A time-dependent vehicle routing problem in the service area of intermodal terminals

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This paper deals with the operational planning of drayage operations in the service area of intermodal container terminals. Drayage operations refer to the full truckload container transport activities that take place on a regional scale around these terminals. They involve the transport of loaded and empty containers between container terminals, container depots, consignees and shippers. Drayage operations are mostly performed by truck and constitute a large part of total costs of an intermodal transport.

Previous research has indicated that the underlying routing problem may be formulated as an asymmetric multiple vehicle Traveling Salesman Problem with Time Windows (am-TSPTW). Several meta-heuristic approaches have been proposed to solve this problem (see [1]). A simplifying assumption made by all these approaches is that travel times are constant over time. In practice, the travel time on a link will depend on the time of the day, especially in the often heavily congested areas where drayage operations take place. In this paper, for the first time a time-dependent problem setting is considered to take into account the hourly variations of travel times due to congestion. The planning period is divided into several time intervals and for each interval the expected speed on a link is determined. Based on this speed information, a travel time matrix is calculated which indicates the travel time between each pair of nodes at each point in time. It is ensured that these travel times satisfy the non-passing or FIFO-principle.

The objective of the problem is to first minimize the number of vehicles needed and second the total duration of the routes. A major difference between a time-dependent and a time-independent problem setting is the complexity of evaluating the effect of a local search move on the secondary objective. In a time-independent problem setting this effect can be evaluated relatively efficiently by storing the appropriate information of the current routes during the search. This is no longer true in a time-dependent problem setting. A local search move may change travel times between all consecutive nodes in the corresponding routes and may even change the optimal departure times of the vehicles at the depot.

A two-phase deterministic annealing algorithm is proposed to solve the problem. In the first phase the number of vehicles is minimized while in the second phase the total duration of the routes is minimized. During each phase, several local search operators are used to find neighbors of the current solution. Each time a feasible neighbor is found, it is temporarily accepted and the corresponding routes are recalculated to obtain the smallest route duration. Based on these new values and the value of the deterministic threshold, it is determined whether the neighbor is permanently accepted or not.

Results show that this algorithm is able to find good quality solutions. Since average computation times are slightly larger than in a time-independent problem setting, several opportunities to speed up the search are discussed.

Future research will focus on the improvement of the algorithm. The local search operators currently in use may be adapted to better take the time-dependent problem information into account. New local search operators may be proposed as well. Finally, additional computational experiments are needed to investigate how the algorithm performs under different travel time conditions.

Références

[1] Braekers K, Caris A, Janssens GK (2013) Integrated planning of loaded and empty container movements. OR Spectrum, Forthcoming (DOI :10.1007/s00291-012-0284-5).