A TUTORIAL ON CROSSDOCKING

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Abstract — ***In crossdocking, the inbound materials coming in trucks to the crossdock facility are directed to outbound doors and are directly loaded into trucks that will perform shipment, or are staged for a very brief time period before loading. Crossdocking has a great potential to bring savings in logistics: For example, most of the logistics success of Wal-Mart, the world's leading retailer, is attributed to crossdocking.In this paper,the types of crossdocking are identified, the situations and industries where crossdocking is applicable are explained, prerequisites, advantages and drawbacks are listed, and implementation issues are discussed. Finally a case study that describes the crossdocking applications of a 3rd party logistics firm is presented.***

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INTRODUCTION

Crossdocking is a supply chain strategy that can accomplish significant reductions in total costs and in lead times in a supply chain. In this strategy, crossdock facilities act as transfer points where inbound product flow is synchronized with outbound product flow to essentially eliminate storage of inventory. Two other strategies applied in distribution of products are the following [1]:

- Traditional distribution with warehouses, where warehouses serve as intermediate stage inventory points,
- Direct shipment, also named "warehouse bypass", where products are shipped directly from suppliers to demand points, bypassing the warehouse/crossdock facility.

As of 1995, there were an estimated 550,000 warehouses in the U.S. alone [2]. Crossdocking is an extremely important strategy, as it can result in considerable savings at many of these and other warehouses by turning them into transfer nodes, rather than storage nodes.

Increased competition in almost every industry, especially retail and grocery industries, has been pushing companies to search for ways of reducing costs throughout the supply chain. For example, grocery retailers and distributors operate under profit margins of approximately 1.5% [3]. Cooperating with supply chain partners to reduce the system-wide costs throughout the supply chain and sharing the benefits is a strategy followed by many companies. The Internet allows companies to communicate among each other in real time at costs significantly lower than the past, when establishing EDI (Electronic Data Interchange) systems was required for real time communication [4]. These listed factors have increased the applicability of crossdocking as a supply chain strategy.

Crossdocking in various forms has been in use for a long time, especially by package delivery companies. However, its recent popularity can be attributed to its extensive use by

Wal-Mart, which implemented this strategy successfully and eventually became the world's largest retailer with more than 5,000 stores throughout the world [5].

Napolitano [6] provides practical guidelines to planning, designing, and implementing a crossdock operation. This tutorial aims at providing a brief tutorial on crossdocking through a review of literature, covering [6] and other sources. We focus particularly on the business practice literature, and answer the following questions:

- What types of crossdocking are available?
- When is crossdocking appropriate?
- What are the prerequisites of crossdocking?
- In which industries is crossdocking applied?
- What are the benefits and drawbacks of crossdocking?
- How is crossdocking implemented?

WHAT TYPES OF CROSSDOCKING ARE AVAILABLE?

Napolitano [6] classifies crossdocking systems to the following three types:

1. Pre-allocated supplier consolidation
2. Pre-allocated crossdocking operator (CDO) consolidation
3. Post-allocated CDO consolidation

When the product is pre-allocated, its destination is determined at the supplier; when the product is post-allocated, its destination is determined at the crossdock facility. When supplier consolidation takes place, the supplier builds the final (possibly multi-SKU) pallets that will be shipped to the final destinations. When CDO consolidation takes place, the final pallets are built by the CDO at the crossdock facility.

Specter [7] identifies eight types of crossdocking. Besides the classification presented in this tutorial, the reader is suggested to review the classification scheme presented in there, as well.

In a distribution center that uses crossdocking, traditional warehousing may also be used. For example, in a Supervalu distribution center incoming products are either crossdocked by feeding into a sortation system and routed to shipping doors, or moved to the four-level inventory area through conveyors [8].

WHEN IS CROSSDOCKING APPROPRIATE?

Geoffrey Sisko suggests that products with predictable, high demand and high cubic volume flow, and perishable products are ideal candidates for crossdocking [9]. For example, [10] reports that the supermarket chain Asda initiated the crossdocking scheme partnering with Kimberly-Clark, the paper industry giant which supplies high-cube, low-value products such as toilet tissue and paper towels. Choice of these products for the pilot crossdocking program is very appropriate, since these would normally occupy significant warehouse space and cause congestion if traditional warehousing were used [11].

Sisko warns that products with "value-added requirements, initial launches and promotional products are not good candidates for crossdocking" [9]. However, in [8] mass merchandisers are reported to implement crossdocking for especially seasonal or promotional items. This conflict in business practice literature suggests that a scientific approach, possibly through building mathematical models, should be followed for identifying which of the two conflicting statements hold under which conditions.

One issue that rises with perishable products (especially cooled, chilled or frozen products) is "lot control" [12]. Manufacturers create products by lots, and tracking the lot is required to have a time-sequenced availability to the customers. Lot control only further complicates crossdocking. One simplification is applying "FIFO Granularity": For example, if FIFO granularity is defined for 3 months, instead of pulling and shipping the older products from storage, crossdocked items that just came in are shipped ([6], page 39). In this approach, the older items are regularly replaced by those that come in new, avoiding product spoilage.

WHAT ARE THE PREREQUISITES OF CROSSDOCKING?

The prerequisites of crossdocking can be listed as follows [6], [13]:

- Partnership requirement: Crossdocking requires total commitment and continuous monitoring at all times by all the parties involved in the crossdocking initiative.

- Effective communication between parties: For crossdocking to operate smoothly information flow has to take place smoothly. This almost always requires investment into information systems technology, and into people that will keep the information systems technology and complex operations working. For example, "Wal-Mart operates a private satellite communication system that sends point-of-sale (POS) data directly to Wal-Mart's 4,000 vendors" [5].

- Complexity in managing operations: The absence of inventories makes it crucial to have a perfect coordination of material flows. Many interrelated decisions at the supply chain and facility level have to be made under numerous resource and time constraints. This is where mathematical models can be of great use.

- Sharing the costs and benefits of crossdocking: Crossdocking may result in savings for some parties and costs or risks for others involved in the supply chain. For example, in a successful crossdocking implementation, the CDO benefits from decreased inventories, labor, and storage space requirements. However, the suppliers involved may have to make significant investment into technology and the retailers may end up with higher inventory levels due to increased lead times [14]. There should be a complete prior agreement between all the parties on how the costs, savings, and risks resulting from crossdocking will be shared [15]. Another example is the following: The CDO would prefer that the outbound trucks can wait for long time periods such that flexibility is achieved in scheduling the unloading of incoming trucks and the loading of the outbound trucks. However if the trucks are operated by a trucking company, that company would not accept to absorb the cost related with the waiting time of its trucks. Some incentive payment has to be made by the CDO to the trucking company in this case [16]. Kurnia and Johnston [15] detail the costs, benefits and risks associated with each party in a particular supply chain with crossdocking.

- Perfect quality requirements: Suppliers are required to perform perfectly with respect to quality, as inspection has to be significantly reduced at the crossdock facility to maintain fast product flow.

One important trend in almost every industry is a decline in bulk-ordering and a shift towards smaller inventory modules [17]. For example, in grocery industry, "the grocery chains are pushing their suppliers to build and ship store-ready pallets of mixed product, instead of a single product" [18]. This means that the burden of sorting full pallet SKUs and merging them into multi-SKU pallets increases. This should be considered when reaching to an agreement and signing the contract with the supply chain partners.

IN WHICH INDUSTRIES IS CROSSDOCKING APPLIED?

Crossdocking has found extensive applications in retail industry. Retail companies reported in business literature to implement crossdocking include Wal-Mart [5], Asda [10], Track 'n Trail [19], Canadian Tire [20], Saks [21], Sears [22], and Belk [23].

Third-party logistics (3PL) companies, and especially LTL companies, are frequently found to operate under crossdocking. For example, New Jersey based National Retail Systems, a 3PL company recently opened a crossdocking facility in New Jersey that serves competing K-Mart and Marshalls department stores simultanously [24]. The facility is fully automated with five miles of conveyor and a sortation system, and serves approximately 500 retail stores. Another 3PL company, Columbian Logistics, serves a large grocery wholesaler by consolidating paper products from four large manufacturers, and distributing them to approximately 200 stores [11]. Bartholdi and Gue [2000] report crossdocking implementations at less-than-truckload trucking companies Southeastern Freight Lines and Viking Freight System. They illustrate an operations research model that was used for determining how to assign inbound/outbound trailers to dock doors at some of the companies' crossdocking facilities.

As of 2001, 3PL companies in the U.S. were estimated to gross about $56 billion, including value-added warehousing, outsourced carriage, transportation management, freight forwarding, and software [26]. This underlines the importance of crossdocking for the industry.

Crossdocking is reported to be implemented in the automotive industry, as well:

- Toyota has built a distribution center in California that reduced lead times of parts from Japan to customers from 25 days to 11 days [8]. Approximately one-third of the estimated 250,000 transactions made per day are crossdocked. In the facility three different forms of crossdocking are implemented.

- Mitsubishi Motor Manufacturing of America has built a crossdocking facility adjacent to the Mitsubishi assembly plant in Illinois [8]. The materials arrive at most two hours prior to each production schedule, supporting JIT (Just-in-Time) at the plant.

- Goodyear Great Britain, a leading tire-manufacturer, made the transition from a traditional supply chain to a crossdocking system, increasing its service level, decreasing its inventory, releasing warehouse space, reducing labor force required, and eventually reducing operating costs by over 12% [27].

Crossdocking is also popular in telecommunications and electronics industries. These industries are characterized by a fast pace of change, with products typically having very short life cycles. Companies reported to implement crossdocking include Thompson Consumer Electronics [28], Panasonic [29], Ericsson [30], and National Semiconductor [22]. The reduced cycle times for delivery through the supply chain enable fast delivery of the products to customers and eliminate the need to carry high inventory levels for products most of which will become obsolete in a short time period.

Another industry where crossdocking is adapted is apparel industry. YoungWorld, a children's apparel and furniture retailer [31], Capacity Inc., an importer of women's sportswear [17], and Urban Outfitters, an apparel and home furnishing retailer [32], are reported to implement crossdocking.

WHAT ARE THE BENEFITS AND DRAWBACKS OF CROSSDOCKING?

The benefits of crossdocking can be listed as follows [6], [9]: Crossdocking

- Allows the efficient consolidation of products.

- Decreases inventory levels due to elimination of storage.

- Enables faster product flow (by eliminating "dwell") .

- Enables more frequent deliveries.
- Decreases inventory obsolescense due to reduced inventory and faster product flow.
- Decreases labor requirements and costs due to decreased material handling (through elimination of putaway to storage and order picking). The typical yearly cost per warehouse worker can be estimated around $40,000 in the U.S. [33].
- Decreases inventory damage costs due to less material handling.
- Decreases the amount of space required, and thus increases the handling capacity of the facility.
- Supports customers' Just-in-Time strategy.
- Accelerates payments to suppliers (which is an important argument that can be used to convince suppliers to participate in crossdocking).
- Improves the relations with the supply chain partners.
- Enables faster completion of incomplete orders due to more frequent deliveries [10].

Decreased costs that are reflected to customers in terms of low prices may put a company into a positive feedback loop with recursive benefits: In the case of Wal-Mart, low prices enabled decreased number and scope of promotions, which made sales more predictable, reducing stockouts and inventory levels, and thus further recuding costs [5].

The major drawbacks of crossdocking occur when the prerequisites listed earlier are not met. Other drawbacks can be listed as follows:

- Risk of stockout: Since the crossdock facility with effectively zero inventory replaces the warehouse with positive inventory, any sudden raises in demand, any unavailability of the product at the suppliers, any delays in the supply chain, or any failure to coordinate perfectly results in costly stockout.
- Union fears of losing jobs: The main savings in crossdocking come from decreased inventory and labor costs, where the latter may cause strong resistance among the workforce.

HOW IS CROSSDOCKING IMPLEMENTED?

At the strategic level, Napolitano [6] suggests a four-phased framework for making the transition to crossdocking that is composed of assessment and negotiation, planning and design, economic justification, and implementation. It is very crucial that any implementation begins with a pilot program, where crossdocking is initially implemented to cover only a win-or-win subset of products and suppliers. The implementation should then be expanded to include other selected products and suppliers.

The number of suppliers in a supply chain with crossdocking ends up to be typically fewer than the initial number of suppliers in the supply chain with traditional warehouses. The reasons for this can be summarized as follows [34]:

- To implement crossdocking, investment is needed to establish the physical and information systems infrastructure, and many suppliers may decline making such investment.
- Coordination of crossdocking operations is simpler when the number of suppliers involved is less.
- When fewer suppliers meet the same demand, they can achieve economies of scale by achieving higher utilization of the vehicle fleet.

At the operational level, the processes involved in a typical retail crossdocking operation can be sequenced as follows (adapted from [6], [15], and [35]):

1) The CDO and the supplier receive order details from the retailer store. If Vendor Managed Inventory (VMI) is implemented, the point-of-sale (POS) data is sent from the retailer store to the supplier (vendor), instead of the order details, and the supplier initiates a shipment when necessary.
2) If pre-allocated supplier consolidation is carried out, the supplier builds store specific pallets and label/tag them. These pallets may be multi-SKU pallets. If CDO consolidation is carried out, then the supplier prepares just single-SKU pallets (to be sorted at the crossdock facility). If pre-allocated CDO consolidation is carried out then each case in the pallet should include the information of which specific store it is heading on a label/tag.

3) The supplier loads the truck that will deliver the shipment to the crossdock facility.

4) The supplier sends the Advance Shipping Notice (ASN) to the CDO.

5) The carrier notifies the CDO on the arrival date and time.

6) At the crossdock facility, the dock door for inbound receiving is determined and the labor and handling equipment are scheduled to meet the delivery.

7) The dock door for outbound shipment (from the crossdock facility) is determined.

8) The outbound carrier is notified of the pick-up time, load description, destination, and delivery date and time.

9) The retailer store is notified of the outbound shipment details.

10) The truck/trailer with the supplier's delivery reaches the crossdock facility.

11) Manual checks are performed on a small percentage of the supplier's delivery, to ensure accuracy of the ASN.

12) If pre-allocated supplier consolidation is carried out, then the pallets in the inbound shipment are transferred to outbound dock door/truck/trailer. Otherwise pallets are broken into cases, allocated to open orders per destination (in the case of post-allocated CDO consolidation), sorted with respect to each retailer store, and loaded to the outbound truck/trailer from the outbound dock door.

13) The outbound truck/trailer leaves the crossdock facility and delivers to the retail store.

Crossdocking may be implemented manually, with almost no automation (called "traditional crossdocking") or may be implemented with automation, with equipment such as conveyors and sortation systems in place (Langnau 2004). The requirement for automation increases when the product variety increases, when the crossdock facility has to carry out sorting of cases, and when more of the demand is for cases rather than pallet unit loads.

A CASE STUDY: EKOL LOGISTICS

Ekol Logistics (http://www.ekol.com) is a leading 3rd party logistics (3PL) firm and a major crossdock operator (CDO) in Turkey. The company operates 7 distribution centers (DCs) in Istanbul, Turkey alone and 3 other warehouses in other cities in Turkey, with a total warehouse area of 120,000 m^2. The firm serves many clients through its DCs, including some of the biggest retail companies operating in Turkey. The clients include an international mass retailer, an appearel and home products retailer, a sportswear retailer, a home electronics company, and a pharmaceuticals company. Ekol also handles distribution of pharmaceutical promotion materials and has initiated a project that is intended to involve the distribution of pharmaceutical products coming from up to 80 pharmaceuticals companies.

The main industries that Ekol carries out crossdocking for can be listed as mass retailing (for a client that we will refer to as ABC), pharmaceuticals, and fast moving consumer goods (FMCG). With respect to the classification given earlier in the paper, the type of crossdocking that Ekol implements mostly is pre-allocated CDO consolidation (type 2 crossdocking), which is referred to as “flow-through” by Ekol managers. The reason that the firm is not able to implement pre-allocated supplier consolidation (type 1 crossdocking) is that most of the suppliers do not wish to undertake the financial and logistic burden of sorting out and labeling their products as pallets before sending them to Ekol’s DCs. Thus Ekol undertakes this burden and carries out the sorting, palletizing, and labeling of most of the products that arrives to its facilities. One other reason for implementing type 2 crossdocking, besides the suppliers’ reluctance, is the problem of quality that is prevalent for certain manufacturing suppliers.

Pre-allocated supplier consolidation (type 1 crossdocking) takes place only for the products of two major international FMCG companies that are delivered to ABC. This accounts for approximately 30% of the volume that Ekol handles at one of its DCs. Ekol also implements traditional warehousing with putaway, storage, and picking for certain products that arrive as a part of the crossdocking activies. These products are seperated from the products that are crossdocked and kept for a certain time period until the demand for them is actualized.

Although the operations carried out by Ekol can not be labeled as the purest form of crossdocking, the managers in the firm take pride in carrying out one of the truest

crossdocking operations in Turkey. Ekol managers refer to operations of a well-established dairy products producer as the purest application of crossdocking in Turkey.

Ekol managers also take pride in managing a "project firm". Instead of offering a fixed set of options to clients' requests, Ekol works with clients in analyzing their supply chains with respect to many dimensions and determining a customized solution. For example, Ekol works with data supplied by clients to compute the increase in costs and lead times if pre-allocated CDO consolidation (type 2 crossdocking) is carried out instead of pre-allocated supplier consolidation (type 1 crossdocking). Ekol also quantifies the increase in costs and lead time when traditional warehousing is carried out instead of crossdocking. The increases in costs and lead times depends heavily on the industry, client, product, supply chain, and market characteristics.

One of the basic reasons that ABC considered outsourcing its logistics operations to Ekol was to eliminate the long truck queues that used to accumulate in front of ABC retail stores. These trucks used to arrive from a multitude of suppliers to deliver less-than-truckload (LTL) quantities. In the logistics activities that Ekol executes, the suppliers' trucks arrive at Ekol's distribution center (DC) and unload their (mostly non-palletized) loads. Ekol then consolidates these products into pallets and ships them to ABC stores immediately.

Ekol faces many challenges in planning and executing the crossdocking operations for ABC and other clients. Most of these challenges are in fact valid for traditional warehousing as well; however due to stricter time constraints they are more heavily pronounced in crossdocking operations. Some of these challenges and the solutions employed by Ekol can be listed as follows:

- Receiving non-palletized shipments: Due to the lack of transportation conditions in Turkey, Ekol typically receives non-palletized shipments. This neccessitates a stricter quality control in receiving operations, and more workers for sorting for the crossdocking operations.

- Meeting the delivery requirements: The shipments out of the DCs are almost always uni-directional, that is, they involve only one way shipments to retail stores. However, especially given the very high fuel prices in Turkey (which are approximately three times those in the United States) the revenues would not be break even with the costs if Ekol used only its own dedicated fleet. Thus Ekol purchases transportation service from trucking

companies. The trucking company for a particular outbound shipment is selected within hours based on whether it has a shipment for the return trip (so that the trucking company will charge only for the delivery trip).

- Assuring delivery quality: To assure quality in delivering shipments to retail stores, Ekol prefers to work with a selected group of best-performing trucking firms on a regular basis.

- Delayed deliveries: Some suppliers deliver their products with delay. In this case their shipment to destinations is delayed to the next delivery.

- The lack of planning by some of the clients: Ekol DCs can become extremely crowded if the clients do not plan their operations properly. For example, the two products that have to be matched for shipping may be arriving in distant time periods, even though they have to arrive in close proximity to match them rapidly and thus carry out crossdocking. The solution that Ekol implements is charging the clients not based on volume alone, but also based on the DC space that they occupy. This indirectly disciplines the suppliers to send their shipments such that they can be coordinated with outbound flow and other inbound flow.

- Facility limitations: Land is very scarce and extremely expensive in Istanbul, Turkey. This makes it difficult to find land to build new DCs that will serve crossdocking. Also, almost none of the existing DCs are built for crossdocking in mind at the first place. Ekol thus has to adopt its operations into existing facilities. For example, the crossdocking operations for ABC are carried out at a DC recently acquired from a furniture producer firm. This DC contains docks on only one side of the building, so crossdocking has to be carried out only from one side of the building. However, a DC with dock doors on both (or even all) sides of the building could have been more efficient. Ekol tries to resolve this problem by enforcing standards when renting/buying a semi-finished building that will serve as a DC.

- Seasonality in products: Seasonality exists in many product families and products. Ekol alleviates the load that this would put in its distribution operations by diversifying its client portfolio such that the demands of different clients complement each other and the flows are balanced throughout the year for the whole operations.

- Quality concerns: Some inbound materials (coming especially from certain countries) to the Ekol DCs have to pass from a more strict quality control. This increases requirements for labor and floor space.

- Customs regulations: The customs limit some of the operations of Ekol. For example, sportswear other than sports shoes pass through Halkali Customs Office, whereas sports shoes are categorized as shoes and pass through Tuzla Customs Office. Even though both of these customs offices are located in Istanbul, Turkey, there is a great distance in between them and a great difference in their distance to each of the Ekol DCs. This situation only increases the coordination burden of Ekol, since now the same demand points may have to be served from two different DCs for the two different products.

- Traffic regulations: Crossdocking requires fast loading and unloading of materials at the DC docks. To enable this, Ekol prefers using special equipment at the back of the vehicles that connect to the docks and speed material loading and unloading. These equipment typically weigh between 750kgs and 1 ton. However, traffic regulations limit the weight of the load of a vehicle to at most 1.5 tons. Ekol resolves this issue by utilizing the equipment only in vehicles that carry low-density products.

One of the greatest challenges for Ekol in planning crossdocking operations is the very short time span available for decision making. Ekol manages its operations with the help of a warehouse management software (WMS) developed in-house. During the interviews with the Ekol managers, the author has noticed that some of the decisions can be made much faster and probably more efficiently through use of appropriate decision support systems. One of these decisions is the problem of loading the vehicles efficiently under various constraints: These constraints include assuring that

- The food items are not loaded next to nonfood items,
- The pallet heights do not exceed 2.2 meters,
- The pallets are loaded on top of each other such as to avoid crushing,
- An SKU (stock keeping unit) is kept in as small number of pallets as possible.

CONCLUSIONS

In this paper,the types of crossdocking were identified; the situations and industries where crossdocking is applicable were explained; prerequisites, advantages and drawbacks were listed; and implementation issues were discussed. Finally a case study that describes the crossdocking applications of a 3rd party logistics firm was presented. The case study shows that there are several challanges faced by 3rd party logistics companies that implement crossdocking. Possible remedies to these challanges used by the selected firm were explained. Since crossdocking requires decision making in compressed time intervals, there is a potential for application of decision support systems that enable making the best decisions in short time intervals.

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