively.

The Bank had its second branch opened in Nigeria, precisely in Calabar in 1900 and, 12 years later, extended its services to Northern Nigeria by opening its Zaria branch. The Kano branch was opened in 1928. Currently with over 570 branches, the First Bank Group has one of the largest branch networks in Nigeria. In 2002, First Bank established a wholly owned banking subsidiary in the United Kingdom, (FBN) Bank (UK) Limited, regulated by the Financial Services Authority (FSA). This became the first Nigerian bank to own a fully-fledged bank in the UK. In 2007, FBN Bank (UK) set up its Paris office to serve as a marketing base to service francophone West Africa. First Bank also has a representative office in South Africa and has obtained a licence to open a representative office in China [12].

A. *Operations of First Bank, Nigeria*

The Number of Waiting Line systems can have single or multiple lines. Banks often have a single line for customers. Customers wait in line until a teller is free and then proceed to that teller's position. Other examples of single-line systems include airline counters, rental car counters, restaurants, amusement park attractions, and call centres [1]. The advantages of using a single line when multiple servers are available are the customer's perception of fairness in terms of equitable waits. That is, the customer is not penalized by picking the slow line but is served in a true first-come, first-served fashion. The single-line approach eliminates shunting behaviour. Finally, a single-line, multiple-server system has better performance in terms of waiting times than the same system with a line for each server.

The multiple-line configuration is appropriate when specialised servers are used or when space considerations make a single line inconvenient. For example, in a super market store some registers are express lines for customers with a small number of items. Using express lines reduces the waiting time for customers making smaller purchases. Examples of single- and multiple-line systems are shown in Figure 1.
One of the factors influencing consumers' perception on service quality is the efficiency of waiting systems. The waiting time is inevitable in the case of random requests. Thus, providing the capacity for a sufficient service is

needed, but it is involving high costs. This is the premise from which the queuing theory starts in designing service systems [1].

Customer flow management refers to customer flow handling as well as to their experiences from the first contact with the company until the delivery of goods/services. Customer flow management plays a key role in increasing the productivity, sales and also in reducing costs, since each customer will be directed to the right place, at the right time and will be served by the adequate operator. Thus, the steps of the customer flow are as follows:

- **pre-reception**: involves using programming in advance, thus resulting a shorter waiting time. It can be made by phone or using the Internet;
- **reception**: customer flow management is opting to place customers in different waiting lines, depending on their needs;
- **waiting**: waiting time optimization can be

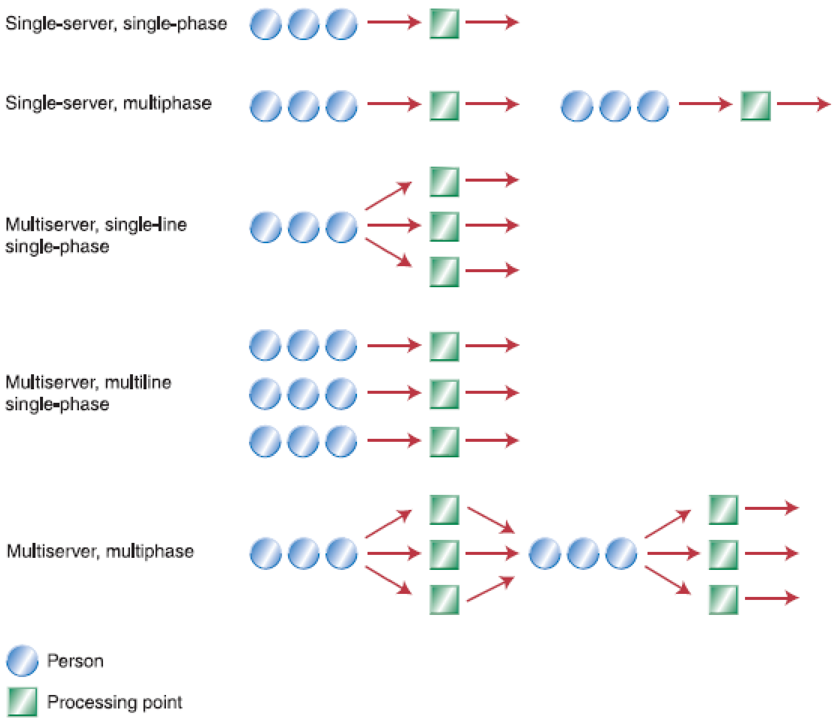

Figure 1. Example of waiting line systems

- achieved by improving the staff planning and increasing the process flexibility;
- **service**: once the customers are waiting in a line, the staff can start the required services;
- **post-service**: after serving, waiting and proceeding times are recorded by the staff;
- **administration**: the records can be used to the current processes assessment, by generating reports, in order to determine the operational efficiency.

- **Stochastic process:** a process organised into states in which movement from state to state is governed by probabilities.

II. LITERATURE REVIEW

The literature adopted some developed models in order to support and assist managers in making the best decisions on waiting lines [5]; [7]. In the management terminology, a waiting line is also called the tail and their characteristic concepts form the queuing theory [6], [9].

This theory explains the analysis of some communication, logistic, manufacturing and services systems [2]. The main advantage of queuing theory resides in determining the important information about waiting times, arrivals and service stations characteristics and about the systems discipline [1].

Waiting line models consists of mathematical formulas and relations used to determine the operating characteristics of these lines which in turn determine the effectiveness of operations of staff. Among these features, as mentioned by [9]:

- the probability that there is no item in the system;
- the average of the items in the waiting line;
- the average of the existent items in the system (the items in the waiting line and the items being served);
- the average time an item spends in the waiting line;
- the average time an item spends in the system (consists of the waiting time besides the service time);

- the probability that an item has to wait for the service.

III. RESEARCH METHODOLOGY

In order to highlight the characteristics of a waiting system, the researchers considered the operations of First Bank, Nigeria because of its years of existence in financial transactions. Although most banks want to provide a service as prompt as possible, there are many cases where there are fewer personnel's as against larger customers.

A *Single-channel waiting line*

The way the customers are served in bank is an example of a single-channel waiting line. That is, the customer request is taken and as the transaction is completed, the request of the next customer in the waiting line is taken. Thus, each customer of the bank goes through a single-channel where he places the request and is being attended to. If there are more customers than can be served, a waiting line arises. The diagram in figure 2 shows a single-channel waiting line for First Bank transaction:

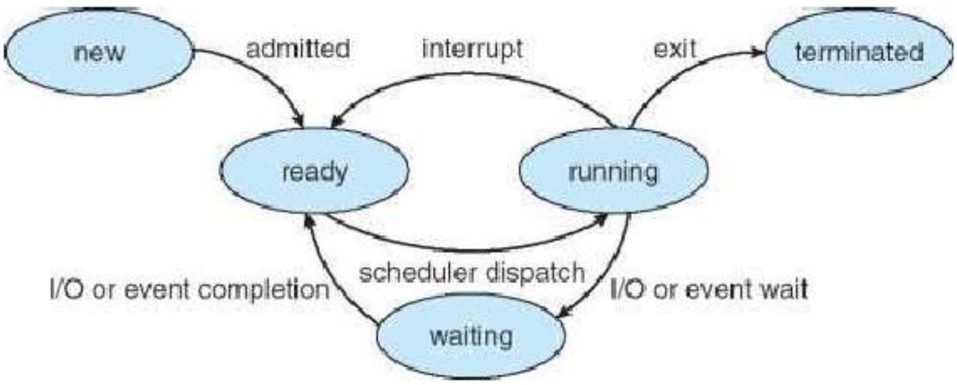

Figure 2: Example of waiting line systems

B. Distribution of Arrivals

A feature of the arrival process is the probability distribution of arrivals in a given time period. In many situations, arrivals occur randomly and independently of other arrivals, such that the estimation of an arrival occurrence is difficult to determine. Thus, the Poisson distribution is the best solution to describe the arrivals pattern.
Starting from the definition of a Poisson distribution of random variables [11] the probability distribution function of x arrivals in a specific time period, is:

$$\mathbf{P(x)} = \frac{\lambda^x e^{-\lambda}}{x!} \quad \text{for } x = 0,1,2 \qquad (1)$$

Where x= the number of arrivals in a time period;
Λ= the mean number of arrivals per time period;
e = 2.71828.
Supposing that in a bank transaction, the mean number of arrivals is 45 customers per hour, the mean number of customers arrived in one minute is λ = 45/60 = 0.75. The probability that x customers arrive in one minute period will b

$$P(x) \; \frac{\lambda^x e^{-\lambda}}{x!} = \frac{0.75\, e^{-0.75}}{x!} \qquad (2)$$

The possibilities of 0,1,2 arrivals in one minute period will be

$$P(0) = \frac{(0.75)^0\, e^{-0.75}}{0!} = e^{-0.75} = 0.4274 \qquad (3)$$

$$P(1) = \frac{(0.75)^1\, e^{-0.75}}{1!} = 0.75e^{-0.75} = 0.3543 \qquad (4)$$

$$P(2) = \frac{(0.75)^2\, e^{-0.75}}{2!} = 0.28125e^{-0.75} = 0.1329 \qquad (5)$$

C. *Service time distribution*
Service time starts when a customer made a request for a service and finishes when the customer is being served. Service time is not constant, but it depends on how complex the request is.

The quantitative analysis highlighted the fact that the exponential distribution of the service time provides the best information regarding the operations of waiting line. If the exponential probabilistic distribution is used then the probability that the service time is less than or equal to a time t will be [11], [9]:

$$\Pi\,(\tau_\sigma \leq \tau = 1 - {}^{\varepsilon - \mu\tau} \qquad (6)$$

where: ts – the time for service;
t – the length of the specified time period;

μ – the mean number of items that can be served in a period;
e = 2.71828.

For example, suppose that in our bank transaction, an operator serves an average of 60 customers per hour. Then, in one minute, the operator will serve $\mu = 60/60 = 1$ customer. If $\mu = 1$, we can determine what the probability of a request to be processed in ½ minute or less, in 1 minute or less, or in 2 minutes or less. Thus, from (6) results:

$$\Pi(\tau_\sigma \le 0.5) = 1-\varepsilon^{-0.5} = 0.3935 \quad (7)$$

$$\Pi(\tau_\sigma \le 1) = 1-\varepsilon^{-1} = 0.6321 \quad (8)$$

$$\Pi(\tau_\sigma \le 2) = 1-\varepsilon^{-2} = 0.8647 \quad (9)$$

D. *Waiting line discipline*

Considering waiting systems and lines, it is necessary to specify the way the elements are arranged for serving, in other words it has to specify the waiting line discipline. In case of banking operations, as in other many cases, the queue discipline is the FIFO type (First In First Out). In other words, the customers are served in order of their arrival in the waiting line. There are situations when the waiting line discipline is type of LIFO (Last In First Out). Such an example is given by persons who are going to use an elevator. Thus, the last person entered the elevator will be the first person to leave it. There are real systems in which the requests need to be served before other based on some priorities [3].

E. *Single-channel waiting line model, with Poisson arrivals and exponential service time*

In order to be able to highlight the way the existing formulas can provide information related to the waiting line characteristics, we turn to our bank transaction as an example. Next, we present the characteristics of the waiting line operations, taking into account the following: λ – the average number of arrivals in a given period of time and μ - the average number of services in a given period of time [9]:

the probability that there is no item in the system:

$$\Pi(0)\ 1-\frac{\lambda}{\mu} \quad (10)$$

the average number of items existing in the waiting line:

$$\Lambda_\theta = \frac{\lambda^2}{\mu(\mu-\lambda)} \quad (11)$$

the average number of items existing in the system:

$$\Lambda = \frac{\Lambda_\pi + \lambda}{\mu} \quad (12)$$

the average time spent by an item in the waiting line:

$$\Omega_\theta = \frac{\Lambda\gamma}{\lambda} \quad (13)$$

the average time spent by an item in the system:

$$\Omega = \Omega_\theta + \frac{1}{\mu} \quad (14)$$

the probability that an item is waiting to be served:

$$\Pi_\omega = \frac{\lambda}{\mu} \quad (15)$$

τhe probability that there are n items in the system:

$$\Pi_v = \left(\frac{\lambda}{\mu}\right)^v \Pi_0 \quad (16)$$

It is worthy to note that the formulas from (10) to (16) can be applied only if μ is greater than λ. In other words, they can be applied only if $\lambda/\mu < 1$. Failing to meet this condition leads to a growing of the waiting line, because the service capacity is insufficient. Next, we are going to determine the operations characteristics in case of bank transactions. Based on previously determined values for $\lambda = 0.75$ and $\mu = 1$ and using formulas (10) – (16), the result is:

$$P(0) = 1 - \frac{0.75}{1} = 0.25$$

$$L_q = \frac{(0.75)^2}{1(1-0.75)} = 2.25 \text{ customers}$$

$$L = 2.25 + \frac{0.75}{1} = 3 \text{ customers}$$

$$W_q = \frac{2.25}{0.75} = 3 \text{ min utes}$$

$$W = 3 + \frac{1}{1} = 4 \text{ min utes}$$

$$P_w = \frac{0.75}{1} = 0.75$$

(17)

F. *Waiting lines models utility*

In case of FBN, the results highlight some important issues about the waiting line operation mode. Thus, the customers have to wait an average of 3 minutes to request for transaction; the average number of customers who have to wait is 2.5 and 75% of arriving customers have to wait for the transaction. These values show that it is necessary to improve the operations occurring within the waiting line. If the managers continue to use the single-channel waiting line, the number of waiting customers will be increasingly higher.

Advantages of queuing system to customers

- Reduces waiting time & speeds up service time.
- It offers freedom to move about in lobby, read advertising brochures or simply take a seat, while waiting for their turn.
- Ensures fair service.
- Improves service quality and hence enhances customer experience.

Advantages of queuing system to Employees

- It offers good working conditions where they can be efficient, yet relaxed without being intimidated by the queue of overlooking people awaiting service.
- Advanced technology features gives more control to the employees thereby empowering them to ensure better service.

Advantages of queuing system to Managers

- It provides detailed reports which allow managers to measure their staff's performance, optimize resource allocation, respond to staff workloads and provide better service to customers.

IV. CONCLUSIONS

The waiting line models play a key role in highlighting the operational effectiveness of FBN and hence the need for improving their characteristics. The analysts are those who decide if there will be any changes regarding the waiting line configuration. In general, in order to improve the operations within the waiting line, there would be the need to improve the service rate. This is possible by adopting one or both of these solutions: (the increase of the average service rate μ) this is possible by either redesigning the waiting line or using other technologies; and (the addition of new service channels) so that more customers can be served simultaneously while the customers would experience less of unproductive time waiting.

V. REFERENCES

[1] Alecu, F., (2004). "Sisteme de asteptare pentru calculul paralel si distribuit", *Romanian Journal of Information Technology and Automatic Control*, Vol. 14, No. 2.

[2] Bejan, A., (2007). *Modelarea timpului de orientare însisteme de asteptare cu priorităţi*, Paper of the PhD thesis in physical-mathematical sciences, Chisinău, (available online at http://www.cnaa.md/files/theses/2007/6944/andrei_bejan_abstract.pdf).

[3] Benderschi O., (2009). *Analiza sistemelor de asteptare cu priorităţi si trafic critic*, Paper of the PhD thesis in physical-mathematical sciences, Chisinău, (available online at http://www.cnaa.md/files/theses/2009/13911/olga_benderschi_abstract.pdf).

[4] Fredéric H. (2007) Scheduling Algorithm Department of Computer Systems Uppsala University daz@it.uu.se

[5] Pang, P., (2004). *Essentials of Manufacturing Engineering Management*, iUniverse Inc., USA.

[6] Shim, J., K., and Siegel, J., G., (1999). *Operations Management*, Barron's Educational Series, USA.

[7] Sweeney, D., J.,Anderson, D., R., Williams, T. A., Camm, J., D., Kipp, and Martin, R. (2010). *Quantitative Methods for Business*, Cengage Learning, USA. *Annales Universitatis Apulensis Series Oeconomica, 12(2), 2010* 622

[8] Sidonia, O. C.,Mihaela J. and Mohammad J. (2010) Characteristics of waiting line models the indicators of the customer flow management systems efficiency. *Annales Universitatis Apulensis Series Oeconomica, 12(2),*

[9] Williams, A., S., (2003). *An Introduction to Management Science – Quantitative Approaches to Decision Making. Tenth Edition*, South-Western, USA. http://www.eutron.ro/categorie/sisteme-si-produse/sisteme-de-management-al-fluxurilor-declienti/19/

[10] Waiting line model: http://www.csus.edu/indiv/b/blakeh/mgmt/documents/OPM101SupplC.pdf

[11] Jaradat M., and Muresan, A., (2004). *Matematici pentru economisti. Teorie si aplicaţii*, Risoprint Publishing, Cluj-Napoca.

[12] Bolaji A, Udechukwu O., Stuart M., Glebb S. and Amaechi A. (2008) "Nigerain Banks and Perception of Risk in PPP Project Delivery" *Journal of Finance and Management in Public Services. Volume 8 Number 2*