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A novel dynamic genetic algorithm-based method for vehicle scheduling in cross docking systems with frequent unloading operation

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ABSTRACT

An important factor for efficiently managing the supply chain is to efficiently control the physical flow of the supply chain. For this purpose, many companies try to use efficient methods to increase customer satisfaction and reduce costs. Cross docking is a good method to reduce the warehouse space requirements, inventory management costs, and turnaround times for customer orders. This paper proposes a novel dynamic genetic algorithm-based method for scheduling vehicles in cross docking systems such that the total operation time is minimized. In this paper, it is assumed that a temporary storage is placed at the shipping dock and inbound vehicles are allowed to repeatedly enter and leave the dock to unload their products. In the proposed method of this paper two different kinds of chromosome for inbound and outbound trucks are proposed. In addition, some algorithms are proposed including initialization, operational time calculation, crossover and mutation for inbound and outbound trucks, independently. Moreover a dynamic approach is proposed for performing crossover and mutation operation in genetic algorithm. In order to evaluate the performance of the proposed algorithm of this paper, various examples are provided and analyzed. The computational results reveal that the proposed algorithm of this paper performs better than two well-known works of literature in providing solutions with shorter operation time.

1. Introduction

In today's competitive market environment, manufacturers and distributors try to rapidly supply products to customers with lower costs. In fact, the physical flow of the supply chain is one of the most important things in implementing supply chain management. Apte and Viswanathan (2000a, 2000b) stated that 30% of price is incurred in the distribution process. Therefore, many companies try to find appropriate methods to efficiently control their material flow. For this purpose, a distribution strategy called cross docking is considered as a good method to reduce inventory while satisfying customers' needs. Cross docking is relatively a new warehousing strategy in logistics (Kuo, 2013). It not only provides good customer service but also yields substantial advantages over traditional warehousing; reduction in inventory investment, storage space, handling cost and order cycle time, as well as faster inventory movement and accelerated cash flow (Apte & Viswanathan, 2000a, 2000b; Cook, Gibson, & MacCurdy, 2005; Kuo, 2013).

Cross docking is defined as a transshipment platform that receives products from a supplier for several destinations and consolidates them with other suppliers' products for a common final delivery to a destination (Kinnear, 1997). In fact, due to consolidation of various shipments to a destination, cross docking results in fewer shipments in full truckloads per destination. Usually, the storage time in cross docking is less than 24 h and sometimes less than an hour (Wen, Larsen, Clausen, Cordenau, & Laporte, 2009; Yu & Egbelu, 2008). There are lots of reported successful implementation of the cross docking which resulted to considerable competitive advantages specifically for industries with high proportions of distribution costs like retail chains (WalMart (Stalk, Evans, & Shulman, 1992)), mailing companies (UPS (Forger, 1995)), automobile manufacturers (Toyota (Witt, 1998)) and less-than-truckload-logistics providers (Gue, 1999).

From a generally point of view, in an ordinary distribution center there are five stages to operate the products: receiving, sorting, storing, retrieving and shipping. It should be noted that all these items impose cost to the system and any approach contributing to cost reduction is worthwhile. A general framework of the cross docking system is illustrated in Fig. 1. The cross docking system generally operates as (1) products arrive at the distribution center (cross docking) by the inbound trucks and are verified at the

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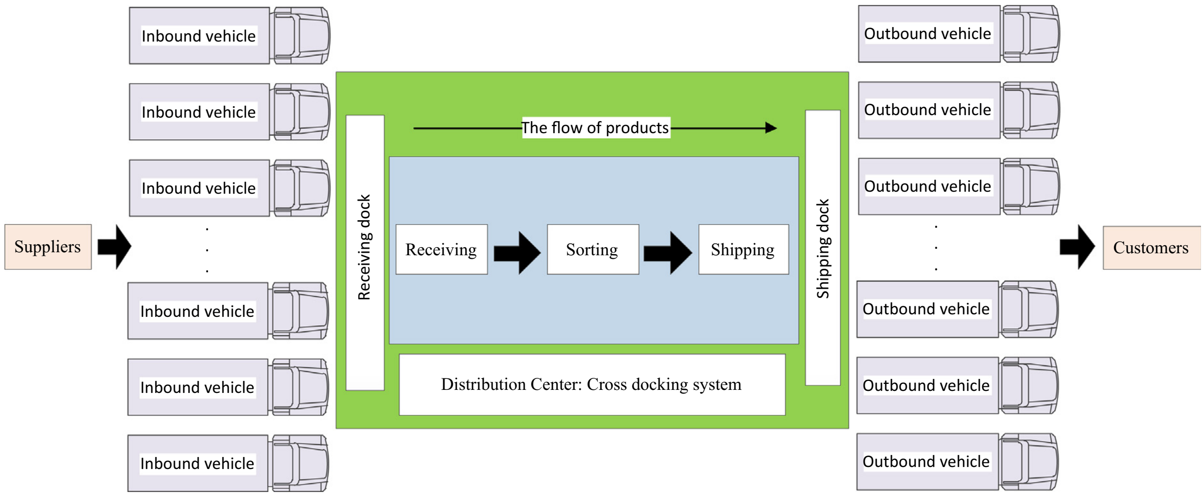

Fig. 1. Framework for cross docking.

receiving docks, (2) products are categorized by destinations, and (3) products are transferred to the proper location on the shipping docks and leave the cross dock facility by outbound trucks. As a consequence of using the cross docking system, the two stages of storage and products retrieval are diminished, and even eliminated by synchronizing the inbound and outbound vehicle flows.

There are some factors needed for a successful implementation of the cross docking system (Moore & Roy, 1997; Schaffer, 1997; Yu & Egbelu, 2008). These factors are (1) short lead times must be considered for the delivery of products because it is supposed that no stock or considerably little stock is held. In fact, if the needed products are not delivered on time, the supplier will face stock shortage and probably back orders; (2) since the arrival and departure schedules of vehicles should be specified in advanced, the required information should be obtained primarily; (3) trough consolidating the homogenous products, the amount of delivery time can be decreased; therefore, we can reliably deal with items that are highly requested by the customers; and (4) good bases for software and hardware are two essential elements for a company in order to run the cross docking system effectively. In fact, the computerized and technological methods for inventory management, material handling and product sorting are considered as the hardware. On the other hand, the availability of information, compatibility of inbound and outbound vehicles, and suitability of sequence of incoming and outgoing products are realized as the software.

Cross docking systems attract many researches to study and develop the concept of cross docking as well as providing some methods in order to improve the efficiency of the cross docking systems. In this field, researchers have studied several cross docking related topics such as system design (Apte & Viswanathan, 2000a, 2000b; Bartholdi & Gue, 2004; Jayaraman & Ross, 2003; Santos, Mateus, & Cunha, 2013; Sung & Song, 2003; Sung & Yang, 2008), simulation (Rohrer, 1995), vehicle routing (Lee, Jung, & Lee, 2006; Mohtashami, Tavana, Santos-Arteaga, & Fallahian-Najafabadi, 2015; Wen et al., 2009), dock door assignment (Kuo, 2013; Oh, Hwang, Cha, & Lee, 2006), vehicle sequencing and scheduling (Bellanger, Hanafi, & Wilbaut, 2013; Boysen & Fliedner, 2010; Liao, Egbelu, & Chang, 2012), distribution planning (Chen, Guo, Lim, & Rodrigues, 2006; Musa, Arnaout, & Jung, 2010), and transshipment scheduling (Larbi, Alpan, Baptiste, & Penz, 2011). Since the scope of this paper is around vehicle scheduling, this subject is reviewed in more details as follows.

Yu and Egbelu (2008) proposed a mathematical model with objective of minimizing the total operation time (makespan) of a cross docking system. In order to schedule vehicles, they pursued three different solution approaches. In the first approach, a mathematical model with the objective of minimizing total operation time of a cross docking operation was developed. The second approach employed complete enumeration to generate all possible truck scheduling sequences to a problem. The complete enumeration approach was included in their study to provide a basis for benchmarking the effectiveness of the other two approaches employed. They stated that due to time complexity requirement, both the mathematical and the complete enumeration approaches are inefficient for solving medium to large size problems. As a result, the third approach was developed to overcome the computational limitation of the mathematical and the complete enumeration approaches. The third approach employed nine heuristic algorithms. Vahdani and Zandieh (2010) considered the problem defined in Yu and Egbelu (2008) with exactly the assumptions of Yu and Egbelu (2008). They applied five meta-heuristic algorithms to schedule the vehicles in cross-docking systems such that minimize total operation time when a temporary storage buffer to hold items temporarily is located at the shipping dock. They illustrated that the meta-heuristic algorithms performs better than the heuristic algorithms of Yu and Egbelu (2008). Konur and Golias (2013) 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. Maknoon and Baptiste (2009) proposed a dynamic programming algorithm, and evolutionary algorithm and a heuristic approach to increase the efficiency of the operation of the cross docking. They maximize the ratio between the total number of directly transiting products to the total number of transiting products by optimizing sequence of both inbound and outbound trucks. Boysen, Fliedner, and Scholl (2010) proposed a dynamic programming method for optimizing the sequence of inbound and outbound trucks at cross docking terminals. Sadykov (2012) proposed an approach to reduce storage in cross docking. When products are unloaded in the receiving dock but the corresponding outbound truck is not immediately available in the outbound door, they are temporary stocked in a storage area and cause increasing storage costs. He proposed a dynamic programming algorithm for optimizing the truck schedule for both inbound and outbound trucks. Unlike many studies in literature, Boysen (2010) proposed a simulated annealing method and dynamic programming for vehicle sequencing in the cross docking system such that a temporary storage was not allowed. That means that after products are unloaded from the inbound trucks, the products have to be loaded into the