Applied Soft Computing 36 (2015) 468–486

Contents lists available at ScienceDirect

Applied Soft Computing

journal homepage: www.elsevier.com/locate/asoc

Scheduling trucks in cross docking systems with temporary storage and repetitive pattern for shipping trucks

Ali Mohtashami*

Department of Industrial Management, Faculty of Management and Accounting, Qazvin Branch, Islamic Azad University, Qazvin, Iran

ARTICLE INFO

Article history:
Received 13 August 2014
Received in revised form 9 February 2015
Accepted 7 July 2015
Available online 30 July 2015

Keywords:
Logistics
Cross docking
Scheduling
Meta-heuristics
Genetic algorithm

ABSTRACT

Cross docking is a logistic concept in which product items are unloaded from inbound trucks into a warehouse and then are sorted out based on customer demands and loaded into outbound trucks. For a dock holding pattern for outbound trucks, two possible scenarios can be defined. In the first scenario, whenever a truck goes into a shipping dock, it does not leave the dock until all needed product items are loaded into outbound truck. In the second scenario, outbound trucks can enter and leave the dock repeatedly. Therefore, in the second scenario it is possible that an outbound truck loads some of its needed products from shipping dock, leaves the dock for another outbound truck, waits and goes into the shipping dock again to load all or part of its remaining product items. This paper proposes a genetic algorithm-based framework for scheduling inbound and outbound trucks in cross docking systems with temporary storage of product items at shipping dock for the second defined scenario such that minimizes total operation time. In order to show the merit of the proposed method in providing a sequence that minimizes the total operation time, the operation time of the proposed method is compared to a well-known existing model by several numerical examples. The numerical results show the high performance of the proposed algorithm.

1. Introduction

Cross docking is a product handling and distribution concept in which product items sorted out and recognized based on customer demands and move directly from receiving dock to shipping dock, without being held as inventory in the warehouse. Cross docking systems can decrease the storage and products retrieval costs in comparison with traditional warehouses, by synchronizing the flows of inbound and outbound trucks. Generally, cross docking is a good strategy for companies that distribute large volume of products and/or serve a large number of stores [1].

Cross docking facilities include four main functions of warehousing. These four major functions are receiving, storage, order picking and shipping. Among these four functions, storage and order picking are typically the most costly. Storage function is costly because of inventory holding costs. On the other hand, order picking is expensive because it needs labor work. Cross docking minimizes the storage and order picking functions of a warehouse while still it allows to receive and to ship the product items. According to what proposed by Yu and Egbelu [1], the general framework of this cross docking system is illustrated in Fig. 1. The cross docking system generally operates as (1) product items arrive at the cross dock facility and are verified at the receiving docks, (2) products are placed on the sortation systems, which are sorted by destinations, (3) products are transferred to the proper location on the shipping docks and leave the cross dock facility.

There are some works in the literature aiming at the concept of cross docking and scheduling transportation facilities in cross docking systems. Buffa [2] showed that logistic costs could be reduced by integrating inbound and outbound trucks in distribution systems. Cross docking operation can achieve this function actually. The most famous application of cross docking is Wal-Mart. Cross docking has helped Wal-Mart to improve its market share and profitability [3]. Moreover, cross docking make great commercial success in Home Depot, Costco, Canadian Tire, FedEx and so on. For perishable products or environment with limited or no storage, cross docking operation can be a helpful technique and can provide low inventory and transportation cost for companies by integrating goods in distribution center [4]. Lau et al. [5] suggested a tabu search algorithm to minimize transportation costs for vehicle routing in cross docking system with specified time windows and a finite number of vehicles. Lee et al. [6] proposed a model integrating cross docking with the pickup and delivery process in

* Correspondence to: Qazvin Islamic Azad University, Nokhbegan Blvd., P.O. Box 34185-1416, Qazvin, Iran. Tel.: +98 2813685089; fax: +98 2813665279.
E-mail addresses: mohtashami@qiau.ac.ir, mohtashami07@gamil.com

http://dx.doi.org/10.1016/j.asoc.2015.07.021
1568-4946/

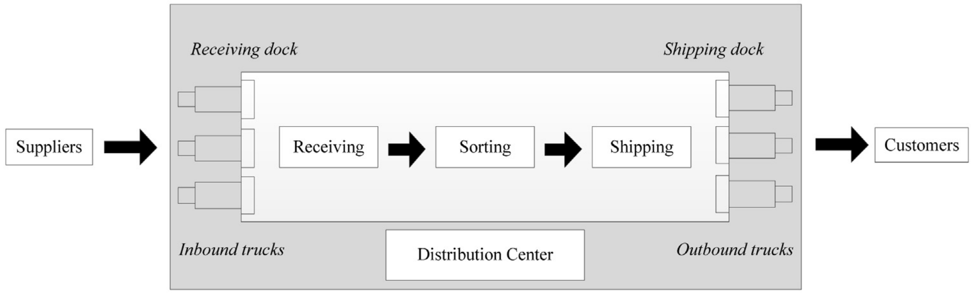

Fig. 1. The framework of the cross-docking system.

the supply chain. Moreover, a mathematical model was developed to determine an optimal vehicle routing schedule which considered cross-docking. Since this problem is known as NP-hard, an algorithm based on a tabu search algorithm was also developed. Mosheiov [7] studied an important version of the vehicle routing problem with pick-up and delivery. The objective in his study was to find a set of vehicle routes that service customers such that vehicle capacity is not violated and the total distance traveled is minimized. He introduced two heuristics that focus on efficient utilization of vehicles' capacities. Chen and Song [4] studied a two-stage hybrid cross-docking scheduling problem in which a precedence criterion must be fulfilled between consecutive jobs. They dealt with the model in two different phases. For problems with small scale, they addressed a mixed integer programming model and solve each problem with CPLEX while for problems with medium and large scale, they proposed four heuristics compared with each other via a given lower bound. Barbarosoglu and Ozgur [8] developed a new tabu search heuristic to solve the single-depot vehicle routing problem of a distribution company carrying goods from a depot to a set of dedicated dealers. Their heuristic proposed a new neighborhood generation procedure which considers the scattering pattern in the locations of the dealers. Boloori et al. [9] worked on a cross docking scheduling problem in a just in time environment in which the delivery of products should conform to pre-determined time schedules. Hence, any late or soon delivery might be inappropriate for customers. Therefore, they considered earliness and tardiness as the two main criteria in a multi-criteria scheduling problem. In addition, these criteria are combined through a penalty factor considering penalties for any soon or late delivery of commodities. Three meta-heuristics have been developed in their paper, to solve the problem. Maknoon and Babtiste [10] proposed two stage approaches for the same problem. The first approach proposed a dynamic programming algorithm for loading/unloading and a heuristic evolutionary algorithm for sequencing. The second approach provided a heuristic and an evolutionary algorithm. It was shown that the second approach is better from the viewpoint of time and profit. Vahdani and Zandieh [11] applied five meta-heuristic algorithms to schedule the trucks in cross-dock systems such that minimize total operation time when a temporary storage buffer to hold items temporarily is located at the shipping dock. Konur and Golias [12] studied a cross-dock operator's truck scheduling problem at inbound doors in case of unknown truck arrival times. They analyzed the cross-dock operator problem of determining a cost-stable scheduling strategy while minimizing the average of total costs. Joo and Kim [13] proposed genetic algorithm (GA) and self-evolution algorithm for a truck scheduling problem with three types of truck: inbound trucks, outbound trucks and compound trucks. The compound trucks play the roles of inbound trucks and outbound trucks. Li et al. [14] considered the cross docking scheduling problem as a two-phase parallel machine problem with earliness and tardiness and proposed two genetic algorithm-based approaches for its solution. Besides, they supposed that the temporary storage is not allowed. Lioa et al. [15] considered inbound and outbound truck sequencing for cross docking operation with objective of minimizing makespan. They proposed two new hybrid differential evolution algorithms and a more realistic operational policy. Agustina et al. [16] focused on the integration of vehicle scheduling and routing in one comprehensive model, which have traditionally been modeled separately. The integrated model also considered product consolidation at the warehouse and respected delivery time windows specified by the customer.

Yu [17] and Yu and Egbelu [1] studied Cross Docking model with Temporary storage in front of the shipping dock and dock Non-Repeat truck holding pattern at the dock (CDTNR). The objective of their study was determining the best truck sequencing for both inbound and outbound trucks in order to minimize total operation time (makespan). Yu [17] proposed Cross Docking model with Temporary storage in front of the shipping dock and dock Repeat truck holding pattern (CDTR). In his study, it is assumed that there is a temporary storage in front of the shipping dock and both the receiving trucks and the shipping trucks can intermittently move in and out of the dock during the time intervals between their task execution. He developed a mathematical model and a heuristic algorithm to solve the problem. He stated that the developed mathematical model for this problem is inefficient and impractical because of the large computational time required even for small problems. In order to assess the performance of the heuristic algorithm, the heuristic solutions need to be compared with the optimal solutions that cannot be found using the mathematical programming model. However, the optimal solution for the CDTNR can be used as the upper bounds for the optimal solutions for the CDTR. Moreover, he stated that the optimal solution for the CDTR must be, at least, as good as or better than the optimal solutions obtained for the CDTNR from the viewpoint of makespan since the CDTR is a more relaxed problem compared to CDTNR. Despite of the later argument, computational results in his study showed that the solutions of developed heuristic algorithm for CDTR is not always as good as or better than the optimal solutions obtained for the CDTNR. In fact, the computational results revealed that in some test problems, the solutions of the CDTR are worse than the solutions of the CDTNR. Therefore, it seems that the proposed heuristic algorithm in Yu [17] for CDTR is not reliable to be used for dock repeat truck holding pattern.

The present paper proposes a solution framework based on genetic algorithm for Cross Docking model with Temporary storage in front of the shipping dock and dock Repeat truck holding pattern for Outbound trucks (CDTRO). For a dock holding pattern for outbound trucks, two possible scenarios can be defined. In the first scenario, whenever a truck goes into a shipping dock, it does not leave the dock until all needed products are loaded into the outbound truck. In the second scenario, the outbound trucks can enter and leave the docks intermittently. Therefore, in the second scenario it is possible that an outbound truck loads some of its products, leaves the shipping dock for another outbound truck,