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Application of Queuing Theory in Traffic Management System

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ABSTRACT
In recent decades, traffic congestion in India has gotten worse. The importance of reliability in the congestion problem is likely the most recent component of congestion that is studied using a range of data sources. Challenges in traffic management arise as a result of increased traffic disruption. India is experiencing a rapid rise in traffic congestion as a result of the increased number of vehicles on the road. In the current research work, the queuing theory and its relevant applications are reviewed. It is widely known that the variety in journey times is a distinct factor contributing to the dissatisfaction of the public and corporate sectors with traffic issues. However, the daily differences in travel circumstances present their own difficulties, necessitating a separate set of problem-solving techniques. The research investigates how queueing theory might be used to manage traffic in Indian cities like Noida, Ghaziabad and Delhi. The day-long pattern of the traffic swarm is accepted by the populace as a normal part of life. In terms of waiting time, utilization analysis and design of system this paper examines the gamut of results from queuing theory.

***KEYWORDS**: waiting time, Utilization Analysis, Reiterative, Traffic System, Queuing Theory.*

I. INTRODUCTION

In big and developing metropolitan regions around the world, increasing traffic congestion is an unavoidable situation. Traffic congestion during rush hours is a natural byproduct of how modern civilizations function. It results from the vast wants of individuals to pursue particular goals, which inevitably overload current transportation infrastructure every day. However, despite attempts at solutions, everyone hates traffic congestion, and it just gets worse. Due to the disruption it creates to commuting and delivery of goods, it can be highly annoying. It is recurring and is caused by a number of variables that vary by location. Lack of internal route extension, poor roads, a high volume of traffic, poorly packed commercial vehicles, and other factors contribute to congestion. Lagos experiences frequent traffic jams due to its dense population and small land area. According to Mala et al. (2016), traffic congestion is a phenomenon that develops on the road network as its use rises. Slower speeds, longer travel durations, and traffic congestion are its hallmarks.

Therefore, in order to reduce the amount of time people wait in line during traffic congestion, the queuing theory's basic principles must be applied. As a result of traffic congestion, commuters experience frustration, car accidents, and fuel waste. As alternate routes are sought, congestion in traffic also has a spillover impact from jammed main routes to subsidiary highways and side-streets. Delays caused by this spillover effect cause people to be late for meetings and other local business activities. According to Mala et al. (2016), traffic congestion happens when a volume of traffic requires more space than the capacity of the existing roads.

The research done by Agner Krarup Erlang, who developed models to represent the Copenhagen telephone exchange, is where queueing theory got its foundation. The concept has been expanded to include uses in the construction of factories, stores, offices, and hospitals as well as in the fields of computing, traffic engineering, and telecommunication.

II. LITERATURE REVIEW

To review the literature and comprehend the research gap, some examples of queuing theory's applicability to traffic congestion on the road are given.

Using a case study of the Kumasi Ashati Region of Ghana, Martin Anokye et al. (2013) address the application of queuing theory to vehicle traffic at signalised intersections. Mala et al. (2016) use the queuing theory to concentrate on the simplicity of traffic congestion. According to Chao et al. (2009) and Quddus et al. (2010), the amount of traffic congestion on the M25 highway has little bearing on how serious car accidents are. But an intriguing conclusion was found about the effect of traffic flow on the seriousness of crashes. In order to shed light on the human dynamics involved in introducing cutting-edge technologies to the vulnerable sectors of the driving population, Yannis et al. (2010) create ordered logic models. According to Glen et al. (2003), the economic advantages of congestion-reduction methods might lead to an increase in traffic. Following an analysis of the causes of urban traffic congestion, Qingyu et al. (2007) propose a framework for the implementation of urban road congestion pricing and other travel management measures. They discovered that tourists join backed-up lines despite the unfavourable externality of urban traffic congestion. In 2007, Jayaram and Lincoln cited two polar instances. In one instance, the calculation of the number is easy, which allows for additional analysis and the derivation of experimentally testable hypotheses as well as the measurement of the relative influence of congestion on distribution costs. One particular instance of this scenario is broadly applicable to one of the research participants' companies, but the other situation is far less tractable. Strasbourg et al. (2008) use lab tests to investigate how public knowledge of historical departure rates affects traffic congestion and trip expenses. The bottleneck model developed by Arnott et al. in 1990 serves as the foundation for the design. Congestion exists in all treatments, and the actual travel costs are remarkably similar to those expected. The number of drivers, the relative cost of a delay, or the accessibility of public data on prior departure rates had no impact on a subject's ability to coordinate. Finding that a parameter-free reinforcement learning model best captures individual behaviour confirms the apparent lack of treatment effects. The road traffic crash (RTC) figures from Luke and Richard (2006) include the number of casualties for each of Australia's eight states and territories, sorted by severity. They evaluate and compare the economic effects of RTCs across these locations using these specifics. The two main contributions of their paper are the subnational breakdown of RTC expenditures for Australia and the precise breakdown of predicted RTC casualties.

CERTAIN NEGATIVE IMPACTS OF TRAFFIC CONGESTION:

• Drivers and passengers time is wasted for stuck in jam due to traffic congestion, which have a negative impact on the economies of the countries.

• It also results in greater fuel waste, which raises air pollution and carbon dioxide emissions.

• Because of traffic delays people are arriving late at employment meetings and education which results in loss of business disciplinary proceedings and other personal losses.

• Because of traffic congestions the emergency vehicle may delay in reaching their location where they are urgently required.

(a) Mean arrival rate (λ)

It refers to the frequency of consumer arrival to the service facility. It can be expressed as a progress in arrival time or as a flow. The equation that is started below can be used to determine the arrival rate if the inter arrival time, or time progression, is known.

It can be expressed as a probabilistic or deterministic distribution, and occasionally demand or inputs are used in place of arrival.

(b) Mean Service Rate (μ)

It is also stated in flow or reaching time progression and it is the rate at which passengers leave a transportation facility. The equation below can be used to determine the service rate if you know the inter service time, which is also known as service time progression.

(c) Number of Servers:

It should be stated how many servers are being used and in what manner. They function, or rather, they function as parallel servers unless a series server is provided.

(d) Queue discipline:

The queuing theory's parameter shows how clients get to a service facility. The following are the various forms of queue discipline.

1) First in first out (FIFO).
2) First in last out (FILO)
3) Served in random order (SIRO)
4) Priority Scheduling
5) Processor Sharing

(1) First in First out (FIFO)-

The First come, First served (FCFS) service discipline is used when customers are attended to in the order in which they arrive.

(2) First in Last out (FILO)-

The way in which, the customers are occasionally served in the reverse order of their entry so that those who arrive last are served first. In the event that no new tasks have come, a task that has just arrived would therefore be handled next. In a similar vein, the first person to enter a lift is also the last person to exit it.

(3) Served in Random Order (SIRO)-
Customers are chosen at random for service under this rule, regardless of when they enter the service system. Due of the equal likelihood that each person in the queue will be chosen in this scenario, the customers' arrival times are irrelevant.

(4) Priority Service-
Customers who use this service are divided into priority classifications based on factors like service time, urgency, or other clearly measurable factors.

(5) Processor Sharing-
In this method, the server rotates round robin between each queue for a predetermined period of time. Every person in the queue is attended to for that duration. It is irrelevant. If a customer's service is finished or not, the next person in line will be served. This is done to prevent server time from being lost due to customer external actions.

Any queuing system is typically made up of customers, or units, who require some sort of service and arrive at a service facility, join a queue if assistance is not immediately accessible, and eventually depart after obtaining the service. A server is a device used to provide the customer with a service or services. A "customer" who arrives to find the server busy may start a queue, join it, or exit the system without obtaining any service despite having waited for some time. In this paper, they are investigated.

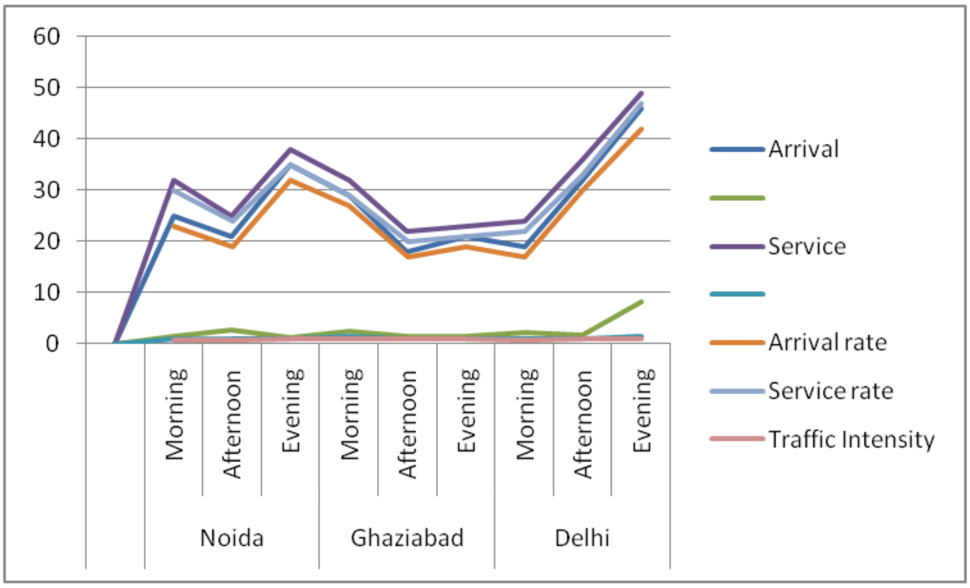
- The traffic light (server) controls the flow of traffic through the signalised intersection by regulating the usage of the road infrastructure by vehicles.
- Units of randomly arriving vehicles form a single file waiting line before being served by a server.
- Depending on the order in which they came, each vehicle is attended to separately in parallel.
- The Arrival Pattern: The spacing between any two consecutive arrivals indicates the pattern in which arrivals take place. The inter-arrival time may vary for our stochastic modelling framework and may be defined by a particular probability distribution that best fits the observed arrival pattern.
- Arrival Rate λ : The average number of cars coming per unit time is known as the arrival rate.
- The Service Pattern: This refers to the way the service is provided and is determined by the amount of time needed to finish the service. The distribution of the service time must be stated under stochastic modelling considerations, just like the arrival pattern.
- Service Rate μ: The average number of cars served per unit of time is provided by the service rate.
- Server Utilization ρ: This displays the server's average usage, as calculated by $\lambda = \rho.\mu$

III. RESULT & DISCUSSION

By using the different parameters stated in this paper on the basis of queuing theory we represent the traffic flow of traffic in the cities of Noida, Ghaziabad and Delhi.

Representation of View of traffic situation of Noida, Ghaziabad and Delhi.

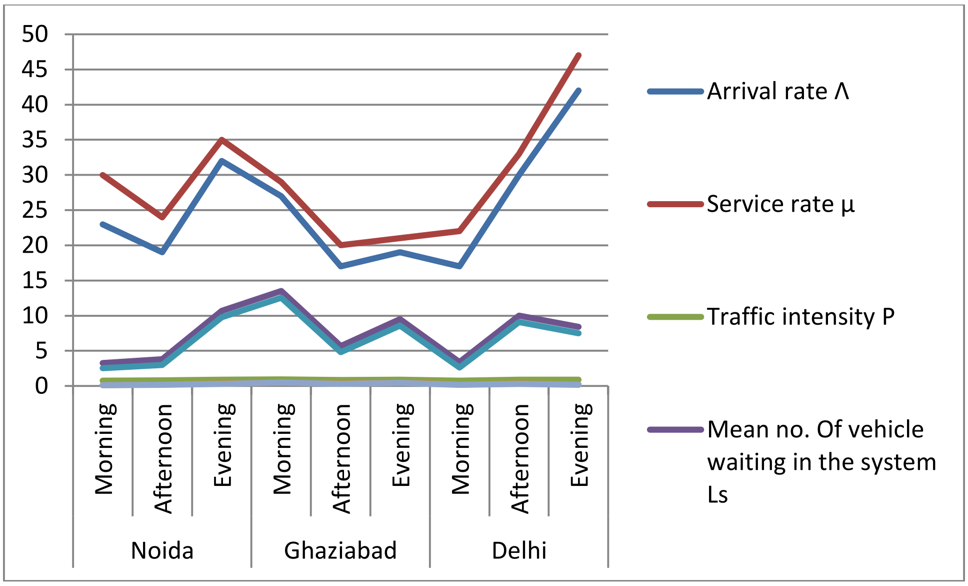
Location	Timing	Arrival		Service		Arrival rate	Service rate	Traffic Intensity
		Vehicle	Min	Vehicle	Min			
Noida	Morning	25	1.39	32	1.07	23	30	0.76666667
	Afternoon	21	2.69	25	1.1	19	24	0.79166667
	Evening	35	1.37	38	1.09	32	35	0.91428571
Ghaziabad	Morning	29	2.55	32	1.47	27	29	0.93103448
	Afternoon	18	1.59	22	1.06	17	20	0.85
	Evening	21	1.53	23	1.05	19	21	0.9047619
Delhi	Morning	19	2.22	24	1.08	17	22	0.77272727
	Afternoon	32	1.79	36	1.1	30	33	0.90909091
	Evening	46	8.26	49	1.47	42	47	0.89361702



Graphical Representation of traffic intensity of Noida, Ghaziabad and Delhi.

Representation of View of traffic situation of Noida, Ghaziabad and Delhi.

Location	Session	Arrival rate	Service rate	Traffic intensity	Average no. of vehicle waiting in the system	Average no. of vehicle waiting in queue	Average waiting time Spent in the system	Average waiting time Spent in the queue
		Λ	μ	P	Ls= A/(μ-A)	Lq= Ls*A/ μ	Ws=1/(μ-A)	Wq=Ws* A/ μ
Noida	Morning	23	30	0.76667	3	3	0.142857143	0.1095238
	Afternoon	19	24	0.79167	4	3	0.2	0.1583333
	Evening	32	35	0.91429	11	10	0.333333333	0.3047619
Ghaziabad	Morning	27	29	0.93103	14	13	0.5	0.4655172
	Afternoon	17	20	0.85	6	5	0.333333333	0.2833333
	Evening	19	21	0.90476	10	9	0.5	0.452381
Delhi	Morning	17	22	0.77273	3	3	0.2	0.1545455
	Afternoon	30	33	0.90909	10	9	0.333333333	0.3030303
	Evening	42	47	0.89362	8	8	0.2	0.1787234



IV. CONCLUSION

As the queuing theory focuses on representing traffic situations using various mathematical terms and formulas, it is an efficient mathematical technique for resolving a variety of traffic issues in any system. The current study is based on a real survey of traffic flow at different times and locations in the cities of Bhopal, Ujjain, and Indore. In order to reduce traffic congestion at a specific moment, the queuing theory is applied. By this work we find out different steps to avoid the congestion.

(1) Increasing road capacity can reduce traffic.

(2) For a certain user group, we can offer a dedicated lane.

(3) A variable massage sign can be erected alongside the road to warn motorists.

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