Review on Cross Docking Quantitative Approaches

Amin Soleimany
Email: soleimani.amin@yahoo.com

Ali Tolooie
Email: Ali.tolooie@Gmail.com

Author(s) Contact Details:
1,2 Faculty of Mechanical, Universiti Teknologi Malaysia, Johor, Malaysia

Abstract—Cross docking is a new distribution center recently is used in order to reinforce inbound shipments and convey a single outbound shipment to gain conservation of scale. The procedure of cross docking consists of three main processes in which is unloading freight from inbound trucks, sorting and loading freight on outbound trucks with no storage or with at least possible storage between. According to cross docking concept these proceedings required to be done less than 24 hours. In this essay we present the definition of Cross docking also we describe the fundamentals opportunities of expanding throughput of cross docking. In this research we reviewed comprehensive literature of cross docking issues based on the main problems and aims. This issues can be categorized as tactical, strategically, and operational. Operational level issues mostly deals with scheduling and dock door assignment while in tactical and strategic level designing the layout and network are the most vital subjects that are dealt with. Base on this review, the gap of knowledge in cross docking can be realized and several opportunities for improving cross docking throughput that not vastly inspected or non-studied point out for future research and provide opportunities and direction for further research in cross docking.

Keywords- Cross docking; Distribution center; Strategically; Tactical; Operational

1. INTRODUCTION

Cross docking is described as a kind of distribution centre for delivery of different products with the aim of eliminating temporary storage. In this essence less operation is needed without storage of products. A cross docking terminal is identified as an assortment centre. The procedure of this method is deliver items directly from arriving trucks to sorting area and after sorting products according to their destination is loading to outbound trucks. The main goal is to omit the need for a storage area in the transportation process in facility. Cross docking method became widely reputed when Wal-Mart used it successfully in their retailers. The idea was to stabilize the delivery by excluding disturbing sources and employ economies of scale in departing shipments. Often items will be in storage for nearly less than a day [1]; [2]. During this time various size items synchronized to the same full capacity truck which dramatically reduces the cost of the delivery [3]. Even though the process looks like a simple shipment, there are some complexities which explicitly point out for more research. Researchers study on some areas like scheduling, optimizing and implementing. One of the fundamental goals of supply chain management is to decrease transportation cost without reducing customer service in organizations. Therefore, there is a significant interest in this new method. By implemented Cross docking properly many benefits can bring about for organizations. Some of them are listed below:

- Decrease storage cost
- Deduce fix price of the storage area
- Reduce shipment lead time
- Increase customer satisfaction via fast delivery

Cross docking can be implemented for different purposes of shipment. In this essay some of the most important kinds of cross docking is declared. Manufacturing cross docking receive and consolidates import stocks for backing up with the aim of on time construction. Distribution cross docking consolidates import items from various origins into a single pallet that starts the shipment process the moment the final item is loaded. Transportation cross docking consolidates deliveries from various sources of Less-than-truckload (LTL) and applied Full Truck load delivery to achieve economies of scale. Retail cross docking receive items from different suppliers and classify into departing trucks for various destinations [4]. Figure 1 indicates a schematic portrait of cross docking for various items that leave for separate destinations.
There are various factors to be studied while making and arranging to implement cross docking system in a supply chain management. Each company has its own concerns about prices, storage space, location definitions, and merchandise verities. It is critical to indicate the necessitation of applying this facility based on companies’ goal. This research objective is to go through the researches already done on cross docking according to problems and aims. Our essay mainly supplies a source of all the major studies on this method, its aims and issues, with the purpose of expanding its throughput. Also, it will be a comprehensive source for further studies on cross docking.

2. LITERATURE REVIEW

Generally, Cross docking problems can be divided into three groups according to decision making level and time horizon which is strategically, tactical and operational. From its decision making levels the models also will considered and investigated according to objectives, modeling approach and methodology. Figure 2 shows the categorization of cross docking problems.

Cross docking problems become a critical issue and have been studied by many researches that tactical and strategically considered as a long term decision making, while operational mostly deals with short term decision making. In this section
different problems concerns with cross docking is presented. The initial steps for cross docking planning is strategic in which deals with appropriate location and also the layout of the cross docking. Subsequent step after the layout and location determined is to make a decision about the flow of materials and products through the cross dock network in order to diminish the cost and time that concerns with tactical decision. Finally, most of the research and work that goes on the operational issue of cross docking is related to developing and improving models for scheduling problems, transportation problems, dock door assignment, and inbound and outbound routing. The next part clarifies and considered Operational planning that concerned with short or midterm planning according to time horizon which might be daily, weekly or monthly in which mostly deals with, transshipment problems and vehicle routing problems. Since operational decision has a great impact on cross docking efficiency some works have been performed in operational level of decision making in order to improve efficiency of cross docking. Next, strategic problems which deal with location and layout of cross docking will be discussed. Finally, tactical problems which related to cross docking network determine and finally operational decision and its related problems will be discussed.

A. Location

Tactical decision level consider midterm planning in which mainly focuses and addresses problems regard of layout and location of cross docking in order to improve effectiveness and throughput of the operation of cross docking. In location area of cross-docks in supply chain network design, Jayaraman et al., (2003) determine an assessment of new heuristics solution procedures. Optimal distribution system designed and utilization strategies utilized the simulated annealing (SA) methodology and explained as two heuristics solution in this paper [6]. This study significantly contributes in two ways. First, they follow the location problem in cross-docking and distribution center. Second, for better understanding of interaction aspects among the several factors, the computational performance is principally evaluated in network design location model but they don’t considered scheduling of cross docking, however the location and routing scheduling problems in cross-docking are studied by Mousavi et al., (2013) in order to minimizing fixed costs and transportation costs from pick up process to the customer locations, penalty costs for lateness in delivering and operational costs are the objective of this research. Their problem which is known as NP-hard problem is related to concurrently design location and routing scheduling model of cross-docking. They offer a new algorithm which is based on a two-stage hybrid simulated annealing (HAS) to solve the model. Diverse problems are accidentally produced and solved by this algorithm [7].

The location of numerous cross-docks and vehicle’s scheduling routing problem are also considered under a fuzzy environment by Mousavi et al., (2013). The related objectives for their two-phase model are minimizing transportation and fixed costs of cross-docks and also operational costs of vehicles. For solving this problem they propose a new fuzzy mathematical programming [8]. After that Mousavi et al., (2014) submit two mixed-integer linear programming (MILP) models that mix for the location of various cross-docking centers and the vehicle routing scheduling problem. Developed Hybrid fuzzy possibility-stochastic programming is presented to solve these models. Finally, diverse problems are applied to evaluate appropriateness of the new two-phase MILP model [9].

B. Layout

Cross-docking faces to several problems during the design and operational phase and has to deal with many decisions. Efficiency has been always influenced by these decisions so it is really important to make a good one. One of the first strategic decisions that be taken are what is the best layout of a cross-dock. After determining the cross dock’s location, choosing the layout of the cross-dock is one of the important decision. The configuration of the internal cross-dock zone and their arrangement is considered as well as the shape of the cross dock in layout.

Hauser and Chung (2006) applied genetic algorithms (GA) which has become very popular as instruments for optimization in order to optimizing of lane layout related to the cross-docking at the Toyota Motor manufacturing plant is determined as an objective. They show GA solution can be achieved so fast, whereas a complete search needs so many times to solve the problem. They obtain a decrease in workload in the cross-docking zone and then reduce lead time. This achievement is due to rearrangement of the lanes [10]. As we are mention previously one of the significant points in warehouse operations is warehouse layout problem. Therefore Örüt et al., (2008) consider cross-docking layout as a distribution-type warehouse. Multiple type products are received from suppliers and then delivered to customers are examined in this research. They design a shape of warehouse shelf for minimizing the carrying costs is determined as an objective. The turnover of products are considered and classified based on distances between the shelves and docks. They use particle swarm optimization algorithm (PSO) to solve mathematical model for achieving the optimal layout. Increasing the two dimensional warehouse designs to several levels is defined as one of the contribution of this research. They discuss
that tradeoff between handling cost and vehicle waiting cost when the dock number increases can be considered as a future work [11].

Using cross docking facilities as a distribution center where products receive and leave in the same day generates dynamic environment for reducing the response times. Vis et al., (2011) studied these dynamic situations, flexibility and comfort ability in reconfiguring storage area layouts is really significant. They represented a dynamic design methodology to choose policies and specify layout rules which can help to determine an effective layout for storage area is defined as an objective in this paper. Royal Horticultural Company Lemkes’s cross docking center in the Netherlands is used as the foundation for analyzing the proposed layout procedures. Saving 16% of total travel distances of employees is achieved by implementing this design methodology [12].

C. Scheduling

Indeed, the assignment problem can be put into scheduling problems by which categorized into operational problem of cross docking and mainly focuses on dock door assignment issue. Generally, the most crucial issue in door assignment problem is to find travel time parallel to travel distance of cargo inside the facility. Poor scheduling brings many disadvantages such as increasing make span that increase the operational cost. Therefore the main goal for scheduling is to decrease the make span as much as possible that effects on cost of operation as well. Saharidis et al., (2012) has presented two new mathematical formulations in which can be used for the scheduling of inbound trucks to doors at a cross-docking facility, and also made comparisons to formulation of the classical machine scheduling. Their first formulation deals with continuous time that is considered and in the second formulation, a discrete time representation is proposed. In addition terminated exact algorithm accompany with numerical results are presented to illustrate and critically evaluate each of the formulation [13]. But the main problem of their models is that they cannot deals with large and wide range problems. Boysen et al., (2010) studied scheduling trucks regard of cross docking terminals and presented a model, in which relies on a some simplifying assumptions with the goal of deriving fundamental insights into the underlying problem’s structure such as its complexity, and to develop a building block solution procedure, that can be used to solve more sophisticated truck scheduling problem [14]. Saharidis et al., (2012), Boysen et al., (2010), and Mohammadi et al., (2010) also studied scheduling problems of cross docking system with temporary storage and developed some models to solve trucks sequencing assignment to dock doors [13]; [14]; [15]. Shakeri et al., (2008) supposed two phase heuristic algorithm for assigning trucks to doors in which the number of truck considerably outweighed the number of dock doors in order to solve cross docking scheduling problems [16]. Mohammadi et al., (2010) focused on minimizing delayed occurring inside cross docking product arrangement to optimize makes pan instead of finding the best trucks sequencing [12]. Both Ting et al., (2012) and Hu et al., (2013) worked on the coordination inbound and outbound problems, even though Ting et al., (2012) mostly considered minimizing total system cost and Hu et al., (2013) focused on optimizing overall make span and travel distances. Regard of vehicle scheduling coordination Ting et al., (2012) considered three different operation strategies and developed a heuristic algorithm to improve both inbound and outbound headway [17]; [18]. Li et al., (2004) represented a model in order to minimize makes pan based on the just in time concept but they main objective was minimizing the penalty incurred by earliness and tardiness of outgoing and incoming trucks and that it has been modeled through Integer Programming. In order to solve these problems they propose meta_heuristic algorithm in which embedded in Genetic Algorithm and Linear programming [19];[20].

D. Transshipment and vehicle routing problem

Generally, transshipment model aim is to find the best flow of products, allocation of product between nodes with best routes. Consequently, when inbound and outbound truckloads are synchronized, transshipment process have to proceed efficiency in order to on time delivery and keeping intermediate inventory inside the facility as low as possible based on the concept of cross docking. Larbi et al., (2009) studied the transshipment problem and considered single strip and stack door and proposed a graph in order to find minimum routes between nodes in which results in minimum cost of transshipment [21]. After that Yu et al., (2008) begin to work on transshipment problem of cross docking with the goal of increase efficiency of cross docking. They determined the sequence of truck in order to minimize make span [22]. Miao et al., (2009) also studied the same issue as Larbi et al., (2009) with the goal of minimizing transshipment cost. They proposed an Integer Programming model and solved it with Genetic algorithm in order to achieve minimum cost of intermediate inventory transportation costs and holding penalty [23]. Larbi et al., (2011) worked on transshipments problem in a single receiving and shipping door of cross dock and regarded three different scheduling policies. In the first policy they supposed complete information for the order of arrivals and the contents of all inbound trucks. But in the other policies they supposed the availability of partial and without complete information on the sequence of upcoming trucks. Finally they presented optimal graph based model for the full information case, and a polynomial time algorithm is presented. They developed
Heuristics for the other two cases. Consequently they made comparison of the costs parallel to each policy in order to help evaluating the value of information in cross dock scheduling problems [24].

The vehicle routing problems is scheduling and planning of routes between different nodes in order to fulfill set of customers order. Vehicle routing problems cope with allocating products between customers. Generally, vehicle routing problem is related to paling problem of finding the best routes to meet the set of customers and mainly deals with distributing one product to the all customers. In this case there are possibilities to have time window and capacity limitation to meet customers need. This problem first investigated by Lee et al., (2006). They developed a tabue research algorithm based on NP-hard model in order to determine the best routing scheduling to monitor flow of products within a supply chain [25]. After that Wen et al., (2008) also study the same problem as Lee et al., (2006) worked on it which is vehicle routing problem of cross docking in order to achieve optimize travel distance in consideration of time criteria in the whole process of transportation of cross docking. The problem modeled through Integer programming and solved by tabue research [26]. Mousavi et al., (2013) focused on the same problem, however they also considered cross docking location in which proposed two phases mixed integer programming and then solved with embedded tabue research algorithm and two-stage hybrid [7]. They considered food distribution and centralized their efforts to solve routing and scheduling problem in order to ensure that food delivery can meet just in time concept and minimize delivery and intermediate inventor cost. They used integer linear programming to model and solve the problem [9].

E. Cross docking models

In the past few decades utilizing cross docking has increased due to its advantages that brings about. Many company applied cross docking to increase productivity of their companies. Some of important researches goals for investigating cross docking exhibited in table below which is minimizing total cost, optimizing travel time and distance and minimizing operational time. Table 1 summarizes some the most important goals of cross docking in the past few years.

<table>
<thead>
<tr>
<th>TABLE 1: cross docking models</th>
<th>Minimizing total cost</th>
<th>Optimizing travel time and distance</th>
<th>Minimizing overall operational time</th>
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<tr>
<td>(Golias et al., 2009)</td>
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<td>(Ting and Lopez, 2008)</td>
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<td>(Shakeri et al., 2008)</td>
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<td>(Boysen et al., 2010)</td>
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<td>(Tavakkoli-Moghaddam and Razmi, 2012)</td>
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<td>(Wen et al., 2009)</td>
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Base on literature the biggest opportunities for cross-docking costs savings are transportation related issues. The better transportation utilization means less cost spend on the fuel. Considerable freight savings also can be achieved by consolidating LTL shipments into TL to the cross-dock and, whenever possible, combining outbound shipments with those of multiple vendors going to the same destination. Cross-docking can also help to Control overall logistics costs. Charkhgard and Tabar (2011) formulated distribution planning problem of cross docking, they formulated it through integer nonlinear programming and solve it by heuristic algorithm in order to minimize transportation costs. Whilst many companies are concern about cost saving but it is not the only goal for cross docking improvement. Recently as the business market become highly competitive the time even become more critical and companies who operates faster can survive. So numerous researchers focus on scheduling of cross docking rather cost only. In the latter environment there may be a predefined sequence and departure time for the outgoing trucks, any item which does not arrive to the loading dock before the departure time will be delayed for the next day, so the performance measure in the problem will be (total weighted) number of delayed shipments [30]. Other researches aim is to minimize the scheduling time span of cross docking using nonlinear programming based on optimization of number of delayed product [15],[24]. The objective of the vehicle routing problem is to minimize the total travel time while respecting time window constraints at the nodes and a time horizon for the whole transportation operation. This general claim for synchronization can be operationalized by minimizing the total
completion time of operations, which are also referred to as make-span in scheduling literature. For a given inbound and outbound sequence of trucks the nearly optimal outbound (in-bound) sequence is determined by a suited Dynamic Programming approach as well as some heuristic procedures [14].

3. Comparison and analysis of previous study

Many of the study about cross docking are according to decision level in which have been discussed. Recently huge amounts of paper about cross docking have been published. Parts of this paper about cross docking deal with general issue such as suitability of cross docking and implementation of cross docking to be effective as much as possible that exhibited in table 3.1. Even though utilizing of cross docking can decrease costs and lead time, but it is important to consider all the strategies and situation and making trade off for selecting the best strategy.

<table>
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<th>Unit costs</th>
<th>Stable and constant</th>
<th>unstable or fluctuating</th>
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<tbody>
<tr>
<td>High</td>
<td>Cross-docking can be implemented with proper systems and planning tools</td>
<td>Traditional distribution preferred</td>
</tr>
<tr>
<td>Low</td>
<td>Cross docking preferred</td>
<td>Cross-docking can be implemented with proper systems and planning tools</td>
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According to Apte and Viswamathan most important factors that can determine the suitability of applying cross docking is discussed and compared it with other strategies and traditional distribution centres. One of the most critical factors in this regard is demand rate of products. Mostly cross-docking implementation is suggested for stable demanded product such as grocery that uses perishable foods. Cross docking is not suitable for products that there is no balanced between incoming and out coming products. Another important factor is stock-out cost. Since cross-docking minimize the level of inventory at the warehouse the risk of stock-out is also higher but the cost of stock-out play an important role. Therefore, based on figure 2.2 cross docking is suitable for stable product demand and low unit stock-out cost and the customary warehouses is suggested for the opposite situation [27]. For the subsequence cases cross docking can be appropriate when system and planning tools are in place to keep the number of stock-outs at proper level. There is also another factor that required to be considered in this case in which is product life cycle, cross docking distance from suppliers and demand quantity [27];[28]. The summary can be seen is table 2.

Several papers deal with cross-docking in a more general way (e.g. suitability for cross-docking and the implementation of cross-docking), while other papers are concerned with a specific type of problem (on a strategic, tactical or operational level). Especially the problems of dock door assignment and truck scheduling have attracted the attention of many researchers. Some of author such as Shuib et al., (2012) just reviewed the specific part of cross docking such as operational aspect of cross docking [29]. Also the Despite this attention, the authors believe that there are still many opportunities to improve and extend the current research.

4. CONCLUSION

According to what that has been discussed, the problems in the cross docking models can be categorized into the three following groups based on their decision levels: Operational, Tactical, And Strategic Level. The operational level mostly deals with the issues such as identifying the best truck scheduling, dock door assignment, transshipment problem and vehicle routing.

Many researchers have already focused on the implementation of cross docking for different kinds of products; therefore many papers have been published in this regard. However, Scheduling of cross docking is by far the most cited problem among the other issues. In spite of all these researches, this study’s authors believe that there are still certain problems which are not fully discussed in any of those works. For example no published work has examined an appropriate product regard of their life cycle for cross docking or no study has ever talked about the role of cross docking in the high demanded products which require fast delivery. In addition for better operation of cross docking less allocation problem investigated especially when there is more than one cross docking. On the other hand, many distribution centers are combination of warehouse and cross docking but there is no study regard of allocation of product to cross docking and warehouse since the operation cost for cross docking and warehouse is different and not all kinds of product are suitable for cross docking.
One other area that needs further research is the layout of cross docking which can improve the flow of product to be more convenient. Designing a cross docking map to avoid product congestion and finding appropriate location for better storage are of the other less discussed issue in this field of study which can significantly improve cross docking operation.

REFERENCES


