Optimal Schedule Modeling for Public Transportation System

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Abstract: ***With rapid development across India, large urban areas have developed. This new metropolitan centers need for transportation facilities have increased fourfold. As India is a developing country public transport is the most important mode of transport. But Public transportation in India is inefficient and inadequate. Public transport has not been able to keep pace with the growing demand for transportation facilities. Therefore it becomes necessary to increase the efficiency of public transport so that more people can shift from private to public transport. The performance of transportation system can be improved by an Optimal scheduling of resources. Optimal scheduling can provide economical and efficient use of fleet resource and provide safe and fast mode of transport to city needs. The proposed method minimizes the waiting time of passengers at stops and to minimize the number of buses require for the same operation. The constraints include load factor, time constraint & frequency constraint. The optimal schedule will subjected to condition of maintaining a minimum number of passengers travelling onboard the buses. This will help to increase the frequency if the demand for service is more and reduce the frequency if demand is less and save considerable amount of money for the agencies. The proposed model is to be applied to an actual route for Nagpur city.***

Keywords: Optimal Scheduling, Public Bus Transport, waiting time,frequency

1. Introduction

With increasing demand in urban centers, demand for public transport has increased fourfold. This increased requirement has put tremendous pressure on exiting public transport infrastructure more so in peak hours. To balance this capacity is increased which adds to cost and congestion on urban roads. Hence increasing the capacity is not always a favorable option. Hence with use of technological advancements the performance of public transport is optimized to meet need of increasing demand. Today bus operations in India are manual and inefficient. This usually leads to missed or late arrivals to scheduled stops, inefficient use of resources, and constant decrease in operating speed. This situation leads to people switching to other mode of transport which is undesirable.

To increase the performance of transit we provide a better schedule, which is aligned with load factor or number of passengers in the bus present upon the capacity of bus. A good schedule is one which minimize the waiting time of passengers while maintaining that adequate passenger board the bus. The following operation is done while working within a set resources, which acts constraints for the proposed model. The model is developed such that demands of both transport system from both the company and user point of view. Load factor is most important consideration for the proposed model due to which the number buses will be increased or decreased according to number of passenger travelling on the route. The proposed model optimizes the headway between buses to allow buses to be assigned to public transport lines in accordance with the demand for the service o the route. The proposed model is tested in real condition for a route in Nagpur city.

2. Literature Review

Liang Xu et al. (2012) have developed a system by using ArcGIS Server technology to provide active bus monitoring and scheduling system. The method uses 3S technology GPS, RS, GIS together, to accomplish the on-time location, information collection and scheduling of the buses. ArcGIS Server give on-time status of each bus which could be observed by the user & authorities also it can calculate the bus arrival time at stops and display distance between two stops. The entire process is carried out by ArcGIS with no human interference which helps achieve new optimum level of optimization. Partha Chakroborty et al (1995) have proposed a method of optimal scheduling of transit networks optimization. They used genetic algorithm technique which is motivated by principles of natural genetics-to solve the scheduling problem the main advantage of using GAs is that the problem can be reformulated in a manner that is computationally more competent than the original problem. The study presents a number of other benefits which include optimal resource allocation and scheduling, scheduling based on fixed vehicle capacity, and network wide optimal scheduling. Sun chuanjiao et al. (2008) proposed a headway optimization and scheduling combination of BRT vehicles. A model based on genetic algorithm is designed to minimize passengers travel costs and vehicles operation cost. The method is analyzed check for various parameters such as Impact of traffic volume and travel speed. The obtained result shows the method help achieve optimal schedule performance. Farhan Ahmad Kidwai et al. (2005) have developed a bus scheduling model using genetic algorithm for transit network. Genetic algorithms are proposed as the computational tool because of their ability to handle large and complex problems. The paper suggest a two phases solution, first allocation of buses on individual routes with maximum link flow as the criteria, and second further reduction of buses on network basis making use of genetic algorithms as an optimization tool.Tan de-rong et al (2011) The paper presents a model for optimal scheduling by rational use of resources & adjusting demand & supply balance. The paper aims to develop a reasonable departure interval through the proposed model. The model is tested and a time table with departure schedule is obtained. Ashish Verma et al (2006) designed model for optimal integrated schedules for urban rail & feeder bus operation. The objective function for schedule coordination is minimization of the total waiting & transfer time of the commuters. The function is subjected to limit of load factor and transfer time.

3. Proposed Model

The objective of the scheduling problem is to minimize the waiting time of passengers at the bus stops and reduce the number of buses required for the job while maintaining adequate number of passenger onboard. The proposed objective is achieved by maximizing the frequency of bus service. There are, however, certain resource limitations and service-related constraints that have to be considered while attempting to achieve the goal of best level of service. The constraints are as follows, the fleet size, load factor .The total number of buses is constant. Also for some routes number of buses maybe fixed. Time constraint includes minimum stopping time at stops for which bus has to wait for certain period of time. Also the stopping time should not be more than higher limit that may cause unease to passengers. Policy headway is the minimum frequency of bus service to maintain at all times during day. Policy headway between two consecutive buses must be less than or equal to certain limit, provided by government agencies.

As many factors affect scheduling process it is necessary to make the following assumptions before modelling for public transportation system. The assumptions are necessary to maintain a standard over the result of the model. The assumptions are,

1. The types of the bus models are alike.
2. The passenger's arrival at the stops obeys uniform distribution.
3. Each passenger obeys the rule of first come, first on the bus.
4. The bus pulls in and pulls out on time according to dispatch time table.
5. The running time between stops must be a certain time; it cannot change following time period changes.
6. Time loss caused by traffic signal is equal in the same interval.
7. Departure interval for a time period will remain equal.
8. The fleet size in the model takes no account of vehicle breakdown and maintenance.

4. Mathematical Formulation

$$\max f = \sum_{j=1}^{J} \frac{Nm}{L*C}$$

Subject to

a) Load Factor: L=n/C $0.75 \leq L \leq 1.25$

b) Fleet Size: $f \leq Q$

Where,

f - Frequency for period j.

Nm - Maximum average number of passengers onboard in period j.

L – Load factor for period j.

j – Time interval.

C - Capacity of bus.

Q – Maximum number of buses on route.

n – Average number of passenger onboard during period j.

5. Problem Solution

The problem is to maintain an adequate number of passengers on bus during the time period. The duration of working hours are divided into time periods and is assumed to be hourly for the present case. The capacity of each bus is seating capacity plus the number of standing persons allowed. Load factor is average number of passenger travelling on the bus upon its capacity.

The product of Load factor and capacity gives the desired occupancy for the period j. For the study we had considered an occupancy of 75% as the minimum frequency to be maintained at all times. If the load factor is not maintained for a time period then the number of buses allocated should be reduced for the same period. Although a minimum frequency of buses is to be maintained at all times to avoid the discomfort to passengers.

The maximum number of passenger onboard for a time period is taken from the data collected at stop. The stop location on a route is selected such that it has maximum number of passenger boarding. The maximum value for total number of passenger for period is taken from the collected data for the duration of study.

6. Testing Proposed Model

The proposed method is applied to a real world conditions on city buses for Nagpur city for the Bardi to Hingna route. The city buses run to and from Bardi to Hingna starting at 6:00am to 10:00pm. The length of route is 16 km and total of 20 buses run daily. The round trip travel time for the route is 1.5 hours (110 minutes) with 27 stops.

The peak hour is considered between 8:00 am to 11:00 am and 5:00 pm to 7:00pm .the frequency for peak hour is 8 buses while for non peak hours it is 6 buses with an interval of 10 minutes in between them. The buses can carry 58 passengers in which 44 are seated and 14 standees.

Table 1: Timetable Of Bardi To Hingna Route

Direction	Start Time					
Bardi to Hingna	6:00	6:10	6:20	6:30	6:40	6:50
	......	21:40	21:50	22:00	22:15	22:30
Hingna to Bardi	6:05	6:20	6:30	6:40	6:50	7:00
	....	22:35	22:45	22:55	23:05	23:25

The stop selected to measure the maximum load is morbhavan stop. The data was collected for working and non working day throughout the schedule run time. The average maximum numbers of passenger boarding the bus are shown in following graph.

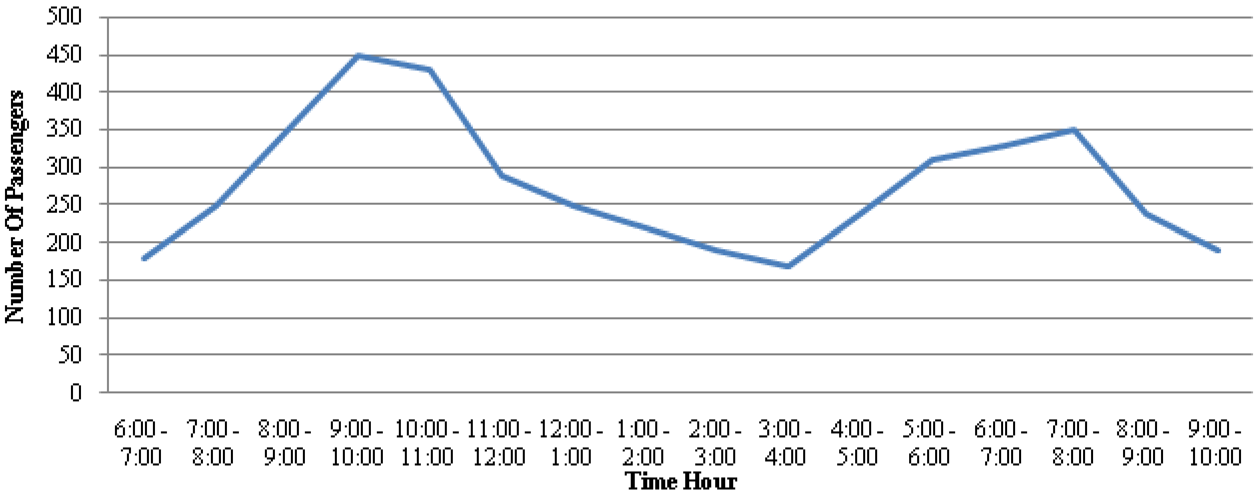

Figure 1: Average Number of Passenger at Stop.

The maximum value for number of passenger for a particular period is chosen from the set of reading for the same period from study days. The average number of passenger a bus carries during that period gives the load factor for that period. From the study it has been seen schedule can be made for working days and non working days with a reduced frequency. The schedule is drawn for each time period so as cater to that specific period demand.

7. Conclusion

From the result of the proposed model we have been able to form an optimal schedule while maintaining a percent load factor. The frequency is optimized according to passenger demand which means increase the level of service; while where the frequency is reduced it would lead to more load on running buses.

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Table 2: schedule for working day

Working Day Schedule					
Time Range	Frequency	Departure Interval(Minutes)	Time Range	Frequency	Departure Interval(Minutes)
6:00 - 7:00	4	15	2:00 - 3:00	5	12
7:00 - 8:00	6	10	3:00 - 4:00	5	12
8:00 - 9:00	8	7.5	4:00 - 5:00	6	10
9:00 - 10:00	8	7.5	5:00 - 6:00	8	7.5
10:00 -11:00	8	7.5	6:00 - 7:00	8	7.5
11:00 -12:00	6	10	7:00 - 8:00	8	7.5
12:00 - 1:00	6	10	8:00 - 9:00	6	10
1:00 - 2:00	6	10	9:00 - 10:00	5	12

Table 3: schedule for non working day

Non-Working Day Schedule					
Time Range	Frequency	Departure Interval(Minutes)	Time Range	Frequency	Departure Interval(Minutes)
6:00 - 7:00	4	15	2:00 - 3:00	5	12
7:00 - 8:00	5	12	3:00 - 4:00	5	12
8:00 - 9:00	6	10	4:00 - 5:00	5	10
9:00 - 10:00	6	10	5:00 - 6:00	7	09
10:00 -11:00	6	10	6:00 - 7:00	7	09
11:00 -12:00	6	10	7:00 - 8:00	7	09
12:00 - 1:00	6	10	8:00 - 9:00	5	12
1:00 - 2:00	5	10	9:00 - 10:00	5	12