Improving Crew Scheduling Of Mass Transport System-A Case Study Of Rajkot City

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***Abstract*—This electron Bus driver scheduling is an important part of every transportation system. In this research study, the solution of bus driver scheduling problem at R.M.T.S, in Rajkot City of Gujarat is studied. In every transportation system there are a number of regulations related to the crew scheduling like maximum work hour, least layover time, trip duration, peak hour factor, idle time, break period, etc. There are many problems coming during preparation of bus driver scheduling. For which the independence constrain for the development of mathematical model of such scheduling problem is developed. This independence constrain is the basis of declaration to meet the work intensity of driver, the time shift of trip & effects of peak and off-peak hours on trip duration. Main objective of this mathematical model is to minimize the total idle time, for which the algorithm is prepared to generate the initial solution based on the ordered sequence. The results showed that the proposed mathematical model for bus driver scheduling provides the effective solution of bus driver scheduling problem by efficient utilization of crew scheduling, which leads to Minimize the total idle time.**

***Index Terms*—Bus driver scheduling, Public transport system**

I. INTRODUCTION

Public transport plays a very significant role in the present scenario of unpredictable transportation demand. Many parameters like frequency, safety, comfort, accessibility, reliability can be improved in making an efficient mass transport system. On the other side in designing an effective and efficient public transportation system, virtually every transit authority in the world must optimize their available resources such that costs are minimized and numerous other criteria are met. Bus driver scheduling and vehicle scheduling also plays an important role in improving the efficiency of public transport system. This research specifically concentrates on improving the bus driver scheduling of Rajkot Mass Transport System (RMTS) by minimizing the idle time of the crew and increasing the total number of trips in a day. Some of the definitions used in this paper are as follows:

Driver Scheduling: It is a solution that contains a set of shifts that cover all the required driver work.
Relief opportunity: It is time and place where a driver can leave the current vehicle for reasons such as taking a meal-break or transferring to another vehicle.
Piece of work: The work between two consecutive relief opportunities on the same vehicle is called piece of work.
Shift: The work a single driver carried out in a day is called a shift. This is composed of several spall of work. A spell contains a number of consecutive pieces of work on the same vehicle. The driver scheduling problem can be formulated as a set covering integer linear programming.
Integer programming: It is an extension of linear programming with only integer values for the decision variables of the problem.

II. PROBLEM STATEMENT

Number of labour regulations have to be considered in scheduling of ant transportation system. If scheduling id done manually there may be a part of crew with long working hours and some with short working hours. As there is much difference in the working hours of the crew, this unfair phenomenon may affect the work and productivity of the driver which reduces the working efficient and the quality of overall bus service.

III. OBJECTIVES

To reduce the idle time of the crew and to increase the number of trips.
To compare the existing schedule with proposed schedule.

IV. LITURATURE REVIEW

The bus driver scheduling has received much attention since last few years. Although very less research has been done in this area some of the literatures hve successfully solved the problem of bus driver scheduling.

Mingming Chena and Huimin Niua(2012), "Research on the Scheduling Problem of Urban Bus Crew Based on Impartiality" studied on the scheduling problem of urban bus crew based on impartiality. They considered impartiality constraint which is on the basis of assurance to meet the time shift of trips and work intensity for the crew, and establishes a crew scheduling model with the objective of minimizing the total idle time. They are assuming (1) The type of urban bus line is a ring one, which means that the starting station and terminal are the same bus station. (2) The departure and arrival time of all trips are determined, and trips have been numbered in sending departure time order (3) The number of crew is large enough to meet the demand for bus trips, and a crew should be restricted to work in the same vehicle during the bus operating time. (4) The type of duty is a single mode. Based on this assumption they give the optimization formulation.

Maikol M. Rodrigues , Cid C. de Souza & Arnaldo V. Moura (2006), "Vehicle and crew scheduling for urban bus lines" described a computational tool developed for solve the urban transportation problem in the large metropolitan area of Sao Paulo, Brazil. They have used hybrid strategy mathematical programming models and heuristics were combined with it for solving the optimization problems related to scheduling.

Jingpeng Li & Raymond S.K. Kwan (2003), "A fuzzy genetic algorithm for driver scheduling" studied on a hybrid genetic algorithm based on the fuzzy set theory for the public transport bus driver scheduling problem. The basic objectives are to minimize the total number of shift & total shift cost. They presented the greedy algorithm framework in GAFE. The mathematical model of fuzzy comprehensive evaluation is then discussed.

Christors Valouxis and Efthymios Housos (2000), "Combined bus and driver scheduling" studied on the combined bus and driver scheduling. In this paper optimized model for the solution of the combined bus and driver scheduling problem is presented for Greece public transport. The planning is presently done manually or follows a fixed inflexible and often inefficient historical set of shift patterns. This paper presents a quick heuristic scheduling procedure for the solution of the problem.

V. STUDY AREA PROFILE

Rajkot with an average elevation of 128 meters (420 ft) located at 22.3°N 70.78°E on the bank of Aji River and Nyari River in the area of 170.00 km² is the fourth largest city of Gujarat after Ahmedabad, surat and Baroda . Rajkot has a central location in the area called the Kathiawar peninsula and its significance is owing to the fact that it is one of the prime industrial centres of Gujarat. Rajkot city is the administrative headquarters of the district of Rajkot. It is the 35th largest urban agglomeration in India with a population of more than 1.28 million as of 2012.

V.I INTRODUCTION TO RAJKOT MASS TRANSIT SYSTEM (R.M.T.S)

RMTS started on 10th Oct'2013. Phase-I was completed with the total 60 buses including 40 Mini+20 Standard Buses Operational on 30 Routes. Phase-II - Jan 2015 with the addition of 30 buses became Operational on 14 new routes. It has more than 550 pickup stands and 94 bus shelters conveniently located @ 400 to 600mt. distance. It consists of two depot including workshop and office facilities. There are three control cabins for effective monitoring and maintaining schedules. More than 38,000 peoples using City bus daily. Bus operates from 6:00 am to 10:30 pm. It covers total 15570 kms. Per day @ 173 kms / bus. It has on board ticketing and real time connectivity with server and a Separate agency for fare collection. There is Real time announcement in bus for upcoming station. It has 50% Concession for Student, Senior Citizen and Physically Disabled people.

VI. DATA COLLECTION AND ANALYSIS

For the purpose of data collection a single route has been selected which has maximum demand. The data of that roué is as follows:

Route name : Trikonbag to Government engineering College.
Route no: 57
Trip start time : 06:00
Trip end time: 19:45
Frequency : no particular frequency maintained
Break time : no particular break time is fixed
No. of buses on this route: 4 (Named as A, B, C, D.)
No. of trips carried out : 8, 8, 6 and 6 respectively by buses A, B, C and D in a day.

From the data it is observed that the trips don't have any fixed layover time. In most of the trips the difference between the arrival time and departure time is very large which is against the selected constraints. The idle time of the crew is very large which needs to be minimized. No fixed schedule is followed. In RMTS two types of buses are available mini Buses and Standard buses. In all route only standard buses are running and frequency observed is very less which can be improved by using mini buses at higher frequency. The difference in the working hours of the crew in all the observed routes is very high.

VII. MODAL DEVELOPMENT

In this research an optimization model is developed which minimizes the idle time of the crew and simultaneously increases the no. of trips.

Objective function of the model:

It can be expressed by minimizing the total idle time of crew.

$y_{ij}^{k}(d_j - a_i)$ it is used for the calculating idle time of crew between two adjacent trips i and j

$\min \sum_{k=1}^{m} \sum_{i=1}^{n} \sum_{j=2}^{n} y_{ij}^{k} (d_j - a_i)$ .....(1)

where n= Number of trips in a day, m=number of crew available in day. i=index of trip, k=index of the crew. ai=Arrival time of trip i. d_i= The departure time of trip i.x_i^k= It is the decision variable which indicates whether trip i is carried out by crew k. it takes two values: 1 if trip i is carried out by crew k or 0 if trip is not carried out crew by k., y_{ij}^{k}=it is a binary zero-one variable which is used to represent the status of trip i and trip j carried out by crew k.

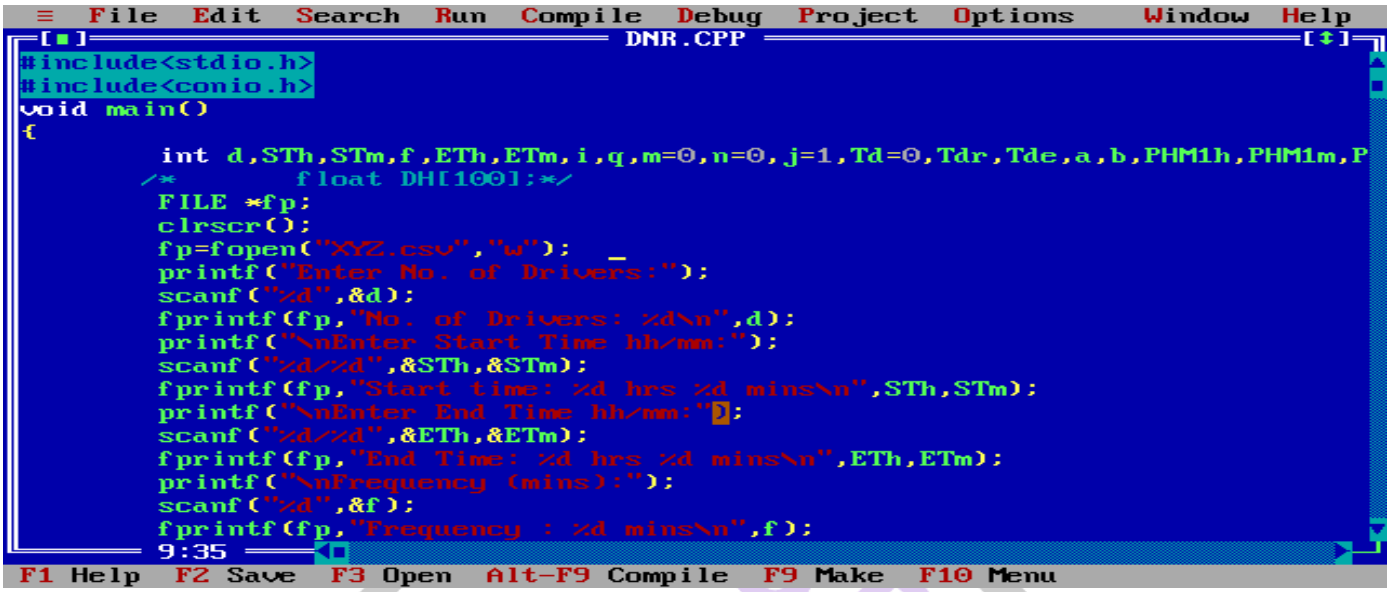

Figure 1 Development of code in c language

VII.II INPUT PARAMETERS OF THE PROGRAM

The parameters which are taken as input in the program for the scheduling are:

No of drivers (Assumed that 1 driver is for 1 bus), Start time of the trip, End time of the trip, Trip duration(normal time taken to complete the trip), Peak hour trip duration, Morning peak hours , Evening peak hours.

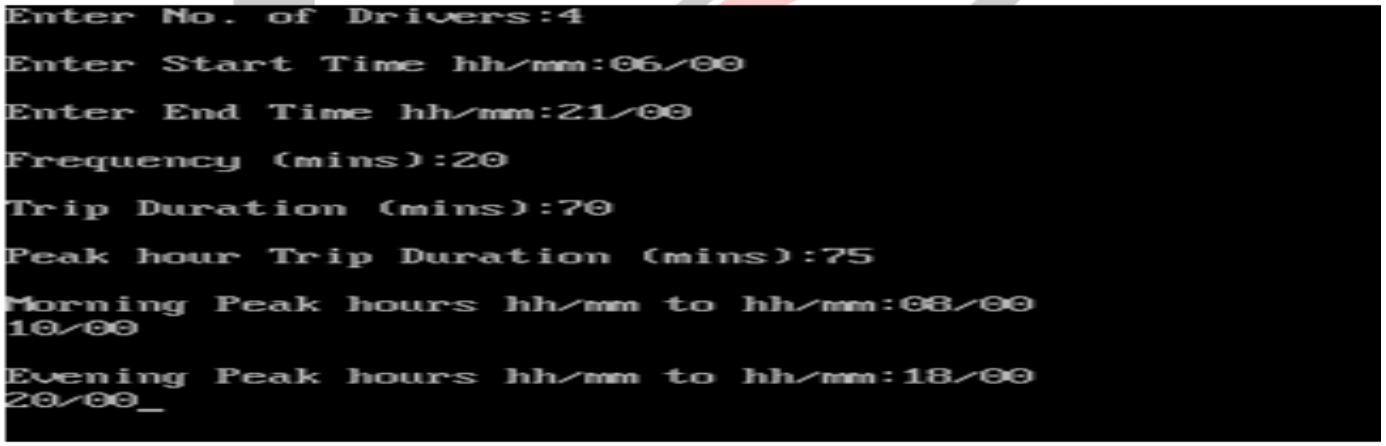

Figure 1 Input page

VII.III. OUTPUT OF THE PROGRAM

Table 1 Suggested Schedule Of Trikonbag To Government Engineering College

series	Trip time	Break time
1	6hrs 0mins 7hrs 10mins	Break time for Series 1 Driver: 12:30 to 13:30
2	6hrs 20mins 7hrs 30mins	Break time for Series 2 Driver: 12:50 to 13:50
3	6hrs 40mins 7hrs 50mins	Break time for Series 3 Driver: 13:10 to 14:10
4	7hrs 0mins 8hrs 10mins	Break time for Series 4 Driver: 13:30 to 14:30
1	7hrs 20mins 8hrs 30mins	
2	7hrs 40mins 8hrs 50mins	

3	8hrs 0mins 9hrs 15mins	
4	8hrs 20mins 9hrs 35mins	
1	8hrs 40mins 9hrs 55mins	
2	9hrs 0mins 10hrs 15mins	
3	9hrs 20mins10hrs 35mins	
4	9hrs 40mins 10hrs 55mins	
1	10hrs 0mins 11hrs 15mins	
2	10hrs 20mins11hrs 30mins	
3	10hrs 40mins11hrs 50mins	
4	11hrs 0mins 12hrs 10mins	
1	11hrs 20mins12hrs 30mins	
2	11hrs 40mins12hrs 50mins	
3	12hrs 0mins 13hrs 10mins	
4	12hrs 20mins 13hrs30mins	
1	13hrs 40mins14hrs 50mins	
2	14hrs 0mins 15hrs 10mins	
3	14hrs 20mins15hrs 30mins	
4	14hrs 40min 15hrs 50mins	
1	15hrs 0mins 16hrs 10mins	Break time for Series 1 Driver: 17:30 to 18:00
2	15hrs 20mins16hrs 30mins	Break time for Series 2 Driver: 17:50 to 18:20
3	15hrs 40mins16hrs 50mins	Break time for Series 3 Driver: 18:10 to 18:40
4	16hrs 0mins 17hrs 10mins	Break time for Series 4 Driver: 19:50 to 20:20
1	16hrs 20mins17hrs 30mins	
2	16hrs 40mins17hrs 50mins	
3	17hrs 0mins 18hrs 10mins	
4	17hrs 20mins18hrs 30mins	
1	18hrs 0mins 19hrs 10mins	
2	18hrs 20mins19hrs 40mins	
3	18hrs 40mins19hrs 55mins	
4	18hrs 40mins19hrs 50mins	
1	19hrs 20mins20hrs 35mins	
2	19hrs 50mins21hrs 00mins	
3	20hrs 05mins21hrs 15mins	

VIII. COMPARISION BETWEEN EXIXTING SCHEDULE AND SUGGESTED SCHEDULE

Table 2 Comparision Between Exixting Schedule And Suggested Schedule Of Route No 57

Trikonbag to Government engineering College						
sr. no	Trip Start Time		Trip End Time		Total No of Trips	
	Existing	Suggested	Existing	Suggested	Existing	Suggested
	06:00	06:00	19:25	20:35	8	10
	07:05	06:20	19:50	21:00	8	10
	07:45	06:40	17:10	21:15	6	10
	09:05	07:00	18:15	19:50	6	9

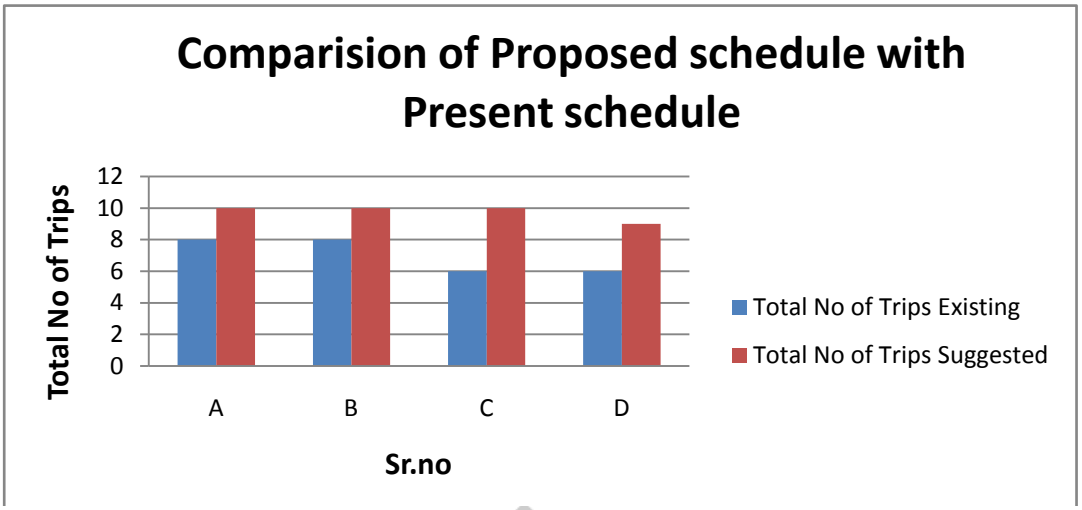

Figure 2 Graph of Comparison Of Proposed And Existing Schedule Of Route No 57

IX. CONCLUSION

From the output of the program and from the comparison table following conclusions can be made:

The idle time of the crew is reduced and the number of trips are increased in the programmed schedule. The break time of all the crew is fixed which was not fixed in the existing schedule. The selected constraints are satisfied and further if needed demand parameter can be included in the program.

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