Heuristic Methods Applied to the Optimization School Bus Transportation Routes: A Real Case

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Abstract. The problem discussed in this paper is similar to the Vehicle Routing Problem (VRP), however new contributions are proposed. In this work a heuristic algorithm is proposed to determine the set of the Bus Stops. A new approach is proposed to construct digital maps containing the roads where the vehicles will be able to travel, since there are no digital maps of these regions. The real distances between the points are calculated and the heuristics Location Based Heuristic with some additional features was used to propose the new routes. The algorithm was named by Adapted Location Based Heuristic (ALBH). The School Transportation Problem was implemented in the State of Parana for 399 cities. We present here the results obtained for 10 of the 399 cities. The results obtained by using this approach showed improvement in daily distance performed and in the amount of the vehicles used to do the job.

Keywords: Vehicle Routing Problem, School Bus Transportation, Heuristics Methods.

1 Introduction

Applications of Operations Research in the transportation field always produce great impact, because these techniques are able to improve the quality of pick-up and delivery service and they can reduce the operating costs of the systems considered. An important application is the School Transportation Problem, which is a special case of vehicle routing with time windows (VRPTW), heterogeneous fleet and considering simultaneous pick up and delivery. In these kinds of problems a set of vehicles make the pick up and / or delivery products or people to consumers dispersed in an area. The goal is to find a set of vehicle routes and schedules that satisfies a variety of constraints and minimizes the total fleet operating costs [1], [2].

The development of models that offer optimal solutions to this problem is complex, because it is a problem that considers many constraints and the computational cost to do this task is high, sometimes it becomes impossible to be performed. For this reason many efforts have been made by researchers in worldwide to find new approaches that can produce good solutions to such problems with low computational cost [3]. Constrains considering vehicle capacity, maximum distance of each route, time windows and minimum coverage of the breakpoints.
In this paper we applied some techniques of Operations Research and heuristic algorithms to solve the real problem of the School Transportation in the Brazilian state of Parana. Using this methodology the manager of the Bus School Transport will be able to improve the service by reducing the time of the students inside the vehicles while minimize the total distance travelled by all the vehicles. In this problem the stop points are mixed, in other words students from different schools and degrees can be picked up and dropped by the same route, since the objective of minimizing the total distance of the route and attend a larger number of students can be hold.

The VRP appears in many applications such as garbage collect, distributions of drinks, gasoline and other products. The School Transportation Problem can be faced like a VRP considering a heterogeneous fleet, consists of determining a set of routes and schedule each vehicle to a route respecting the vehicle capacity constrains. The demand points are the student homes, and constrains to determine the routes are the vehicles capacity, the maximum time spent for each student into the vehicle may be limited by maximum length of the route. This paper was carried out in three steps. The first step is to determine the breakpoints (Bus Stops - BS) of the vehicles, considering the maximum distance that students can walk from their homes until these points. In the second stage the distances between two Bus Stop and/or School Points (SP) are calculated. Finally, in the third step we applied the Location Based Heuristic (LBH) with some proposed adaptations to be used in the real situation, and it was called Adapted Location Based Heuristic (ALBH) to route and schedule the buses so as minimizing total operating costs respecting the constrains to find a feasible solution for the problem.

2 Literature Review

In the literature few records of practical applications of theories of VRP to the School Bus Transportation are found. In [4] students are assigned to an intersection of streets adjacent to streets from their homes, and a subset of these points is considered potential points to solve the traditional routing problem.

In [5] Tabu Search is used to solve the traditional routing problem, showing results by solving several problems of the literature and presenting comparisons of their results with other techniques, but in general the solved problems are small.

A formulation of Integer Linear Programming to solve the School Bus Transportation is presented in [6], with appropriate restrictions in a Flemish region, where some comparisons and partial solutions to small problems are shown by testing feasible solutions and comparing the computational time by using this technique and similar others.

Some techniques that can be used to solve the VRP is shown in [7], including traditional techniques such as Clark Wright savings, 2-stage methods, and even metaheuristics like Tabu Search. Results are presented comparing all the techniques shown in the article, using as parameters both the computational time as the quality of each solution.

Reference [8] show 3 techniques to solve the problem of School Bus Transportation in New Jersey City, they are: the Clarke and Wright Savings, the computer program