A new Hybrid Evolutionary Algorithm for Dial-A-Ride Problems

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ABSTRACT

This work aims at planning the vehicle routes and schedules within Dial and Ride Problems. Therefore, we propose a new hybrid evolutionary algorithm that combines the evolutionary schema with a Tabu Search method. New controlled mutation operators and an original crossover for minimizing the redundancy of solutions are investigated. A comparison between different hybridized methods is operated on benchmark instances from the literature. Computational experiments show the effectiveness of our method in comparison with the current techniques from the state-of-the-art.

KEYWORDS

Urban logistics, Demand responsive transport, Tabu Search.

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1 INTRODUCTION

This study addresses a well-known demand responsive transport problem named the Dial-A-Ride Problem (DARP) [6]. Despite the efficiency of exact method on optimization problems [1, 2], we focus here on metaheuristics and more especially hybrid evolutionary techniques. Indeed, hybridization approaches combining evolutionary algorithms with local search techniques are beneficial when solving the DARP problem (see, [3, 4, 7, 9]). In the work of [9], a variable neighbourhood search is integrated into columns generation and combined with a large neighbourhood search. A marriage of an evolutionary algorithm with a local search technique in [4] is performed through the operators' dynamic management during the search. In [3], exact and local search-based methods are combined providing good results on DARPs. Despite the Tabu Search (TS) effectiveness in solving DARPs [6, 8], less attention was paid to its hybridization as a local search in an evolutionary schema. Therefore, we propose a new Hybrid Tabu Search (H-TS) method to quickly converge and minimize the computation time on DARP instances. Original mutation and crossover operators are invested. Our developed method is experimented on the DARP benchmark instances of Cordeau and Laporte [5] which were tested by other algorithms of the literature. Then a fair comparative study of our hybrid method with these state-of-the-art algorithms is conducted. The outputs indicate the effectiveness and the adaptability of the new hybrid method. This extended abstract recalls first the definition of the Dial-A-Ride Problem. Section 3 presents the main components of the H-TS algorithm. The computational results are presented and discussed in Section 4. Section 5 concludes the paper.

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2 PROBLEM PRESENTATION

The Dial-A-Ride Problem is a passenger-oriented vehicle routing problem, where a set of known requests is satisfied. A request defines a set of persons who require a transportation service from a location to another. A set of requests may be satisfied by one vehicle with respect to its maximal capacity. All the vehicles start their tours at a predefined depot and return to it at the end of their tours. A maximal total tour duration is assigned to the vehicles. The passengers have to specify when they wish to be picked up and when they have to be at their destination. Thus, requests are scheduled according to time windows. Passengers may have inconvenience time defined as the riding time spent aboard a vehicle. This time is bounded by a maximal ride time. The main objective of the DARP is then the minimization of the total travel cost under the vehicles, the requests and the schedules constraints.

3 THE PROPOSED METHOD

The solution of a DARP is a set of vehicle tours, each of which can be coded as a chromosome which genes are a pick-up or a delivery node. The initial solution is constructed using an insertion heuristic with a polynomial complexity relying on the number of requests and vehicles used. Then, individuals are generated by mutation for composing the initial population. Two mutation operators are dynamically managed over the search to increase the perturbation of individuals. With the first one, the requests' allocation is perturbed with temporary stops of vehicles during their customer pick ups. In particular, a random non-visited pick-up node can be forbidden to be visited by a vehicle allowing its allocation to another vehicle. The second mutation permutes two successive delivery nodes in a vehicle's route, which impacts the scheduling of requests in a solution. Then, a new crossover is used for locally diversifying individuals. It consists in exchanging two different sequences of requests by swapping their positions among two routes in two parents. These sequences are selected from those that are common between the two parents. This aims to minimize the redundancy of solutions in the search space. In order to intensify the search, a Tabu Search is carried out with a new neighbourhood strategy which redirects a vehicle during the requests' schedule. The evolutionary computations evolve through the exploration and the exploitation of the population until a stopping criterion is met.

4 EXPERIMENTAL RESULTS

To validate the new Hybrid Tabu Search, we test it on two different classes of instances named A and B. These are the benchmark problems of Cordeau et al. [5] with a total vehicles number up to 8 and that of requests up to 96. The locations are defined as geometric positions. The density of the networks in A is higher than in B, and it is almost the same for all the instances, which is not the case for class B instances. The H-TS algorithm is run for 1000 iterations and average results over five runs on all the instances are reported. We compare the results found with the ones of the Deterministic Annealing (DA) algorithm [3], the Hybrid Large Neighbourhood Search (H-LNS) [9] and the Evolutionary Local Search (ELS) [4] tested on the same instances of DARPs [5]. Table 1 shows the results obtained with our H-TS, the H-LNS, and the ELS on the instances from the class A. For the DA method, the results were not provided in this class. For the sake of clarity, we have chosen to report only 10 out of the total 21 instances of each class. Each instance (I) is defined by the total number of vehicles (m) and the number of requests (n). The comparison is based on the best cost obtained ($costs$) with each of the methods. Whenever a method produces the best result, the cost is indicated in bold font.

Table 1: Results of the Hybrid TS and other metaheuristics on A instances

m	n	I (A)	H-LNS	ELS	H-TS
2	16	a2-16	294.25	294.25	294.25
3	24	a3-24	344.83	344.83	344.83
3	30	a3-30	494.85	494.85	494.85
4	32	a4-32	485.5	485.5	485.5
6	48	a6-48	604.12	604.12	604.12
5	50	a5-50	686.63	**686.62**	**686.62**
5	60	a5-60	808.48	**808.42**	**808.42**
6	60	a6-60	820.30	**819.25**	**819.25**
7	84	a7-84	1036.17	**1033.62**	1086.62
8	96	a8-96	1234.78	**1230.5**	1233.91

According to Table 1, the solutions of the Hybrid TS have the same costs as the ones of the compared methods on the five first instances. For the next three ones, our method aligns with the ELS which provides better costs than the other method. However, for the last two cases, the best results are found by the ELS. Let us note that the H-TS is however more efficient on the instance a8-96 than the H-LNS.

The results of the Hybrid TS converge also with the ones of the other methods on five instances of class B, see Table 2. However, the H-TS is more effective than the other compared methods on the instances b4-48 and b7-84 of Table 2 despite the high density of the corresponding networks. Moreover, a better cost is provided by the DA for the b8-96 instance. For this instance, the cost obtained with the H-TS is still acceptable. Our H-TS algorithm performs well on both the classes A and B of problems even on large instances with more than fifty requests. However, it can still be enhanced for the remaining instances which were not improved.

Table 2: Results of the Hybrid TS and other metaheuristics on B instances

m	n	I(B)	H-LNS	DA	ELS	H-TS
2	16	b2-16	**309.41**	**309.41**	**309.41**	315.90
3	24	b3-24	394.51	394.51	394.51	394.51
3	36	b3-36	603.79	603.79	603.79	603.79
4	48	b4-48	673.81	673.81	674.2	**671.26**
6	48	b6-48	**714.83**	**714.83**	**714.83**	715.41
5	50	b5-50	761.4	761.4	761.4	761.4
5	60	b5-60	902.52	**902.04**	**902.04**	**902.04**
6	60	b6-60	860.07	860.07	860.07	860.07
7	84	b7-84	1211.27	1203.81	1203.37	**1202.80**
8	96	b8-96	1187.80	**1185.65**	1186.97	1208.79

5 CONCLUSION AND PROSPECTS

This paper proposed a new resolution method for the DARP. The solving approach consists of a hybridized evolutionary tabu search algorithm. This algorithm is based on efficient mutation, crossover, and tabu search techniques. A first implementation of the proposed Hybrid Tabu Search on benchmark instances of DARPs yielded encouraging results. This leads us to extend its application to other benchmark instances and in particular real-life cases.

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