A Multi Objective TS-Method for the Static DARP

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1. Introduction

The dial-a-ride problem (DARP), is a variant of the pickup and delivery problem (PDP), consists of designing vehicle routes of n customers transportation requests. The problem arises in many transportation applications, like door-to-door transportation services for elderly and disabled people or in services for patients. This paper consider a static multivehicle DARP, which the objective is to minimize a combined costs of total travel distance, total duration, passengers waiting time, the excess ride time of customers, and the early arrival time while respecting maximum route duration limit, the maximum costumer ride time limit, the capacity and the time window constraint. We propose a two-phase scheduling method combined to the tabu search heuristic, for the static multivehicle DARP.

The method consists on the first step to generate an artificial tight time window for all strengthened time window, in the second step on defining a list of precedence vertex of any node. We impose that the service in each vertex begins before its successor. The heuristic applied to the multi-objective DARP. The total cost calculated by a multi-objective function, handled by combining the multiple objectives into one objective by minimizing a sum of weighted objectives. Our experimentation carries out best results for Cordeau and Laporte Benchmark test problem, compared to the presented results in literature, more particularly GA and VNS algorithms.

2. Solution Methodologies

The solution methodologies used, depart from the preprocessing step, before the optimization procedure is started. The time window tightening techniques applied as described by Cordeau et al., The second preprocessing step consists to define a list of precedence vertex for each node that satisfies the order relation. To generate the first incumbent solution s, we construct the initial solution completely at random like the procedure employed in (Cordeau & Laporte, 2003). In each TS-iteration a best solution s' is selected from the current neighborhood $N_k(s)$. To avoid cycling, solutions recently visited are declared forbidden, or tabu, for a number of iterations, unless they constitute a new incumbent.

In this work, we opt for the easy neighborhood structure. Let s be a given solution. The set of neighbors of s denoted $N(s)$, is obtained by removing a request i from a route k, and then reinsertion into another route k'. In fact it is the same structure used in (Cordeau et al., 2003), Indeed be k_1 and k_2 two routes, where $k_1 \neq k_2$. Deleting the request pair $(i, i+n)$ from the route k_1, and the insertion of pickup vertex i and the delivery vertex $i+n$ in route k_2, are performed so as to minimize the total increase in $f(s)$. Keeping the two vertices i and $i+n$ closely connected in the route, allow consequently optimal results in ride time. Moreover, the complexity to check all constraints will be reduced, particularly load and time window constraint.

3. Evaluation

The evaluation procedure of a given solution based upon the "Forward slack time", defined firstly by Savelsbergh (Savelsbergh, 1992), and developed by Cordeau et al. This procedure can delay as much as possible early service to reduce the duration of the tour and travel times. This procedure does not induce the violation in time windows constraint. However, to set the beginning of service in the best possible way, such that route duration is minimal and ride time limits are respected where possible. The route evaluation is based on the forward time slack F_i, defined firstly by Savelsbergh.

4. Instances and tests

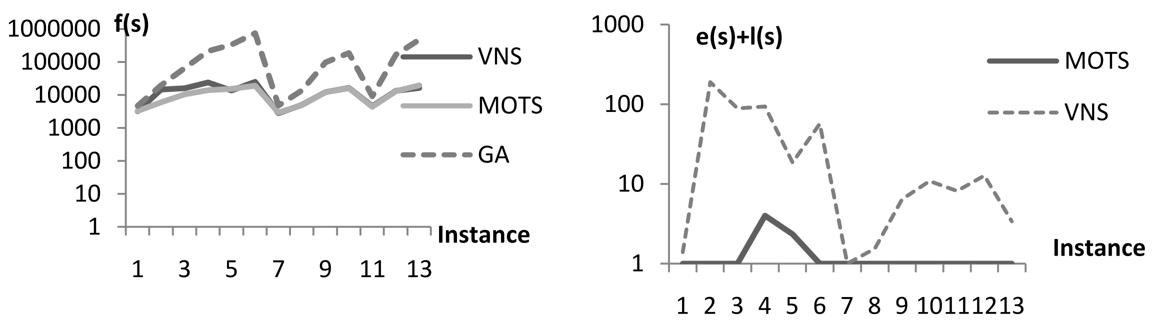
All instances of DARP concerned by our tests, given by Cordeau et al., available at: http://neumann.hec.ca/chairedistributique/data/darp. They are based on realistic assumptions and data provided by the Montreal Transit Commission (MTC). Half of the requests are outbound and half inbound. They are divided into classes (a) and (b), the difference being that class (a) instances have tighter time windows. In the instances, m denotes the number of vehicles and n is the number of requests.

To test the flexibility of the proposed method (MOTS), we adapt the objective function to the one used by Jorgensen (GA Method) and Parragh (VNS Method). They minimize a weighted combination of total routing costs, total excess ride time with respect to direct ride time, total waiting time with passengers aboard the vehicle, and route duration. Furthermore, the solution framework in (Jorgensen et al., 2007) allows time window, route duration, and ride time violations, but penalizes them. The objective function thus applied is the following,

$$f(s) = w_1 c(s) + w_2 r(s) + w_3 l(s) + w_4 g(s) + w_5\big(w(s) + e(s)\big) + w_6 t(s) + w_7 d(s)$$

Early arrivals $e(s)$ are penalized in the same way as late arrivals $w(s)$. The authors set the weights to $w_1 = 8, w_2 = 3$, $w_3 = 1$, and $w_4 = 1$,, and $w_5 = w_6 = w_7 = n$. The following evaluation function is applied, in order to accommodate the above objectives. We adapted our evaluation function to the following same function proposed by Parragh (Parragh et al., 2010). Obtained results are shown in the following figures.

$$f'(s) = w_1 c(s) + w_2 r(s) + w_3 l(s) + w_4 g(s) + w_5 e(s) + \alpha q(s) + \beta d(s) + \gamma w(s) + \tau t(s)$$



(a): Total Costs **(b): Combined passenger waiting and early arrival**

Fig. MOTS vs. GA and VNS on a logarithmic scale.

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