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Analysis of Traffic Congestion Atuba Junction (Auchi) with Queuing Theory Using Tora Software

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ABSTRACT

Traffic congestion at intersection is on the increase as the numbers of vehicles increases in Auchi metropolis, which causes delay and also led to accident that has claimed human life. M/M/1 model was used to analysed the queuing characteristic of the intersection to determine the arrival rate and service rate of the vehicles. An operation research software known as TORA version 2.5 was used to analyze the arrival and service time data obtained to determine the operating characteristics of the M/M/s model for the intersection. The result showed that the average traffic intensity of the intersection is more than the optimal traffic intensity of 0.5 which means the intersection is congested.

Keywords: Intersection, Queuing model, Traffic Congestion, Traffic intensity

INTRODUCTION

With the rapid growth in urbanization, there has been a massive increase in the number of motor vehicles on the road, which has led to an increase in the urban/rural traffic; this has given birth to increased pressure on the roads. As a result of this, the urban/rural road networks have become overloaded. Traffic continues to increase leading to congestion; road intersections often result in the vehicles waiting in lines and the intersections get even more crowded during peak hours. As a consequence, congestion and accidents have increased; environmental pollution has become more serious. The effect of this has become one of the most serious challenges our communities are facing at the moment. And the main reason for traffic congestion and obstruction is shortage in intersection's capacity, rather than the road capacity. Therefore, it is necessary to re-design and re-structure the intersections, facilities and traffic management transformation for effective vehicular movement. Operational research is a scientific approach to analyze problems and making powerful decisions. In operational research, queuing theory is a mathematical technique to minimize the waiting time of a particular queuing system (Fred and Scott, 2013). Whenever, the problem of congestion arises in the course of traffic management, the queuing theory and its application always comes into picture.

When a city's road network is unable to accommodate the volume of traffic that uses, it is called Traffic congestion, this situation is caused by rapid growth in motorization and with less than corresponding improvement in the road network, traffic management techniques and related transport facilities. Thus, traffic congestion is a phenomenon that is associated with urban environment all over the world. This is because we need transport to move from one place to another, especially when trekking becomes inefficient. While traffic congestion has been managed very well in some developed countries, it has continued to defy solutions in the developing world. The forecast of Global Traffic Volume (GTV) shows that the phenomenon would double between 1990 and year 2020 and again by 2050 (Engwitch,

2012). This type of growth pattern, as envisaged by the end of year 2020 and 2050, is an indication of what the future congestions portends for people living in urban environment. Many urban centers in Nigeria suffer from inadequate facilities that could ensure smooth urban movement. This is because the rapid growth of cities anywhere in the world has impact not only for the land use but also for the spatial expansion. For example, the commuting distance of Lagos increased from 20km in 1970 to 35km in 1995 while that of Kaduna increased from 6km to 10km during the same period. In Akure, the commuting distance increased from 5.2km in 1966 to 6.4km in 1976, 10.5km in 1986, 13km in 1996 and 19km in 2006 (Ogunbodede, 2006). The increase in commuting distance has impact on trip attraction, fares paid by commuters and traffic build-up in some land use areas. It also shows the need for different modes of transportation. Thus, a number of factors have been found to influence trip generation, attraction and distribution in any urban environment.

Traffic congestion is a situation on road networks especially at intersections which occurs as its use increases, and is characterized by slower speeds, longer trip times and increased vehicular queuing. The objective of traffic analysis is to provide a practical method of quantifying the degree of traffic congestion (Fred and Scott, 2013). An intersection is an at-gradejunction where two or more roads meet or cross. Intersections may be classified by number of road segments and traffic control.

Queuing Theory

Queuing theory is a major topic for applied mathematics that deals with phenomenon of waiting and arises from the use of powerful mathematical analysis to describe production processes (Masurdi, 2011).

Queuing theory is also known as the theory of overcrowding; it is the branch of operational research that explores the relationship between the demand on a service system and the delays suffered by the users of that system (Ajay and Girish, 2013).

The study of queue deals with quantifying the phenomenon of waiting in lines using representative measures of performance, such as average queue length, average waiting time in queue and average facility utilization (Taha, 2002).

Queuing Model

Queuing models provide the analyst with a powerful tool for designing and evaluating the performance of queuing systems (Banks *et al.,* 2001*).*

- **M/M/1 queuing model** is a queue system whose model follows Poisson arrivals, exponential service and single-channel service or server.
- **M/M/s queuing model** implies Markovian arrival rates, exponential service rates and multiple server system channels model.

- **M/G/1 Queuing Model**

  The M/G/1 model follows Poisson arrivals, general service time and single channel model. Constant service times are used when customers or units are processed according to a fixed circle.

Temporally Ordered Routing Algorithm (TORA) Software

TORA is operation research software. It is an algorithm i.e. a mathematical set of instructions or programs, for routing data across wireless mesh networks. It was developed by Vincent Park & Scott Corson at the University of Maryland and the Naval Research Laboratory. Operation Research is a

qualitative approach that solves problems, using a number of mathematical techniques. It is the scientific study of operations for the purpose of making better decisions.

MATERIALS AND METHOD

The techniques and procedures employed in order to achieve the set aim and specific objectives of the study include data collection method, data analysis using TORA software to obtain the operating characteristics value of the adopted model M/M/s

Method of Data Analysis

In the study, the pattern of arrival follows Poisson Distribution and service time follows Exponential Distribution and the server is more than one. The M/M/s queuing model was adopted based on the queuing characteristics of the intersections.

Data collection

The data was collected in the study area (UBA) havingfour channels respectively. The system comprises of multiple servers. The pattern of arrival and service rates follow Markovian distribution with multiple servers in an infinite manner. The data were generated by manual means using audio recording devices, video camera by the three set of different team of 8-persons stationed at the stop line of every junction with two persons at each of the four approaches/channel to the intersection monitoring the number of cars arriving on queue and number of cars leaving the queue within the hour of seven (7:00a.m) and seven thirty (7:30p.m). The peak hours was further classified into morning (7:01-11:20am), afternoon (12.01-4:00p.m) and evening (4:01-7:30p.m) for each of the channel of the intersections. A total of twenty-four (24) persons participated in the data collection and recording of the arrival and service time for five working days. The arrival time and service time were gotten from the camera and the audio recording devices. The data were recorded on coding sheet designed by the researcher.

Data processing

An operation research software known as TORA version 2.5 was used to analyze the arrival and service time data obtained to determine the operating characteristics of M/M/s model for each of the intersections. The average arrival time and average service time gotten from the video camera and audio recording devices were inputted into the software which gives the arrival rate, service rate and the utilization factor value.

RESULTS AND DISCUSION

The arrival rate and service rate of UBA intersection is recorded in Table 1. The UBA1 through UBA4 are the channels to the intersection. The average rate of arrival for each of the session is higher than the average of the service rate which gives the value of traffic intensity.The traffic intensity values for each channels is higher than the optimal traffic intensity value of 0.5, which means the intersection is congested.

Table 1: UBA Junction Traffic Data

Junction Description	Morning			Afternoon			Evening		
	Arrival Rate	Service Rate	Traffic intensity	Arrival Rate	Service Rate	Traffic intensity	Arrival Rate	Service Rate	Traffic intensity
UBA1	6.27	5.21	0.701	6.18	5.29	0.600	6.10	6.41	0.620
UBA2	5.90	5.74	0.647	6.10	6.44	0.616	6.22	6.19	0.616
UBA3	6.46	5.75	0.676	5.33	5.98	0.590	6.21	5.99	0.598
UBA4	5.89	7.75	0.545	6.52	5.88	0.676	6.26	6.10	0.678
Average	**6.13**	**6.11**	**0.642**	**6.03**	**5.89**	**0.621**	**6.20**	**6.15**	**0.628**

Overall Arrival and Service Rate

Figure1 shows the arrival pattern of vehicles in UBA junction. The X-axis represents the number of arrived vehicles while the Y-axis represents the probability of random arrival of vehicles. The histogram shows that there are 0.0035% chance of eight(8) or nine(9) vehicles that arrived at the juction at the same time.

Figure 2 reveals the service car pattern at the UBA junction. The service rate decreased exponentially as the number of cars serviced at time t increases. The tendency of queue at the junction is at maximum. In addition, about one to two vehicles had equal probability of being serviced at 0.06 implying 6% chance of being served. As the number of vehicles increased, the time of servicing tends to decrease at varying probabilities.

However, the probability for six(6) to eight(8) vehicles to be serviced are negligible (very small), which is at about 0.0001.

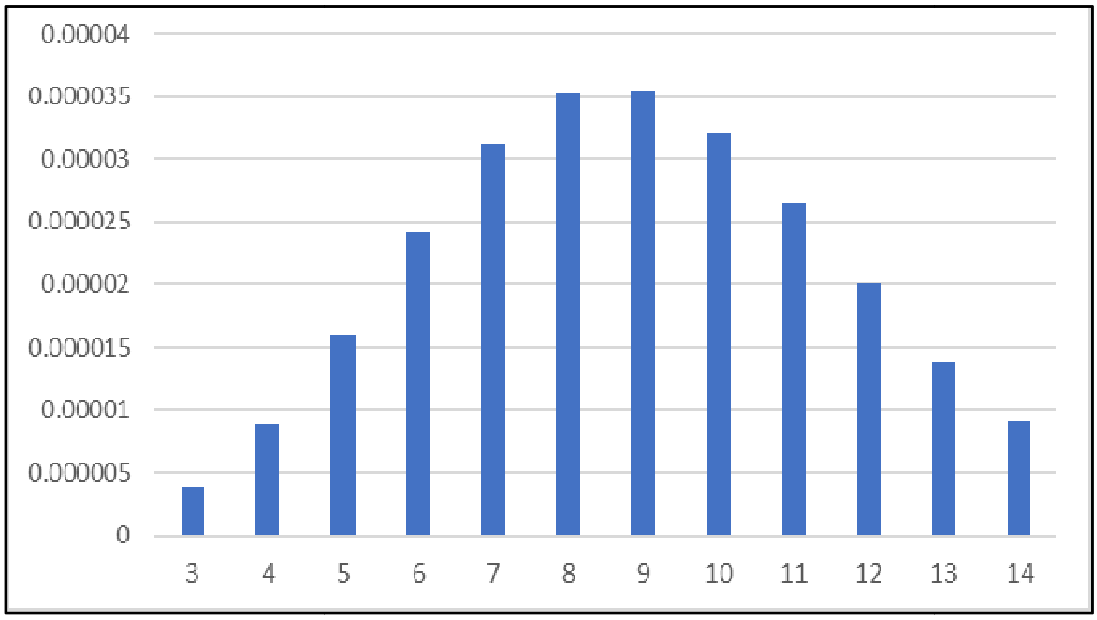

Figure 1: UBA Junction Overall Arrival Pattern

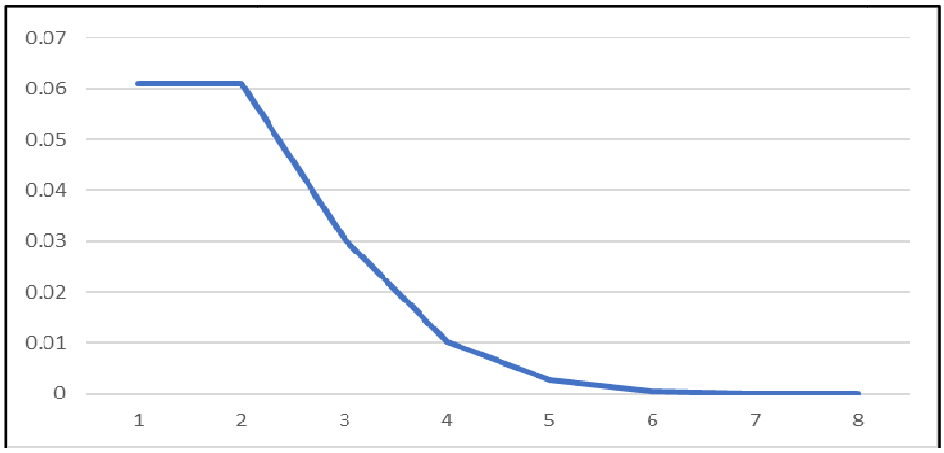

Figure 2: UBA Junction Overall Service Pattern

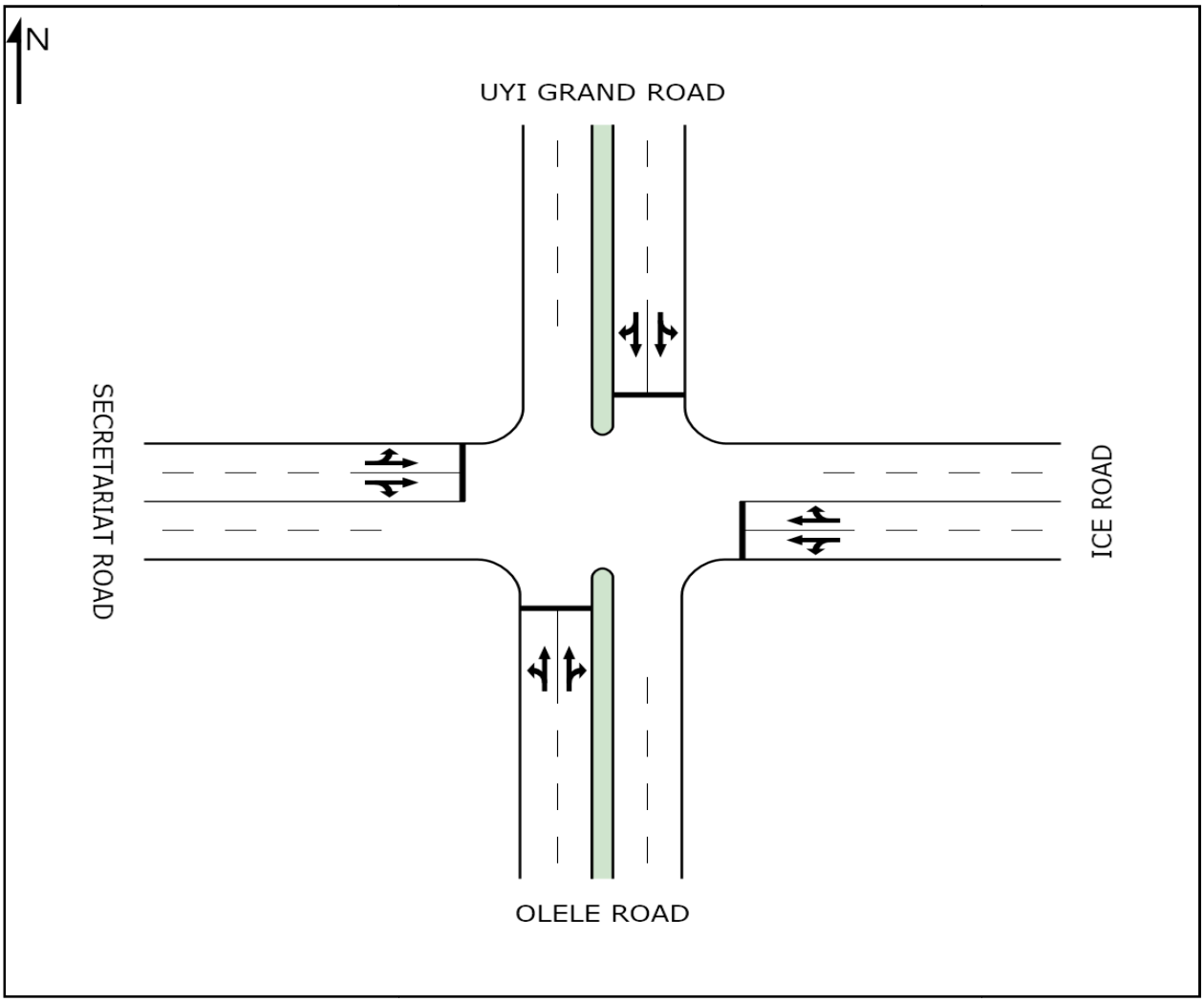

Figure 3: UBA Intersection showing the Road channels

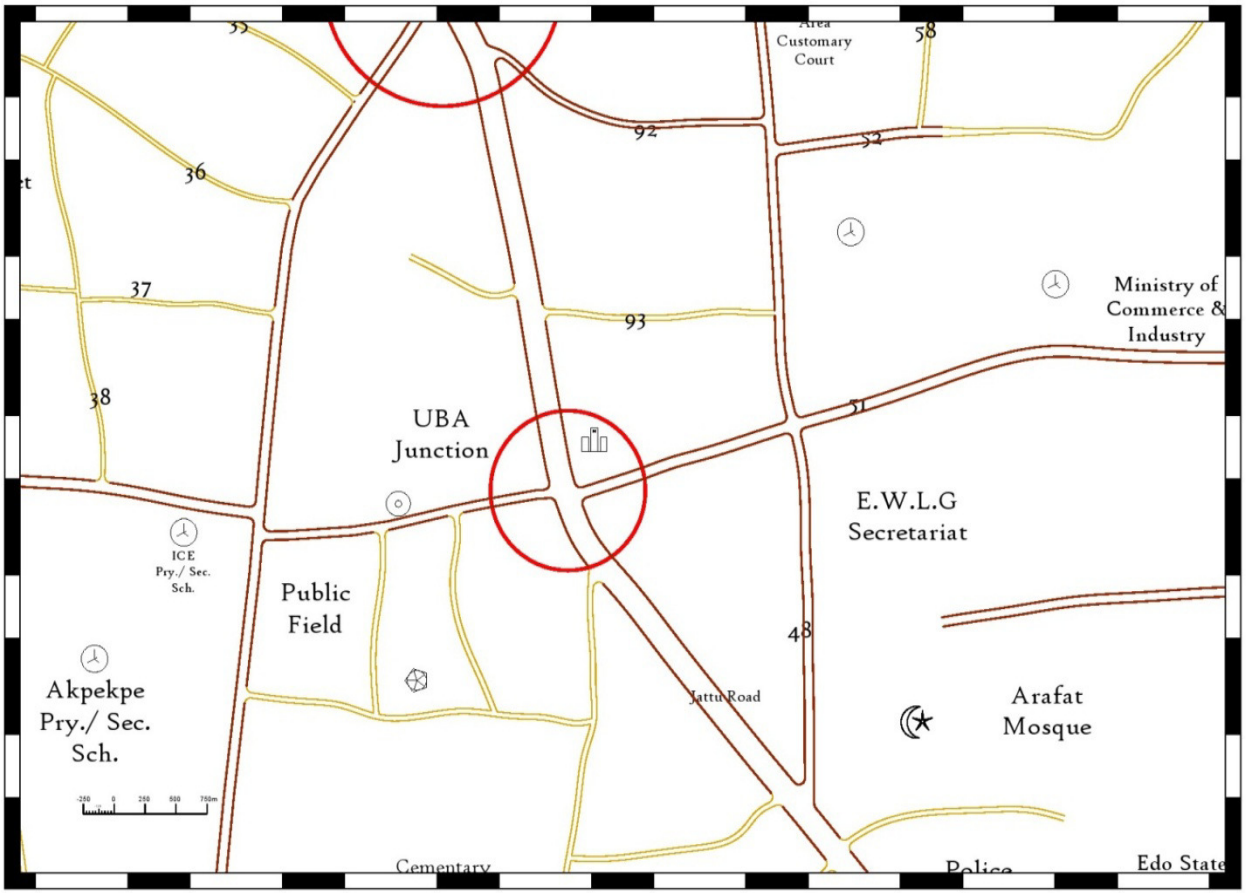

Fig 4: Road network in Auchi metropolis

CONCLUSION

This study has investigated traffic congestion UBA intersection within Auchi metropolis using queuing theory, TORA software. Some of the findings from the study are summarized as follows:

The pattern of arrival and service rates follow Markovian distribution with multiple servers in an infinite manner. Therefore, the model used is markovian arrival rate, exponential service rate and multiple server system (M/M/s).

The degree at which the server was utilized i.e. the utilization factor or traffic intensity, at the three sessions shows values that are higher than the optimal traffic intensity value of 0.5 and any value higher than 0.5 shows high rate of congestion. The congestion of the intersectionis mainly at the peak hours of the day (morning and evening).

RECOMMENDATION

1. The bank should be given order to create a parking space for its customers to avoid parking along the road close to the intersection.

2. The government should construct a rotary at the intersection to enable the vehicle move freely without colliding each other.
3. The government should construct a traffic signal at the intersection to allow free movement of vehicles.
4. The government should enforce the law by sanctioning any motorist that inappropriately park along the road sides close to intersections.

REFERENCES

Ajay, K. S. and Girish, K. S. (2013). Queuing theory approach with queuing model: A Study, *International Journal of Engineering Science Invention*, 2(2): 1-11.

Banks, J., Carson, J. S., Nelson, B. L., and Nicol, D. M. (2001). Discrete Event System Simulation, (3rd Edition). London: Prentice Hall International Series, Pp 7-13.

Fred, L. M. and Scott, S. W. (2013).Principles of Highway Engineering and Traffic Analysis.5th Edition, published by John Wiley & Sons, Asia.

Masurdi, M. (2011): Application of queuing models to customers management in the banking system. American Research Journal of Bio-Sciences. 1(2): 1-8

Taha, H.A. (2002).Operations Research; An introduction, 7th edition. Prentice Hall Publisher, United State of America.

Ogunbodede, E.F. (2006) Application of GIS to the Management of Traffic Congestions in Akure, Ondo state, Nigeria. PGD Project submitted to RECTAS, ObafemiAwolowo University, Ile- Ife, Nigeria

Engwitch, D. (1992), Towards an Eco-City; Calming the Traffic.Envirobook , Publishers.

