Dock Assignment and Truck Scheduling in Crossdocks

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1 Introduction

The truck dock assignment problem arising in cross dock management problem, has been receiving an increasing attention during the recent decades. This is evidenced by several recent surveys ([1], [2], [3]) devoted to the problem of resource management, assignment and scheduling in cross docks.

In modern logistics, the concept of crossdocking originates from the idea of consolidating Less Than Truck Load (LTL) shipments from different sources and re-distributing them as rather consolidated (possibly Truck Load (TL)) shipments with better utilization of fleets and assets. In what is often referred to as the *Supply Chain of Future* or *Industry 4.0*, given the tendencies and the forces in this landscape, the context of shared infrastructures, collaborative, cooperative and coopetitive operations, crossdocks will play a vital role along the supply chain. In Supply Chain of Future, crossdocking remains the key contributor in the complementary KPIs (key performance indicators) including the environment friendliness and energy efficiency of operations in addition to its main goal of exploiting economies of scale and avoiding deployment of underutilized trucks and maintaining a sustainable business including all its implications (i.e. cost of operations, service level etc.).

We study a dock assignment and truck scheduling problem arising within crossdocks. In the literature, variants of this problem are often modeled as big-M-like mixed integer programming formulations, which are known for their computational difficulties and often poor bound quality restricting their practical uses. In this work, we propose a new integer programming (IP) model with $\mathcal{O}(n^4)$ variables. We then propose a Dantzig-Wolfe reformulation and an efficient branch-and-price algorithm as well as a VNS-like approach for solving real-life size instances of this problem. Our extensive computational experiments confirms the efficiency and productivity of our exact solution method as well as the proposed heuristic algorithm (the VNS-like approach).

2 Problem description and modeling

The problem is described as following :

A set of trucks (to be loaded or unloaded), $\mathcal{J} = \{1, \dots, N\}$ *and a set of bi-functional docks (loading and unloading)* $\mathcal{D} = \{1, \dots, D\}$ *of a cross-dock are given. Every truck* $j \in \mathcal{J}$ *has an arrival time,* r_j*, a strict latest departure time,* d_j *(if missed, the truck has to be scheduled for the next day departure), a docking time* δ_j*, which is the time spent for aligning the dock in front of a gate and the setups required by both the truck and the dock to start the loading/unloading operation and a processing time* p_j *(unit of time intervals) which is required to load/unload a truck, all are given. In its general form, every truck* j *may belong to different clients and carries different cargo with different levels of sensitivity translated to penalty cost,* f_j*, for every unit of waiting time before getting admission for service. A penalty cost* g_j *is charged when truck* j *is not served at all. We would like to minimize the waiting cost of every single truck such that it* *can leave the soonest possible and also to minimize the weighted penalty cost of missed trucks in the daily planning of the crossdocks.*

It must be noted that in this case, no capacity constraint is imposed on the crossdock as there is a sufficient temporal stacking space within the crossdock without causing operational inefficiencies.

2.1 Mathematical model

For the sake of respecting the volume of the abstract, we do not refer to the models we have proposed for the problem.

Added to the model we have proposed for the problem, to improve the quality of the polyhedral description of the model, several sets of strengthening valid inequalities are identified.

3 Our contribution, conclusions et perspectives

We proposed two mathematical programming models for the problem of dock assignment and truck scheduling with bi-functional docks. While the first one is an straightforward big-M formulation, our emphasis is on the second one that has been particularly designed for decomposition and column-wise solution approaches. It has been shown that by solving the compact model directly using Cplex, only very small size instances could be solved to optimality or even reaching to a feasible solution at all. We proposed a solution framework based on Dantzig-wolf reformulation and a branch-and-price approach equipped with a warm start heuristic that can very efficiently solve real-size instances of the problem in reasonable time. In addition to this exact technique, we also proposed an algorithm that shares similarities with adaptive large neighborhood search (ALNS) and Variable Neighborhood Search (VNS) approaches. Our computational experiments also confirm efficiency of this later method.

Further research directions include integration of further features of the real practice, polyhedral analysis of the pricing problems (including identifying some classes of facet-defining tightening valid inequalities) and some clever (combinatorial) solution algorithms for the pricing problem to improve the efficiency of the solution process.

Références

[1] Nils Boysen and Malte Fliedner. Research on warehouse operation : A comprehensive review. *European Journal of Operational Research*, 177(1) :1–21, 2007.

[2] Nils Boysen and Malte Fliedner. Cross dock scheduling : Classification, literature review and research agenda. *Omega*, 177(1) :413–422, 2010.

[3] Van Belle, Jan and Valckenaers, Paul and Cattrysse, Dirk. *Cross-docking : State of the art*. *Omega*, 177(1) :827–846, 2012.