

A tabu-embedded simulated annealing algorithm for a selective pickup and delivery problem

T. Maes, K. Ramaekers, G.K. Janssens

Hasselt University, Agoralaan - Gebouw D, BE-3590 Diepenbeek

e-mail : {tabitha.maes, katrien.ramaekers, gerrit.janssens}@uhasselt.be

A. Caris

Research Foundation Flanders (FWO), Egmontstraat 5, BE-1000 Brussels

e-mail : an.caris@uhasselt.be

Several actors are involved in the transport of goods. To model freight transport, the different actors who take part in the decision making process have to be represented. In Maes et al. (2012) a conceptual framework is presented to model freight transport. The key actors in this framework are firms, carriers, and forwarders. This allows the model to work on an activity-based level, focusing on the different activities of each actor. The decision making process of carriers is one of the key aspects in modelling logistic decisions in a behaviour based transportation model. When modelling at an activity-based level, the behaviour of carriers has to be taken into account. The framework of Maes et al. (2012) formulates decisions of the carrier as a selective pickup and delivery problem (PDSP). This is a novel approach to model logistic decisions in models with the objective to explain and predict freight flows. One of the important decisions a carrier has to make is whether or not to accept a transport request in order to maximize his profit. The selection of requests in a paired pickup and delivery problem is not often studied in literature. Next to this decision, he also needs to schedule the transport orders that are accepted into the different vehicles and construct a routing plan, given time and capacity limitations.

The PDSP is NP-hard as it is a generalization of the travelling salesman problem. To be able to generate good results a Tabu-embedded Simulated Annealing (TSA) algorithm is proposed. This algorithm is initiated with a parallel insertion heuristic. Four local search operators are defined to improve the initial solution. A distinction may be made between classical PDP search operators and search operators specifically developed for the PDSP. Two new local search operators are defined to deal with the selection of transport requests consisting of paired pickup and delivery locations. The TSA algorithm starts with the insertion heuristic to create a first feasible solution. This solution is further improved by use of the improvement heuristic. Instead of repeating the tabu search until the procedure terminates, it is restarted from the current best solution after several iterations without any improvement. At the same time the global annealing temperature is reset. The generation of new best solutions is done using simulated annealing. To avoid cycling, the visited solutions are recorded into a tabu set, which contains the total profit of a solution. Since the probability of two different solutions ha-

ving the same total profit is very small, it is sufficient to keep track only of total profit.

For the PDSP no ready-to-use benchmark data is available. None of the available benchmark data for PDP include revenues. Therefore, the results cannot be compared. Still, benchmark data of Li and Lim (2001) were used to compare the TSA algorithm. Because the problem studied was not entirely the same, adaptations are made to compare the results. In the PDP of Li and Lim (2001) all requests have to be accepted and no revenue is given to perform a request. In the PDSP not all transport requests have to be performed by the carrier. Requests are only selected if they lead to profitable vehicle routes. Furthermore, the algorithm was thoroughly tested on the ability to solve a PDSP with the help of 32 carefully chosen instances. A full factorial design was set up with five characteristics, which were each tested for their high and low values.

Although the TSA algorithm is developed to solve the PDSP and does not take into account the number of vehicles used, it achieves good results for the benchmark instances of Li and Lim (2001). Six of the twelve chosen instances are solved to their best known solution. In two other instances the total distance travelled is lower than the best known solution, but the number of vehicles used is higher. As the TSA algorithm only minimizes the distance travelled and not the number of vehicles used, it may be considered as a better solution. In the PDSP a carrier is considered with a fixed vehicle fleet and an excess of transport requests. The assumption is made that fixed costs of the vehicle fleet remain the same whether they are used or not. This means that all vehicles will be used in order to accept as many requests as possible and optimize the profit. Hence, the heuristic will always minimize the distance and not the number of vehicles used. The remaining four instances have a gap in distance with the best known solution of less than 3,6%.

Références

- [1] Li H. and Lim A. : A metaheuristic for the pickup and delivery problem with time windows. *Proceedings of the 13th IEEE International Conference on Tools with Artificial Intelligence*, 2001, pp. 160-167.
- [2] Maes T., Ramaekers K., Caris A., Janssens G.K. and Bellemans T. : Integrating consolidation options in a new conceptual freight transportation framework. *Proceedings of the European Simulation and Modelling Conference*, 2012, pp. 345-349.