# PRODUCT ALLOCATION TO CROSS DOCK AND WAREHOUSE USING GENETIC ALGORITHM

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Specially dedicated to *mother* and *father* and *my kind sisters*.

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# ABSTRACT

The main goal of this project is to use a genetic algorithm to allocate different product to a cross dock and warehouse of a distribution center. In spite of the enormous quantity of researches on product allocation to distribution center, allocating different products to cross dock and warehouse is less investigated. In order to fill this gap, this research was conducted analytically using a genetic algorithm to allocate different products to a distribution center. Particularly, one distribution center (located in the South East of Asia) along with 19 products were used as the case of this study. Based on the available literature, the existing constraints were evaluated and used for the aim of ranking different products based on their importance level. Finally, A genetic algorithm were used to allocate the different product to both cross dock and ware house considering the processing cost, demand, capacity and related constraints and determine the best combination of cross docking and warehouse to minimize processing cost as much as possible. The results showed that processing cost of products allocation to cross docking and warehouse can be improved through using genetic algorithm by $215 compared to Li te al. (2008).

# ABSTRAK

Tujuan utama penulisan ini membincangkan mengenai penggunaan Algoritma Genetik untuk menentukan kedudukan produk yang berbeza pada dok silang dan gudang di pusat pengedaran. Walaupun banyak kajian mengenai kedudukan produk telah dilakukan, tetapi kajian yang seumpama terhadap produk yang berbeza adalah amat terhad. Bagi memenuhi jurang ini, satu kajian analatikal telah dijalankan bagi tujuan yang sama. Sebagai keutamaan, satu pusat pengedaran (lokasi di Asia Tenggara) bersama 19 produk-produk telah dijadikan sebagai kajian kes. Berdasarkan maklumat dari penulisan yang sedia ada, kekangan yang wujud dinilai dan dijadikan sebagai sasaran tanda aras setiap produk yang berbeza dengan menjadikan tahap kepentingan sebagai asas. Akhir sekali, Algoritma Genetik digunakan untuk menentukan produk-produk tersebut pada dok silang dan juga pada gudang dengan mengambil-kira kos penyelenggaraan, permintaan, keupayaan dan kekangan lain yang berkaitan dan kombinasi dok silang dan gudang yang ulung di tentukan untuk mengurangkan kos penyelenggaraan sebanyak mungkin. Hasil kajian menunjukkan bahawa kos memproses peruntukan produk untuk menyeberangi dok dan gudang boleh diperbaiki melalui menggunakan algoritma genetik oleh $ 215 berbanding dengan Li te al. (2008).

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

A traditional warehouse has four major functions – receiving, storage, order picking and shipping. Among the four major functions, storage and order picking are the most costly: storage because of inventory holding costs, and order picking because it is labor intensive.

Cross docking, as a relatively new logistics technique that was first used by Wal-Mart, is widely applied in the retail and trucking industries to rapidly consolidate shipments from disparate sources and realize economies of scale in outbound transportation. Cross docking essentially eliminates the storage function of a warehouse while still allowing it to serve its consolidation and shipping functions. The idea is to transfer incoming shipments directly to outgoing trailers without storing them in between. Based on this, shipments typically spend less than 24 hours at the facility, sometimes less than an hour. Cross docks are essentially transshipment facilities to which trucks arrive with goods that must be sorted, consolidated with other products and loaded onto outbound trucks. Outbound trucks may be loaded for a manufacturing site, a retail outlet, or another cross dock, depending on the application. In a warehouse, goods are received from vendors and stored in devices like pallet racks or shelving. When a customer requests an item, workers pick it from the shelves and send it to the destination. In a cross dock, goods arriving from the vendor already have a customer assigned, so workers need only move the shipment from the inbound trailer to an outbound trailer bound for the appropriate destination.

The term cross docking‖ can be used to describe a range of different types of operations, Napolitano (2008) proposed the following classifications scheme: Manufacturing cross docking – receiving and consolidating inbound supplies to support Just-In-Time manufacturing. For example, a manufacturer might lease a warehouse close to its plant, and use it to consolidate kits of parts. Since demand for the parts is known, there is no need to maintain stock.

Distributor cross docking – consolidating inbound products from different vendors into a multi-SKU pallet, which is delivered as soon as the last product is received. For example, computer distributors often source components from different manufacturers and consolidate them into one shipment in merge-in-transit centers, before delivering them to the customer. Transportation cross docking – consolidating shipments from different shippers in the Less-than-truckload (LTL) and small package industries to gain economics of scale. For small package carriers, material movement in the cross dock is by a network of conveyors and sorters; for LTL carriers it is mostly by manual handling and forklifts. Retail cross docking – receiving product from multiple vendors and sorting onto outbound trucks for different stores. Cross docking has been cited as a major reason Wal-Mart surpassed Kmart in retail sales (Stalk, 1992). Opportunistic cross docking – in any warehouse, transferring an item directly from the receiving dock to the shipping dock to meet a known demand. Another way to classify cross docking operations is according to when the customer is assigned to an individual pallet or product. In pre-distribution, the customer is assigned before the shipment leaves the vendor, so it arrives to the cross dock bagged and tagged for transfer. In post-distribution cross docking, the cross dock itself allocates material to its stores.

The end product of a cross dock operation is a loaded container bound to its intermediary or terminal destination. Thus the cost of the overall logistics operation can be reduced if the space in the outbound trailer is utilized to its maximum.

However it seems simple but the complexity of cross docking have been investigated by many scientist in fields of scheduling, optimization and operation research .There is no doubt that most of the companies try to dwindle shipping costs

parallel to appropriate level of customer service so cross-docking appeared as an interesting operation (Soltani and Sadjadi, 2010). Figure 1.1 shows concept of cross docking.

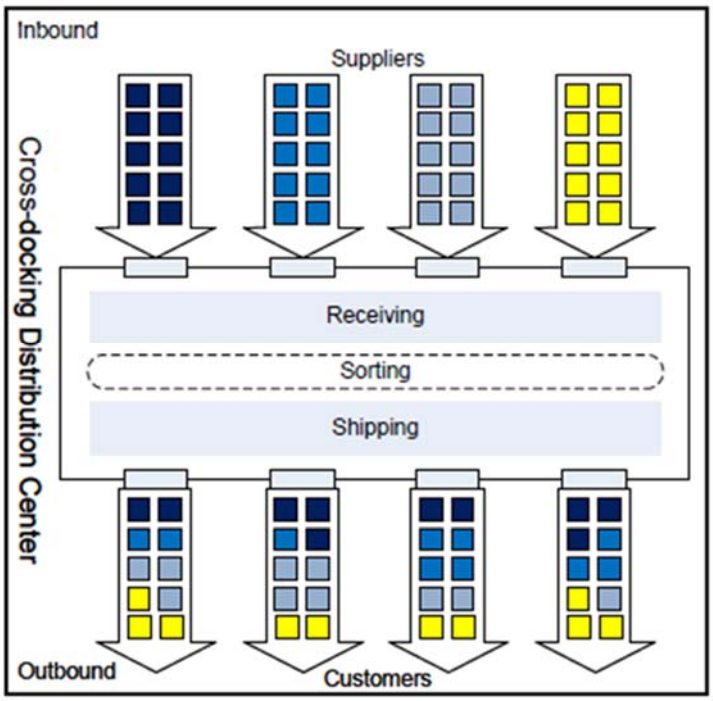


**Figure 1.1** Cross-dock definition (Soltani and Sadjadi, 2010)

## 1.2 Background

There are numerous factors that need to be considered when making an informed decision to implement cross-docking into an organization. Every organization has their priorities in terms of costs, warehouse space, geographical specifics, and product types. Therefore the advantages and disadvantages of implementing cross-docking into your organizations supply chain need to be considered and weighed up in order to make the right decision. The below list of advantages and disadvantages is designed to assist in this process;

Advantages of cross-docking, reduces material handling, reduces need to store products in warehouse, no need for large warehouse areas, reduced labor costs (no packaging and storing), reduced time to reach customer. Transportation has fuller loads for each trip therefore a saving in transportation costs while also being more environmentally friendly.

1. Products are moved more quickly through a cross dock.
2. Easier to screen product quality.
3. Elimination of processes such as ‘pick-location’ and ‘order picking’.
4. Cross docking terminals are less expensive to construct than your average warehouse.
5. High turnover of products with everything moving quickly through the cross docking terminal. Products usually spend less than 24 hours here.
6. Products destined for a similar end point can be transported as a full load, reducing overall distribution cost.

Disadvantages of cross-docking are much management attention, time and planning is necessary to make it work effectively. Setting up the cross docking terminal structures would take quite a bit of time and capital to start with. Some suppliers would not be able to deliver customer ready products to the cross docking terminal. A sufficient number of transport carriers are necessary for the cross docking terminal to run smoothly, therefore is mainly dependent on trucking. A high volume of product is necessary to be cost effective. The organization has to have a conformable reliance that their suppliers will deliver the right product in its right amount to the cross docking terminal on time which doesn’t leave too much room for error. Understanding the advantages and disadvantages of cross-docking and how they fit with your organization is an important step for evaluating the supply chain process and deciding whether Cross-docking is right for your organization. Make sure you understand the key factor requirements of your organization. For example: High Volume Turnover, Rapid turnaround, Perishable goods are all factors that indicate a successful fit for Cross-Docking. Analyze your key factor requirements and decide from there.

## 1.3 Problem statement

Cross docking system of supply chain must be modeled and scheduled to reduce costs and time in order to improve performance to meet logistics goals. However there is lack of basic model to deal with this problem to help logistic managers to make appropriate decision regarding of cost and time of cross dock scheduling. In this project the basic problem that being assessed is investigating to find the best product allocation in cross docking. Supply chain management distribution centre is combination of both warehouse and cross docking. Therefore, it is critical for operator of distribution centre to be aware of what types of product have to be allocated to cross docking parallel to be aware of how much of those products. Industries highly required model in order to support cross docking and warehouse decision making and plan for allocation of product between cross docking facility and warehouse. Based on previous researches many of the most company are interested in moving from traditional storage to a cross-dock without any cost evaluation. This trend might have effect on the suppliers and manufacturers operations costs. Furthermore there is no conclusive research that demonstrates and compares the detailed dynamics of the distribution mechanism of traditional storage and cross-docks. However many company find the need for both warehouse and cross docking but there is a lack of decision making tools that helps them in order to determine appropriate quantity of different products for allocating to cross docking and warehouse. In addition to product allocation between cross docking and warehouse there is a few researches on cross docking scheduling in which is the interest of many researchers. Thus we need to develop specific knowledge using specific data in conjunction with generic concepts and models and improve cross docking scheduling.

## 1.4 Research Objective

The objective of this study is to propose a model with the goal of product allocation to cross docking and warehouse to help operation managers in making appropriate decision concern with different types of product and also the quantity of

product allocated to cross docking and warehouse in a way that eliminate the waste of time and cost as much as possible with the goal of improving cross docking throughput. Such a model, then, could be used to help distribution manager in big scale operations. In addition to determine appropriate combination of facility between cross docking and warehouse for a distribution centre.

## 1.5 Research Scope

This study will use linear programming to propose a model for assignment problems and solve by Genetic algorithm for the best possible product assignment in consideration of cost and time in order to improve throughput of cross dock facility. The research is intended to perform a model for cross docking performance in order to provide cost and time performance data of distribution processes as they exist to compare the proposed model in terms of cost and time performance data with the model generated by Li et al (2008).

## 1.6 Summary

This chapter introduced the study. Also, this chapter mentioned about the problem background and statement of the problem. The objective and scope of this project have also been described.

# REFERENCES

Agustina, D., Lee, C. K. M., and Piplani, R. (2011, December). Cross docking scheduling with delivery time window and temporary storage. Industrial Engineering and Engineering Management (IEEM), 2011 IEEE International Conference on, IEEE.

Alvarez, J. C. (2004). "High-throughput docking as a source of novel drug leads." Current opinion in chemical biology 8(4): 365-370.

Borgwardt, K.-H. (1982). "The average number of pivot steps required by the simplex-method is polynomial." Mathematical Methods of Operations Research 26(1): 157-177.

Boysen, N., Fliedner, M., and Scholl, A. (2010). "Scheduling inbound and outbound trucks at cross docking terminals." OR spectrum 32(1): 135-161.

Charkhgard, H. and A. A. Y. Tabar (2011). "Transportation problem of cross-docking network with three-dimensional trucks." African Journal of Business Management 5(22): 9297-9303.

Cheng, R., Gen, M., and Tsujimura, Y. (1996). "A tutorial survey of job-shop scheduling problems using genetic algorithms—I. Representation." Computers & Industrial Engineering 30(4): 983-997.

Ghiani, G., Laporte, G., and Musmanno, R. (2004). Introduction to logistics systems planning and control, John Wiley & Sons.

Goldberg, D. E. (1989). Genetic algorithms in search, optimization, and machine learning, Addison-wesley Reading Menlo Park.

Golias, M. M., Saharidis, G. K. D., Boile, M., Theofanis, S., and Zhang, T. (2009). Scheduling inbound trucks at a cross-docking facility: A multi-objective and a hierarchical approach. International Conference on Industrial Engineering and Systems Management, Montreal, Canada.

Holland, J. H. (1992). Genetic algorithms. Scientific american, 267(1), 66-72.

Hu, J. H., Ma, Y. H., Jiang, J., Yang, N., Duan, S. H., Jiang, Z. H., ... and Guo, L. H. (2004).. "Cognitive impairment in mice over-expressing [gamma]-aminobutyric acid transporter I (GAT1)." Neuroreport 15(1): 9-12.

Juell, P., Perera, A., and Nygard, K. E. (2003, November). Genetic Algorithm to improve a solution for a General Assignment Problem. CAINE, Citeseer.

Larbi, R., Alpan, G., Baptiste, P., & Penz, B. (2011). "Scheduling cross docking operations under full, partial and no information on inbound arrivals." Computers & Operations Research 38(6): 889-900.

Larbi, R., Alpan, G., and Penz, B. (2009). Scheduling transshipment operations in a multiple inbound and outbound door crossdock. Computers and Industrial Engineering, 2009. CIE 2009. International Conference on, IEEE.

Lee, Y. H., Jung, J. W., and Lee, K. M. (2006). "Vehicle routing scheduling for cross-docking in the supply chain." Computers & Industrial Engineering 51(2): 247-256.

Li, Z., Sim, C. H., Low, M. Y. H., & Lim, Y. G. (2008). Optimal product allocation for crossdocking and warehousing operations in FMCG supply chain. Service Operations and Logistics, and Informatics, 2008. IEEE/SOLI 2008. IEEE International Conference on, IEEE.

Majumder, M. and S. K. Ghosh (2013). Decision Making Algorithms for Hydro-power Plant Location, Springer.

Megiddo, N. (1984). "Linear programming in linear time when the dimension is fixed." Journal of the ACM (JACM) 31(1): 114-127.

Miao, Zhaowei, Andrew Lim, and Hong Ma (2009). "Truck dock assignment problem with operational time constraint within crossdocks." European Journal of Operational Research 192(1): 105-115.

Miao, Z., Lim, A., and Ma, H. (2010). "Solving a hub covering location problem under capacity constraints by a hybrid algorithm." Journal of Applied Operational Research 2(2): 109-116.

Mousavi, S. M. and R. Tavakkoli-Moghaddam (2013). "A hybrid simulated annealing algorithm for location and routing scheduling problems with cross-docking in the supply chain." Journal of Manufacturing Systems 32(2): 335-347.

Napolitano, M. (2008). "The cross-dock revolution: are you in or out?" Logistics Management 47(4).

Rodrigue, J.-P. and T. Notteboom (2009). "The terminalization of supply chains: reassessing the role of terminals in port/hinterland logistical relationships." Maritime Policy & Management 36(2): 165-183.

Rodrigue, J. P. (2006). "Transportation and the geographical and functional integration of global production networks." Growth and Change 37(4): 510-525.

Sahu, A. and R. Tapadar (2006). Solving the Assignment Problem using Genetic Algorithm and Simulated Annealing. IMECS, Citeseer.

Shakeri, M., Low, M. Y. H., and Li, Z. (2008). A generic model for crossdock truck scheduling and truck-to-door assignment problems. Industrial Informatics, 2008. INDIN 2008. 6th IEEE International Conference on, IEEE.

Soltani, R. and S. J. Sadjadi (2010). "Scheduling trucks in cross-docking systems: A robust meta-heuristics approach." Transportation Research Part E: Logistics and Transportation Review 46(5): 650-666.

Stalk, G., Evans, P., and Sgulman, L. E. (1992). Competing on capabilities: the new rules of corporate strategy, Harvard Business Review.

Tavakkoli-Moghaddam, R. and J. Razmi (2012). "A New Model for Cross Dock Scheduling Considering Product Arrangement." International Proceedings of Economics Development & Research 35.

Ting, C.-J. and A. G. R. López "Dock assignment and truck scheduling problems at cross-docking terminals."

Vasiljevic, Dragan, Miroslav Stepanovic, and Oliver Manojlovic. (2013). "Cross docking implementation in distribution of food products." Economics of Agriculture/Ekonomika Poljoprivrede 60(1).

Wen, Min, et al. "Vehicle routing with cross-docking. (2009). "Vehicle routing with cross-docking." Journal of the Operational Research Society 60(12): 1708-1718.

Xiangyu, Cheng, Zhang Yan, and An Chunyu. (2012). Application of Improved Genetic Algorithm in Solving a Type of Connector Transportation Problem Based on MATLAB. Proceedings of the International MultiConference of Engineers and Computer Scientists.

Yan, H. and S.-l. Tang (2009). "Pre-distribution and post-distribution cross-docking operations." Transportation Research Part E: Logistics and Transportation Review 45(6): 843-859.

Yu, W. and P. J. Egbelu (2008). "Scheduling of inbound and outbound trucks in cross docking systems with temporary storage." European Journal of Operational Research 184(1): 377-396.