Advances in Truck Scheduling at a Cross Dock Facility

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ABSTRACT

In this paper the authors deal with the scheduling of inbound and outbound trucks to the available inbound and outbound doors at a cross dock facility. They assume that all trucks served at the facility need to meet several deadlines for deliveries and pick-ups and thus request a departure time window from the facility, penalizing the facility operator, on a unit of time basis, if that deadline is not met. To solve the resulting problem with reasonable computational effort, a memetic algorithm is developed and a number of computational examples show the efficiency of the proposed solution algorithm and the advantages of scheduling inbound and outbound trucks simultaneously, as opposed to sequentially.

Keywords: Cross-Docking, Heuristics, Memetic Algorithms, Optimization Methods, Truck Scheduling

INTRODUCTION

In today’s customer driven economy, moving products quickly, efficiently, and cost effectively offers a distinctive comparative advantage to companies. To this effect, an increasing number of companies are finding that crossdocking operations can play an integral part of their distribution model, partially replacing or complementing existing warehousing policies. In a typical logistics distribution network, products are sent to a warehousing facility for storing, retrieving, sorting and reconsolidating (Sunil & Meindl, 2002). Products are subsequently sent out to retailers upon request. However, as inventory costs represent one of the main costs in a supply chain, crossdocking becomes an attractive alternative to warehousing. Cross dock is a material handling operation, whereby products move quickly and directly from inbound trucks (ITs) to outbound trucks (OTs), after being resorted or consolidated with limited storage needs, normally not exceeding 24 hours (Laumar, 2008). This type of facility is generally

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used in “hub-and-spoke” arrangements, where (de)consolidation of cargo occurs, as in the case of transshipment, with products delivered to customers in truckloads (TL). Since first pioneered by the Wal-Mart Corporation -where about 85% of its commodities are delivered through cross dock facilities- companies are increasingly starting to adopt cross dock operations. A survey of 547 industry professionals, carried out by Saddle Creek, showed that 52% of the respondents used cross dock and 13% plan to do so within the next one to two years (Laumar, 2008; Saddle Creek Corporation, 2008).

Problems relating to cross dock facilities can be categorized into two groups: a) problems that consider the facility as a node within a larger transportation network; and b) problems that focus on the operations of the facility (inbound doors, staging, and outbound doors). The former problems (Donald et al., 1999; Sung & Song, 2003; Dobrusky, 2003; Lee et al., 2006; Wen et al., 2008) include: a) the routing of vehicles from/to the cross dock facility; b) the location and the demand allocation to the cross dock facility; and c) the design of the supply chain network given the cross dock facility. The latter problems (Miao et al., 2009; Song & Chen, 2007; Bozer & Carlo, 2008; Yu & Egbelu, 2008; Boysen et al., 2008) include: a) optimization of operations at the inbound doors (IDs); b) optimization of operations at the outbound doors (ODs); c) optimization of operations within the storage area of the cross dock facility. ID operations consist of the assignment of a time slot; door; unloading cargo from the ITs; recording of data on incoming products and their characteristics; and assignment of temporary storage locations, if needed. OD operations consist of the assignment of a time slot and door; loading cargo to the OTs; generation of manifests; and recording of information on shipment and vehicle. Operations within the temporary storage area consist of the allocation of temporary storage space to the incoming cargo; deconsolidation of cargo; planning of packing and consolidation of materials; locator systems; etc. Cargo arriving at the cross dock facility may be loaded directly onto an OT (one-touch complexity); staged on the dock and then loaded onto an OT (two-touch complexity); or staged on the dock, reconfigured and then loaded on an OT (multiple-touch complexity). Depending on the complexity of the cross dock facility (one-touch, two-touch, multi-touch), optimizing the different operations can become rather tedious. As the planning of cross dock facilities includes the scheduling of inbound and outbound transportation, which makes the problem more dynamic than mere warehousing operations, improvements in this area have appeared only recently (Laumar, 2008). One of the most important functions in a cross dock environment is the determination of those docks to which incoming and outgoing trucks should be assigned. For an excellent critical literature review of cross dock operations we refer to Boysen and Fliedner (2010).

The latter type of problem is considered here. We deal with the scheduling of ITs and OTs to the available IDs and ODs. Our truck scheduling approach builds on two previous papers by Li et al., (2004) and Alvarez-Perez et al., (2009) who presented optimization models to schedule ITs and OTs so as to minimize the total earliness and tardiness of incoming and outgoing cargo, assuming a deadline of departure (for both ITs and OTs) in the form of a point in time. Our model introduces departure requests in the form of a time window, where the facility operator is penalized if that departure time window deadline is not met (as opposed to the point in time departure in Li et al., 2004 and Alvarez-Perez et al., 2009). Minimization of both early and tardy departures is consistent with a just-in-time (JIT) philosophy, where both earliness and tardiness are discouraged. An ideal schedule is therefore one where all trucks depart the cross dock facility within the requested time window. Minimizing total delayed or early departures affects the productivity of the facility (i.e. total throughput). We consider this aspect by including an addi-
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