

An analysis of modelling logistics operations solutions to support lean management

by Chris Ashmead

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University of Wales Trinity Saint David's
School of Engineering
Modelling Logistics Operations (M5X01280)
Modelling Operations To Support Lean Management
Chris Ashmead
1902167
BSc (Hons) Logistics and Supply Chain Management

Abstract

Warehousing is a vitally important element within a company's supply chain to facilitate the safeguarding of material flow, ensure the consolidation of stock, improve product quality, and increasing a products price through a series of value-added processes. Although most warehouse managers and their workers try to ensure the smooth running of a warehousing environment is maintained, this is not always the case. Due to the ever-increasing demand from consumers in wanting to receive their products at the earliest opportunity, this has meant that a company have had to increase the number of orders from their suppliers in a bid to fulfil such requirements. Consequently, due to the increase in orders, all warehouse employees were presented with the challenge of finding adequate and feasible locations to place products within the warehouse whilst guaranteeing that once a product has been located, it can be picked and dispatched promptly and efficiently. On account of this, many organisations have begun to seek new and innovative measures through the implementation of simulation modelling capabilities. They have started to utilise it to capture various warehousing criteria, such as changes in warehouse design, to reduce the amount of time needed to locate, pick, store, and distribute the multiple commodities within their warehouses.

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1. Introduction

Warehousing is an indispensable element of a company's supply chain. It is utilised to provide the much-needed assistance of protecting the distribution of digitised information and physical material, guaranteeing the consolidation of stock, strengthening a product's quality and increasing the value of an item through a range of different value-added processes. However, regardless of the numerous measures and strategies that both warehouse managers and their associates have orchestrated regarding the previous factors mentioned above, there are still certain areas within the warehouse environment where persistent problems are often manifested. Most notably, in recent times, due to the emergence of the global coronavirus pandemic, there has been a radical change in consumer behaviour to purchase goods online. As a result, this has profoundly impacted the warehouses of many large conglomerates who have had to increase the number of orders of products and raw materials to ensure that they can satisfy demand. As a consequence, this has presented a series of perennial problems, firstly to identify the best possible locations for where the additional stock can be housed and secondly, the sizeable increase in time taken to locate, pick, store and distribute products. As means of confronting these issues head-on, many organisations have begun to construct and implement modelling simulation to find a desperately needed solution (Kofler et al., 2010).

This paper aims to show how modelling and simulation software can effectively solve the Storage Location Assignment Problem (SLAP). Particular attention is focused on order picking and efficient route selection whilst also explaining what problems were encountered and subsequently rectified to ensuring the model worked adequately.

2. Storage Location Assignment Problem (SLAP)

Order picking for organisations is recognised to be the most time consuming and exorbitant operation within a warehousing environment. According to De Koster et al, (2007), order picking alone constitutes significantly high costings which equates to an astonishing fifty-five per cent of the total expenditure of all warehousing activities. The application of modelling and simulation for SLAP and order picking has been vastly explored and implemented by numerous researchers. Xiao and Zheng (2010) and Xiao and Zheng (2012) applied modelling capabilities for assessing the performance capability of a production warehouse. Frazeele and Sharp (1989) created a simulation model based on a notion of the correlated storage assignment based around an order picker being appointed to pick a plurality of items in a single trip.

In contrast, Heskett (1963) orchestrated a simulation model in an attempt to improve the complexity surrounding picker travel times. Heskett (1963) created a meticulous warehouse layout that was heavily focused on ensuring that fast-moving stores and items of a heavy nature were to be located as close to ground level within a warehouse's racking system. The researcher concluded that the picking and travel time between locations were drastically reduced by implementing such measures. However, Parikh and Meller (2009) stipulate that a central issue regarding the storage location assignment problem is picker blocking, which occurs due to limited space being available between the aisles within the warehouse. As a result, this causes

congestion as pickers are unable to get past one another, which has had a dramatic impact not only on a pickers' travel time but also on the time that is needed to pick items. Moreover, Chen and Lu (2012) then discuss how the utilisation of simulation modelling was extraordinarily useful in solving the storage location assignment problem for outbound containers within a maritime environment. The researcher produced a simulation model to determine the best configuration for containers being placed onboard ships in an effort to reduce the time needed for vessels to be unloaded and loaded when they arrive at ports and to minimise the associated docking costs.

3. Methodology used to Solve SLAP

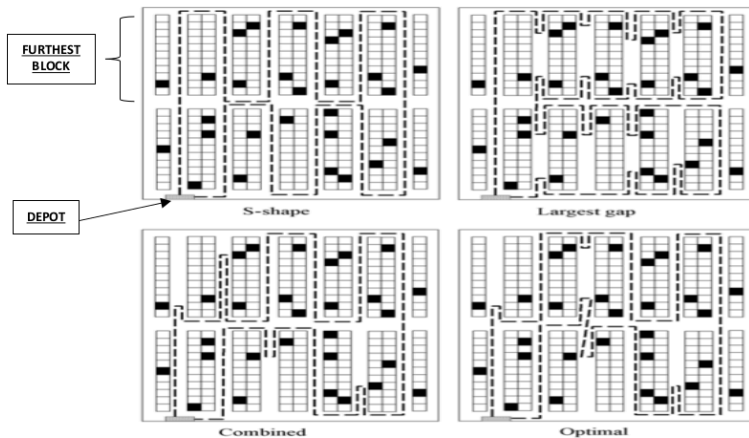
A series of methods were implemented to address and solve SLAP, which was based upon ensuring products were placed in locations adjacent to each other to see if that has a significant impact on reducing the time taken by operatives to pick items. Furthermore, the simulation of the SLAP was then tested using different routing methods to see if they would also play a significant role in reducing the picking time for pickers even further. Each of these routing methods/heuristics is detailed, with a full pictorial representation shown in figure 1.

- **S - Shape routing method:** A picker begins at the first aisle of a warehouse and transits through it entirely on the left side, collecting only one pick from the order and then exits the aisle on the opposite side to the way that an operative entered it. This whole process is then repeatedly carried out with all the remaining aisles within the warehouse until every item on the picking list has been collected.
- **Midpoint routing method:** A midpoint routing method is based on separating the storage layout within a warehouse into halves. Then the picker enters the aisle on one half and collects all goods. Then in the second half, the picker transits the aisle on either the right or left side and continues to pick the remaining items for the order.
- **Largest Gap:** The largest gap relates to the largest distance covered by a picker to collect goods. This strategy is considered advantageous over the midpoint routing method if only a few goods need to be picked as it significantly reduces the time required for goods to be selected. Furthermore, the largest gap strategy is also considered beneficial over the S - Shape routing method as it can lessen the travel time for a picker to arrive at a location.
- **Combined routing method:** A combined routing method begins and finishes at the main entrance to the warehouse; the route itself has a distinctively clear pattern to reduce the time spent searching for stock locations and to minimise the chance of any picking errors from occurring. A picker firstly traverses through the far-left aisle, which comprises of items that are situated at the furthest block to where the depot is located. Afterwards, the picker then transits the remaining blocks consecutively from left to right, ensuring that they exit the aisle in the same way that it was entered. Such a process is carried out until all items from the picking list have been collected.

- **Optimal routing method:** As the name implies, the optimal routing method is used to determine the shortest distance that a picker needs to travel to collect products. This routing method encompasses both a mixture of an S-shape and largest gap routing methods. Therefore, it could be considered as the most viable and rational option for solving SLAP. It can, however, be somewhat disadvantageous by :
 - Creating routes that may appear to be disjointed to an order picker may at times lead to disorder and cause the diverge away from the route that has been created
 - Not taking cognisance of crowded aisles or that a change in direction may be laborious

Figure 1 - Various routing methods used within the warehouse

(De Koster et al , 1999)



4. Simulation Model

For the purpose of testing the planned methodology, a simulation model was produced using Anylogic software. The reason why the multifaceted simulation software of Anylogic was selected was as a result of the numerous advantages that it provided.

- Produces a visual representation of the individual process steps, which helps to substantiate the variety of methods that are used within the simulation
- Anylogic's software is highly versatile, allowing for a user to enter in a multitude of different parameters
- The software is equipped with an assortment of pre-set and diverse experiments, namely optimisation and parameter variation, which are extremely valuable for examining the effects of employing several designs, including routing, batching and SLAP methods.

4.1. Data Input

Due to the lack of actual data, the Anylogic simulated model produced is of a working example of a company which is known as company A. Therefore, all figures inputted into the model were of a fictional nature. Table 1 depicts an initial review of the data that was collected with company A's warehouse.

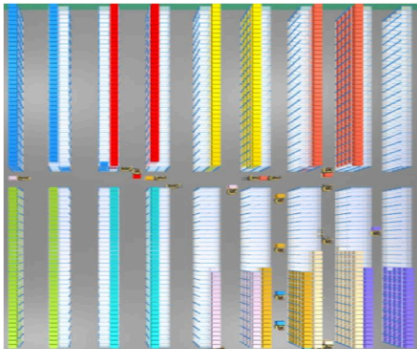
Table 1 - Primary analysed data of company A

SKU'S	50,000 SKU'S
Orders	3,100,000 orders
Line items	30,000,000 items ordered

4.2. Simulation Framework

Due to the exceptionally adaptable and simplistic nature of the Anylogic's simulation software, a fully functioning simulation model was produced. It displayed in intricate detail a complete configuration of the quantities of aisles, cross-aisles and levels, and the accurate measurements of the width and length of company A's warehouse. Figure 1 shows a screenshot of a sample of the warehouse racking layout design of Company A produced using Anylogic, whilst Table 2 displays a comprehensive list of all the various parameters used to create the simulation within the Anylogic software. The selected parameters were used to evaluate the impact of the clustering method on the overall performance of the model. Additionally, for performance comparability, other SLAP approaches were also utilised within the simulation model, such as cube-per-order-index, which is an order assignment used to locate inventory within a warehouse that works on the same principles as the clustering method.

Figure 2 - Warehouse shelving layout



Number of Aisles	8
Number of Cross-Aisles	4
Warehouse Length	500
Warehouse Width	700
Locations in Aisle	40
Levels in Each Location	5
Number of SKU's	50,000
Number of Orders	10,000
SLAP Method	Gravity Clustering

Table 2 - parameters from Anylogic's configuration tab

4.3. Model validation

As a means to validate the different SLAP and routing methods used with the simulation model, the most simplistic arrangement of the model was first produced to validate the technique that was being applied progressively. The primary model encompassed a singular block warehouse with only two cross-aisles and five aisles. With each of the processes being added, it could then be visually inspected to see if the model as a whole was running efficiently. By way of example, for S-Shaped routing, the simulation allows the user to visually examine the path that an operative has taken to pick the SKUs for an order. Subsequently, the path of the S-Shaped Route of the singular block warehouse was then compared with an S-Shaped Route carried out within a multi-block warehouse to see if there was a notable difference in the time that it was taking to collect and locate products.

5. Problems encountered during the modelling process

Overall, the running of the simulation model was generally unproblematic when all different parameters and routing methods were considered. However, there were several occasions where problems had arisen. Firstly, Anylogic in itself can be viewed as a complicated programme to master initially due to the vast number of functionalities found within its digital interface. Secondly, when the model was run, there was a significant lag in communication between different modelling agents, which often impacted the total cycle time of the simulation, which produced biased results.

6. Model results

After the simulation was run for ten complete cycles to compare the various routing configurations (S-shape, midpoint, largest gap, combined, optimal), the two different SLAP methods (clustering and cube-per-order-index) and the modelling parameters had been considered. The analysis concluded that the most efficient route to be used within company A's warehouse was an S - Shape method using a clustering SLAP technique.

Conclusion

To summarise, this paper has provided a thoroughly coherent explanation of how Anylogic's modelling and simulation have been highly influential in successfully solving the Storage Location Assignment Problem (SLAP) within a warehousing environment. Additionally, it has shown through the working example of Company A's warehouse that if both modelling and simulation is conducted correctly. It can raise efficiency levels considerably through its ability to analyse a diverse array of different routes, which has helped to deduce the travel time for operatives to find suitable locations for products whilst alternatively reducing the time for goods to be picked. Therefore, it can be said that for organisations wanting to be more pliant, farther sighted and better prepared for any unforeseen circumstances from events of an unprecedented nature that may hamper their warehousing practices. The implementation of modelling and simulation will undoubtedly provide the much-needed assistance to mitigate against any such problems by offering a clear-cut solution.

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