Scientific Journal of Impact Factor (SJIF): 4.72

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 3, March -2017

A Review on Optimization of Bus Driver Scheduling

Sunny Patel[1], Prof. (Dr.) P. J. Gundaliya[2]

[1]Student, Civil Engineering Department, L.D. College of Engineering, Ahmedabad.
[2]Professor, Civil Engineering Department, L.D. College of Engineering, Ahmedabad.

Abstract — *Efficiency of any transportation system pivot on mainly on parameters such as accessibility, reliability, comfort, frequency, safety etc. Vehicle scheduling and bus driver scheduling are also considerable parameters which affects the quality of public transport system. For any public transport system to work efficiently, optimization of all these parameters are required to gain maximum benefits to the operators as well as commuters at minimum cost. Following work focuses specifically on bus driver scheduling keeping in mind the labour agreement rules and the research on the optimization of bus driver scheduling using heuristics approaches like genetic algorithm, tabu search algorithm has been reviewed.*

Keywords- *optimization, vehicle scheduling, Bus driver scheduling, public transport system, algorithm*

I. INTRODUCTION

Bus driver scheduling has obtained plentiful attention in the last decade. Driver scheduling problem consists to find a trips which also covers the vehicle schedule. Driver schedule should be in such a way that all the resources effectively utilized and satisfy all the constraints which are formed by the company and labour union rules. It is stated to find the minimum cost of daily duties, which covers all trips or vehicle blocks. A driver's duty is a part of work that can be allocated to a driver. Journey of a vehicle between its departure from the garage and its returns to the garage called vehicle blocks. Vehicle blocks are divided into pieces of work, such division occurs only at a relief point like, a time and a place at which change of drivers is possible. Therefore we can say that driver scheduling problem have multiple conflicting objectives and constrain.

By using conventional approaches, it is hard to decide optimal solution for such multiple conflicting problems. Several formulations and algorithms has been proposed for the crew-scheduling problem.

Scheduling software developers have options to choose how to perform the scheduling tasks. Many of them choose to perform driver and vehicle scheduling at the same time. Some algorithms have been designed to build crew shifts directly by using the units of bus work. In this task, first an effective bus schedule is created. After that a driver schedule is formed which cover all the bus work, then vehicle schedule is re-written so that the vehicles should follow any driver limitations.

1.1. Driver Scheduling

For effective public transportation system, optimization of their available resources is necessary for every transit authority in the world. Resource optimization should be in such way that costs are minimized and several other criteria are met. In any transit systems planning process includes network route design, setting time tables, vehicle scheduling and driver scheduling respectively. Apart from cost minimize, the standards involved in driver scheduling task are operational time, number of vehicles and drivers required, driver-satisfaction criteria such as including driver union rules. As such, driver scheduling task become multi-objective problem.

Usually bus driver scheduling problem have multi-objective related to the minimizing the total number of bus driver. Driver scheduling problems have multiple conflicting objectives and constrain. It is hard to generate optimal solution for such multiple conflicting objectives by using the conventional approaches. It is found that GA (Genetic Algorithm) performs fit for such multi objective problems (Jingpeng Li & Raymond S.K. Kwan 2003).

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.

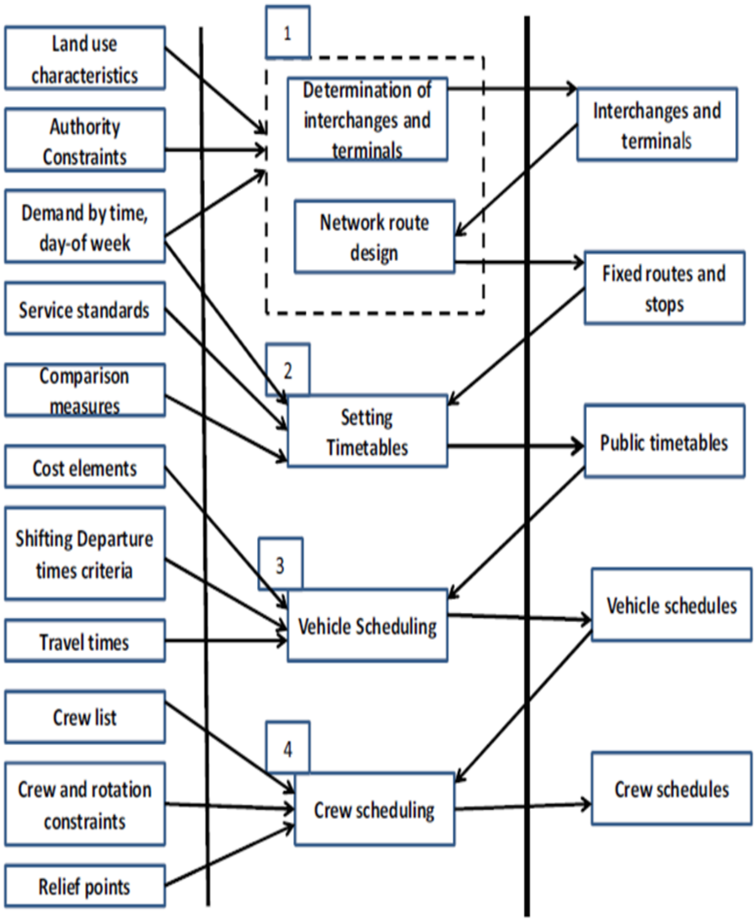

Fig. 1: Planning process at Public Transport Company

1.2. Labour Agreement Rules

The rules which governs the building of duties are mostly determined by past practices and local conditions which are agreed between bus company and driver union as internal regulations while other regulations are provided by the government. Some of the rules are given as guidelines which are relaxed i.e. SOFT rules and some are adhered to HARD rules. Most rules are relevant to all bus companies even though their parameters differ, while some are the additional rules made by the company itself which needs to be considered for driver requirements. The tightness of the rule plays an important part in the scheduling process.

Typically, the global rules are:
- The paid allowance for signing on and off the garage.
- The maximum time a driver can work without a meal break.
- The minimum length of meal break.
- The minimum layover time.
- The total working time.
- The total spread over (duration between the beginning and the end of the trip).

II. LITERATURE REVIEW

Mingming Chena and Huimin Niua (2012), studied on the urban bus crew scheduling problem based on the constraint of impartiality. Impartiality constraint was considered to meet work intensity for the crew, time shift of trips and found a crew scheduling model with the objective of minimizing the total idle time. They were assumed (1) Bus line is a ring one. which means that the starting station and terminal station are the same bus station. (2) Crew number is sufficient to meet the demand for bus trips. (3) Departure time and arrival time of all trips are determined and then departure time is set in descending order. (4) Duty type is a single mode. Based on this assumption they gave the optimization formulation.

Objective function:
It was expressed to minimize the total idle time of crew.

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

Constraints:

1) Each trip will carry out by exactly one crew. Therefore, we have

$$\sum_{k=1}^{m} x_i^k = 1, \ \forall i$$

2) The relationship between binary zero-one variable y_{ij}^{k} and variable x_i^k can be stated by the below equation.

$$y_{ij}^{k} = x_i^k x_j^k$$

3) Each crew should satisfy the time shift constraint, which means the difference between departure time ($x_j^k d_j$) of latter trip and arrival time ($x_i^k a_i$) of former trip should not be less than the minimum layover time T_0.
4) Work intensity constrain should be satisfy by the crew, which means the total work time of individual crew does not exceed the work hours T_1.

$$\sum_{k=1}^{m} x_i^k (a_i - d_i) \leq T_1, \forall k$$

5) Impartiality constraint was introduced to minimize the work time difference between crews, which means the maximum work time and minimum work time of crews should not exceed the specified value T_2. For that G_k parameter introduced.

$$G_k = \sum_{k=1}^{m} x_i^k (a_j - d_i) \leq T_2$$

Definition use in this model: -
n= Number of trips in a day, m= Number of crew available in day, k= Crew index, i= Trip index, a_i = Arrival time of trip i, d_i = Departure time of trip i, T_0 = Least layover time for each crew. T_1= Maximum Number of work hours for each crew. T_2= Maximum work hour difference value between two different crew. y_{ij}^{k} is a zero-one variable which is used to represent the status of trip i and trip j carried out by crew k. x_i^k = It is the decision variable for trip i is carried out by crew k. it takes two values: if trip i is carried out by crew k it values 1 or if trip is not carried out by crew k it values 0.

Bastian Amberg et al. (2011), presented delay-tolerance approaches for vehicle schedules and crew schedules. They considered different sequential, partial-integrated and integrated planning methods to increase delay-tolerance of vehicle and crew scheduling. In their study two different types of approaches were proposed: approaches using historical delay data and approaches using no information about possible delays. They deal with delay-tolerance by adjusting buffer time between adjacent crew schedules and vehicle schedules. Buffer time was adjusted in such a way that, planned cost did not increase greatly.

Goel and Kok (2009), studied truck driver scheduling problems considering the European Union regulations for team drivers where a sequence including locations were visited. The standard limits of driving time were considered and the schedules were prepared.

Maikol M. Rodrigues et al. (2006), developed a computational tool for urban transportation problem in the large metropolitan area of Sao Paulo, Brazil. In this research paper, they have used hybrid strategy in which, mathematical programming models and heuristics were combined. Authors also stated that, combination of mathematical model and heuristic should give better results in real life conflicting restrictions.

Jingpeng Li and S.K. Kwan (2003), studied on a hybrid genetic algorithm based on the fuzzy set theory for the public transport bus driver scheduling problem. Their basic objective was to minimize the total number of shift and ultimately minimize the total shift cost. A greedy algorithm (GA) was used in which schedule was constructed by selecting shifts from a very large set of pre-generated shifts. In that process, Individual shifts as well as whole schedule have to be evaluated. On such evaluations, Fuzzy set theory was applied. At last, they carried out results comparison using real-life problems.

Christors and Housos (2000), studied on the combined bus driver scheduling. They presented optimize model for combined bus-driver scheduling problem in Greece. Combined bus-driver scheduling was introduced with the special requirement that the driver and his bus remain always together and such this obligation comes from the fact that most of the buses owned by driver. All these trips organized into shifts and assigned to buses from the data of late in the afternoon of the previous day. In the beginning the planning was done manually or follows a fixed schedule. Schedule was inflexible and often inefficient historical set of shift patterns. A CGQS (Column Generation Quick Scheduling) was used for the solution of the problem.

Optimization formula:

$$min \sum_{j=1}^{n} C_j X_j \qquad Subjected\ to, \sum_{j=1}^{n} a_{ij} x_j \leq 1, \quad i \in B$$

$$\sum_{j=1}^{n} b_{kj} x_j = 1, \quad k \in T$$

Definition use in this model: -

n = Number of generated shift. i = index of busses. J = index of shift. k = index of crew. B = set of busses. T = set of segment. a_{ij} = 1 if bus i is covered by shift j, otherwise value is 0. b_{kj} = 1 if trip segment k is covered by shift j, otherwise value is 0. 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.

Helena Lourençoet et al. (1998), presented solution of real crew scheduling problems in a public transportation bus company by using the Metaheuristics approach. In their research, main application was for bus transportation companies. In their scheduling problem, where all data came from bus crew they designate the problem as the BDSP (Bus Driver Scheduling Problem). Metaheuristics approach presented in this research paper can also be applied to other real life crew-scheduling problems in different sectors like train and airlines companies.

At present, primary programs in use for driver and vehicle scheduling are: TRAPEZE, HASTUS, and TRACS.

2.1. TRAPEZE

TRAPEZE (Fulton, 2006) is optimization software. It optimizes vehicle and bus driver scheduling together or individually as per the need of the user. Before generating an optimal solution, hard and soft constraints are specified by user. Soft constraints control quality control aspects while, hard constraints are labour union rules of working, management panels, and vehicle and crew limitations. User can also allow to choose cut pay, cut shifts and decrease overtime pay. In this step, labour union agreements and predefine part-time vs. full-time employees are also considered. Additionally, transit agency also determines the maximum and minimum number of buses available for services and number of buses stored at a specific depot.

Three stages are implemented for driver and vehicle scheduling problem. In first stage, large problems are split into homogeneous sets and then constraints modelling done by using linear programming. In second stage, sub problems are combined. For that, linear programming is used to extract shifts. For small size problems, integer linear programming is used to generate the solution. In last stage, it is determined that consecutive pieces of work that can be performed by the same bus by working out the solution. After that, segments are shift to improve the solution by using the assignment.

By 2013, BEST (Brihan Mumbai Electric Supply & Transport) installed TRAPEZE planning and scheduling system. TRAPEZE reduce administrative hours from 4-5 weeks to 2-3 days. It also helps in bring down manpower cost by 4% without affecting actual service level.

2.2. HASTUS

HASTUS optimizing scheduling software was developed 30 years ago. Initially, this optimization tool has been developed for need of specific transit companies. Vehicle scheduling and crew scheduling problems can be solved individually or combined as per user need. Initially, problem is dividing into the blocks then into pieces of work, then pieces of work are matches to form drivers' schedules. After that, schedule is assigned to actual operators, and finally solution is improved using heuristic approach (Wren and Rousseau, 1995). Software contains subsystems HASTUS-Bus, HASTUS-Macro, and HASTUS-Micro, respectively. All these subsystems are fully integrated, HASTUS-Macro is considered an "intelligent-interactive" system as it also allows the interaction between mathematical optimization tools and user input.

III. RESEARCH EXTRACT

It is observed that when transit agency reached an adequately large fleet size as well as employment size increases, it is necessary to adopt an automated system for better operation of organization. As automated system performs driver and vehicle scheduling in such a way that will provide the most efficient and cost effective service to the passengers and organization. At present TRAPEZE, HASTUS, and TRACS are three primary programs currently in use for driver and vehicle scheduling. Each program's objective is to minimize the cost and allowing users to enter any constraints particular to their agency or labour union agreements. All of these optimization programs have identical objective functions. All of these methodologies have acceptable for significant cost savings for public transit agencies in terms of the amount of money spent on drivers, vehicles, and manpower to perform the scheduling task itself. Automated system is beneficial as there is still scope for improvement in these methodologies.

Prior information required for optimization: total number of buses, number of crew members, number of trips, arrival time and departure time of each trip, layover time, frequency of buses, break time etc.

IV. CONCLUSION

Driver Scheduling if done manually, it may not be able to satisfy all the constraints and also consumes more administrative hours. Genetic algorithm proves to be very efficient for Bus Driver Scheduling along with mathematical model. Integer linear programming, Hybrid Genetic algorithm, Tabu search algorithm, Greedy algorithm, metahuristics etc. results in efficient optimization with minimum cost in comparison of manual scheduling.

REFERENCES

[1] Asvin Goel and Leendert Kok (2009) "Efficient Scheduling of Team Truck Drivers in the European Union" Operational Methods for Production and Logistics, University of Twente P.O. Box 217, 7500AE, Enschede, Netherlands.
[2] Bastian Amberg, Boris Amberg and Natalia Kliewer (2011) "Increasing delay-tolerance of vehicle and crew schedules in public transport by sequential, partial-integrated and integrated approaches" ELSEVIER ,Freie Universität Berlin, Garystr. 21, 14195 Berlin, Germany.
[3] Christos Valouxis and Efthymios Housos (2000) "Combined bus and driver scheduling" PERGAMON, Department of Electrical and Computer Engineering, University of Patras, GR-26500 Rio, Patras, Greece.
[4] Fores, S. and Proll, L. "Driver Scheduling by Integer Linear Programming- The TRACS II Approach", University of Leeds Report 98.01,1998.
[5] Gunther Zapfel and Michael Bogl (2007). "Multi-period vehicle routing and crew scheduling with outsourcing options" ELSEVIER, Institute of Production and Logistics Management, University of Linz, Austria.
[6] Helena Ramalhinho Lourenço, Jose Pinto Paixao & Rita Portugal (1998) "Metaheuristics for the Bus-Driver Scheduling Problem" ISSN: 0041-1655 Department of Economics and Management, Universitat Pompeu Fabra, R.Trias Fargas 25-27, 08005 Barcelona, Spain.
[7] Jingpeng Li and Raymond S.K. Kwan (2003) "A fuzzy genetic algorithm for driver scheduling" ELSEVIER, School of Computing, University of Leeds, LS2 9JT Leeds, UK.
[8] Kwan, A.S.K, Parker, M.E., Kwan, R.S.K, Fores, S., Proll, L., Wren, A. Recent Advances in TRACS, Proceedings from the 2004 Conference on Advanced Systems for Public Transport (CASPT).
[9] Mingming Chen and Huimin Niu (August 1–3, 2012) "Research on the Scheduling Problem of Urban Bus Crew Based on Impartiality" ELSEVIER, 8th International Conference on Traffic and Transportation Studies Changsha, China..
[10] Maikol M. Rodrigues & Cid C. deSouza & Arnaldo V. Moura (2004) "Vehicle and crew scheduling for urban bus lines" ELSEVIER ,Departamento de Informa´ tica, Universidade de Fortaleza.

