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A Comparative Study of Waiting Lines Between Multiple Single Server Model and the Real-Time Observed Data

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Abstract: Inefficiency and Non-frequency of conventional transit systems at Peri-urban areas result in delay in the travel time and cause inconvenience, dissatisfaction for the commuters. In order to evaluate the efficiency of the existing transit systems, Multiple single server model is established for two servers. Both Mathematical calculation and Real-time observation are carried out in the research. The model has been checked with the actual data surveyed. This paper presents a comparative study between the results from Multiple single server model and the data collected from real-time observation of 24 hours for seven days. A case study is provided to show up to what extent the model can be applied to a simple point-to-point system.

Index Terms: Arrival, Delay, Departure, Queue, Queue length

I. INTRODUCTION

Most cities in the world are experiencing severe problems caused by increased road traffic in terms of delays, fuel consumption, accidents, noise and environmental pollution. The unchecked use and growth of the private vehicles and the great difficulties associated with altering urban infrastructure to keep pace create a very worrying panorama for decision makers trying to provide answers.

Waiting on a queue is really inconvenient and gives a bad experience for the commuters, but reduction in the waiting time usually requires strategic planning and investment. The two main requisites in the analysis of delay for the current model are arrival rate and departure rate. We usually analyze queues in order to find the mean waiting time in the queue, the mean waiting time in the system, distribution of number of customers in the queue, sufficiency of existing number of servers etc. Decisions regarding the amount of capacity to provide for a server and the number of additional servers required must be made by any service provider for optimality.

The present study analyses the applicability of Multiple single server model for estimation of delay or waiting time of certain modes of public transportation in the study area i.e., Uppal to Ghatkesar corridor of Hyderabad city, Telangana District, India. This paper presents a comparative study between the results of calculated field delay and that of Multiple single server model for calculation of delay. Videography technique was used for data collection purposes. The organization of this paper is as follows. Sections-2 gives a brief description of Literature available on Queuing models applications in road transportation system. The methodology has been shown in Section-3. Section-4presents the analysis using the proposed Multiple single server model. The final Section-5 gives conclusion and recommendations.

II. LITERATURE REVIEW

There are various studies on waiting lines in transportation system. (S. P. Anusha et al, 2016) analyzed the traffic conditions at an signalized intersection in certain urban area by queuing theory using erroneous automated data, (Asim Karim et al, 2003) computed Queue delays and lengths using a deterministic traffic flow model based on the estimated work zone capacity.(D. M. Tate, 1990)conducted a study on performance measures for queuing models and presented a technique for modeling due-dates in a classical queuing framework,(Angel Ibeas Portilla et al., 2009) quantified the influence badly parked vehicles and on-street parking maneuvers by applying an M/M/∞ queuing model in the city of Santander, Cantabria, Spain.(Maoqing WANG et al.,2011)applied queuing theory to calculate ship's traffic capacity of the Three Gorges-Gezhouba hydro project and with the influence of ship's flow between the two locks under consideration, a model of double-stage M/M/n queuing model is established. (Dr Deepak Yaduvanshi et al., 2011) applied queuing theory to optimize waiting time in hospital operations. (Branislav Dragovićet al., 2011) evaluated port performance by queuing models and compared different modelling approaches in queuing theory. (Shantanu Das et al., 2004) developed a modified approach to treat various parameters of vehicular traffic (flow, density and speed) in the Minneapolis- St. paul metro area. (Olorunsola S. A et al., 2014) determined the optimal bed count and its performance measure by analyzing patient flow in hospital using queuing theory. (Arpita Saha et al., 2017) determined delay at signalized intersection under mixed traffic conditions to assess the level of service by modifying the existing HCM model. (Muhammad Imran Qureshi et al., 2013) examined the behavior and patterns of arrival of students in a university through observation method. The department of student affairs of different universities is investigated in this study. Queuing theory is adopted for analyzing waiting in lines/queues.

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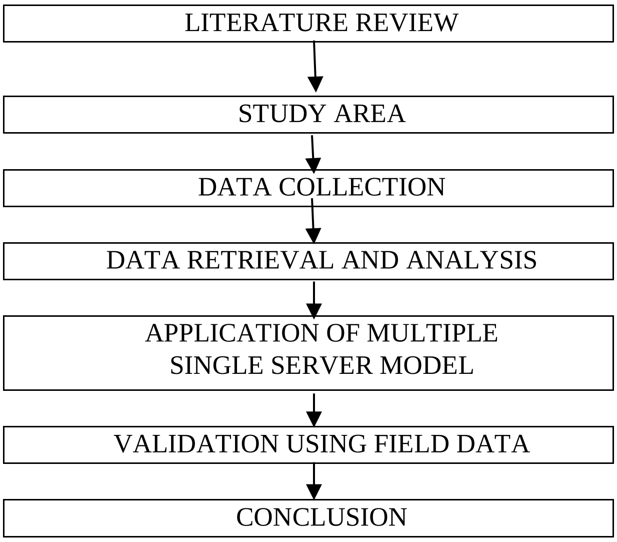
In most of the above papers mentioned in the literature review, the Queuing theory has been adopted in the calculation of waiting time and queue length. Few papers used either of the two methods for measuring delay, those are HCM model and Webster's model. These delay models have been developed according to the traffic conditions in the USA and UK, respectively. Nature of the traffic in these countries is primarily homogeneous and follow lane discipline. As there is no any standard method for developing countries, researchers in many parts of the world are using the same formulae to estimate delay at signalized intersections. Traffic in developing countries is highly heterogeneous in nature with extremely poor lane discipline. Therefore, it is necessary to investigate the performance of the previous models in heterogeneous traffic condition before their actual implementation in field. In addition to these models, measurement of delay can be possible by the other two methods mentioned in these paper. They are Multiple single server model and using Radar speed gun. This paper presents a comparison of the results obtained in these two methods.

III. METHODOLOGY



A. Study Area

A Corridor of Uppal – Ghatkesar of length 16.3 Km has been selected for the study as NH 163 (National Highway 163 (previously NH 202) is a National Highway in India that links Hyderabad in Telangana and Bhopalpatnam road in Chhattisgarh)is passing throughout the corridor and it is one of the busiest corridors of the city, a study says that about 14,68,748 vehicles cross Uppal junction every day. From the past 10-15 years traffic density has been increased enormously leading to severe traffic jams even during non-peak hours.

B.Field Data Collection and Extraction

Two types of data have been collected. One type of data gives the arrival and departure rates of two selected modes of public transport (city buses and passenger autos) by selecting the start and end points of the queue on the either ends of corridor, videography method was used for this data collection covering peak and non-peak hours. Another type of data has been fetched from manual traffic survey by licensed plate method. Data were collected of 24 hours for seven days. Two cameras were set up on the approaches of intersections to simultaneously capture the arrival and departure of the vehicles. One camera was placed on the upstream side of the studied approach to record vehicle arrival time, while the other was placed on the downstream side of the approach to record departure time of the same vehicles whose arrival time has already been recorded. By playing the videos of both arrival and departure taken in the field were played in the laboratory to calculate traffic volume, arrival rate and departure rate, related information were extracted for all the cycles in terms of number of vehicles. Vehicles were classified into six different categories, namely, two-wheelers, Cars, LCV, HCV, Buses and Autos. The observed traffic composition at the corridor is shown in Fig-1.The moment a vehicle enters into the boundary of the corridor is considered its entry time. Similarly, the moment the vehicle completely crosses boundary line of the corridor is noted as exit time of that vehicle. Traffic arrival and departure data were extracted for 30 minutes intervals.

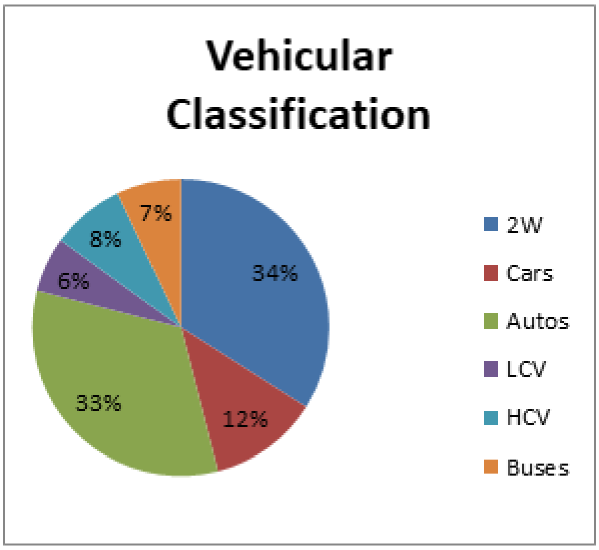


Figure I. Vehicular Classification at the Study area

IV. ANALYSIS AND RESULTS

A.During Morning Peak hours

(a)Arrival rate of vehicles from Uppal towards Ghatkesar

Time interval	Autos	City buses
7:30-8:00	280	45
8:00-8:30	274	38
8:30-9:00	292	39
9:00-9:30	314	43
9:30-10:00	304	41
Total	1464	206

Table- I

(b) Departure rate of vehicles at Ghatkesar

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Time interval	Autos	City buses
8:00-8:30	232	28
8:30-9:00	216	27
9:00-9:30	238	31
9:30-10:00	284	36
10:00-10:30	312	45
Total	1282	167

Table-II

(c) Delay Measurement Using Multiple Single Server Model

(i) For Autos :

TIME INTERVAL	Arrival Rate	Cumulative Arrival Rate	Departure rate	Cumulative Departure rate	Queue length	Delay time (Minutes)
30 Min	280	280	232	232	48	6.20
30 Min	274	554	216	448	106	14.72
30 Min	292	846	238	686	160	20.17
30 Min	314	1160	284	970	190	20
30 Min	304	1464	312	1282	182	17.5

Table no III

Average Delay (in Minutes) = 15.72

(ii) For City buses :

TIME INTERVAL	Arrival Rate	Cumulative Arrival Rate	Departure rate	Cumulative Departure rate	Queue length	Delay time (Minutes)
30 Min	45	45	28	28	17	18.20
30 Min	38	83	27	54	29	32.22
30 Min	39	122	31	85	37	35.80
30 Min	43	165	36	121	44	36.67
30 Min	41	206	45	167	39	26

Table no IV

Average Delay (in Minutes) = 29.78

B.During Evening Peak hours

(a)Arrival rate of vehicles from Ghatkesar towards Uppal

Time interval	Autos	City buses
4:00-4:30	286	40
4:30-5:00	282	36
5:00-5:30	272	34
5:30-6:00	247	34
Total	1087	144

Table no V

(b)Departure rate of vehicles at Uppal

Time interval	Autos	City buses
4:30-5:00	202	28
5:00-5:30	226	31
5:30-6:00	294	36
6:00-6:30	312	39
Total	1034	134

Table no VI

(c)Delay Measurement Using Multiple Single Server

Model

(i) For Autos :

TIME INTERVAL	Arrival Rate	Cumulative Arrival Rate	Departure rate	Cumulative Departure rate	Queue length	Delay time (Minutes)
30 Min	286	286	202	202	84	12.47
30 Min	282	568	226	428	140	18.58
30 Min	272	840	294	722	118	12.04
30 Min	247	1087	312	1034	53	5.10

Table no VII

Average Delay (in Minutes) = 12.05

(ii) For City buses :

TIME INTERVAL	Arrival Rate	Cumulative Arrival Rate	Departure rate	Cumulative Departure rate	Queue length	Delay time (Minutes)
30 Min	40	40	28	28	12	12.86
30 Min	36	76	31	59	17	16.45
30 Min	34	110	36	95	15	12.50
30 Min	34	144	39	134	10	7.70

Table no VIII

Average Delay (in Minutes) = 12.38

C. Delay measurement by the data from Licensed plate method and using Radar speed gun

(a)During Morning Peak hours

Average speed of the autos through the corridor found by radar gun= 42 kmph

Hence to travel 16.3 Km, it takes 23 minutes

Average travel time of Autos found by licensed plate method= 36 minutes; Delay= 13 minutes

Average speed of the City buses through the corridor found by radar gun= 34.50 kmph

Hence to travel 16.3 Km, it takes 28.35 minutes

Average travel time of buses found by licensed plate method= 49 minutes; Delay= 20.65 minutes

(b)During Evening Peak hours

Average speed of the autos through the corridor found by radar gun= 42 kmph

Hence to travel 16.3 Km, it takes 23 minutes

Average travel time of Autos found by licensed plate method= 33.50 minutes; Delay= 10.50 minutes

Average speed of the City buses through the corridor found by radar gun= 34.50 kmph

Hence to travel 16.3 Km, it takes 28.35 minutes

Average travel time of buses found by licensed plate method= 39 minutes; Delay= 10.65 minutes

V. CONCLUSION AND RECOMMENDATIONS

Intersections are the most common places in a road network where vehicles have to face significant delay while traveling. In order to calculate the delay for an entire trip, it

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is impossible to calculate the delay at each individual intersection. In that case, the delay calculation can be comfortably done using Multiple single server model and Field delay calculation method as mentioned in this paper. Moreover, these methods are applicable in developing nations like India, Where the traffic is highly heterogeneous in nature and lane discipline is poorly maintained. If conventional approaches like HCM, Webster’s and Queuing models give erroneous results, either of these two methods can be adopted for the calculation of Delay and Queue length. Out of the two proposed methods, the field method of calculation of delay using Radar speed gun underestimated the delay. Because it does not accounts for number of stoppings and timely behavior of traffic besides it is more tedious to get accurate results by this method. Hence, the delay calculation by mathematical model for Multiple single servers holds good for mixed traffic conditions, poor lane discipline, number of stoppings and different driving behavior in developing countries like India, unlike in developed nations.

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