# ANALYSIS OF TRAFFIC CONGESTION AND TRAVEL TIME USING QUEUING MODEL: A CASE STUDY OF IWO ROAD INTERSECTION, IBADAN, OYO STATE, NIGERIA

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**Abstract**
One of the problems in a developing country like Nigeria is traffic congestion. It is an increasing problem in urban areas as it increases travel duration. Traffic congestion at intersection is on the increase in Ibadan since the number of vehicles increase per minute, which eventually lead to traffic delay. The study was conducted at the Iwo Road intersection in Ibadan, the capital of Oyo State. The data collection was done by observation and tallying. The observation and manual counting were done during the peak traffic periods and off-peak periods (7:30 am – 8:30 am; 8:30 am - 9:30 am; 4:00 pm- 5:00 pm; 5:00 pm- 6:00 pm). The method of analysis used in this paper is the multiple server queuing modeling system (M/M/S): (/FCFS). The traffic intensity was obtained and we also computed the average number of vehicles in the system and in the queue. We obtained the average waiting time of vehicles in the system and in the queue using the M/M/S queuing model to analyze the queuing characteristics at the intersection. The result of the analysis showed that the traffic situation is intense on Mondays, Saturdays and Sundays. Hence, we have been able to show that queuing model is applicable at the Iwo Road and established that the flow of vehicles through the intersection is more than the capacity of the intersections.

**Keywords**: Traffic Congestion, Queuing Theory, M/M/S Queuing Model, Traffic Intensity.

## 1.0 INTRODUCTION

Manoj *et al.,* (2019) stated that the role of transportation in human life cannot be overemphasized. According to Irunokhai *et al.,*(2020) transportation is an important aspect of human civilization as it reflects the economic level and technological advancement of a given society. We can also see that high volume of vehicles, the inadequate infrastructure and irrational distribution of development are the main reasons for increasing traffic jam, when vehicles are forced to stay in a place for a long time, Traffic jam makes drivers to get enraged and take harsh decisions. Nigeria's road infrastructure and development has lagged behind prominently in most parts of the country. This as stated in Aderinola *et al.,*(2020) is most noticeable in rural areas. Operation research is a quantitative approach that solves problems using a varied number of mathematical techniques. It is the scientific study of operations for the purpose of making better decisions. Queuing theory was developed in 1909 by A.K Erlang, a Danish telephone engineer in an attempt to study arrival of telephone calls in a telephone exchange (Brockmeyer *et al.,*1948). In this work we use the M/M/S queuing model. In the usual Kendall's notation, the first M in M/M/S, indicates that the arrival times follow a Poisson distribution, the second M indicates exponential service times, while S in the notation indicates that there are multiple servers.. According to the work of Aderinola *et al.,*(2020), the assumptions associated with this type of queuing model are: arrivals are at random at the server stations and follow a First-In, First-Out (FIFO) queue discipline, with no balking and no reneging, they are independent of each other; arrivals follow the Poisson distribution; the service times follow the negative exponential distribution. The service times are also independent of each other but with known average. It is also assumed in the M/M/S queuing model that the average departure rate $\mu$ is greater than average arrival rate $\lambda$. Manoj *et al.,* (2019) have shown that there is a need to study the intersections, intensities, and maintain social order. Several authors in the literature including; Adeleke and Adebiyi (2005, Ajayi and Girish (2013) and Akmaz and Celik (2016), have applied queueing theory in a variety of circumstances with some useful results. Martin et al (2013) applied queueing theory to vehicular traffic at a signalized intersection by considering the performance measures. The work of Tsetimi and Orighoyegha (2021) used the M/M/S model to solve the problem of congestions on petroleum tank farms, in which the expansion of existing service channels was recommended in order to optimize quality service delivery and efficiency in the system. Tsetimi (2013), stated in his work that queuing models can be used to represent a wide variety of manufacturing systems. He also indicated that application of these models is usually differentiated by data randomness and time dependency in which two main types stand out, namely: deterministic and stochastic models. Multistage manufacturing systems involve n $\geq$ 2 finite number of stages. While some multistage manufacturing systems produce a single product, many such systems involve multiproduct production lines. The survey of some queuing models in multistage manufacturing systems by Tsetimi (2013) shows that queuing models are readily adapted in multistage manufacturing systems because of the nature of such systems. He also went further to explain that multistage manufacturing systems are real life situations and as such some of the assumptions for classical queuing models may not hold in many cases. Thus, he further stated that in the solution methodology for some queuing models in multistage manufacturing systems that there is ample use of heuristics. As a follow-up to this work, the present work takes a look at the solution methodology with special emphasis on the use of heuristics for queuing models in multistage manufacturing systems. According to Tsetimi (2007), the nature of multistage manufacturing systems enhances the use of queuing models as the backbone modeling technique for such systems. Queues involve waiting, multistage manufacturing systems involve several stages and the downstream stages generally have to wait for inputs from the upstream stages.

## 2.0 DESCRIPTION OF STUDY AREA

Ibadan is located in Oyo State, Nigeria and is made up of largely Yoruba speaking individuals. It is known as the largest indigenous city in Nigeria with a total area of 3,080 square kilometers. Ibadan was founded in the nineteenth century, at about 1829. Total population of the five local government areas is 1,889,776, while that of the outlying communities is 1,413,018. It is not a city of remote antiquity, but it is highly metropolitan and urbanized. The study was conducted in Ibadan metropolis the capital state, which is the third largest metropolitan area by population in Nigeria after Lagos and Kano. It is made up of eleven local government areas. In 2006, the commission, put the population growth rate at 3.18% and the city's population was estimated to be 3,565,108. The rate which the population of Ibadan is growing has significant implications for traffic congestion. As the city is rapidly expanding in area and population, traffic congestion has become a major problem in the city.

## 3.0 DATA COLLECTION METHOD

In order to ascertain the waiting time of commuters and vehicles during road traffic situation, there are various techniques and methods used in traffic survey (traffic counting) but for the purpose of this paper, the data collection was done by manual counting. The observation was made during the peak traffic periods and off peak periods

(7:30 am – 8:30 am; 8:30 am - 9:30 am; 4:00 pm- 5:00 pm; 5:00 pm- 6:00 pm).

**4.0 METHOD OF ANALYSIS**

In this work we use the M/M/S with a *first-come-first-serve* (FCFS) queue discipline. It is the most widely used queuing system in analysis. It is a good approximation for a large number of queuing systems. The queuing system assumes Poisson arrival process with rate $\lambda$ and the departure rate with parameter $\mu$. In this system, it is assumed that all vehicles are independent i.e their decisions to use the system are independent of each other which is clearly stated in the work of Farayibi & Adesoji (2016). An M/M/S queuing calculator was used in analyzing the data collected.

**5.0 M/M/S: (∞/FCFS) QUEUING MODEL**

In this queuing system, there is more than one service channel in which the number of vehicles in the queuing system is greater than the number of service channels, a queue is formed. In this model, the first M denotes the Poisson arrival or exponential inter arrival time while the second M denotes the Poisson departure or exponential service times and S denotes the multiple server or channels. Departure rate at each channel is the same as $\mu$ which is clearly stated in the work of Farayibi & Adesoji (2016).

**6.0 THE MULTIPLE - SERVER QUEUING MODEL (M/M/S)**

The model begins with the computations of

$$\rho = \frac{\lambda}{s\mu} \quad for\ S \geq 2$$

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

$$N_s = \frac{\lambda\mu\left(\frac{\lambda}{\mu}\right)^s}{(s-1)!\,(s\mu-\lambda)^2} P_0 + \frac{\lambda}{\mu}$$

$$N_q = N_s - \frac{\lambda}{\mu}$$

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

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

$$P(n \geq s) = \frac{\mu\left(\frac{\lambda}{\mu}\right)^s}{(s-1)!}(s\mu - \lambda)P_0$$

$$P(n < s) = 1 - P(n \geq s)$$

where,

S = Number of service channel

$\lambda$ = Mean arrival rate

$\mu$ = Mean service rate

$\rho$ = traffic intensity

$P_0$ = Probability of having no vehicle in the system

$P(n \geq s)$ = probability that a vehicle has to wait

$P(n < s)$ = probability that a vehicle enters the system without waiting

$N_s$ = Expected number of vehicles in the system

$N_q$ = Expected number of vehicles in the queue

$W_s$ = Average waiting time in the system

$W_q$ = Average waiting time on queue

**6.1 Computation for multiple – server case (M/M/S) –** $s \geq 2$

For $n = 1,2, \dots, S,$

$$C_n = \left(\frac{\lambda\mu}{n!}\right)^n \qquad (1)$$

For $n = s, s+1, \dots$

$$C_n = \frac{(\lambda\mu)^n}{s!\, s^{n-s}} \qquad (2)$$

$$P_0 = \frac{1}{\left[\sum_{n=0}^{s-1} \frac{\left(\frac{\lambda}{\mu}\right)^n}{n!} + \frac{\left(\frac{\lambda}{\mu}\right)^s}{s!}\left(\frac{s\mu}{s\mu-\lambda}\right)\right]} \qquad (3)$$

$$N_s = \frac{\lambda\mu\left(\frac{\lambda}{\mu}\right)^s}{(s-1)!\,(s\mu-\lambda)^2} P_0 + \frac{\lambda}{\mu} \qquad (4)$$

$$P(n \geq s) = \frac{\mu\left(\frac{\lambda}{\mu}\right)^s}{(s-1)!} (s\mu - \lambda) P_0 \qquad (5)$$

$$P(n < s) = 1 - P(n \geq s) \qquad (6)$$

$$N_q = N_s - \frac{\lambda}{\mu} \qquad (7)$$

$$W_s = \frac{N_s}{\lambda} \qquad (8)$$

$$W_q = \frac{N_q}{\lambda} \qquad (9)$$

Equations 1 – 9 are used to calculate the relevant parameters for our models. We also applied Equations 10 – 16 for the traffic intensity and measures of performance. The calculated values are presented in Tables 3 – 10. Tables 1 shows the observed per minute arrival and departure times of vehicles at New Ife Road. Similarly, the observed per minute arrival and departure times of vehicles Olodo Road are shown in Table 2.

**Table 1: Per minute arrival and departure of vehicles for seven days at New Ife Road**

| Day | Time | Number of vehicles arriving | Number of vehicles departing |
|---|---|---|---|
| Monday | 7:30am – 8:30am | 49 | 25 |
| | 8:30am – 9:30am | 52 | 28 |
| | 4:00pm – 5:00pm | 37 | 19 |
| | 5:00pm – 6:00pm | 45 | 24 |
| Tuesday | 7:30am – 8:30am | 54 | 30 |
| | 8:30am – 9:30am | 47 | 26 |
| | 4:00pm – 5:00pm | 53 | 30 |
| | 5:00pm – 6:00pm | 40 | 22 |
| Wednesday | 7:30am – 8:30am | 40 | 30 |
| | 8:30am – 9:30am | 53 | 37 |
| | 4:00pm – 5:00pm | 46 | 28 |
| | 5:00pm – 6:00pm | 41 | 25 |
| Thursday | 7:30am – 8:30am | 39 | 28 |
| | 8:30am – 9:30am | 46 | 26 |
| | 4:00pm – 5:00pm | 49 | 30 |
| | 5:00pm – 6:00pm | 49 | 26 |
| Friday | 7:30am – 8:30am | 55 | 30 |
| | 8:30am – 9:30am | 54 | 29 |
| | 4:00pm – 5:00pm | 42 | 22 |
| | 5:00pm – 6:00pm | 59 | 31 |
| Saturday | 7:30am – 8:30am | 54 | 26 |
| | 8:30am – 9:30am | 58 | 30 |
| | 4:00pm – 5:00pm | 54 | 28 |
| | 5:00pm – 6:00pm | 53 | 27 |
| Sunday | 7:30am – 8:30am | 42 | 22 |
| | 8:30am – 9:30am | 58 | 30 |
| | 4:00pm – 5:00pm | 43 | 27 |
| | 5:00pm – 6:00pm | 41 | 26 |

**Table 2: Per minute arrival and departure of vehicles for seven days at Olodo Road.**

| Day | Time | Number of vehicles arriving | Number of vehicles departing |
|---|---|---|---|
| Monday | 7:30am – 8:30am | 48 | 20 |
| | 8:30am – 9:30am | 55 | 24 |
| | 4:00pm – 5:00pm | 59 | 26 |
| | 5:00pm – 6:00pm | 52 | 28 |
| Tuesday | 7:30am – 8:30am | 48 | 30 |
| | 8:30am – 9:30am | 48 | 29 |
| | 4:00pm – 5:00pm | 50 | 29 |
| | 5:00pm – 6:00pm | 54 | 31 |
| Wednesday | 7:30am – 8:30am | 48 | 35 |
| | 8:30am – 9:30am | 53 | 30 |
| | 4:00pm – 5:00pm | 49 | 29 |
| | 5:00pm – 6:00pm | 55 | 30 |
| Thursday | 7:30am – 8:30am | 58 | 35 |
| | 8:30am – 9:30am | 48 | 32 |
| | 4:00pm – 5:00pm | 45 | 35 |
| | 5:00pm – 6:00pm | 45 | 25 |
| Friday | 7:30am – 8:30am | 49 | 21 |
| | 8:30am – 9:30am | 52 | 28 |
| | 4:00pm – 5:00pm | 52 | 27 |
| | 5:00pm – 6:00pm | 47 | 23 |
| Saturday | 7:30am – 8:30am | 45 | 25 |
| | 8:30am – 9:30am | 52 | 29 |
| | 4:00pm – 5:00pm | 59 | 30 |
| | 5:00pm – 6:00pm | 45 | 23 |
| Sunday | 7:30am – 8:30am | 49 | 21 |
| | 8:30am – 9:30am | 52 | 23 |
| | 4:00pm – 5:00pm | 54 | 25 |
| | 5:00pm – 6:00pm | 47 | 22 |

## 7.0 TRAFFIC INTENSITY AND MEASURES OF PERFORMANCE

The following formulae are for measuring traffic intensity and performance at Iwo road intersection

i. Probability of having no vehicle in the system

$$P_0 = \frac{1}{[\sum_{n=0}^{s-1} \frac{\left(\frac{\lambda}{\mu}\right)^n}{n!} + \frac{\left(\frac{\lambda}{\mu}\right)^s}{s!}\left(\frac{s\mu}{s\mu-\lambda}\right)]} \qquad (10)$$

$\rho = \frac{\lambda}{s\mu}$ = traffic intensity $, for\ S \geq 2$

S = number of service channels

$\lambda$ = mean arrival rate

$\mu$ = mean service rate

ii. The expected number of vehicle in the queue

$$N_q = N_s - \frac{\lambda}{\mu} \qquad (11)$$

iii. The expected number of vehicle in the system

$$N_s = N_q + \frac{\lambda}{\mu} \tag{12}$$

Also,

$$N_q = \frac{\lambda\mu\left(\frac{\lambda}{\mu}\right)^2}{(s-1)!\,(s\mu-\lambda)^2} P_0 \tag{13}$$

iv. The average waiting time in the queue

$$W_q = \frac{N_q}{\lambda} \tag{14}$$

v. The average waiting time in the system

$$W_s = \frac{N_s}{\lambda} \tag{15}$$

vi. The probability that a vehicle has to wait

$$P(n \geq s) = \frac{\mu\left(\frac{\lambda}{\mu}\right)^s}{(s-1)!}(s\mu-\lambda) P_0 \tag{16}$$

**8.0 PRESENTATION AND ANALYSIS OF DATA**

Table 3 and Table 4 indicate the Day, Time, Arrival rate $(\lambda)$, Departure rate $(\mu)$, Traffic intensity $(\rho)$, Average number of vehicles in the system $(N_s)$, Average number of vehicles in the queue $(N_q)$, Average time spent in the system $(W_s)$ and Average time spent in the queue $(W_q)$.

**Table 3: Performance measure analysis for New Ife Road using M/M/2 queuing model**

| DAY | TIME | $\lambda$ | $\mu$ | $\rho$ | $N_s$ | $N_q$ | $W_s$ | $W_q$ |
|---|---|---|---|---|---|---|---|---|
| Monday | 7:30am – 8:30am | 49 | 25 | 0.9800 | 49 | 47 | 1.010 | 0.970 |
| | 8:30am – 9:30am | 52 | 28 | 0.9285 | 13 | 12 | 0.259 | 0.224 |
| | 4:00pm – 5:00pm | 37 | 19 | 0.9736 | 37 | 35 | 1.013 | 0.961 |
| | 5:00pm – 6:00pm | 45 | 24 | 0.9375 | 15 | 13 | 0.344 | 0.302 |
| Tuesday | 7:30am – 8:30am | 54 | 30 | 0.9000 | 9 | 8 | 0.175 | 0.175 |
| | 8:30am – 9:30am | 47 | 26 | 0.9038 | 10 | 8 | 0.210 | 0.172 |
| | 4:00pm – 5:00pm | 53 | 30 | 0.8833 | 8 | 6 | 0.152 | 0.118 |
| | 5:00pm – 6:00pm | 40 | 22 | 0.9090 | 10 | 9 | 0.262 | 0.216 |
| Wednesday | 7:30am – 8:30am | 40 | 30 | 0.6667 | 2 | 1 | 0.060 | 0.027 |
| | 8:30am – 9:30am | 53 | 37 | 0.7162 | 3 | 1 | 0.055 | 0.028 |
| | 4:00pm – 5:00pm | 46 | 28 | 0.8214 | 5 | 3 | 0.110 | 0.074 |
| | 5:00pm – 6:00pm | 41 | 25 | 0.8200 | 5 | 3 | 0.122 | 0.082 |
| Thursday | 7:30am – 8:30am | 39 | 28 | 0.6964 | 3 | 1 | 0.069 | 0.034 |
| | 8:30am – 9:30am | 46 | 26 | 0.8846 | 8 | 6 | 0.177 | 0.138 |
| | 4:00pm – 5:00pm | 49 | 30 | 0.8166 | 5 | 3 | 0.100 | 0.067 |
| | 5:00pm – 6:00pm | 49 | 26 | 0.9423 | 17 | 15 | 0.343 | 0.305 |
| Friday | 7:30am – 8:30am | 55 | 30 | 0.9166 | 11 | 10 | 0.209 | 0.175 |
| | 8:30am – 9:30am | 54 | 29 | 0.9310 | 14 | 12 | 0.259 | 0.224 |
| | 4:00pm – 5:00pm | 42 | 22 | 0.9545 | 21 | 19 | 0.512 | 0.466 |
| | 5:00pm – 6:00pm | 59 | 31 | 0.9516 | 20 | 18 | 0.342 | 0.309 |
| Saturday | 7:30am – 8:30am | 54 | 26 | 1.0380 | 27 | 29 | 0.496 | 0.535 |
| | 8:30am – 9:30am | 58 | 30 | 0.9667 | 29 | 27 | 0.508 | 0.475 |
| | 4:00pm – 5:00pm | 54 | 28 | 0.9642 | 27 | 25 | 0.509 | 0.473 |
| | 5:00pm – 6:00pm | 53 | 27 | 0.9814 | 53 | 51 | 1.009 | 0.970 |
| Sunday | 7:30am – 8:30am | 42 | 22 | 0.9545 | 21 | 19 | 0.512 | 0.466 |
| | 8:30am – 9:30am | 58 | 30 | 0.9667 | 29 | 21 | 0.508 | 0.475 |
| | 4:00pm – 5:00pm | 43 | 27 | 0.7963 | 4 | 3 | 0.101 | 0.064 |
| | 5:00pm – 6:00pm | 41 | 26 | 0.7885 | 4 | 3 | 0.102 | 0.063 |

**Table 4: Performance measure analysis for Olodo Road using M/M/2 queuing model**

| DAY | TIME | $\lambda$ | $\mu$ | $\rho$ | $N_s$ | $N_q$ | $W_s$ | $W_q$ |
|---|---|---|---|---|---|---|---|---|
| Monday | 7:30am – 8:30am | 48 | 20 | 1.2000 | 5 | 8 | 0.113 | 0.163 |
| | 8:30am – 9:30am | 55 | 24 | 1.1458 | 7 | 10 | 0.133 | 0.174 |
| | 4:00pm – 5:00pm | 59 | 26 | 1.1346 | 8 | 10 | 0.047 | 0.172 |
| | 5:00pm – 6:00pm | 52 | 28 | 0.9285 | 13 | 11 | 0.259 | 0.224 |
| Tuesday | 7:30am – 8:30am | 48 | 30 | 0.8000 | 4 | 3 | 0.093 | 0.059 |
| | 8:30am – 9:30am | 48 | 29 | 0.8275 | 5 | 3 | 0.109 | 0.075 |
| | 4:00pm – 5:00pm | 50 | 29 | 0.8621 | 7 | 5 | 0.134 | 0.100 |
| | 5:00pm – 6:00pm | 54 | 31 | 0.8709 | 7 | 5 | 0.134 | 0.101 |
| Wednesday | 7:30am – 8:30am | 48 | 35 | 0.6857 | 3 | 1 | 0.054 | 0.025 |
| | 8:30am – 9:30am | 53 | 30 | 0.8833 | 8 | 6 | 0.152 | 0.118 |
| | 4:00pm – 5:00pm | 49 | 29 | 0.8448 | 6 | 4 | 0.086 | 0.120 |
| | 5:00pm – 6:00pm | 55 | 30 | 0.9166 | 11 | 10 | 0.209 | 0.175 |
| Thursday | 7:30am – 8:30am | 58 | 35 | 0.8285 | 5 | 4 | 0.063 | 0.063 |
| | 8:30am – 9:30am | 48 | 32 | 0.7500 | 3 | 2 | 0.071 | 0.040 |
| | 4:00pm – 5:00pm | 45 | 35 | 0.6428 | 2 | 1 | 0.049 | 0.020 |
| | 5:00pm – 6:00pm | 45 | 25 | 0.9000 | 9 | 8 | 0.211 | 0.171 |
| Friday | 7:30am – 8:30am | 49 | 21 | 1.1667 | 6 | 9 | 0.131 | 0.179 |
| | 8:30am – 9:30am | 52 | 28 | 0.9285 | 13 | 12 | 0.259 | 0.224 |
| | 4:00pm – 5:00pm | 52 | 27 | 0.9629 | 26 | 24 | 0.509 | 0.472 |
| | 5:00pm – 6:00pm | 47 | 23 | 1.0217 | 46 | 49 | 0.991 | 1.034 |
| Saturday | 7:30am – 8:30am | 45 | 25 | 0.9000 | 9 | 8 | 0.211 | 0.171 |
| | 8:30am – 9:30am | 52 | 29 | 0.9833 | 57 | 55 | 1.009 | 0.974 |
| | 4:00pm – 5:00pm | 59 | 30 | 0.9783 | 59 | 57 | 1.008 | 0.975 |
| | 5:00pm – 6:00pm | 45 | 23 | 0.9783 | 45 | 43 | 1.011 | 0.968 |
| Sunday | 7:30am – 8:30am | 49 | 21 | 1.1667 | 6 | 9 | 0.131 | 0.179 |
| | 8:30am – 9:30am | 52 | 23 | 1.1304 | 8 | 10 | 0.156 | 0.199 |
| | 4:00pm – 5:00pm | 54 | 25 | 1.0800 | 13 | 15 | 0.240 | 0.280 |
| | 5:00pm – 6:00pm | 47 | 22 | 1.0681 | 15 | 17 | 0.322 | 0.368 |

Table 5: Indicates the Day, Average Arrival rate $(\lambda)$, Average Departure rate $(\mu)$, Traffic intensity $(\rho)$, Average number of vehicles in the system $(N_s)$, Average number of vehicles in the queue $(N_q)$, Average time spent in the system $(W_s)$ and Average time spent in the queue $(W_q)$ for each day on the New Ife Road.

| DAY | $\lambda$ | $\mu$ | $\rho$ | $N_s$ | $N_q$ | $W_s$ | $W_q$ |
|---|---|---|---|---|---|---|---|
| Monday | 46 | 24 | 0.9549 | 28 | 27 | 0.656 | 0.614 |
| Tuesday | 48 | 27 | 0.8990 | 9 | 8 | 0.200 | 0.170 |
| Wednesday | 45 | 30 | 0.7560 | 4 | 2 | 0.086 | 0.052 |
| Thursday | 46 | 27 | 0.8349 | 8 | 6 | 0.172 | 0.136 |
| Friday | 52 | 28 | 0.9384 | 16 | 15 | 0.330 | 0.293 |
| Saturday | 55 | 28 | 0.9875 | 29 | 33 | 0.630 | 0.613 |
| Sunday | 46 | 26 | 0.8765 | 14 | 11 | 0.305 | 0.267 |

Table 6: Indicates the Day, Average Arrival rate $(\lambda)$, Average Departure rate $(\mu)$, Traffic intensity $(\rho)$, Average number of vehicles in the system $(N_s)$, Average number of vehicles in the queue $(N_q)$, Average time spent in the system $(W_s)$ and Average time spent in the queue $(W_q)$ for each day on the Olodo Road.

| DAY | $\lambda$ | $\mu$ | $\rho$ | $N_s$ | $N_q$ | $W_s$ | $W_q$ |
|---|---|---|---|---|---|---|---|
| Monday | 53 | 24 | 1.1022 | 8 | 10 | 0.138 | 0.183 |
| Tuesday | 50 | 30 | 0.8401 | 6 | 4 | 0.117 | 0.008 |
| Wednesday | 51 | 31 | 0.8326 | 7 | 5 | 0.125 | 0.109 |
| Thursday | 49 | 32 | 0.7803 | 5 | 4 | 0.098 | 0.073 |
| Friday | 50 | 25 | 1.0195 | 22 | 23 | 0.472 | 0.477 |
| Saturday | 50 | 27 | 0.9599 | 42 | 41 | 0.809 | 0.772 |
| Sunday | 50 | 23 | 1.1113 | 11 | 13 | 0.212 | 0.256 |

**Table 7: Performance measure analysis for New Ife Road using M/M/4 queuing model**

| DAY | TIME | $\lambda$ | $\mu$ | $\rho$ | $N_s$ | $N_q$ | $W_s$ | $W_q$ |
|---|---|---|---|---|---|---|---|---|
| Monday | 7:30am – 8:30am | 49 | 25 | 0.4900 | 2.118 | 0.158 | 0.043 | 0.003 |
| | 8:30am – 9:30am | 52 | 28 | 0.4642 | 1.979 | 0.122 | 0.038 | 0.002 |
| | 4:00pm – 5:00pm | 37 | 19 | 0.4868 | 0.153 | 0.153 | 0.057 | 0.004 |
| | 5:00pm – 6:00pm | 45 | 24 | 0.4687 | 0.123 | 0.123 | 0.045 | 0.003 |
| Tuesday | 7:30am – 8:30am | 54 | 30 | 0.4500 | 0.105 | 0.105 | 0.035 | 0.002 |
| | 8:30am – 9:30am | 47 | 26 | 0.4519 | 0.107 | 0.107 | 0.041 | 0.002 |
| | 4:00pm – 5:00pm | 53 | 30 | 0.4416 | 0.096 | 0.096 | 0.035 | 0.002 |
| | 5:00pm – 6:00pm | 40 | 22 | 0.4545 | 0.110 | 0.110 | 0.048 | 0.003 |
| Wednesday | 7:30am – 8:30am | 40 | 30 | 0.3333 | 0.026 | 0.026 | 0.034 | 0.001 |
| | 8:30am – 9:30am | 53 | 37 | 0.3581 | 0.036 | 0.036 | 0.028 | 0.001 |
| | 4:00pm – 5:00pm | 46 | 28 | 0.4107 | 0.068 | 0.068 | 0.037 | 0.001 |
| | 5:00pm – 6:00pm | 41 | 25 | 0.4100 | 0.032 | 0.068 | 0.042 | 0.002 |
| Thursday | 7:30am – 8:30am | 39 | 28 | 0.3482 | 0.097 | 0.032 | 0.037 | 0.001 |
| | 8:30am – 9:30am | 46 | 26 | 0.4423 | 0.067 | 0.097 | 0.041 | 0.002 |
| | 4:00pm – 5:00pm | 49 | 30 | 0.4833 | 0.131 | 0.067 | 0.035 | 0.001 |
| | 5:00pm – 6:00pm | 49 | 26 | 0.4711 | 0.115 | 0.131 | 0.041 | 0.003 |
| Friday | 7:30am – 8:30am | 55 | 30 | 0.4583 | 0.124 | 0.115 | 0.035 | 0.002 |
| | 8:30am – 9:30am | 54 | 29 | 0.4655 | 0.139 | 0.124 | 0.037 | 0.002 |
| | 4:00pm – 5:00pm | 42 | 22 | 0.4772 | 0.137 | 0.139 | 0.049 | 0.003 |
| | 5:00pm – 6:00pm | 59 | 31 | 0.4758 | 0.209 | 0.137 | 0.035 | 0.002 |
| Saturday | 7:30am – 8:30am | 54 | 26 | 0.5192 | 0.148 | 0.209 | 0.042 | 0.004 |
| | 8:30am – 9:30am | 58 | 30 | 0.4833 | 0.146 | 0.148 | 0.036 | 0.003 |
| | 4:00pm – 5:00pm | 54 | 28 | 0.4821 | 0.159 | 0.146 | 0.038 | 0.003 |
| | 5:00pm – 6:00pm | 53 | 27 | 0.4907 | 0.139 | 0.159 | 0.040 | 0.003 |
| Sunday | 7:30am – 8:30am | 42 | 22 | 0.4772 | 0.148 | 0.139 | 0.049 | 0.003 |
| | 8:30am – 9:30am | 58 | 30 | 0.4833 | 0.146 | 0.148 | 0.036 | 0.003 |
| | 4:00pm – 5:00pm | 43 | 27 | 0.3981 | 0.059 | 0.059 | 0.038 | 0.001 |
| | 5:00pm – 6:00pm | 41 | 26 | 0.3942 | 0.056 | 0.056 | 0.040 | 0.001 |

**Table 8: Performance Measure Analysis for Olodo Road using M/M/4 queuing model**

| DAY | TIME | $\lambda$ | $\mu$ | $\rho$ | $N_s$ | $N_q$ | $W_s$ | $W_q$ |
|---|---|---|---|---|---|---|---|---|
| Monday | 7:30am – 8:30am | 48 | 20 | 0.6000 | 2.831 | 0.431 | 0.059 | 0.009 |
| | 8:30am – 9:30am | 55 | 24 | 0.5729 | 2.632 | 0.340 | 0.048 | 0.006 |
| | 4:00pm – 5:00pm | 59 | 26 | 0.5673 | 2.593 | 0.324 | 0.044 | 0.005 |
| | 5:00pm – 6:00pm | 52 | 28 | 0.4642 | 1.979 | 0.122 | 0.038 | 0.002 |
| Tuesday | 7:30am – 8:30am | 48 | 30 | 0.4000 | 1.660 | 0.060 | 0.035 | 0.001 |
| | 8:30am – 9:30am | 48 | 29 | 0.4137 | 1.726 | 0.071 | 0.036 | 0.001 |
| | 4:00pm – 5:00pm | 50 | 29 | 0.4103 | 1.810 | 0.086 | 0.036 | 0.002 |
| | 5:00pm – 6:00pm | 54 | 31 | 0.4354 | 1.832 | 0.090 | 0.034 | 0.002 |
| Wednesday | 7:30am – 8:30am | 48 | 35 | 0.3428 | 1.401 | 0.030 | 0.029 | 0.001 |
| | 8:30am – 9:30am | 53 | 30 | 0.4416 | 1.863 | 0.096 | 0.035 | 0.002 |
| | 4:00pm – 5:00pm | 49 | 29 | 0.4224 | 1.768 | 0.078 | 0.036 | 0.002 |
| | 5:00pm – 6:00pm | 55 | 30 | 0.4583 | 1.948 | 0.115 | 0.035 | 0.002 |
| Thursday | 7:30am – 8:30am | 58 | 35 | 0.4142 | 1.728 | 0.071 | 0.030 | 0.001 |
| | 8:30am – 9:30am | 48 | 32 | 0.3750 | 1.545 | 0.045 | 0.032 | 0.001 |
| | 4:00pm – 5:00pm | 45 | 35 | 0.3214 | 1.308 | 0.022 | 0.029 | 0.000 |
| | 5:00pm – 6:00pm | 45 | 25 | 0.4500 | 1.905 | 0.105 | 0.042 | 0.002 |
| Friday | 7:30am – 8:30am | 49 | 21 | 0.5833 | 2.706 | 0.373 | 0.055 | 0.008 |
| | 8:30am – 9:30am | 52 | 28 | 0.4642 | 1.979 | 0.122 | 0.038 | 0.002 |
| | 4:00pm – 5:00pm | 52 | 27 | 0.4814 | 2.071 | 0.145 | 0.040 | 0.003 |
| | 5:00pm – 6:00pm | 47 | 23 | 0.5108 | 2.236 | 0.193 | 0.048 | 0.004 |
| Saturday | 7:30am – 8:30am | 45 | 25 | 0.4500 | 1.905 | 0.105 | 0.042 | 0.002 |
| | 8:30am – 9:30am | 52 | 29 | 0.4482 | 1.896 | 0.103 | 0.036 | 0.002 |
| | 4:00pm – 5:00pm | 59 | 30 | 0.4916 | 2.127 | 0.160 | 0.036 | 0.003 |
| | 5:00pm – 6:00pm | 45 | 23 | 0.4891 | 2.113 | 0.156 | 0.047 | 0.003 |
| Sunday | 7:30am – 8:30am | 49 | 21 | 0.5833 | 2.706 | 0.037 | 0.055 | 0.008 |
| | 8:30am – 9:30am | 52 | 23 | 0.5652 | 2.579 | 0.318 | 0.050 | 0.006 |
| | 4:00pm – 5:00pm | 54 | 25 | 0.5400 | 2.413 | 0.253 | 0.045 | 0.005 |
| | 5:00pm – 6:00pm | 47 | 22 | 0.5340 | 2.376 | 0.240 | 0.051 | 0.005 |

**Table 9:** Indicates the Day, Average Arrival rate $(\lambda)$, Average Departure rate $(\mu)$, Traffic intensity $(\rho)$, Average number of vehicles in the system $(N_s)$, Average number of vehicles in the queue $(N_q)$, Average time spent in the system $(W_s)$ and Average time spent in the queue $(W_q)$ for each day on the New Ife Road.

| DAY | $\lambda$ | $\mu$ | $\rho$ | $N_s$ | $N_q$ | $W_s$ | $W_q$ |
|---|---|---|---|---|---|---|---|
| Monday | 46 | 24 | 0.4774 | 1.093 | 0.139 | 0.045 | 0.003 |
| Tuesday | 48 | 27 | 0.4495 | 0.104 | 0.104 | 0.039 | 0.002 |
| Wednesday | 45 | 30 | 0.3780 | 0.040 | 0.049 | 0.035 | 0.001 |
| Thursday | 46 | 27 | 0.4362 | 0.102 | 0.081 | 0.038 | 0.001 |
| Friday | 52 | 28 | 0.4692 | 0.152 | 0.128 | 0.039 | 0.002 |
| Saturday | 55 | 28 | 0.4938 | 0.148 | 0.165 | 0.039 | 0.003 |
| Sunday | 46 | 26 | 0.4382 | 0.102 | 0.100 | 0.040 | 0.002 |

**Table 10:** Indicates the Day, Average Arrival rate $(\lambda)$, Average Departure rate $(\mu)$, Traffic intensity $(\rho)$, Average number of vehicles in the system $(N_s)$, Average number of vehicles in the queue $(N_q)$, Average time spent in the system $(W_s)$ and Average time spent in the queue $(W_q)$ for each day on the Olodo Road.

| DAY | $\lambda$ | $\mu$ | $\rho$ | $N_s$ | $N_q$ | $W_s$ | $W_q$ |
|---|---|---|---|---|---|---|---|
| Monday | 53 | 24 | 0.5511 | 2.508 | 0.304 | 0.047 | 0.005 |
| Tuesday | 50 | 30 | 0.4148 | 1.757 | 0.076 | 0.035 | 0.001 |
| Wednesday | 51 | 31 | 0.4162 | 1.745 | 0.079 | 0.033 | 0.002 |
| Thursday | 49 | 32 | 0.3901 | 1.621 | 0.060 | 0.033 | 0.001 |
| Friday | 50 | 25 | 0.5099 | 2.248 | 0.208 | 0.045 | 0.004 |
| Saturday | 50 | 27 | 0.4697 | 2.010 | 0.131 | 0.040 | 0.002 |
| Sunday | 50 | 23 | 0.5556 | 2.518 | 0.212 | 0.050 | 0.006 |

## 9.0 DISCUSSION

The traffic congestion at the Iwo road intersection was observed between the period of 7:30 am – 8:30 am; 8:30 am – 9:30 am; 4:00 pm- 5:00 pm; 5:00 pm – 6:00 pm making it a total of 4hrs daily for a period of seven days. The study location includes new Ife road and Olodo road in Ibadan. The M/M/S queuing model was adopted for the purpose of this paper. It was observed from Table 3 and Table 4 that the traffic intensity is either greater than 1 or it is approaching 1, which shows that there's congestion at the intersection. From Table 7 and Table 8, we can see clearly that after we applied the M/M/4 queuing model to analyze the data, we observed that the traffic intensity was less than 1, which shows that there is no more congestion since the number of server was increased.

## 10.0 Conclusion

In this paper, we adapted the M/M/S queuing model to analyze the traffic congestion and travel time at the Iwo road, Ibadan metropolis. We have also established the traffic dynamics and parameters of the Iwo road intersection. The of queueing theory using the M/M/S queuing model is most suitable where there are long queues and congestion. The congestion of Iwo Road intersection is mainly in the mornings and evenings. The result of the analysis shows that the flow of vehicles through the intersections is more than the capacity of the intersections. Excessive queues and time wasting at traffic intersection would be reduced at the Iwo Road intersection and other road intersection across the country if the service channel is given attention either by expanding it or increasing the number of service channel using the best queuing models. The following recommendations are suggested for the efficacy, improvement, quality service and reduction of the traffic congestion at the Iwo road intersection in Ibadan, Oyo State. The number of service channels should be increased from M/M/2 to M/M/4 for the two major roads that leads to the intersection where the traffic congestion occurs. The queue characteristics of the Iwo road intersection should be considered. The Oyo State road transport management system should ensure that queuing theory is applied to the problem of traffic congestion of the state.

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