Routing and Scheduling Problem of N-Side

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1 Introduction

The last European Study Group with Industry (ESGI) conference, which was held in Avignon on May 2016, has attracted a lot of industrial partners and academic researchers to work together on real practical problems. Sébastien Mouthuy from the N-Side company presented a vehicle routing and scheduling problem for the transportation of patients to medical centers by using a heterogeneous fleet of vehicles. It is a real problem raised by one of its client, which needs to be solved efficiently. One specificity of the problem is that the duration of the consultations is uncertain and a patient may change the vehicle for going back home. The deterministic version of the problem is a close variant of the dial-a-ride problem (DARP), which is the subject of several recent research projects (*e.g.*, [1, 2, 3]). The growing interest on this topic has been motivated by the great difficulty of this combinatorial optimization problem.

2 Problem description

The real problem raised by the N-Side company is about transportation of people from their home to medical centers and then bringing them back at the end of the visit. There is a fleet of vehicles available for the transportation in the company. If a client can be not served, a taxi will be used, which is very costly. They aim at minimizing the total cost for delivering all the patients. To this end, they try to serve as many patients as possible by using company's own vehicles. This problem can be briefly formulated as follows :

Given parameters :

— A set of available vehicles V with heterogeneous transportation capacities (*e.g.*, 4 seats), and equipment.

— A set of patients P with given information, such as their location, the location of the health center they're going to, their appointment time, t_A, and the duration of the appointment, δ_A.

Constraints :

— Each patient $p_i \in P$ should arrive at his medical center before the appointment time t_A^i ;

— A challenging flexibility is that if a patient goes to a medical center by a vehicle, he must go back home on a vehicle also, but not necessarily the same ;

— A patient should not wait for more than t_H minutes at the hospital before and after his appointment (so this can lead to a total $2t_H$ minutes wait at the health center);
— The ride time of a patient p_i is upper bounded by t_R^i;
— The working time of a driver is upper bounded by T

Objective : The objective is to plan the travelings of vehicles' such that the maximum patients can be transported while respecting all the time constraints (departure time, rendez-vous time, and arrival time to home) as well as the vehicle capacity constraint.

3 Proposed Methods

The presented problem of N-Side involves two subproblems : routing and scheduling. Nine people has chosen to work on this problem and participated in the discussions. Benefiting from the different expertise of our group members, several methods have been proposed to solve a subproblem, or the whole problem :

— A global mixed integer linear programming (MIP) model is formulated, which permits to solve the studied problem optimally for small instances. Some preliminary results are obtained on some special graphs. But it is not scalable for real instances.
— Another MIP model is proposed to solve the routing subproblem by selecting the optimal routes. At fist, a randomized insertion heuristic was used to generate a set of feasible candidate routes under constraints like the number of routes, the maximal duration of a route, the travel time, the time window of each patient, and the capacity of each vehicle. The proposed MIP is performed to select the best ones maximizing the number of patients served.
— A cluster-based global routing heuristic algorithm is also proposed. Clustering analysis is performed first on the given instance. The basic idea is to divide the clients into clusters according to their geographical locations and required equipment. For each resultant cluster, we then try to solve the vehicle routing problem with time window constraint using algorithms proposed in the literature like insertion based heuristic algorithm.

Some interesting preliminary results have been obtained at the end of ESGI. **The originality and contribution of this work is two-fold : (1) a real problem is studied by people from different research domains with different points of view, and (2) different methods (or preliminary ideas) have been proposed to solve or partially solve it**.

4 Conclusions and future work

N-Side has presented a routing and scheduling problem in ESGI, which is similar to the famous dial-a-ride problem (DARP). To this end, several possible approaches have been proposed, for instance global MILP formulation, MIP based routes selection method, cluster-based routing heuristic algorithm. Due to the limitation of working time in the ESGI conference, only the main ideas and some preliminary results have been presented. Further improvements are needed for solving the real instances provided by N-Side.

Références

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