A new cross-docking strategy in a JIT logistic system : Truck scheduling and supplier/product assignment

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1 Introduction

Cross-docking, as a logistic policy in the distribution part of supply chain, is implemented to improve transport and delivery activities by consolidating the products. Cross-dock is distribution facility in which the goods arriving by the inbound trucks are unloaded, sorted, consolidated based on their destination and loaded onto the outbound trucks.

Various decision problems, arising in cross-docking, have been studied in the literature. They could be classified into strategic, tactical and operational problems. Vehicle scheduling, as an operational problem, is an important concern in the cross-dock planning which is largely considered by researchers. For instance, simultaneous scheduling of the inbound and outbound trucks and considering JIT policy for delivering the products have been studied by [1] and [2].

In this research, a new extension of truck scheduling in cross-docking is presented in which the JIT principle is considered for the products (JIT customer demands), as well as the loads and destination of the outbound trucks are not predefined, but they must be determined.

2 Problem description

A set of inbound trucks (I) containing the containers of different products (P) come from the suppliers and arrive to the cross-dock in the estimated specific times. In a Just-In-Time (JIT) policy, each customer needs an amount of these products in a specific time windows ($[e_{pd},\ f_{pd}]$). A set of outbound trucks (J) must carries the needed containers to the customers during the relevant periods. Each destination has a list of approved suppliers for each product and the outbound trucks must be loaded through theses containers.

The outbound truck can leave the cross-dock with less-than truckload (LTL) if there is no more certified container with met time windows available. In this study, the split shipment is possible and it means that a destination can be served by different trucks. The problem is to determine the schedules for the inbound and outbound trucks, and the load amount to be transported from each inbound truck (supplier) to every outbound truck (destination). In other words, in addition to the truck scheduling, assignment of the suppliers to the destinations for each product type and assignment of the outbound trucks to the destinations are determined.

3 Solution procedure

A mixed-integer mathematical model is developed for the above-mentioned combinatorial optimization problem. The problem involves three sub-problems, one truck scheduling and two assignment problems. Each one of these sub-problems is a complex optimization problem.

3.1 Mathematical model

The objective is to minimize the waiting times of the pallets inside the cross-dock, while minimizing the non-supplied demands by adding a penalty cost for each non-supplied pallet.

The constraints of the model involve the truck scheduling, Number of inbound and outbound doors, capacity inside the cross-dock, Demand and JIT delivery constraints.

3.2 Symmetry breaking

Considering that the outbound trucks are heterogeneous, multiple solutions could be obtained having the same objective values. Two categories of the symmetry breaking constraints (one for assignment of the trucks to destinations and other for the assignment of the trucks to time periods) are added to improve the efficiency of the model.

3.3 Decomposition of the formulation

In consideration of the inherent complexity of the problem and large number of constraints, a matheuristic approach based on the decomposition of the formulation is proposed to solve this combinatorial problem. Scheduling of the outbound trucks, assignment of these trucks to the destinations and determining the load of each one are solved at the first step. The values of the decision variables are used as the parameters to the second sub-problem. In the second step, schedules of the inbound trucks and number of pallets that must be shipped from the inbound trucks to each outbound truck, are determined. A set of 23 instances of different sizes have been evaluated and a synthesis of their results is presented in table 1.

	Cplex	Symmetry breaking	Decomposition
Optimal solution obtained	8/23 = 34.78%	17/23 = 73.91%	5/23 = 21.73%
Max GAP (Percentage)	100% for 5 instances	1.29%	1.47%
Mean CPU time	1202.17	501.30 s	3.60 s

TAB. 1 – Numerical results

4 Conclusion and perspectives

A new extension of truck scheduling in cross-docking is presented in this research, which is a combination of three NP-hard sub-problems. An integrated mathematical model is proposed and is improved by adding a set of symmetry breaking constraints. The numerical results show the overcoming of the model with these constraints. Furthermore, a decomposition of the formulation method is employed. The complexity of the problem has been significantly decreased by using this decomposition. Table 1 shows the efficiency of the proposed methods to solve the problem. Developing a meta-heuristic or a hybrid solution method for this new cross-docking decision problem could be considered as the future research.

Références

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