A Genetic Algorithm for the Dial-A-Ride Problem with private vehicles and privacy settings

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Keywords: *transportation, DARP, metaheuristic, Genetic Algorithm.*

1 Introduction

This paper addresses the Dial-A-Ride Problem (DARP) [1] using Private Vehicles and Alternative Nodes (DARP-PV-AN). The DARP aims at defining routes for a fleet of vehicles in order to ensure a set of users' pickup and delivery transportation requests, considering a number of operational constraints and taking into account the Quality of Service (QoS). Earliest publications from the 80s were focusing on the single vehicle case. A survey of recent works dedicated to the DARP can be found in [2]. In the DARP-PV-AN, the on-demand transportation service can be performed either by a public fleet or by clients using their own vehicle (private vehicles). However, the use of these vehicles raises some privacy concerns. They are addressed in the DARP-PV-AN by setting several potential pickup/delivery nodes for each transportation request, thus masking the private address. A Genetic Algorithm (GA) is used to compute solutions on a set of dedicated instances.

2 The DARP with Private Vehicles and Alternative Nodes

The DARP is formally defined on a complete weighted digraph $G = (N, A)$, with a heterogeneous fleet F of K vehicles and a set R of n transportation requests. The graph is defined by the set of nodes $N = \{0,1, \dots, 2n\}$, with 0 representing the depot, and the set of arcs A. For each node $i \in N$, $[e_i; l_i]$ is its time windows (e_i is the earliest starting time and l_i is the latest starting time), its service duration is d_i and its demand is q_i. Given an arc $(i, j) \in A$ where $i, j \in N$, t_{ij} is the transportation time and c_{ij} is the transportation cost. The set of transportation requests $R = \{1, \dots, n\}$ is created such that for each request $r \in R$, its pickup node is r and its delivery node is $n + r$. Thus $P = \{1, \dots, n\}$ and $D = \{n + 1, \dots ,2n\}$ are, respectively, the pickup and the delivery subsets. F is the fleet of vehicles such that for each $k \in F$, Q_k is its capacity.

In the DARP with Private Vehicles and Alternative Nodes (DARP-PV-AN), a subset $R' \subseteq R$ of clients can use their own vehicle, both for their request and for handling the requests of other clients. In case client $r \in R'$ uses its vehicle, the trip starts at r, stops at $n + r$ and the vehicle's capacity is Q_r. If the request $i \in R$ of a client is handled by a private vehicle, its privacy is ensured by a set of alternative pickup nodes N_i in addition to its initial pickup node i and a set of alternative delivery nodes N_{n+i} in addition to its initial delivery node $n + i$. For each client i transported by a private vehicle, a node $\lambda^+ \in N_i$ and a node $\lambda^- \in N_{n+i}$ have to be selected for the solution; the initial pickup i and the initial delivery $i + n$ nodes can only be used for the public fleet. Thus, it is harder to guess the user's exact location. Moreover, two subsets N_i and N_j can share some nodes, indicating two client i and j can be handled at the same position.

3 Numerical experiments

To solve this problem, we propose a hybrid method combining a genetic algorithm with integer programming. A solution computed by the genetic part of our algorithm consists of a set of trips. Each trip is composed of a vehicle and a set of client requests. Exact method computes for each trip the best visiting order if it exists. Moreover, at the end of each generation we use the CPLEX solver to select a set of already generated trips, in order to find new solution with a better objective value. These solutions are then introduced in the current population before the selection phase.

Results for the GA are reported on Table 1. Solutions are evaluated on the total travel distance. 10 runs are done for each instance, each one with a different seed. The best (Best) and average (Avg) value found, the average time (minutes) to reach solutions (T*) and the total time limit (T) are reported. All experiments have been carried on an Intel Xeon e7-8890 processor, scaling around 4.8 GFLOPS. For each instance, |R|, $|N^T|$, |F| and |R'| are respectively the number of requests, the total number of nodes (initial and alternative), the size of the public fleet and the number of private vehicles.

					GA (10 runs)			
Name	**|R|**	**|N|**	**|F|**	**|R'|**	**Best**	**Avg**	**T***	**T**
PCD_20_0	10	61	4	0	811.35	811.35	0.01	10.00
PCD_20_2	10	61	4	2	715.54	715.54	0.03	10.00
PCD_20_4	10	61	4	4	715.54	715.54	0.03	10.00
PCD_20_6	10	61	4	6	643.13	643.13	0.03	10.00
PCD_20_10	10	61	4	10	388.95	388.95	0.01	10.00
PCD_40_0	20	125	8	0	1109.59	1109.59	0.12	15.00
PCD_40_2	20	125	8	2	1028.41	1028.41	0.15	15.00
PCD_40_6	20	125	8	6	741.63	741.63	0.09	15.00
PCD_40_8	20	125	8	8	667.43	667.43	0.30	15.00
PCD_40_10	20	125	8	10	614.78	614.78	0.48	15.00
PCD_40_20	20	125	8	20	487.84	490.72	0.08	15.00

TAB. 1- Results on DARP-PV-AN instances

4 Concluding remarks

We presented an extension for the DARP that allows the combination of two types of fleets and the use of alternative nodes set for private vehicles. A hybrid GA metaheuristics is proposed to compute solutions of good quality. Results are reported on a set of small instances to show the impact of the GA on the DARP-PV-PN. Work is currently done to improve the exact method that computes the best trip visiting all the given nodes. This will allow the GA to perform more iterations and thus, to solve larger instances more efficiently.

References

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