Modelling carrier decisions in an activity-based freight transportation framework: a pickup and delivery selection problem

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Abstract

This paper focuses on the modelling of carrier decisions within an activity-based freight transportation model. To model freight transport, the different actors who are included in the decision making process have to be represented. One of these actors is the carrier. The decisions of a carrier can be formulated as a selective pickup and delivery problem. The objective is to maximize the profit gained by selecting transport requests. This allows a better representation of the influence of carrier decisions on the logistic module within an activity-based freight transportation model. Local search operators are presented to solve the problem.

Keywords: Logistic decisions, Freight transport modelling, PDSP

To represent logistic decisions within an activity based freight transportation model, decisions of a carrier have to be modelled. A carrier faces the daily problem of optimally scheduling his transport orders. Each day a carrier receives transport requests from his clients, which have to be executed within a certain time period. To obtain a maximal profit the carrier has to group certain orders and create an optimal sequence of pickup and delivery tasks. The assumption mostly made is that all requests have to be fulfilled. In reality a carrier can refuse a transport order when he believes this order is not profitable. In our activity-based framework (Maes et al., 2011) only current requests are taken into account and the possible loss of future requests is ignored. If a request is accepted it will generate revenue when the transport is completed. When a carrier has to decide whether a certain request is accepted, the problem is defined as a Pickup and Delivery Selection Problem (PDSP).

In a PDSP not all transportation requests have to be fulfilled. A carrier receives transportation requests and has to decide whether he will take the responsibility of the transport or not. Unknown requests of the future cannot be taken into account when considering the current request. Hence, the PDSP is modelled as a static planning problem. In literature this problem is not often investigated, but several variations on the problem exist. Two main bodies of routing literature are relevant for the PDSP. On the one hand Vehicle Routing Problems (VRP) with profit and on the other hand literature concerning Pickup and Delivery Problems (PDP). The

PDP is more relevant to the problem presented, however profit maximization has been more applied to VRP. PDSP can be seen as a variation of these two problems.

To be able to formulate a PDSP model key characteristics related to this problem are presented. First of all, not all requests have to be accepted and every fulfilled request results in a profit. Every request has a time window for pickup and delivery, only hard time windows are considered. Pickup has to occur before delivery of each request (Precedence constraint). Furthermore, pickup and delivery have to be performed by the same vehicle (Pairing constraint). A homogenous vehicle fleet is used with a limited capacity. Departure and arrival of the vehicles are in the depot of the carrier. All requests consist of less-than-truckload shipments. The objective is to maximize profit gained from executing selected requests. Therefore, a travel cost is assigned to each kilometre.

An initial solution is created by a parallel insertion procedure based on the earliest time window of pickup nodes. Requests are inserted at the end of a route based on the greatest increase in profit. At the end of the insertion heuristic requests that are already accepted are reordered to find a better route. The insertion heuristic results in an initial solution which is feasible and can be optimized later by an improvement heuristic. Four local search operators are created to alter the initial solution. The EXCHANGE and SHIFT operator try to find better combinations of requests by exchanging either two requests between routes or by moving a single request to another route. Moreover, the SHIFT operator may reduce the number of vehicles used. A third operator, the INSERT operator, is used to accept more requests by inserting unserved requests into routes. Finally, the SWITCH operator improves the current solution by replacing low profit requests with unserved requests that lead to a higher profit. These four local search operators are incorporated in an improvement heuristic, which is iterated until no further improvement can be found.

Benchmark data from Li and Lim (2001) are used to test the improvement heuristic. This data allows evaluating the ability of the heuristic to generate routes at a lowest possible cost, with all requests accepted. Own datasets are generated to test the heuristic on the ability to select requests. A metaheuristic is developed to further improve the results.

References

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