Design of warehousing system in order picking process: literature review

Tiara Melinda*, Nazaruddin and Rosnani Ginting
Magister of Industrial Engineering, Universitas Sumatera Utara, Almamater Street
USU Campus, Medan 20155.

*Email: tiaramelinda009@gmail.com

Abstract. The warehouse is one part of a company that is holding an important role in the supply chain as a link between producers with the consumer. One of the most dominant activities in warehouse operations is the order picking process. This activity is very important because it directly affects consumer services. Even order picking generally spends around 55% of total warehouse operating costs. The purpose of this paper is to build a framework that affects the order picking process using the Genetic Algorithm method. Some variables that influence the order picking process, especially the efficiency of order picking time include travel time, search time, pick time, setup time, number of workers and efficiency of workers. One of the causes of the high time of orders picking is the preparation of products that are not right in the warehouse. Genetic algorithms are used to find the best combination of product compilation. So that it is expected that improvements in the order picking process can improve warehouse efficiency.

1. Introduction
Warehousing management is the most important activity and logistics activity that greatly influences supply chain activities [1]. Warehouses are generally related in various stages starting from the source, production, and distribution of goods, starting from raw materials, goods in the process and final products [2].

Warehousing design is an important part of warehouse management. It is important to note that the warehouse has an impact on the efficiency and effectiveness of the supply chain in each manufacturing company [3]. Inefficient warehouse operations can cause high warehouse operating costs [4]. One of the most important activities in warehouse operations is the order picking process. Order picking is the process of removing products from a storage area to meet consumer demand. This activity is the most labor intensive operation in the warehouse because it still tends to be done manually [5]. Order picking generally consumes a large part of the total labor activity in the warehouse (Durry even claims up to 60%) and order collection covers 55% of all warehouse operating costs [6].

Placing products into the right locations can increase labor efficiency, especially in the order collection, employment and use of labor. One of the order picking systems that can improve the efficiency was to find the best combination of product storage locations that are expected to minimize the retrieval time and can maximize work efficiency [4]. The use of Genetic Algorithms can provide a more efficient solution because it results in shorter search times so that this can also affect warehouse operating costs [7]. Genetic Algorithms have advantages over other conventional optimization methods, because this method always operates on all population points (strings), so Genetic Algorithms use solution populations rather than single solutions to find problem-solving [8]. This
paper focuses on determining the variables that affect the process of picking orders at the warehouse. Add with some relevant literature from journals and literature studies that show several variables from researchers to solve order picking. The approach used is the Genetic Algorithm method.

2. Genetic algorithm method
This paper uses the Genetic Algorithm method as an optimization technique based on the principles of genetics and evolution [4]. In the application of the concept of genetic evolution in optimization problems, there must be two problems solved, namely determining the code for a potential solution and defining the objective function to be optimized [9]. Genetic algorithms work by coding the parameters, not by the parameters themselves. Genetic algorithms encode decision variables from search problems into strings called chromosomes. Population size is determined by the researcher. Solution evaluation is done to distinguish the best solution from the worst, where this step is called the fitness function. The algorithm starts by setting the initial population of the existing solution candidates and developing solutions to search problems using genetic operators such as selection, crossover, and mutation. This step is carried out until one or more criteria are met [10].

The basic steps in the genetic algorithm can be seen in Figure 1. Illustrations of the genetic algorithm steps are as follows [4]:

a. Parameter Setting, there are several parameters used in genetic algorithms such as chromosome number, crossover rate, mutation and number of iterations.

b. Chromosome coding, each chromosome is coded randomly, where the values in each bit must represent the zone index.

c. Selection is a step to determine the chromosome that will be used as parents.

d. Crossover is a step to produce the next generation.

e. Mutation, the results of the numbers must be randomized between r (0.1) ≤ m, then a mutation must be done. If not, then proceed to the next step.

f. Fitness function calculation, At this stage, a smaller fitness value is chosen because the goal is to minimize.

g. Repeat step c, until all chromosomes are updated.

h. If the criteria are met, the iteration is stopped. If not, then go back to step c.

![Figure 1. Basic steps of genetic algorithms.](image-url)
3. Literature review

3.1. Order picking

The warehouse is an important component in the supply chain. The main purpose of most warehouses is to facilitate the movement of goods through the supply chain to the final consumer [11]. Warehouse design is important in warehouse management. Inefficient warehouse management can cause large losses [4]. Generally, warehouses consist of several areas which can be seen in Figure 2, such as pallet area, sorting area and item collection area [12].

Order picking is a large activity that can have a significant influence on the level of warehouse productivity [4]. Order picking is one of the main objectives of most warehouses to retrieve goods needed by customers from inventory and then collected for subsequent delivery in good and timely conditions [11]. One of the problems in warehouse layout design is order picking systems that aim to minimize costs arising from all activities related to the layout such as reception, retrieval, storage, sorting, and shipping [4]. Order picking is a labor-intensive activity in the warehouse that is done manually so it requires a very large cost [13]. Order taking generally consumes a large part of the total labor activity in the warehouse (Durry even claims up to 60%) and order collection covers 55% of all operating costs [14].

![Figure 2. General description of warehouse area.](image)

3.2. Genetic algorithms

Genetic algorithms are an example of the transfer of mathematical technology using evolutionary simulation which aims to solve optimization problems from various sources [15]. The essence of the
The genetic algorithm is to gradually find the best solution from so many solutions. First, the genetic algorithm works by making several solutions at random, of course, from this first stage the solution is probably still bad. The solution will experience an evolutionary process continuously and will produce a better solution. Each solution formed represents one chromosome and one individual consists of one chromosome. A collection of these individuals will form a population, from which this population will be born to new populations up to a specified number of generations [16].

A genetic algorithm has been proposed and used over the past few years to complete a number of case studies in research. Several studies related to problems in the order picking process that can be solved using the genetic algorithm can be seen in Table 1.

| No. | Year | Title                                                                 | Problem                                                                                                                                                                                                 |
|-----|------|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | 2018 | Integrated order batching and distribution scheduling in a single-block order picking warehouse considering S-shape routing policy | Services do not satisfy customers because of long processing and shipping times and high labor and shipping costs, thereby reducing warehouse competitiveness.                                           |
| 2   | 2016 | Application of metaheuristic based clustering algorithm to item assignment in a synchronized zone order picking system | Customer waiting time is too long so it is necessary to increase warehouse utilization to reduce customer waiting time.                                                                                      |
| 3   | 2016 | A genetic algorithm for minimizing energy consumption in warehouse   | Too high service time greatly affects the warehouse operating costs.                                                                                                                                       |
| 4   | 2016 | Order picking in a parallel aisle warehouse with turn penalties      | In the process of picking orders, a turn in the warehouse can reduce the efficiency of order picking because it reduces speed and increases the risk of collisions with workers or other vehicles. |
| 5   | 2015 | Order batching in a pick and pass warehousing system with group genetic algorithm | The occurrence of workload imbalances at each order picking zone and the number of batch numbers on the system.                                                                                           |
| 6   | 2014 | Evaluating order picking performance trade offs by configuring main operating strategies in a retail distributor: a design of experiment approach | Job evaluation needs to be done to harmonize warehouse efficient steps with the main operating strategies, namely location of storage, batching and routing.                                           |
| 7   | 2014 | Planning of order picking process using simulation and a genetic algorithm in multi-criteria scheduling optimization | The number of personnel and equipment per activity is less efficient as well as scheduling procedures that have not been sequential.                                                                   |
| 8   | 2014 | Multi-objective routing and scheduling of order pickers in a warehouse | Travel time spent to complete the order picking process is very high.                                                                                                                                     |
| 9   | 2013 | Order picking area layout and its impact on the efficiency of order picking process | Congestion problems in the order picking area that affect the locking time of workers during order collection.                                                                                           |

Based on Table 1, it can be seen that one of the problems that often occur in the warehousing process is the inefficient order picking process. As explained earlier, the order picking process consumes almost all warehouse operations. One way to improve warehouse efficiency is by placing the product in the appropriate position. In addition, finding the best combination of each product can reduce the
order picking time. One method that can be used to solve this problem is a genetic algorithm. Table 1. also shows that genetic algorithms can be used to solve some warehousing problems, especially those related to the order picking process.

3.3. Genetic algorithm variables
Problem-solving in the order picking process using genetic algorithms can be influenced by several variables. Route policy determines the order of the order taker who will take the product from the order list. This policy focuses on operator travel time which generally has the most order picking activities. Distribution of order picking time with manual retrieval operations can be seen in Figure 3.

![Figure 3. Distribution of order picking time.](image)

Figure 3 shows that travel time consumes 50% of the total order processing time so that it can be determined as a key indicator of the order picking system performance. Compared to other activities during order picking, travel is the most focused activity to be improved and making policy routes must be developed specifically to reduce the distance of taking orders so as to reduce the costs associated with order picking activities [17].

Several studies related to the variables that influence the order picking process can be seen in Table 2.

| No. | Year | Inventor of Variables | Variable                                      |
|-----|------|------------------------|-----------------------------------------------|
| 1   | 2016 | Kuo, dkk               | Pick time                                     |
| 2   | 2016 | Ene, dkk               | Order arrival time                            |
|     |      |                        | Order due time                                |
|     |      |                        | Warehouse layout feature                      |
| 3   | 2016 | Celik, dkk             | Travel time                                   |
| 4   | 2016 | Rakesh                 | Travel time                                   |
|     |      |                        | Travel cost                                   |
|     |      |                        | Warehouse dimension                           |
| 5   | 2015 | Chao, dkk              | Picking time                                  |
| 6   | 2014 | Claudia, dkk           | Order maturity time                           |
|     |      |                        | Total picking time                            |
| 7   | 2014 | Molnar, dkk            | Travel time                                   |
|     |      |                        | Picking time                                  |
|     |      |                        | Labor cost                                    |
|     |      |                        | Number block aisle                            |
Based on Table 2., it can be seen that genetic algorithms can be used to solve problems in the process of picking orders in the warehouse. The time taken by workers to complete the order picking order is called batch processing. The processing time consists of the following elements: [18]

a. Travel time is the time frame needed by the order picking operator starting from the initial station to the location of the first product collection, between the location of the product collection and from the location of taking the final product to return to the initial station.

b. Search time is the time span used to identify product items.

c. Pick time is the time span needed to move the product from the storage location to the transportation device.

d. Setup time is the time required in the administration process at the beginning and end of each order picking process.

e. The efficiency of workers is the use of time picking orders that do not require a lot of time and a lot of workers.

4. Conclusion

The main purpose of this paper is expected to provide an understanding of the warehousing process, especially in the process of picking orders. As explained earlier, picking orders is the most dominant activity in the warehouse so the activity is estimated to spend around 55% of the cost of operating the warehouse. Even order taking generally consumes a large portion of the total labor activity in the warehouse by up to 60%. So that by carrying out warehouse management, especially in the matter of picking orders, it can have a significant effect on the level of warehouse productivity.

One method that can be used to solve problems in the order retrieval process is to use the genetic algorithm method. This paper uses genetic algorithms as a problem-solving method because it has several advantages over other conventional methods such as:

- Genetic algorithms operating with coded versions of the problem parameters are not the parameters themselves so the genetic algorithm works with coding solutions, not with the solution itself.
- Almost all conventional optimization techniques search from one point but genetic algorithms always operate on all population points (strings) because genetic algorithms use solution populations rather than a single solution to find solutions to problems.
- Genetic algorithms use fitness functions for evaluation so that they can be placed for all types of continuous and discrete optimization problems.
- Genetic algorithms use probabilistic transition operations, while conventional methods for continuous optimization apply deterministic transitions, where the genetic algorithm uses the operation.

Problem-solving using genetic algorithms using several variables that affect the order picking process, namely travel time, pick time, search time, setup time and worker efficiency. The expected results from the application of this method are to be able to improve warehouse efficiency by finding the best combination of each product storage location so that it can minimize the time taken and can maximize work efficiency.
References

[1] Muppani (Muppant) V R, Adil G K. 2008. Efficient Formation of Storage Classes for Warehouse Storage Location Assignment: Simulated Annealing Approach. Omega 36(4): pp 609–18
[2] Alan Rushton. 2010. The Handbook of Logistics and Distribution Management. (USA: Great Britain)
[3] Rakesh. V, Gajendra K A. 2016. Design of Order Picking Warehouse Factoring Vertical Travel and Space Sharing. Int J Adv Manuf Technol: Springer-Verlag London
[4] R.J Kuo, P.H Kuo, Yi Ruei Chen, F.E Zulvia. 2016. Application of Metaheuristic Based Clustering Algorithm to Item Assignment in a Synchronized Zone Order Picking System. Applied Soft Computing 46: pp 143-50
[5] Claudia C, Ander E, David C, Fernando L. 2013. Evaluating Order Picking Performance Trade-Offs by Configuring Main Operating Strategies in a Retail Distributor: A Design of Experiments Approach. Taylor&Francis : International Journal of Production Research Vol. 51, No. 20, pp 6097-6109
[6] Mangfei Yu. 2008. Enhancing Warehouse Performance by Efficient Order Picking. Eramus University : Amsterdam
[7] Seval Ene, Liker K, Asli A, Nursel O. 2016. A Genetic Algorithm for Minimizing Energy Consumption in Warehouse. Elsevier Journal Energy 114: pp 973-80
[8] Sivanandam S.N, Depa. 2008. Introduction to Genetic Algorithm. (New York: Springer Berlin Heidelberg)
[9] Hsu C-M, Chen K-Y, Chen M-C. 2005. Batching Orders In Warehouses By Minimizing Travel Distance With Genetic Algorithms. Comput Ind;56:169-178.
[10] Sastry K, Goldberg DE, Kendall G. 2014. Genetic Algorithms. In: Burke EK, Kendall G, Editors. Search Methodologies-Introductory Tutorials In Optimization And Decision Support Techniques. New York: Springer Science+Business Media.; p. 93e117
[11] Alan Rushton, dkk. 2010. The Handbook of Logistics and Distribution Management. USA : Great Britain
[12] Kees Jan Roodbergen. 2001. Layout and Routing Methods for Warehouses. The Neteherlands TRAIL Research School. ISBN 90-5892-005-4
[13] M. Seyedrezaei, S.E Najafi, A. Aghajani, H. Bagherzadeh Valami. 2012. Designing a Genetic Algorithm to Optimize Fulfilled Orders in Order Picking Planning Problem with Probabilistic Demand. Int. J. Research in Industrial Engineering (Iran :Islamic Azad University Tehran.), pp. 40 – 57
[14] Mangfei Yu. 2008. Enhancing Warehouse Performance by Efficient Order Picking. RSM Eramus University : Rotterdam. ISBN 978-90-5892-167-3
[15] Sivanandam S.N, Deepa S.N. 2008. Introduction to Genetic Algorithm. Springer Berlin Heidelberg : New York
[16] Resmana Lim, Kartika Gunadi. 2004. Optimasi Pengambilan dan Penataan Ulang Barang Di Gudang Dengan Penerapan Stack Menggunakan Metode Genetic Algorithm
[17] Tompkins, J., White, J., Bozer, Y. and Tanchoco, J., 2010, Facilities Planning, John Wiley & Sons, Hoboken,.
[18] Henn Sebastian, Verena Schmid. 2013. Metaheuristics for Order Batching and Sequencing in Manual Order Picking Systems. (Germany: Otto Van Guericke University Magdeburg Computer & Industrial Engineering.) 66 pp 338 - 351