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Truck scheduling in logistic networks with transhipment centers

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Abstract

The primary purpose of transhipment centers is to consolidate freights in order to benefit from economy of scale in transportation. However, their limited capacity can slow down the process of dispatching trucks that results in delays inside the network. We aim at studying the integrated transhipment network and finding a minimum-cost routes as well as load synchronization at transhipment centers to satisfy a set of transportation requests. The problem is applied to manufacturing and retail companies in which shipments are consolidated through multiple channels before final delivery.

In logistic network, transhipment centers can perform additional duties alongside their main functions (i.e. perform some value added services such as labeling and re-packing). Thus, transportation requirements provide rules for trucks to visit distribution centers. Based on the aforementioned description, this research at this context can be classified in two groups:

In the first group of studies, each product requires to visit at least one center before the final delivery. An exact approach to schedule trucks have been presented in (Mues and Pickl, 2005). Other studies tackle the problem by heuristic methods (variation of tabu search) to solve real life problems (See Lee et al., 2006, Liao et al., 2010, Wen et al., 2009 and Tarantilis, 2013). In all these studies the network contains only one center to consolidate all truck loads. Moreover, it is assumed that the network has enough capacity to simultaneously process all trucks at the same time.

The second group of studies consider the distribution centers as a transhipment opportunity. In this case shipments can directly deliver without visiting the terminal. The mathematical formulation of the problem is presented in (Cortés et al., 2010) and (Rais et al., 2013). Several heuristics have been proposed to tackle real-life problems. Mitrovic-Minic and Laporte, 2006 presented heuristic to schedule vehicles for courier company. Similar problem in the context of passenger transportation is studied in (Masson et al., 2013). Finally, Petersen and Ropke, 2011 present parallel adaptive large neighborhood search to schedule trucks in the context of delivery perishable product. In all these studies, it is assumed that each truck can visit at most one transhipment center during its traveling route.

Our research belongs to the first category of studies. We consider a general situation in which products can be consolidated through multiple transhipment channels. In order to

avoid delays and generate a realistic plan we also take into account the capacity of transhipment centers.

We formalize the problem and present a mixed integer linear programming for that. The model provides us with an optimal solution for small instances. In addition, we have developed a heuristic based on the adaptive large neighborhood search framework. The algorithm has three main components: 1) destroy: it removes a set of transportation request by predefined operators. 2) repair: the removed requests are re-inserted into the solution by repair operators and 3) an adaptive mechanism to dispatch search time among operators based on their historical performance.

We have performed computational experiments using our algorithm and compared its solution against the solution of the mathematical model. We have generated 72 instances and run the algorithm five times for each. The results are compared with the mathematical model solved by CPLEX. The computational results demonstrate that our approach finds a high quality solution within a reasonable time for instances up to 100 transportation node.

In addition, we have defined several scenarios regarding the density of shipments in various areas. We performed the algorithm for each case and compared the results with traditional hub-spoke network setting. Then, we identified cases in which truck routing with transhipment is advantageous comparing to traditional hub-spoke network design.

Keywords

Vehicle routing, Transhipment center, Optimization, Heuristics

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