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Multiple cross-docks scheduling using two meta-heuristic algorithms ☆

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A B S T R A C T

This paper considers a truck scheduling problem in a multiple cross docks while there is temporary storage in front of the shipping docks. Receiving and shipping trucks can intermittently move in and out of the docks during the time intervals between their task execution, in which trucks can enter to any of the cross docks. Thus, a mixed-integer programming (MIP) model for multiple cross docks scheduling is developed inspired by models in the body of the respective literature. Its objective is to minimize the total operation time or maximize the throughput of the cross-docking system. Moreover, additional concepts considered in the new method is multiple cross docks with a limited capacity. In this study, there are two types of delay times. The first type occurs when there is a shipping truck change and the second one occurs when the current shipping truck does not load any product from a certain receiving truck or temporary storage and waits until its needed products arrive at the shipping docks. To solve the developed model, two meta-heuristics, namely simulated annealing (SA) and firefly algorithms (FA), are proposed. In addition, a procedure for trucks scheduling in a state of a constant discrete firefly algorithm for the discrete adaptation has been proposed. The experimental design is carried out to tune the parameters of algorithms. Finally, the solutions obtained by the proposed SA and FA are compared.

1. Introduction

Cross docking is a warehousing strategy that involves movement of material directly from the receiving dock to the shipping dock with a minimum dwell time. Cross docking can effectively bring substantial reductions in the transportation cost without increasing the inventories while simultaneously maintaining the level of customer service in a constant level. Cross docking can also lead to the reduction of the order cycle time, improving the flexibility and responsiveness of the distribution network. This paper provides a framework to understand and design cross docking systems and discusses techniques that can improve the overall efficiencies of the logistics and distribution operation (Apte & Viswanathan, 2000). Yu (2002) discussed a cross docking problem under various assumptions. He proposed a model by assuming that there is a temporary storage in a cross docking system and each of two groups of trucks of receiving and shipping of loaded trucks can alternatively enter into cross-dock. The temporary storage allows trucks to deliver more cargos, which are storage for future shipments. The other trucks, which are responsible for shipping cargos to final destinations, can also use this temporary storage to meet final customers' needs. With regard to recent researches, which are available in literature of cross docking, there is no paper considering several docks and capacity constraints. Therefore, we discuss the case with several docks and capacity constraints. In the other words, each receiving truck is allowed to select one cross dock for unloading. Fig. 1 depicts a schematic representation of the proposed model for a cross docking terminal.

An outline of the remainder of this paper is as follows. In Section 2, a literature review of cross-docking problems is presented. Section 3 describes the mathematical formulation of model. In Section 4, we propose simulated annealing and firefly algorithms to find near-optimal solutions for the problem and their pseudo codes for solving the model. The Taguchi method is used for the parameters setting. Section 5 presents the experimental design and Finally, Section 6 draws the conclusions of the research and suggests possible further work.

2. Literature review

One of the earliest technical papers on cross docking systems is done by Wurz (1994) in which he point to this point that a distribution center can change to a dynamic and intelligent center. Rohrer (1995) discussed modeling methods and issues applied to

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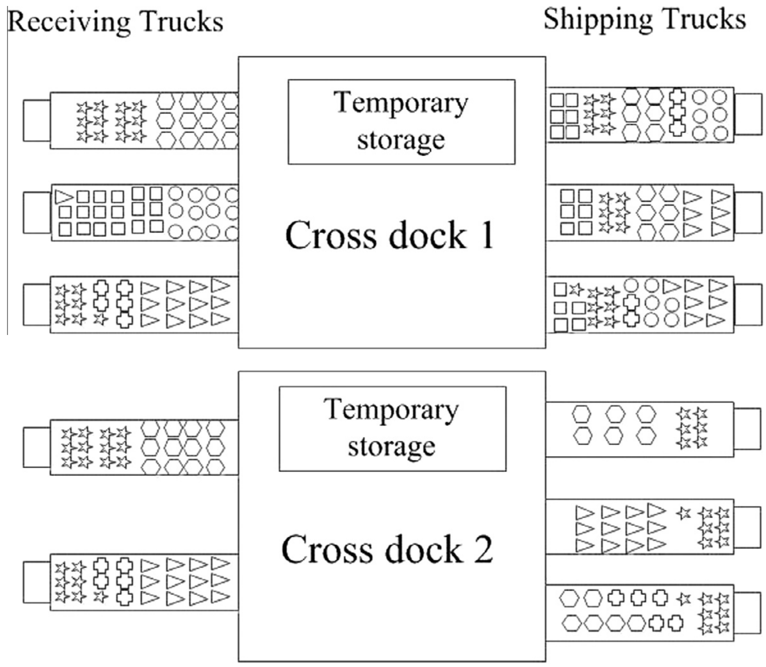

Fig. 1. Cross docking with multiple cross docks and temporary storage.

cross docking systems. He also described how simulation helps a success in cross docking systems design by determining an optimal hardware configuration and software control and establishing failure management strategies before cross docking problems are encountered. There is no any implementation issue was discussed. Schwind (1995, 1996), Cooke (1996, 1997), Kinnear (1997), Donaldson, Johnson, Ratliff, and Zhang (1999), Bartholdi and Gue (2004) and Napolitano (2000) addressed the importance of cross-docking and described the design processes for the cross-docking system.

Forger (1995) discussed implementation of cross docking operation in Chicago Area Consolidation Hub (CACH). Apte and Viswanathan (2000) offered a framework for understanding and designing cross-docking systems, including techniques for improving the overall efficiencies of logistics and distribution networks. Their framework and techniques derive from a review of previous literature and an investigation of warehousing practices during several field visits. Thus, they presented issues related to the network structures used for warehousing, the design of physical and information flows in cross-docking, and analysis and management systems.

In general, there are a few studies in the literature of scheduling transportation facilities in cross-dock systems. Lau, Sim, and Teo (2003) suggested a tabu search algorithm to minimize transportation costs for vehicle routing in a cross-docking system with specified time windows and a finite number of vehicles. Lee, Jung, and Lee (2006) proposed a model integrating cross-docking with the pickup and delivery process in the supply chain. Also, a mathematical model was developed to determine an optimal vehicle routing schedule considered cross-docking. Since this problem is known as NP-hard, an algorithm based on a tabu search algorithm was also developed.

Mosheiov (1998) handled the pickup and delivery problem as a kind of vehicle routing problem. He developed a mathematical model to minimize transportation cost and maximize the efficiency of vehicles. Afterwards, two heuristic algorithms were proposed to find a good solution in a reasonable amount of time.

Yu (2002) proposed methods to solve the cross-docking problem considering 32 models. For instance, three models focus on the number of the docks in the distribution facility, the pattern of cross docks for trucks and the presence or absence of temporary storage. His study aims to find sequences of receiving trucks and shipping in a cross dock and minimizing the operational time. He also suggests four approaches. In the first approach, a mixed-integer programming (MIP) model attempts to minimize the makespan of a cross-docking operation. However, the MIP is not suitable for modeling the problem in this study because of the exponential growth in variables and constraints as the number of receiving trucks, shipping trucks and products increase. In the second approach, a mathematical programming model applies different objective functions to minimize the number of matching pairs of trucks while still satisfying product requirements. Although the number of variables and constraints are lower for the second model, compared with the first MIP model, which means it can solve a much larger problem, this approach demands a considerable amount of time, which renders it unattractive and ineffective for solving large problem. In the third approach, another approach employs heuristic algorithms that can find solutions to problems very quickly, though they do not guarantee the optimal solution.

Yu and Pius (2008) developed nine heuristics for this problem. In the forth approach, the final approach uses meta-heuristic methods. Yu (2002) employed tabu search to solve the problem. Two other hybrid and robust meta-heuristics are proposed in this research that could efficiently solve the studying cross-dock problem. In the following subsections, the third and fourth approaches are explained. Alpan, Larbi, and Penz (2011) considered a truck scheduling problem, in which the objective function is not associated with time; however, preemption of unloading and loading functions is allowed. Konur and Golias (2013) identified suitable trucks' sequence with unknown arrival times for trucks by proposing a bi-objective GA. Alpan, Ladier, Larbi, and Penz (2011) considered several heuristics to attain this objective. Numerical experiments are presented and the results are compared with the optimal solution in order to evaluate the performance of their