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Pickup and delivery of automobiles from warehouses to dealers

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ABSTRACT

This paper considers a truck loading and routing problem in automobile outbound logistics. Everyday, a third-party logistics (3PL) company receives a number of orders from several auto manufacturers and needs to assign the orders to available trucks which pick up the orders from the warehouses where the orders are kept and deliver them to dealers. Each order corresponds to a specific car required by a given dealer and is associated with a value and one of the three car types, small, medium or large. The value of an order is defined by whether it is an emergency order and how many days it has been waiting to be assigned to a truck. Each delivery truck is allowed to visit a pre-specified subset of cities, and is associated with a specific capacity configuration, which specifies the number of slots available for each of the three car types. The problem is to assign a subset of the orders to available trucks and create a route for each truck to maximize the total reward of the assigned orders, defined as a given weight times the total value of the assigned orders minus the total transportation cost incurred, subject to a number of constraints. A column generation based heuristic algorithm is developed where the LP relaxation of the problem is decomposed into a master problem solved by a LP solver and a number of subproblems solved by a dynamic programming based algorithm. The proposed algorithm is evaluated by comparing its solutions to upper bounds and shown to be capable of generating near-optimal solutions for practically sized problems in reasonable computational time. The algorithm is also compared to a rule-based greedy method used in practice based on real data sets from a 3PL company and shown to outperform the greedy method by a large margin.

1. Introduction

The automobile industry is one of the largest industries in the world. In 2016, 24.38 million and 17.46 million automobiles are sold in China and in the U.S., respectively (China Association of Automobile Manufacturers, 2016; Alliance of Automobile Manufacturers, 2016). Every major automobile manufacturer has a massive logistics network that supports its production and sales activities. For example, in North America alone, Ford Motor Company has 13 full production plants capable of producing 2.5 million vehicles for final delivery to a network of 4000 dealers (Hylton, 2014). Most automobile

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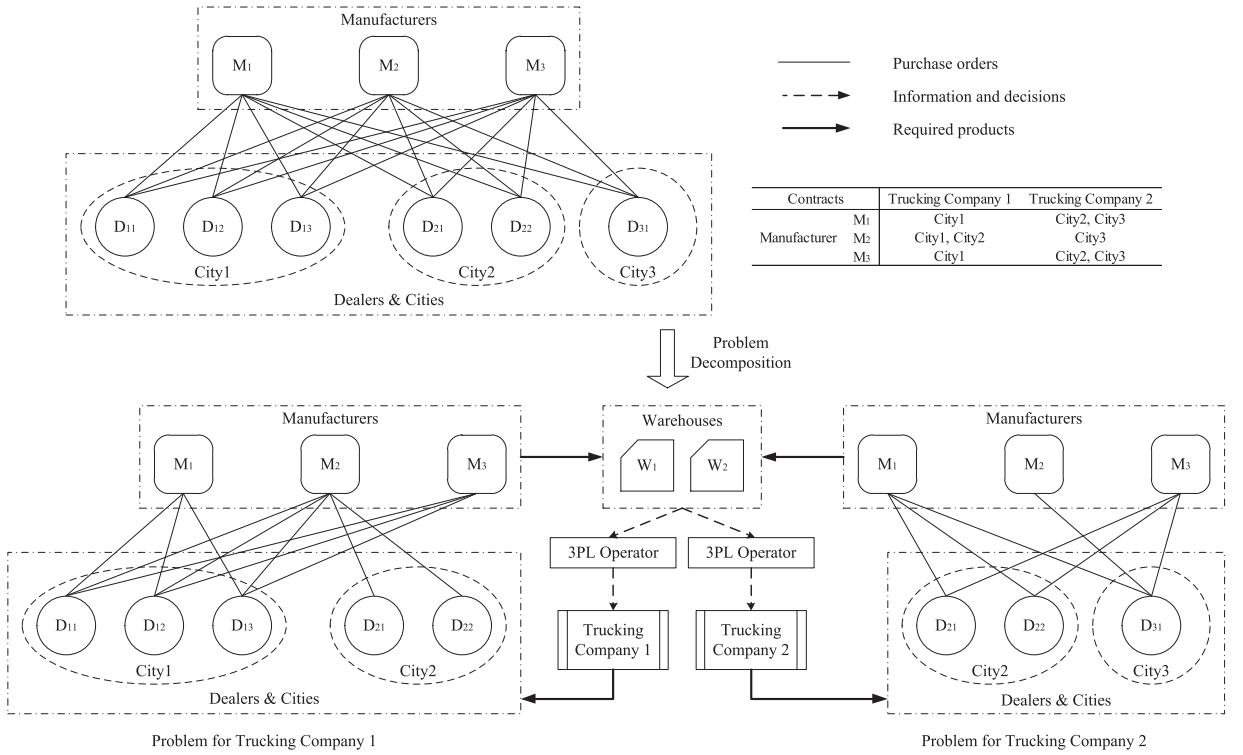

Fig. 1. Relations among manufacturers, trucking companies and dealers.

manufacturers outsource their logistics operations to third party logistics (3PL) providers. In the U.S., it costs automakers billions of dollars every year to transport new cars from production plants to domestic dealers (Hylton, 2014).

We consider an optimization problem of pickup and delivery of completed automobiles from warehouses to dealers that is faced by Anji Automotive Logistics CO., LTD, the largest automobile 3PL company in China. In 2016, Anji delivered more than 4.29 million automobiles for 15 automobile manufacturers from 30 warehouses to thousands of dealers all over the country, using more than 20 thousand trucks provided by several trucking companies that Anji works with. The same pickup and delivery problem or its close variants are faced by many other automobile logistics companies.

Dealers from all over China send purchase orders to automobile manufacturers. Each order corresponds to one car with a specific make, model and design configuration. Some of the required cars are already in stock at outbound warehouses if the manufacturers have made them based on sales forecast. Otherwise, the manufacturers will first assemble the cars ordered by the dealers and then store them at the outbound warehouses. In both cases, each order is released to the 3PL company involved (i.e., Anji) as soon as the required car is stored in one of the outbound warehouses. The 3PL company works with several trucking companies to ensure that the ordered cars are delivered to the dealers as soon as possible.

Due to the complexity and large scale of the involved decisions, it is not practical to consider all the orders and all the available trucks together as a single optimization problem. Instead, in practice, as described below, the orders and trucks are divided such that the problem is decomposed and made more tractable.

Between each trucking company and each manufacturer, the 3PL company made a pre-negotiated contract, which specifies that all the orders to this manufacturer from the dealers located in a certain group of cities can only be picked up and delivered by trucks provided by this trucking company. The specific group of cities involved in the contract is normally determined by constraints associated with the trucking company, such as the specific regions that the trucking company operates. Each manufacturer may work with multiple trucking companies. Similarly, each trucking company may work with multiple manufacturers. To make the problem tractable, the 3PL company divides all the released orders from different manufacturers into groups such that each group of orders is contracted to and handled by a specific trucking company only. Consequently, there is a separate optimization problem corresponding to each trucking company. The problem we study in this paper deals with the problem of one trucking company. Fig. 1 illustrates an example of how the original problem in practice is decomposed. As shown in the figure, there are three manufacturers, two warehouses, two trucking companies and six dealers located in three destination cities in the illustrated original problem. Dealer D_{11}, D_{12} and D_{13} are in City 1, dealer D_{21} and D_{22} are in City 2, and dealer D_{31} is in City 3. Every manufacturer sells cars through every dealer. Based on the contracts between the manufacturers and the trucking companies as shown in the table in the upper right part of the figure, the orders can be divided into two groups. Orders from the dealers in City 1 to manufacturer M_1, M_2 and M_3