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Application of Queuing Model to Ease Traveler's Flow in Nigerian International Airports.

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Abstract: *The study examined the application of queuing model to ease travelers' flow in the Nigerian international airports. Travelers experiencing long queuing for boarding and arrival at the airport is not only at the local airports but also a growing concern to the stakeholders at the international airports,these queues have led to loss of time, resources and contributed to creating health problems for some travelers while on queue in which some have even collapse and die in the process. This study aims to develop a structural model (or flow chart) to ease travelers flow within different operational servicing units in the Nigeria Airport. The study employed observational and ex-post facto research designs. The population of the study are infinite (travelers at the airports) and finite (entire international airports in Nigeria). Cochran's (1977) formula was used to get the sample size from infinite population to be 246. Convenient sampling technique was used to select two international airports wile accidental sampling technique was used to select the sample from the infinite population. Content validity and Cronbach's alpha reliability was used to measure the research instrument. The observational data were analysed using TORA optimization application. After a three-day observation of the travelers' movement at 6 airlines desk at the chosen airport with the introduction of multiple queue multiple server in parallel model developed reveals on the average for the 6 airlines, number of customer in the system is 4.04 travelers, while the average number of travelers waiting in a queue per hour is 1.49. The average time traveler spent in the system (wait-inline and been served) is 0.022 (1.33minute) while the average time a traveler spends in the queue waiting for service is 0.0096 (0.58minutes).*
Key words: *Multiple queue-multiple server, Queue, Queuing, Queuing model, Traffic intensity, Travelers' flow.*

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I. Introduction

Queuing is an everyday occurrence affecting people shopping for groceries, buying gasoline, making bank deposit or waiting on the telephone for the first available airline reservations to answer. Queuing may also take the form of machines waiting to be repaired, trucks in line to be loaded or unloaded, travelers at the airports to purchase tickets or aircrafts lined up on the runway waiting for permission to take-off (Erlang, 1909). Queues also occur in filling stations, bus stops, canteens and hospitals where patients wait for minutes, hours, days or months to receive services, waiting before, during or after being attended to. The unpleasant experience of waiting in line or queue can often have a negative effect on the rest of travelers' experience (Ademoh & Anosike, 2014; Scotland 1991). The way in which managers address the queue issues is critical to the long-term success of their firms (Davis, Aquilano & Chase, 2003). Many organizations such as banks, hospitals, airlines, telecommunications companies, and police departments, routinely use queuing models to help manage and allocate resources in order to respond to demands timely and cost efficiently (John, 2010; Medhi, 2010).

The three basic components of queuing process are arrivals, service facilities and the actual queue. Based on these three components, Kendall (1953) developed a notation "A/B/C/D/E/F" that has been widely accepted for specifying the pattern of arrivals, the service time distribution, and the number of channels in the model. This notation often used for queuing is called Kendall notation. Many times, the last three alphabets from the Kendall notation are omitted so that the notation becomes A/B/C or more (where A/B/1) notation used for single- channel queuing model with Poisson arrivals and exponential times, while A/B/C notation used for multiple channel queuing model with Poisson arrivals and exponential service times (Krajewski, Ritzman & Malhotra, 2011).

Queuing process in the airport has become very complex problem to solve manually due to the patterns in arrival, service and departure. The airports have less capacity to serve all arrivals and departures promptly in nearly all the international airports resulting into queues, rowdiness and randomness which create some waiting times (Medri, Djere & Kanmoun, 2009). In this regard, Jay and Bary (1993) and Roland (2009) put to test queuing model activities in airport services in which waiting line occurred.

Aviation practice began in Nigeria, barely seventeen years after the 'wright brothers' (Orville & Wilbur Wright, 1920) first flight in 1903. Though it started as a purely military operation with the landing of British Royal Air Force aircraft in a polo field in Maiduguri which marked the beginning of aviation practice (Diepriye & Onyinka, 2005). It gradually assumed the character of a civilian operation in the decades that followed (Decker, 2002). Thereafter, the Royal Air Force continued to operate in West Africa and by 1925, the British had stationed a squadron in the Sudan. The British commander sought approval from the Colonial Office in England to operate frequent cross-country flights from Khartoum to Maiduguri (Ejuka & Steve, 1987). By 1930, civil and military aircraft were carrying passengers across boundaries and touching down in places like Kano, Sokoto, Bauchi, Minna, Oshogbo and Lagos while British Imperial Airways embarked on regular passenger and mail services. Subsequently, Lagos and Accra became hubs for flights en-route to the Middle East and India. This was the beginning of aviation practice in Nigeria (Obitayo, 1998).

II. Problem Statement

Travelers experiencing long queuing for boarding and arrival at the airport is not only at the local airports but also a growing concern to the stakeholders at the international airports. These queues have led to loss of time, resources and contributed to creating health problems for some travelers while on queue in which some have even collapse and die in the process. A survey conducted by a travel website published by Punch Newspaper on the 17th of October 2015 supported the Bulletin of Department of Transport (DFT, 2014) which revealed that queuing has become a serious concern in both domestic and international Airports. The survey also submitted further that travelers have been raising issues on online discounted fares, pattern of arrival, service rate, service pattern, traffic intensity and delay experienced during queue by travelers at the Airport, Complaints about the airport services system which center on less capacity to service all arrivals and departures promptly in nearly all international airports, resulting into rowdiness, randomness, crowds, chaos, confusion, cancellation of flights, poor quality of services, inefficient of queuing system, increase in cost of operations and poor safety standard creating some waiting time before boarding were also identify as problems. Some studies conducted to assess different queuing problems reveals that adoption of single queue multiple server to address the problem of queuing in the banking sector has not adequately solved the problem of queuing in the banking sector (Adedoyin, Alawaye & Taofeek, 2014; Amos, Kenneth & Onuche, 2015; Anichebe & Agu, 2013; Baale, 2002; Muhammed & Heni, 2014; Odirichukwu, Tonye & Odii, 2014; Wallace, Christian & Frank, 2015).

Roshi and Ratnam (2015) used analogy dissection in examining the variability of aircraft passengers' movement problem with emphasis on rate of arrival and departure in India International Airport using single queue multiple server but could not address the problem of queuing at the airport. Also, Thagarag and Seshaiah (2014) adopted queuing model to analyse airport capacity and delay using analytical approach and simulation. They reveal that high traffic intensity created problem of queuing at the airport. However, Ademoh and Anosike (2014) used Single Queue Multi Server approach to develop a mathematical model to solve queuing problem of air transport passengers at Nnamdi Azikwe International Airport (NAIA) Abuja. Their studies revealed that despite the development of the mathematical model, the Airport continues to experience the problems of queue due to the type of queuing system applied creating unnecessary delay and ineffective services.

Notwithstanding the existing research from different literatures, it is evidenced that queuing still persists in a lot of sector with reference to Nigeria International Airports. However, there is need to introduce and use better model to minimize waiting time, reduced delays and improve efficiency in the aviation sectors particularly the airport service. This research therefore evaluates the existing model and develop an appropriate queuing model to enhance performance of Airport Services in Nigeria.

Objective of the Study

The objective of the study is to apply Multiple Queue Multiple Server Queuing Model to enhance the Performance of Airport Services in Nigeria by developing a structural model (or flow chart) to ease travelers flow within different operational servicing units in the Nigeria Airport.

III. Literature Review

Conceptual Review

Queue

A queue for the purpose of this study is the aggregation of travelers waiting for a service functions from the arrival to the service facilities (travelers flow) in terms of arrival rate, service rate, time spent both in the queue and in the system including service utilization and sometimes probabilities inclusive (Bluma, 2012). It is an everyday occurrences or part of our everyday life which result when the number of calling units exceeds the number of available service centers (Hiller & Lieberman, 2010). Queue is also noticed during working hours when we are joining bus, or driving cars to work, at phone boots, filling stations, at Airports when travelers queue to purchase tickets, in the hospital patience queue to see doctor, also in the banking hall and a lot of others. Consequently, since it has become part of our everyday life, what we need to do is to minimize the delay it might cause to some acceptable level. Queues are integral parts of any service system, which refers to the whole situation from arrival of inputs to departure (Medri, et al.,2009).

The problem of queuing involves a trade-off between the cost of travelers waiting time and the cost of providing faster service (Kalvaty, 2012). Researchers have argued that service waits can be controlled by operations management, in this context operations management deals with the management of how travelers queue and service coordinated towards the goal of rendering effective service at least cost, to achieve this, management needs to determine the optimum service points, minimize waiting time and other queuing parameters, and as well, coordinates the activities at the facilities with a complex system such as Banks, Airports, Hospitals "and so on" by using tools like Queuing Theory Model, Linear Programming Model, Simulation Model or any mathematical model which can be used to optimize performance measure of the system. (Joris, Dieter & Herwig, 2011).

Queuing System

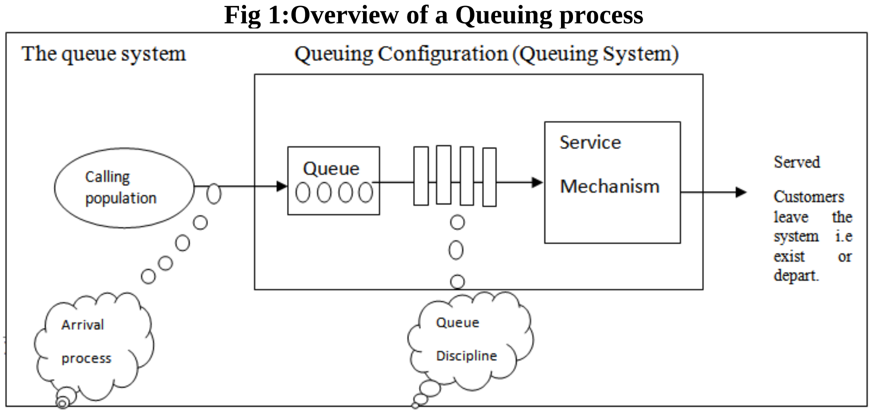
A queuing system is a system that follows either the arrival rate of travelers or arrival at service facilities or both which are subjected to control. Therefore, a queuing system can simply be described as travelers arriving for service, waiting for service if it is not immediate and if having waited for service, leaving the system after been served. The term "customers" is used in general term and not simply necessarily a human customer. For example, a customer could be a ball bearing waiting to be polished, an airplane waiting-in-line to take off, a computer programme waiting to be run, or a telephone call waiting to be answered (Taha, 2010; Amos, et al., 2015).

Queuing system causes inconvenience and economic loss to individuals and organizations. Hospitals, Airlines, Banks, Manufacturing Firms, Seaports and so on, which must be efficient in other to minimize the total waiting cost and the cost of providing service to their travelers. Therefore, speed of service is increasingly becoming a very important competitive parameter (Katz, Larson & Larson, 1991). Davis et al.(2003) asserted that providing ever-faster service with the ultimate goal of having zero travelers queuing process has recently received managerial attention for several reasons. First, in the more highly developed countries, where standard of living is high, time becomes more valuable as a commodity and consequently, travelers are less willing to wait for service. Secondly, there is a growing realization by organizations that the way they treat their travelers today significantly impact on whether or not their services will encourage traveler's loyalty. Finally, advances in technology such as global telephone link, computers and internet have provided firms with ability to provide faster services. Administrators, physicians and managers are continuously finding means to deliver faster services, believing that the waiting period will affect their service evaluation negatively, (Cooper & Schindler, 2010; Jacquillat & Odoni, 2015).

Fundamental of Queuing Theory

Queuing theory is a branch of operations research known as service system theory or wait in the line theory. It is used to study the objective of a service request generated by the randomness of travelers' arrivals and service rate (Trani, 2011). Queuing model in this context is used to approximate real queuing situation which are developed on the bases of queuing classified into input source and output queuing system, that is the arrival, the queue, the service mechanism and queue discipline (Event, 2013). Among the first developed model in queuing is the single queue, single-server model as illustrated in Fig 2.1. Single server model is a single server with single line of travelers, a situation where travelers arrived on a single line served by a single service facility or server step by step (Dawson, 2009). For any application of queuing model to any situation, the input process and output process should first be described (Blanc, 2011).

Fig 1:Overview of a Queuing process



Source: Design by the Researcher 2016.

Input and Output Process in Nigeria Airport Service

Input process as contained in the configuration of the queuing system is the arrival process of travelers in the airport where travelers arrive randomly from infinite or finite source (calling population). At this point, travelers arrived and join the queue awaiting service. In Airport service the group of individuals from which arrival comes into the system is referred to as the calling population with variance sizes (Blanc, 2011). At any point in time travelers arrived at the queue, need to be served following a specific queuing discipline, and after the service is performed, travelers leave the system (Hiller & Liberman, 2010). The provision of services using service discipline without been given any priority until when travelers leave the system is referred to as output process. An example of this brief description of input process and output process is shown below in Table 1.

Table 1: Input and Output process in the Nigeria airport services

Service Industry	Input Process	Output Process
Aviation (Airport)	Arrival of travelers at the airport, purchase tickets, boarding pass through various check point (Arrival rate and service rate)	Services discharge from check points to boardinglounge until after boarding (items waiting, waiting time, items in residence and residence time)

Source: Design by the Researcher 2016.

A very important point to be noted before proceeding with further discussion on the queuing system at the airport service is the capacity to handle the incoming travelers with a minimum delay so that travelers waiting time is a short-term phenomenon and servers who serve the travelers may be less busy while waiting for travelers to arrive (Event, 2013). Another important factor worth mentioning is the key word in queuing models "average" or "mean". In the output process where the model takes the average or mean of the random numbers of travelers arriving, service time, arrival intervals and so on (Sharma, 2012).

Characteristic of Queuing System

Queues are not an unfamiliar phenomenon and to define it requires specification of the characteristics or component which describes the queuing system, such as arrival pattern, queue, service channels (no of servers), queue discipline, service mechanism, system capacity and the exist. (Adedayo, et al., 2006). Medhi (2003) opined that the main characteristic that determines the appropriateness of a queuing system are the arrival, the queue, service channel or number of servers, queue discipline, service mechanism, system capacity and exist. While Sharma (2012) refers to the component as calling population (or input source) queue process, queue discipline, and service process (or mechanism including exist).

Pattern of Arrival

Pattern of arrival is the arrival of the entity at a service point. This process involves a degree of uncertainty concerning the exact arrival and the number of entities arriving. And to describe this process, there are some important attributes such as the sources of the arrivals, the size of each arrival, the grouping of such arrival and the inter-arrival times (Cooper & Shindler, 2010). The time between arrival otherwise called inter-arrival time could be probabilistic or deterministic in nature (Adedayo, *et. al,* 2006). Arrival can occur from infinite population (unlimited) or finite (limited or restricted population), (Sharma, 2012).

According to Davis, *et.al*, (2003) there are four main distinct part of queue that exist as shown in Fig 2 the pattern of arrival could be (controllable or uncontrollable); the size of arrival (could occur one at a time or in bulk); the distribution pattern (could be whether the time between arrival is constant or follows a particular statistical distribution such as a Poisson, exponential, Erlang and so on); and the degree of patience whether the arrival stay in line to complete the process before boarding or leave, not able to complete the process due to impatient or one problem or the other.

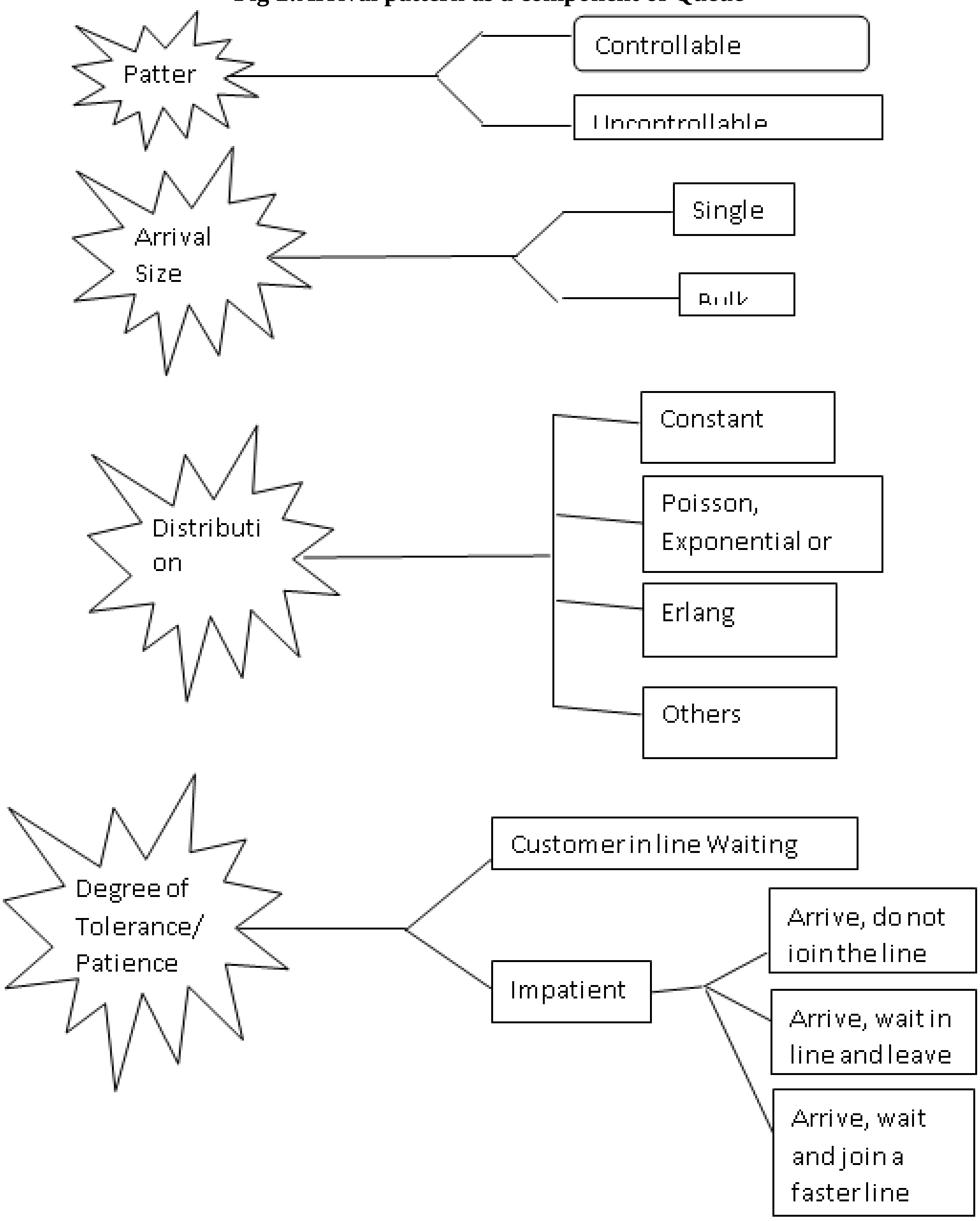
Queue behavior

Queue occurs when travelers wait before being attended to or before being served when the server is engaged. Queues exist when the arrival is more than the service facility which could be finite or infinite (Blanc, 2011). A queue is infinite when we have an unlimited number of travelers but it is finite when the capacity that contains it is small (Zoran & Brainslay, 2005).

Queue Discipline

Queue discipline refers to the priority rule by which travelers are served, that is the order in which items received service (Hillier & Lieberman, 2010). According to Olaniyi, (2014) and McGuire (2010) there are two main categories by which travelers are served which are pre-emptive priority: where the items in the queue are arranged so that the item with the highest priority in the system is served first and there is no displacement of items in service, while non-pre-emptive occur when the last item in the system were served first.

Fig 2:Arrival pattern as a component of Queue



Source: Davis, Aquilano & Chase (2003)

Also, Winston(2011) asserted that the common type of queue discipline is first come, first served (FCFS or FIFO), where customers are served in order of arrival. In this study the case airports use FCFS queuing discipline. Although, sometimes there are other service disciplines: last come, first served (which happens sometime in case of medical patients, diplomats and first-class travelers), or service-in-random order and priority rule. Davis *et al*, (2003) assert that reservation first, business class, first highest profit of travelers, largest orders, first best travelers, first best waiting time in line, and soonest promised date are other examples of queue discipline. Other discipline is service in random order where travelers are selected from the queue based on some order of priority (Taha, 2010).

Service Mechanism

Service mechanism describes the number of servers, the number of travelers being served at any time, duration and mode of service which could be either constant or random. If the service time is constant, it takes the same amount of time to take care of each traveler and if random, the service time may vary greatly. Travelers arriving who finds out that, one free server may choose at random any one of the servers for receiving service and if he finds that the server is busy he may join a queue common to all servers, this is evident when travelers are purchasing tickets at the Airports. The first travelers from the common queue goes to the server who becomes free first (Odirichukwu, *et al* 2014).

Queue System Capacity

According to Kobayachi & Mark (2009), Capacity of the system may be finite with limited number of travelers or infinite with unlimited number of travelers where queue may grow to any size. Furthermore, space provided may be limited and filled to capacity to the extent that an arrival will not be able to join the system and will be lost to the system. The system is called a *delay system* or a *loss system,* according to whether the capacity is infinite or finite respectively (Medhi, 2003).

Exit/Departure

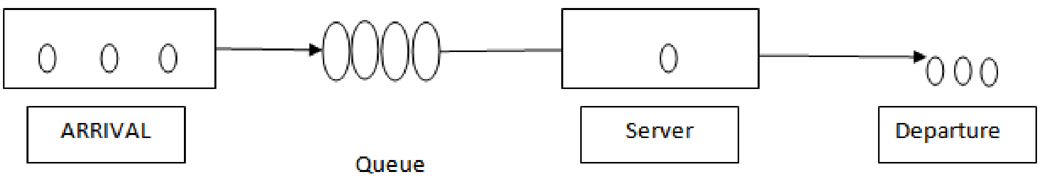
After travelers arrive and served at the service facility by the server, he or she leaves the service facility and assumed that such travelers may not returning to the system (Kobayachi & Mark 2009)

Types of queuing System Structure

Thereexists various queuing system structure in literature, however among these various types according to (Hui, &Tao2000; Artalejo& Gomez-Corral, 2008) are categorized into four queuing system structure and parameters.

Single-Server Single Queue System: This is a structure in which single queue of travelers are formed and served by a single service facility or by a single server one after the other. Example is travelers queue at the Nigeria airport, queuing for tickets, before exist as shown in Fig 2.

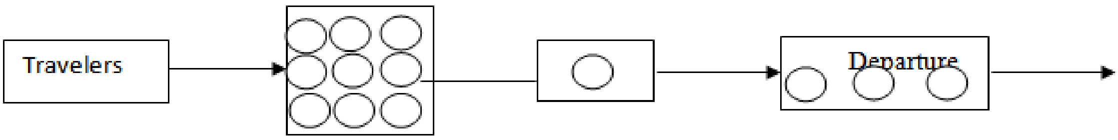
Fig 3: Single Queue Single-Server System



Source: Adedayo, Ojo and Obamiro (2006) Queue

Single-Server Multiple Queue System: In this situation there exist a multiple queue with travelers being served at each service facilities in series. This is illustrated in Fig: 4 for example, travelers arrived at the airport to purchase ticket, and passes through the respective servers like boarding pass, luggage checks, security checks before boarding.

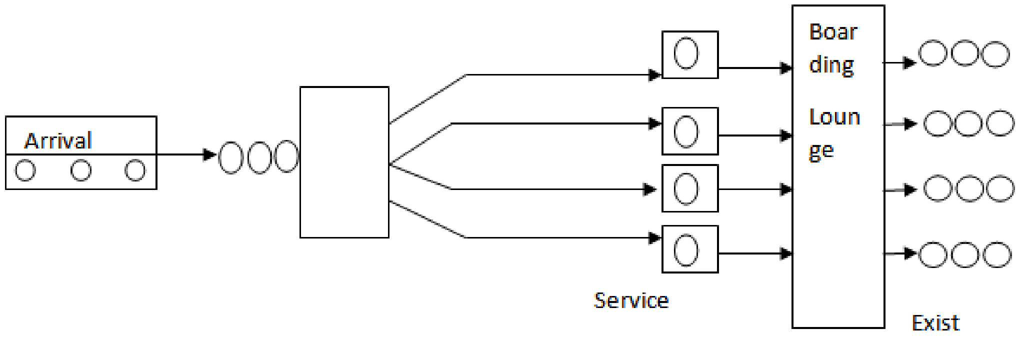
Fig 4: Single server multiple queuing system



Source: Adedayo, Ojo and Obamiro (2006)

Multiple server single queue System: This is the type of a queuing system whereby thereexists more than one service facility (servers) providing identical services but drown on single waiting line. This is evident from travelers after purchase of ticket move to various checking points before exist as Illustrated in Fig 5 (Medri, *et.al* 2009; Blanc, 2011).

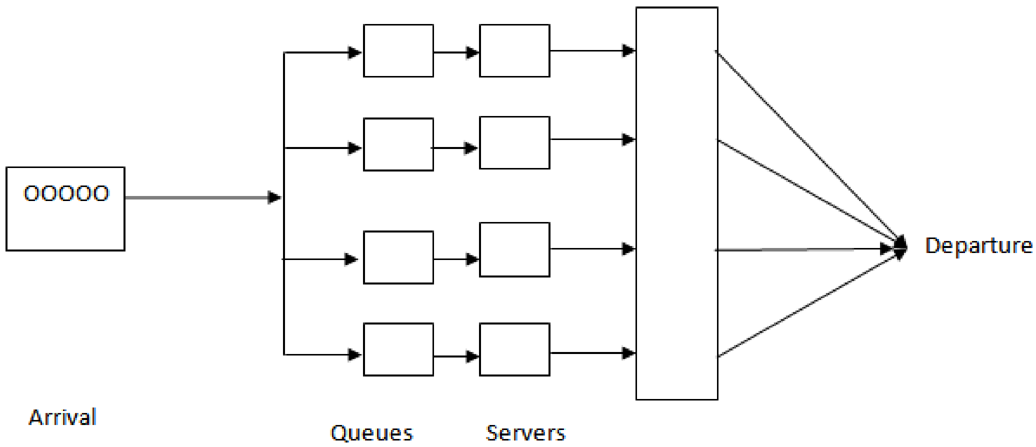
Fig 5: Multiple Server Single Queue System



Source: Medri, etal. (2009); Blanc (2011)

Multiple Server Multiple Queue System (or Parallel Queue): Medri, et al. (2009) opined that this type of queuing system has various numbers of queues and complex network of multiple servers involved as can be depicted in Fig 6. This is the type of queuing model that is adopted in this study.

Fig 6:Multiple Server Multiple Queue System in Parallel



Source: Medri, et.al (2009)

IV. Theoretical Framework

Queuing Theory

Queuing theory was developed by Erlang in 1904 as the oldest and most widely used quantitative technique for analysis in management. Erlang in 1909 in his paper titled the theory of probability and telephone conversation laid the foundation for Poisson and exponential distribution in queuing theory as a tool for performance evaluation in management. At the end of World War II, Erlang early work was extended to more general problems thereafter, it has been extensively practiced or utilized in industry settings or retail sector-operations management under the purview of decision analysis and to business application of queuing (Odior, 2013). Queuing theory can be very useful in identifying appropriate level of staff, equipment and birds in making decisions about resource allocation and design a new service (Vaze& Barnhart, 2012). Kendall (1953) was the pioneer who viewed and developed queuing theory from the perspective of stochastic queuing process. The literature on queuing theory and diverse areas of its applications as grown tremendously (Event, 2013).

Grossand Harris (2016);Odior, (2013) state that queuing theory is a collection of mathematical models of various queuing process. It is used extensively to analyze production and service processes exhibiting random variability in market demand (arrival time) and service time. This line of thought is in agreement with the views of (Christensen, 2006; Akinuli, 2015).Taha (2010) opined that queuing theory is part of the mathematical theory of the formation and behaviour of queue or waiting lines.

Kalavaty (2012) opined that queuing theory is an operations management approach that developed a numerical approximation scheme to estimate the state probabilities of the system over time, allowing estimate of average delay and average queue size to be calculated. Sharma (2012) further developed the solution method with the theory and provide the approach's appropriateness for application to time- varying queues in airport system. Queuing theory provide managers/airport operators with a useful set of decision making formulas and algorithms for the designing of airport system and services (Ronald, 2009). The problem of jointly selecting runway configurations and the balance of arrival and departure service rate were first formulated by Bertsimas, Frankovich& Odoni (2011) as an Integer Program based on deterministic queue dynamics. Jacquillat, *et al.* (2014) design a programme on Dynamics that can be used to solve the problem of stochastic queue dynamics and stochastic operating conditions. They showed that stochastic modeling of airport operations in terms of service utilization has significant impact on optimal policies.

Assumptions of Queuing Model

Hui& Tao (2000); Hiller & Liberman (2005) opined that a single channel style system model is one of the most widely used and simplest queuing model in a queuing system with the following assumptions which must be carefully studied.

1. Arrival are independent of preceding arrival, but the average number of arrivals (arrival rate) does not change over time
2. Arrival rate is described by a Poisson probability and come from an infinite source or from a very large population
3. Service time occur according to a specific probability distribution in particular according to exponential probability distribution
4. Every arrival waits to be served regardless of the line
5. Arrival are served on a first come first serve basis
6. Service time varies from one traveler to the next and are independent of one another with a known average rate.
7. The average service rate must be higher than the average arrival rate and the available space for travelers waiting in the queue must be infinite or unlimited.

V. Resarch Methods

This study adopted observational and ex-post facto methods. Observation method was used to gain insight into the movement of travelers at the airport without making attempt to control them by observing their arrival pattern, number of servers, service pattern at various service points. While ex-post facto was adopted to have access to past records of travelers arrival and departure from the airports through the use of data from manifest, memos and publications by Federal Airport Authority of Nigeria (FAAN), Annual reports, international journals, in-house published journals of the industry, particularly from National Civil Aviation Authority (NCAA), the regulatory body of the industry who is responsible for data gathering. The population of this study is finite and infinite in nature,the finite in this case is the entire international airports in Nigeria, Murtala Muhammed International Airport Lagos, Nnamdi Azikwe International Airport Abuja, Port Harcourt International Airport Port Harcourt, Mallam Aminu Kano International Airport Kano, Akwa-Ibom International Airport Enugu, Sam Mbakwe International Airport Owerri while the infinite population of the study consists of the entire travelers in the international airport who are coming from infinite population source.Because it is not feasible to cover the entire international airports and travellers in Nigeria's airports, purposive sampling procedure was used to select the two international airports that are more saturated and busy in terms of human traffic in Nigeria while Cochran (1977) was used to determine the sample size of (246) travelers at the two airports. They are Murtala Muhammed International Airport Lagos and Nnamdi Azikwe International Airport, Abuja. The two airports serve as the main aviation hub with the massive traffic of travelers departing and arriving the facilities for official, commercial, business and personal activities in the aviation industry (Odufunwa *et al*, 2008).). In using observation methods, travelers were observed so as to obtain information on their arrival and service time for a particular time period. Walliman (2011) asserted that observation entails systematic noting and recording of events, behaviours and artifacts (objects) in the social settings chosen for the study, the observational record is frequently referred to as field notes- detailed, non-judgmental, concrete description of what has been observed.Data collected were analyzed and presented using descriptive statistical tools, mathematical queuing formulas and TORA Optimization tool.

Traffic Intensity Experienced In The Nigeria Airport Services (Jan-Dec 2015)

The computed result for Traffic intensity experienced at both airports are given as server utilization of ten (10) and presented in Table 2.

Ws column from TORA Output showed the average time traveler spends in the system including the service time, while Wq is the average time travelers wait in the queue before being served. Therefore, for ten servers in Table 2, average time spent in the system (Ws) which include the waiting time and service time was 0.10537 hours (6.322 minutes), while the average time travelers wait in the queue for getting served (Wq) was 0.00 hours (0.00 minutes) which implies that as traveler arrived, they are served with increase in number of servers used.Ls column from TORA output in Table 2 shows the average number of travelers in the system for each month. The column indicated that on average 1.05 traveler approximately one traveler will be in the system at a time and average of zero will be in the queue (L_q) with more servers. However, the essence of the number of hours as shown in the analytical queuing solution was to derive the accurate hours or minutes a traveler is likely to stay in the system before departing or boarding the Aircraft considering the current queuing system in the airports.

Table 2: TORA Output for 10 servers

	Λ	μ	Po	Ls	Lq	ws (hrs)	Wq (hrs)	*Ws* (mins)	*Wq* (mins)
JANUARY	239.41	232.40	0.35695	1.03016	0	0.0043	0	*0.258*	*0*
FEBRUARY	214.59	210.28	0.36042	1.0205	0	0.00476	0	*0.2856*	*0*
MARCH	220.59	216.15	0.3604	1.02054	0	0.00463	0	*0.2778*	*0*
APRIL	220.59	216.15	0.3604	1.02054	0	0.00463	0	*0.2778*	*0*
MAY	223.23	217.58	0.35845	1.02597	0	0.0046	0	*0.276*	*0*
JUNE	215.81	208.57	0.35533	1.03471	0	0.00479	0	*0.2874*	*0*
JULY	236.99	231.38	0.35907	1.02425	0	0.00432	0	*0.2592*	*0*
AUGUST	289.08	282.02	0.35878	1.02503	0	0.00355	0	*0.213*	*0*
SEPTEMBER	245.92	240.10	0.35907	1.02424	0	0.00416	0	*0.2496*	*0*
OCTOBER	227.74	220.76	0.35643	1.03162	0	0.00453	0	*0.2718*	*0*
NOVEMBER	216.51	210.66	0.3578	1.02777	0	0.00475	0	*0.285*	*0*
DECEMBER	256.51	248.15	0.35569	1.03369	0	0.00403	0	*0.2418*	*0*

λ (9.97), μ (9.49), L_S (1.0508), W_S (0.10537)(6.32mins), Rholc (0.1026), L_q=0&W_q=0

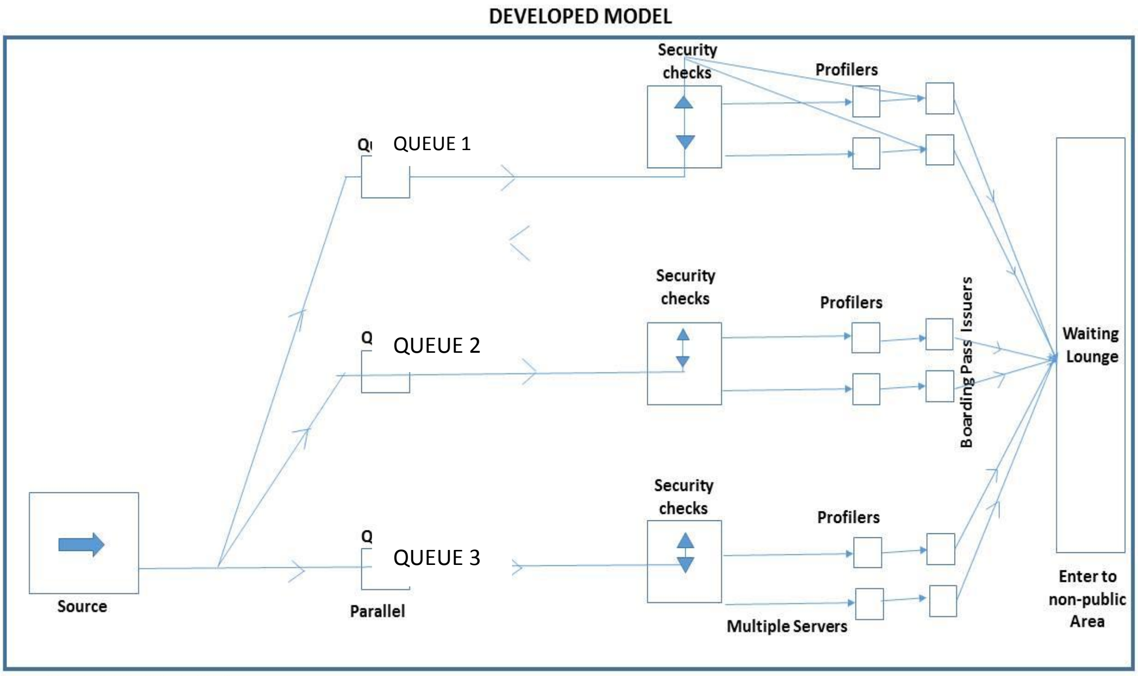
λ (9.97), μ (9.49), L_S (1.0508), W_S (0.10537)(6.32mins), Rholc (0.1026), L_q =0&W_q=0

Source: Researcher's Computation, 2017

STRUCTURAL MODEL FOR BOTH AIRPORTS (MMIA AND NAIA)

The model developed is a closed dynamic system on the basis of the layout of the whole system. Travelers come from the source which represents the initial access to the check-in system and queue for check-in desks, move from security checks to profilers and subsequently to the boarding pass issuers for collection of their boarding pass and after, enter into the non-public area (Waiting Lounge).

Multiple Queue Multiple Server Model in Parallel



Source: By Researcher 2017

This model was practically put in operation at the two Airports used for this study, with the aid and assistance of the operation managers after obtaining the required authorization.observational data were collected for three (3) consecutive days on travelers and result of the analysis of the travelers at departure wing of both Airports from 6 airlines using an Erlang's delay probability- a queuing multiple model with a fixed but varied number of servers and limited space. The emphasis here is not ascertaining the effectiveness and efficiency of the system only but also using performance parameters to determine the probability that travelers are delayed waiting for boarding. As pointed out in A/B/S model, we assume Markovian arrival and service time (LOS). Number of servers used during observation varied for different number of Airlines to ascertain and determine the impact of travelers delay before boarding. One merit of using this model is that it allows probability of delay to be easily computed with known arrival rate and service rate with probable number of services (Irefen, et al. 2007). Data were collected based on arrival and service rate at both Airports for various airlines. Multiple queue multiple server in parallel were introduced for each airline with varying servers.

Table 3: Queuing Analysis of Travelers at each Airline of the Departure Wing for MMIA and NAIA

	Airline1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6
λ	155.50	137.80	146.90	179.73	214.13	181.37
μ	56.86667	64.63	60.06667	73.83333	76.73333	66.2
No of servers	3	4	5	6	8	10
Rho/c	0.911489	53%	49%	41%	35%	27%
Po	0.02177	11%	8%	9%	6%	6%
Ls	11.35	2.35	2.56	2.46	2.8	2.74
Lq	8.61737	0.23	0.11	0.02	0.005	0.00022
Ws	0.073	0.01716	0.001744	0.01305	0.01305	0.01511
Wq	0.05542	0.00168	0.00079	0.00016	0.00002	0.00000

Source: Field Survey 2017

The probability that servers for airline 1 are all busy is 0.9115 (91%) while the probability that there are no travelers in the system is 0.0218 (2%), the average number of travelers in the system (in waiting line and being served) is 11.35 travelers per hour, while the average number of travelers waiting in a queue per hour is 8.62 travelers. The average time a traveler spends in the system (in waiting line and being served) is 4.38 mins, while the average time a traveler spends waiting in line for service is 3.3mins with length of stay (LOS) given as 1.08 mins invariably airlines with higher servers between 6 and 10 servers have lesser (LOS) than other airlines.

VI. Discussion of Findings

However, three (3) days observations of the travelers' movement at 6 airlines desk at the chosen airport with the introduction of multiple queue multiple server in parallel model developed reveals that travelers delay before boarding was minimal compared to the single queue multiple server currently in use for all airlines. The probability that there are no travelers in the system is 7%. On the average for the 6 airlines, number of customer in the system is 4.04 travelers, while the average number of travelers waiting in a queue per hour is 1.49. The average time traveler spent in the system (wait-inline and been served) is 0.022(1.33minute) while the average time a traveler spends in the queue waiting for service is 0.0096(0.58minutes). This shows that the average time a traveler spent in waiting for service is approximately 1 min showing the effectiveness of the developed model. This is in line with Adedayo et al, (2006) that indicated that the closer the traffic intensity of a queue system is to zero, the more effective the operations of the server of the queue system is noted to be and this server would have less queues giving rise to an effective queuing structure. This study's findings are novel and part of the study's contribution to knowledge

VII. Conclusion

The introduction of multiple queue multiple server in parallel shows that the average time a traveler spends in waiting for service was approximately 1 min which minimize wait-in-line in the system compared to the current model in used where on average a traveler spent 6.33 minutes in the system and invariably reduces probabilities.

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