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# Analysis of Traffic Management and Application of Queuing System

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***Abstract***

Traffic congestions are always frustrating to the road users. Congestions are formed due to different reasons like reduced capacity of road stretch, accidents, overcrowding etc. The traffic congestions result in delays. Delay is a more subtle concept. Delays are defined as the difference between the particular time period on a given segment and a few ideal time periods of that segment. These delays will surely end up in queues. Queues occur whenever immediate demand exceeds the capacity to provide a service. Here the need of application of queuing theory arises. Queuing theory was developed to supply models capable of predicting the behaviour of systems that provide service for randomly arising demands. Queuing theory deal with the study of queues (waiting lines). A queuing system is one during which customers arrive for service, wait for service if it is not immediately available, and advance to subsequent server once they have been serviced. This paper mainly deals with the different application of queuing theory in transportation sector. Applications mainly include the application of queuing theory in material transportation system, in management of traffic intensity, for the performance analysis of toll plaza, to reduce traffic accidents, at Signalized Intersection etc.

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## Introduction

Traffic congestion occurs in busy and populated areas. It is often very frustrating due to the delay it causes on vehicular movement for commuters and item delivery. It is periodical and has several causative factors depending on the area. The causes of congestion include lack of internal route expansion, bad roads and many vehicles in transit, poor packing by commercial vehicles and the like. Traffic congestion is common in Lagos because it is heavily populated with a small land mass.

Reference [1] describes traffic congestion as a situation on road network which occurs as its use increases. It is characterized by slower speeds, increased trip times and queuing of vehicles. It is therefore necessary to apply the principle of queuing theory to optimize the waiting time in queuing system as experienced in traffic congestion. The effect of traffic jam includes commuters' frustration, vehicle collision and fuel wastage. Traffic congestion also has spill over effect from congested main routes to secondary roads and side-streets as alternative routes are sought. Such spill over effect results in delays which successively leads to late arrivals for meetings and business activities within locality. Reference [1] assert that traffic congestion occurs when a mass of traffic requires space greater than the available road capacity. According to [2] queuing theory is the mathematical study of waiting lines or queues. In queuing theory a model is constructed so that queue lengths and waiting times can be predicted. Generally, queuing theory may be a branch of research because the results are utilized in making business decisions about resources required within the provision of services. A queue is a waiting line but queuing is used broadly to cover variety of problems usually for economic balance and optimization involving waiting and delay in serving people or servicing machines and equipment.

## II. QUEUING THEORY

Queuing theory was developed to provide models capable of predicting the behaviour of systems that provide service for randomly arising demands. Queuing theory deals with the study of queues (waiting lines).The earliest use of queuing theory was in the design of a telephone system; randomly arising calls would arrive and need to be handled by the switchboard, which had a finite maximum capacity. Applications of queuing theory are found in fields such as; traffic control, hospital management, and timeshared computer system design. The following terms are commonly utilized in queuing theory; Customers: The persons or objects that require certain service are called customers. Server: The person or a machine that gives certain definite service is understood as server. Service: The activity between server and customer is called service, this consumes some time. Queue or Waiting line: A scientific arrangement of a gaggle of persons or objects that await for service. Arrival: The method of consumers coming towards service facility or server to receive a particular service.

## III. APPLICATION OF QUEUING THEORY

A. Queuing Theory in Material Transportation System using Truck Surface mining is that the commonest mining method worldwide; open pit mining accounts for quite 60% of all surface output. Reference [3] uses queuing technique to optimize the transportation at Lafarge WAPCO (Sagamu plant) Nigeria. Queuing theory was developed to model systems that provide service for randomly arising demands and predict the behaviour of such systems. Time of arrival at excavator area (hr/min/sec), time of first load by excavator into the truck (hr/min/sec), number of loads, time of departure from the excavator (hr/min/sec) and time taken to load trucks gotten from the Lafarge (Sagamu plant) was analysed to develop a model M/M/1: FCFS/∞/∞, based on the assumption of single channel and single server with infinite number of queues. The model was used to calculate the arrival rate, service rate and number of server which at the end of it gives 7turcks/hour, 21trucks/hour and 1loader respectively. The result shows that because the size of the haulage truck getting used increases, shovel productivity increases and truck productivity decreases. An effective number of trucks must be chosen that will effectively utilize idle time, increase productivity and reduce cost of production to the barest minimum. The idle time gotten is 66.6%; this indicates that an additional 8 to 9 trucks can be added to the company truck fleet to make use of the idle time; since time translate to cost. Reference [4] proposes a completely unique queue-based modelling approach for aircraft arrivals at an airport and analyses the strategies for air traffic tactical control which will mitigate arrival delays while allowing future increasing air traffic volumes. The modelling approach is motivated by a datadriven analysis of actual flight plans and radar data corresponding to the arrival traffic in 2016 and 2017 at Tokyo International Airport. This analysis estimates the arrival delays under increasing arrival rates and indicates that the most delayefficient arrival tactical control strategy is to increase airspace capacity close to the arrival airport. In particular, allowing one or two additional aircraft in the airspace within approximately 60 NM around the airport significantly reduces the arrival delays even in the case when the arrival rate increased up to 20% more than the current operations. The proposed approach provides support to the decision-making process of prioritizing tactical control strategies under various traffic conditions, i.e., providing support for introducing new operational procedures, designing route structures, introducing automation support for controllers. As future work, they plan to develop arrival optimization models for aircraft arrivals at an airport under increased traffic volumes such that arrival delays are minimized. B. Queuing Theory in the Management of Traffic Intensity Reference [5] apply the queuing theory in minimizing vehicular traffic congestion using four

routes/channels in Victoria Island as case study. This study is focused on the management of vehicular traffic based on queuing theory. It is assumed that the time interval between successive arrival and service times is independent and normally distributed. The system is also assumed to reach a stable state with constant arrival and service rates. The study also adopts the FCFS (first come first serve) approach where the vehicles are made to line up or queue according to their time of arrival as customers waiting to be served by a signal of functioning traffic light in a given channel or location to minimize traffic congestion. The number of vehicles in each service station for every channel is counted and the time in minutes noted when waiting to be served and after being served. These values are used to derive the arrival and service rates of the vehicles. This situation was observed for 5 days in peak hours of morning, afternoon and evening (7-10am, 12-3pm and 5-8pm respectively). This study reveals that traffic intensity is highest in the morning session when commuters are reporting for work/business and in the evening session at the close of work/business. It is therefore necessary to allot more time at intersections for traffic into such routes in the morning and evening sessions. The increase of traffic light time will reduce traffic intensity which in turn minimizes delays on such routes/channels at peak periods of morning and evening sessions. Reference [6] analyzes the importance of queuing theory in the field of traffic management system for this Bhopal, Indore, Ujjain city which were located in the India is chosen. The paper review the range of queuing theory results in the area of waiting time, utilization analysis and design of system the traffic crowd follows a repeatable pattern during the day and the proper people accepts it as a daily routine. The work is based on the actual survey of traffic flow at various times at different locations of Bhopal, Ujjain and Indore city. The application of the queuing theory is exploited to minimized the traffic congestion at a particular time. By this work they found out different steps to avoid the congestion. Like, the traffic can be reduced by increasing road capacity, provide separate lane for specific user group, variable massage sign can be installed along the roadway to avoid road users, increasing width of channel of congested route, applying parking restrictions for the motor vehicle. C. Queuing Theory to address Traffic problems at a Highway Toll Plaza Reference [7] analyze the current situation, of traffic congestion, at a highway toll plaza using queuing theory and suggest possible solutions to encourage greater efficiency, thus reducing waiting time of the customers and money wasted because of that. This study has been carried out in various phases, i.e. problem identification, data collection, data analysis and results at a specific Toll Plaza in North India. The data analysis in the study helps to find out the current operational effectiveness of the Toll Plaza through parameters like, Arrival Rate, Service Rate and Number of

toll booths. On analyzing the clustered graph (Mean number of vehicles in an hour vs Time of day) it was concluded that on both Sunday and Monday the peak hour is 5-6 pm and non-peak hour 4-5 am. Therefore, analysis was done in the peak hours as obtained from the graph using WinQSB software. The results show that during peak hours the mean waiting time is around 10 minutes and 5 minutes during non-peak hours. Service rate per server per minute currently is 4.3. If service rate is increased than waiting time decreases at a good pace up to a certain limit which was concluded from the sensitivity analysis. There are various steps and policies that need to be taken up to bring down the waiting time. Increasing the number of toll booths will help in reducing the length of the queue, Technologies like RFID, Mobile Collectors, and Smart card system would help in increasing the service time drastically, in turn reducing the waiting time. Another option can be put up a red light 1 km before the toll so that there is smooth vehicular flow at the toll. An LED (Light-Emitting Diode) screen can also be installed few kilometers before the toll describing the waiting time, length of queue in each lane. This will help commuters in getting into the right lane with less waiting. Less waiting in the system saves money as less fuel will be wasted. In this way the system can be optimized decreasing the queue length of the customers and time a customer spends in the system. Finally, possible solutions are suggested which may be recommended and implemented on various Toll Plazas within the country. Reference [8] presents an improved model base on M/M/1 queue theory for designing the toll plaza by considering different ways of charging in the actual toll service system (human-staffed, automated and electronic toll collection), and applies the Non-dominated Sorting Genetic Algorithm II (NSGA-II) to optimize the design of lane number and charging mode layout. As per [9] toll should be designed and planned in such a way that minimum time would be wasted in the queuing area. The toll booths are planned on the basis of queuing area. Queuing theory involves parameters like arrival, number of lanes, service time, waiting time, merging area. In present study road inventory, traffic volume, space mean speed, arrival rate, time headway and service rate are analyzed. A detailed study was carried out to analyse the performance of a tool booth. The following conclusion was drawn from the observed data; it had been found that flow remained constant on both directions 375 and 345 (veh/hr), the inter time of vehicle arrival between two vehicle was found out be 10 seconds on both the directions, the waiting time in the queuing area was found out to be 10 seconds as general, as the density increases the effective speed decreases thereon road section. D. Queuing Theory to Vehicular Traffic to reduce accidents Reference [10] establish the queue model for the Nakuru – Salgaa road Stretch and test the model with real data from the Case Study. Data was collected between the Soil- junction and the Total

junction. They derive the arrival rate, service rate, utilization rate and the probability of Bulking using the M/M/1 queuing model. It was estimated that the arrival rate at the Soiljunction is 37 vehicles per minute and at total junction the service rate is 44 Vehicles per minute this does not march the dwindle service rates in section that are now black spots. The average number of vehicles on single road stretch was on average 15 per minute with some sections recording a high of 40 vehicles per minute and the utilization of the sections of stretch was on average 0.8. The benefit of performing the queue analysis for the road stretch is finally discussed and recommendations provided. Reference [11] sets up the M/M/1 queuing model, analyses the traffic intensity of Palasia intersection (Indore city, India) through analyzing the queuing theory deeply, and uses the model to research the settings of the lane and signal timing that's supported a particular degree of accuracy. E. Queuing Theory to Vehicular Traffic at Signalized Intersection Reference [12] seeks to model the vehicular traffic flow and explore how vehicular traffic could be minimized using queuing theory in order to reduce the delays on roads in the Kumasi metropolis of Ghana. The Of omicron traffic intersection within the Kumasi metropolis of Ghana is currently operating with one service channel each from the varied routes to the intersection. This paper sets up the M/M/1 queuing model, analyses the traffic intensity of Palasia intersection (Indore city, India) through analysing the queuing theory deeply, and uses the model to analyze the settings of the lane and signal timing timing that's supported a particular degree of accuracy. The results showed that traffic intensity, ρaccording to the results further performance improvement measures can be suggested.

## V. SUMMARY

A queuing system is one during which customers arrive for service, wait for service if it is not immediately available, and advance to subsequent server once they have been serviced. Queuing models in transportation are more likely to concentrate on the non-stationary characteristics of queuing, as well as on the optimization of system design and system control.The queuing theory is an effective mathematical technique for solving various traffic problems of any system as queuing theory focused on representation of traffic situation by using various mathematical terms and formulas. This paper mainly deals with the different application of queuing theory in transportation sector. Applications mainly include the application of queuing theory in material transportation system, in management of traffic intensity, at Signalized Intersection, for the performance analysis of toll plaza, to reduce traffic accidents, etc. Methodology that can be adopted for application of queuing theory in transportation is also discussed in this paper.

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