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LƯU KHO HỖN HỢP TRONG KHO THƯƠNG MẠI ĐIỆN TỬ

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Tóm tắt

Các nhà bán lẻ thương mại điện tử phải đối mặt với thách thức trong việc tập hợp một số lượng lớn các đơn đặt hàng lấy hàng quan trọng về thời gian, thường có ít dòng đơn hàng và quy mô đơn hàng nhỏ. Để giải quyết hiệu quả nhiệm vụ này, nhiều nhà kho trong phân khúc này được tổ chức theo mô hình kệ hỗn hợp. Sử dụng các phương pháp nghiên cứu định tính thông qua các trường hợp điển hình, chúng tôi khám phá liệu việc phân vùng hỗn hợp có phải là chính sách phù hợp trong trường hợp kho bãi thương mại điện tử hay không. Với mục tiêu phát triển một thế hệ nhà kho và trung tâm phân phối mới với mức độ hiệu quả tối đa, bài viết này đề cập đến các định nghĩa, đánh giá và một số khuyến nghị cho những mô hình và hệ thống tổ chức nêu trên.

Từ khóa: thương mại điện tử, kho bãi, lưu trữ hỗn hợp

MIXED-SHELVES STORAGE IN E-COMMERCE WAREHOUSING

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Abstract

E-commerce retailers face the challenge to assemble a high number of time-critical picking orders, generally with few order lines and small order sizes. To efficiently solve this task, many warehouses in this segment are organized according to the mixed-shelves paradigm. Using qualitative research methods through case studies, we explore whether mixed-shelves storage is an appropriate policy in the case of e-commerce warehousing. With an aim of the development of a new generation of warehouses and distribution centers with a maximum degree of efficiency, this paper addresses definitions, evaluations and some recommendations for those organizational adaptations.

Keywords: e-commerce, warehousing, mixed-shelves storage

1. Introduction

The rapid development of e-commerce makes warehouse efficiency a focus. As one of the core operations of the warehouse, picking occupies an important position in the operations of the entire warehouse. Despite its growth in the distribution industry, the efficiency of "picking" has not yet been improved, and its work cost accounts for a large percentage of the entire logistics cost.

To this end, this study analyzed the literature content on the use of mixed-shelves storage in manual warehouse storage and order picking. Additionally, we investigated the extent to which these methods have been considered in this field and proposed future research opportunities to improve manual order picking in human-centered logistics systems. Therefore, this study extends previous works and highlights how unproductive picker walking time can be reduced.

2. Literature review

According to Statista, 2022, sales volumes of e-commerce have increased dramatically in the past few years, especially during COVID-19 pandemic, which ultimately lead to a new generation of warehousing (Boysen et al., 2019) together with its fundamental functions, i.e. receiving, order picking, storage, and shipping (Gu, Ginnis, Goetschalckx, 2007). However, there are just a few papers on storage and order picking already existing. Weidinger and Boysen (2017) indicated the prospect of highly efficient picking performance thanks to mixed-shelves storage.

3. Methodology data

This study was carried out during February and March of 2023. We employed the research keeping strategy, which comprises contrasting trustworthy papers and journals, to accomplish the aforementioned goal. Our goal is to make use of the data and statistics that are already available in these sources.

4. Results and Discussions

4.1. E-commerce warehousing

E-commerce warehousing is the practice of expressly keeping products for online sale (Darren DeMatas, 2021). It is where products are received, stored, picked, packed, and shipped to customers who place orders online. E-commerce warehouses are equipped with advanced technologies such as automation, robots, and sophisticated inventory management systems that enable efficient and accurate order fulfillment. The location of the warehouse is also crucial for timely delivery of orders to customers.

E-commerce warehouses are any of the several warehouses that may be utilized to meet the storage needs of an ecommerce firm, including public warehouses, private warehouses, cooperative warehouses, government warehouses, fulfillment centers, smart warehouses, bonded warehouses and consolidated warehouses. In a similar vein, E-commerce warehouse management includes all the procedures necessary to run an E-commerce warehouse, such as:

- Controlling the workforce in the warehouse.
- Keeping products secure.
- Maintaining an inventory of the warehouse's equipment and supplies (raw materials and finished goods).
- Inventory management, including both raw materials and finished goods (can include a process such as FIFO, first-in, first out).
- Tracking every step of the process from when the goods enters the warehouse to when it is shipped to the consumer.
- Establishing and sustaining connections with shipping carriers.
- Forecasting demand to prevent issues of overstocking or running out of supplies.
- Maintaining the required safety measures to guarantee the security of all personnel, supplies, and equipment and to avoid any accidents.

4.2. Mixed-shelves storage

E-commerce retailers face the challenge to assemble large numbers of time-critical picking orders, of which each typically consists of just a few order lines and low order quantities. To efficiently solve this task, many warehouses in this segment are organized according to the mixed-shelves paradigm.

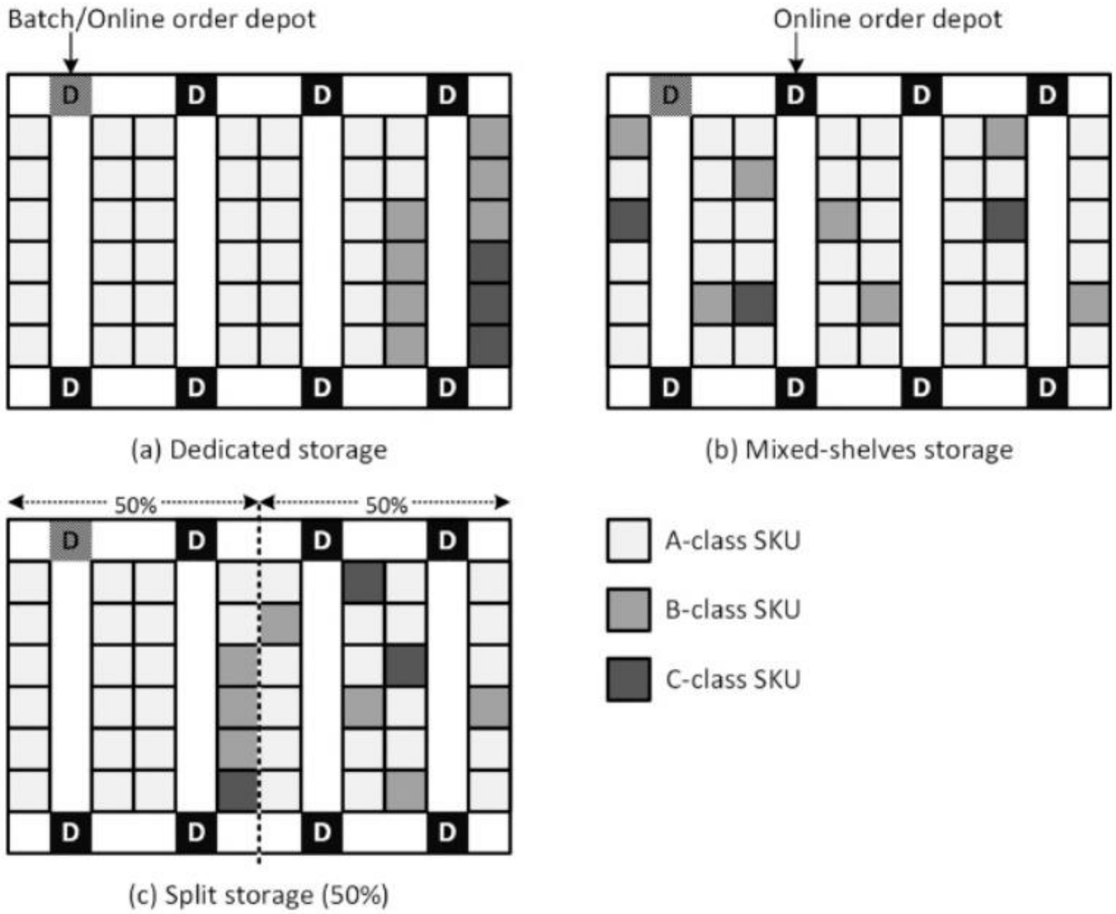

Figure 1: Mixed-shelves paradigm and other types of storage

Source: ScienceDirect.com

Incoming unit loads are isolated into single units, which are randomly spread all over the shelves of the warehouse (Weidinger & Boysen, 2018). In such a setting, the probability that a picker always finds a demanded stock keeping unit (SKU) close-by is high, irrespective of his/her current position in the warehouse. In spite of this organizational adaptation, picker routing, i.e., the sequencing of shelf visits when retrieving a set of picking orders, is still an important optimization problem. In a mixed-shelves warehouse, picker routing is much more complex than in traditional environments: Multiple orders are concurrently assembled by each picker, many alternative depots are available, and items of the same SKU are available in multiple shelves. Unit loads are purposefully broken down into single items and randomly spread all over the racks of the warehouse. The main goal of mixed-shelves storage is to significantly lower the average distances from any location in the warehouse to the nearest unit of each SKU by dispersing units across the warehouse. This raises the possibility that a sought-after SKU is close by. Furthermore, mixed-shelves warehouses frequently contain a number of entry points (depots) where finished orders are delivered to the main conveyor system. In this way, Pickers' unproductive wandering diminishes significantly as a result (e.g., de Koster, Le-Duc, & Roodbergen, 2007), and delivery deadlines may be reached more effectively. Scattered storage comes without excessive automation, so that by adding or removing pickers an adaptation to varying workloads is easily possible. As long as there is enough room in the warehouse for rack placement, the big assortments of the B2C segment appear to be unproblematic as well. In case of fluctuating capacity scenarios, the standardized and low-tech equipment also enables scalability, more pickers and racks may simply be added to or withdrawn from a warehouse. Finally, the lower order quantities also lessen the possibility that a picker may need to visit numerous storage locations to gather enough units of an SKU that is ordered in a greater number. This would increase the walking time, so that care has to be taken that the SKU diversity of the racks fits the order sizes in a mixed-shelves warehouse.

4.3. Situation, effects and cases

4.3.1. Current situation of put-away operations and drawbacks

This section of our paper details the most common put-away procedures in the global scale, formulated for a conventional multi-parallel aisle warehouse layout with two cross-aisles. This type of warehouse is classified as a non-palletized racking system (3D warehouse) since the logistic items to be stored are boxes, packages and so on, and they are managed manually. Each aisle has multiple storage locations in multiple height levels as seen in Figure 5.1

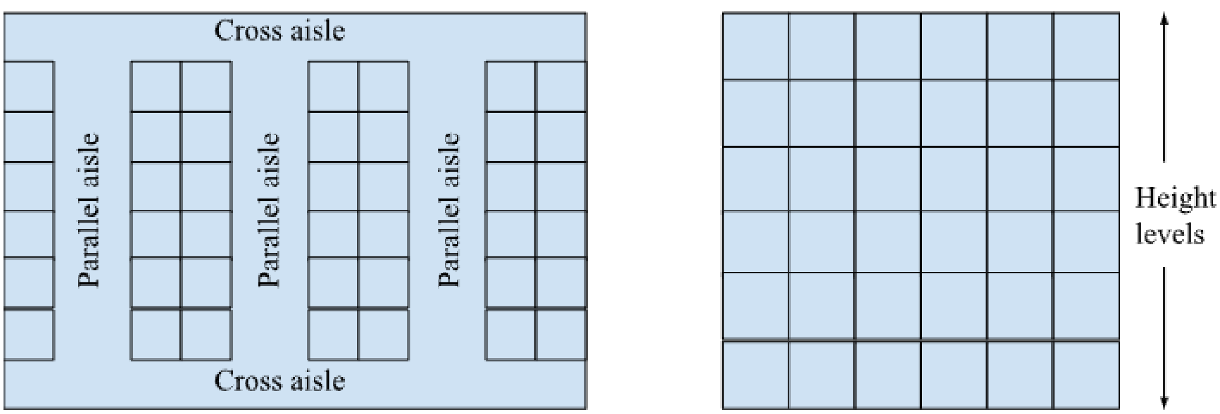

Figure 2: Superior view of the warehouse and front view of a parallel aisle

Source: Gómez-Montoya, 2020, p.4

The current put-away procedure allows assignment of any possible storage location for each product, representing a random storage policy. The WMS is the information system used to state the location for the product, attending to availability and logistic constraints (e.g., load capacity, volume, non-cross-contamination between products). The WMS output is considered as a known input for the PRP. It has to be noted that put-away time will depend on the storage location allocated to each product.

The products are put at the pre-allocated storage locations using Material Handling Equipment (MHE). The received products to be put away are linked to an arrival document. Each arrival document is formed by product identification codes and the number of products to be stored as well as specific characteristics such as temperature, nature of the product, relative humidity, expiration date, among others.

A put-away route is formed by a sequence of storage locations to be visited. The products of each arrival document or put-away list must be assigned to one route. Usually, a set of put-away routes are generated based on the load and volume capacity constraints of a homogeneous MHE and the number of products to be allocated.

This current put-away operation proves to be too complex because multiple products linked to an arrival document must be allocated to the assigned storage locations in each work shift for a DC. Therefore, a slotting method must be implemented to assign storage locations in a multilevel rack storage system, which directly impacts put-away routes.

In addition, costly and limited logistic resources such as MHE, intensive labor force, and ICT are usually used to execute put-away operations (unloading, inspection, handling and so on). Therefore, the put-away process must be performed in the minimum time and with an efficiency-based approach. An agile put-away operation improves replenishment of storage locations, which impacts positively on the effective inventory management and the performance of DCs. For this reason, the minimum operation time is set as the objective function of the problem.

4.3.2. Effects of mixed-shelves storage on order-picking operations

- Reduction in unproductive walking time during order picking

The item-to-location correspondence is deemed to be the focus of the mixed-shelves, or the scattered storage strategy (Liu & Leng Poh, 2023). The strategy aims to level the distribution of items belonging to the same SKU throughout the warehouse space. This means that the average distances from anywhere in the warehouse toward the closest unit of each SKU are considerably reduced. As a result, the probability of always having some items per stock-keeping unit close by is increased, which is intended to reduce the unproductive walking time during order picking. Furthermore, mixed-shelves warehouses often have multiple access points, which can be called depots, where completed orders are handed over to the central conveyor system. In this way, the unproductive walking of pickers considerably decreases and tight delivery schedules can better be met (Boysen et al, 2018).

- Increased efficiency in order-picking activities with strategic product placement

Different SKUs with different criteria and characteristics can be assigned to the most suitable areas for optimal picking. For example, according to Yu and de Koster (2013), full-turnover storage assigns SKUs according to their turnover, and SKUs with the higher volume of sales are assigned to more conveniently accessible locations.

Frazelle and Sharp (1989) also proposed that products with a high correlation may be placed together because they are typically placed together in an order. This helps increase efficiency and reduce time when fulfilling orders (Jiang et al, 2020).

- Increased complexity of picker-routing problems

In a mixed-shelves warehouse, picker routing is much more complex than in traditional warehouses: Multiple orders are simultaneously assembled by each picker, many alternative depots are available, and items of the same SKU are available on multiple shelves (Weidinger et al., 2019). Factors such as alternative depots, selection issues or the capacity of workers' picking carts have to be taken into account when optimizing such a warehouse.

- Application of mixed shelves storage in modern B2C warehouses with modern technology

As opposed to traditional warehouses and distribution channels, warehouses reserved for e-commerce retailers that are in the business-to-customer segment have four characteristics, or rather, four challenges they have to tackle, according to Boysen, de Koster, and Weidinger (2019). One, they tend to deal with small orders due to the nature of their customers, who are small and private households. This means that the picking order consists of just a few order lines, each demanding only very few items. Two, online retailers often offer a large assortment of products compared to brick-and-mortar stores. This phenomenon is described using the term "long tail" (Brynjolfsson, Hu, & Smith, 2003). Another challenge is the varying workload, which is due to the highly volatile demands depending on the offered selection, for example, end-of-season or year sales. Most online businesses also recorded dynamic growth over the past years. Thus, the scales of warehouses should be adaptable in order to quickly and effectively react to the constantly changing demands. The final characteristic is the tight delivery schedules, since next-day or same-day delivery services have become an integral part of many businesses as well as their competitive advantage. As a result, this significantly reduces the time window for order picking and increases the burden on warehouse operations.

According to Weidinger (2018), mixed-shelves or scattered storage setup is designed specifically for the unique requirements of modern B2C warehouses. Because mixed-shelves storage contributes to decreasing picking time and increasing convenience thanks to the implementation of strategic product placement, it allows for multiple different orders to be processed as fast and accurately as possible. Today, mixed-shelves storage is rapidly gaining popularity among household online shopping channels like Amazon, as well as department stores and supermarkets that are looking to expand their online goods selection.

This type of storage benefits from the advanced information system implemented in all modern B2C warehouses and distribution centers as well. Handheld electronic devices are commonly used to locate the needed products, so workers can avoid the pressure of having to memorize products' locations - which is a difficult challenge, especially in random mixed-shelves warehouses (Jiang et al, 2020).

4.3.3. Cases of Amazon - the leading company in the E-commerce Industry

Amazon is the leader in online retail. Companies Market Cap (2023) reports that Amazon generated $502.19 billion in 2022 alone, outpacing growth in every year prior. According to SKU (2021), weighing in at approximately 150 million square feet of storage space spanning across a multitude of warehouses, Amazon has one of the world's largest storage spaces. There are more than 100 in the United States alone, each with at least a 100,000-square-foot floor plan.

One of the biggest reasons for their success in warehouse management (Fulfillment by Amazon) is the chaos of their warehouses.

Amazon's B2C business model allows it to stow items in the warehouse based on a straightforward principle. If there is space for it, that is where it goes. When shipping to consumers, they are more than likely ordering a single item rather than an entire box or pallet of items. This allows Amazon to split an incoming shipment into individual pieces and stow the products whenever possible.

For example, if Amazon receives a box of 100 bars of soap, they store it individually as 100 bars of soap in as many as 100 different locations, rather than finding space for the entire box of bars. Amazon's database system will tell where there is empty shelf space and need to fill it up as quickly as possible to maximize efficiency. Almost all products are arranged like this, except for products that are too large such as refrigerators and washing machines. They're not in order of size or best-selling.

- Stowing and Picking techniques in Amazon's warehouses

- Stowing

For manual stowing stowers walk through the shelves and place the items on the shelves. To keep track of the locations they take the item, scan the shelf, scan the item, and place it on the shelf. If there is no space on the shelf, then they ask the computer for a new location.

For robotic stowing, it is still a human who puts the item onto the shelf. The difference is that the stower no longer walks to the shelf, but a small orange robot lifts up the entire shelf and brings it to the stower. The technical term used at Amazon for these shelves is "pods," and they have tens of thousands of these pods in a warehouse. The storage racks will be a continuously rotating system to bring the empty space to the outside.

After inserting the item into the pod and clicking confirm, the stower gets the next location or pod for the next item. They navigate robots using QR codes on the floor.

If there is not enough space at the pod location, the stower must not put it on another spot on the same pod, but instead gets a new location or pod by the computer. Problem solvers will look at why the slot in the pod is already full. Similarly, if the stower notices damage, the item also goes into an "amnesty bin" to be checked out later.

- Picking

With manual picking, someone is walking along the shelves picking up stuff. They push a cart with yellow boxes and have a handheld scanner. The scanner tells them the shelf location for the next pick. Since this is a random storage system, the shelf area may include other products, and the same product may also be on other shelves. The picker scans the shelf barcode followed by the item. If everything is okay, the picker moves on to the next location.

Similar to robotic stowing, the robotic picking does not use a robot to grab items off the shelf. The worker at the picking station sees on a monitor the next item including a picture of the item, how many of it, and which slot in the yellow pod the item is. The worker simply grabs the item out of the pod, scans it, and puts it into one of multiple totes as determined by a computer. Similar to a pick-by-light, the placement is indicated by a light above the tote. Hence similar to a supermarket checkout, the worker simply held the item under the scanner before dropping it into the tote.

Similarly to the stowing, if anything is out of order, the worker is not instructed to fix it, but instead to give a signal to problem solvers who will sort it out. To help with this process, a camera takes a photo of the side of the pod that was picked after the picking. An artificial intelligence algorithm tries to find out if the photo is consistent with the expected pod content. If the algorithm senses a difference, it may be sent to a human problem solver.

- The Benefits of Random Storage in Amazon

If there is a separate "soap" area, employees may have to walk hundreds of meters to get to that area. But if the soap is in 100 random places, the staff will most find it sooner

To utilize a traditional warehouse fixed floorplan when managing the shipment of 600 million different products would be impossible. If they need a separate area for soap and other products, perhaps the size of the warehouse needs to be many times larger. Placing products anywhere has space is an effective way to save warehouse space.

Amazon carries almost 600 million different products and ships up to 25,000 packages a day from each of its 145 global fulfillment centers. With economies of scale, Amazon can offer consumers lower prices. Lower prices to consumers allow Amazon to sell more products, and more product volume results in even lower prices from manufacturers. Therefore, they only need to sell a soap to a customer, not a box of 100 soaps to the store for retail, so there is no need to store 1 box of 100 soaps.

By randomly stowing individual items wherever there is space, there is no need to create space for the next box of incoming inventory. This allows the outgoing shipments to be picked from all over the warehouse, making an often unseen efficiency since there is probably one of the items close at hand to the selector, cutting down on wasted movement during the picking process.

This also helps to reduce the burden of warehouse management. Instead of having someone count the remaining rows, everything is automated by computers. With just a few clicks, the manager can find out exactly how much of this "soap" is in stock without having to go to the warehouse to check the accuracy.

4.4. Evaluations and recommendations for future applications

4.4.1. Evaluation

On the one hand, mixed-shelves storage is well fit with e-commerce retailing warehouse's characteristics. According to Boysen et al., 2019, e-commerce warehouses require tight delivery schedules since many online retailers even promise same-day deliveries. This leads to the fact that order fulfillment procedures become more time-sensitive. Such a storage policy can decrease unproductive picking trip times in e-commerce environments in which orders typically consist of a few items in low numbers by raising the possibility that items from the same order can be discovered in close places. Cornelissens et al. (2023) proved that the sum of pairwise distance is reduced by 65% with scattered storage policy compared to that with a traditional volume based storage policy. In addition, an unnecessity for heavy automation in scattered storage makes it simple to adjust to changing workloads by adding or reducing pickers. Moreover, as long as there is enough room in the warehouse for rack placement, the big assortments of the B2C segment appear to be unproblematic as well.

On the other hand, scattered storage method poses a problem with large orders. In these situations, the picker must go to several storage locations of the specified SKU until sufficient quantities are gathered, which is extremely time-consuming and energy-consuming. Besides, prioritizing orders, assigning them to pickers, and routing pickers are the three key decision-making issues that need to be resolved during order picking. Prioritization is primarily determined by the urgency of the orders, which is, for example, affected by the importance of the client, the promised delivery dates, and the departure timings of the targeted delivery vehicles. The burden should be distributed fairly among pickers, and orders allocated to the same picker should fit together so that quick picking routes are possible. These considerations must be made while assigning orders to pickers. However, there is currently no scientific decision-making support for mixed-shelves warehouses, such as how to arrange mixed-shelves or where to put intermediate aisles and depots. Without IT assistance, it is impossible to locate individual units in mixed racks, thus pickers must be outfitted with a handheld scanner or another device (such as a pick-by-voice solution) that points them in the direction of the picking places.

4.4.2. Recommendations

- Optimizing warehouse layout design & storage assignment

To optimize order picking in warehouses operated mainly by human pickers, a thorough study need to be conducted and frequently revised to maintain an efficient movement of goods in the warehouse:

- Not all warehouse designs are suitable for implementing mixed-shelves storage strategy. An E-commerce warehouse with scattered storage should adequately accommodate for an extensive flow of goods and vehicles, storing and tracking a wide range of SKUs, and be able to handle great fluctuation in the number of seasonal/promotional goods. Lin, H. (2019) suggested cloud warehouse, a warehousing initiative that integrates automated equipment and digitalized systems to perform better goods circulation required in E-commerce.

- Storage assignment on an efficient E-commerce warehouse could utilize a class-based system. As a combined method of dedicated and random assignment, class-based storage assignment divides goods into different classes, then randomly distributes them among the storage.

- Routing method: Assigning best routing method to substantially reduce transporting time of pickers, whether S-shape, largest gap, combined, mid-point or optimal.

- Batching & Zoning: Depending on the nature of the goods inside such a warehouse, batching, zoning and a combination of both methods should be implemented reasonably to reduce picking time.

- "Part-to-Picker" picking system

- Automated Storage & Retrieval System (AS/RS): An automated system that efficiently and securely store items in a compact footprint. They also allow users to easily and quickly retrieve items when needed, with minimal human intervention where goods are classified and picked by robotic lines. An efficient AS/RS system will improve inventory management, optimize space, decrease moving & picking time by 70%, and reduce labor cost (Mourral, 2020). Despite high costs & technological requirements, AS/RS propose the future of E-commerce warehouses with integrated systems of smart storage assignment and order picking by machines.

- Robotic Mobile Fulfillment System (RMFS) is currently experimented in E-commerce warehouses, in which automated guided vehicles carry movable shelves to the corresponding picking stations to complete the picking. RMFS is highly scalable, customizable and flexible, with great room for time and cost optimization and of high scientific & business interest.

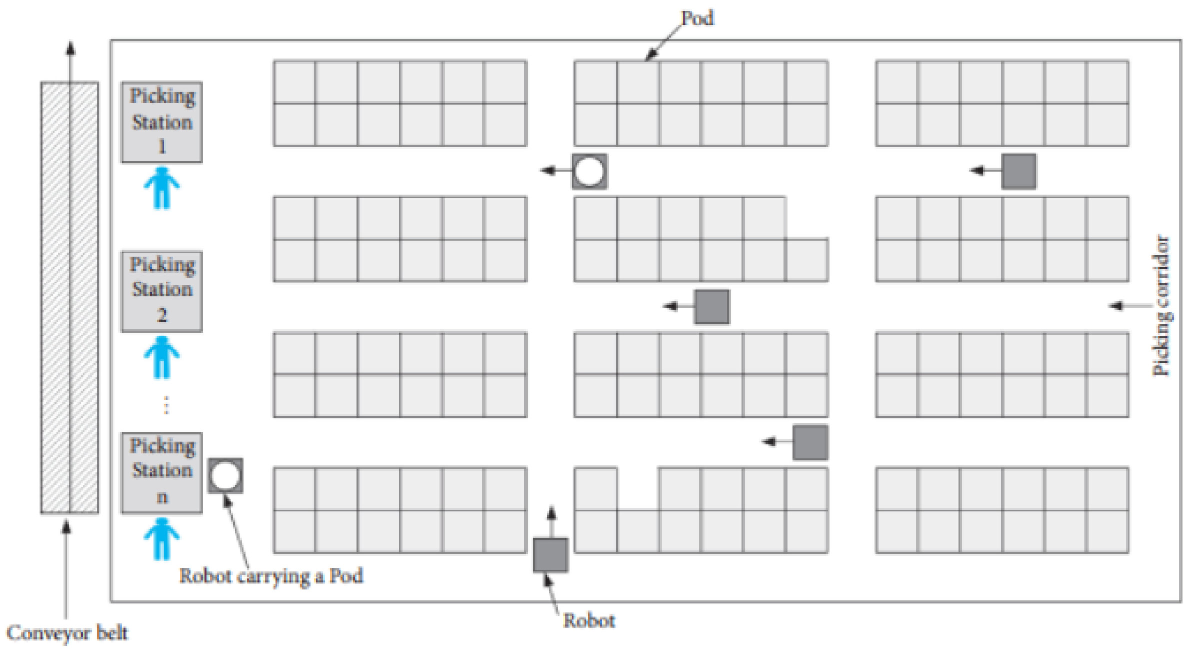

Figure 3: Typical layout of an RMFS system

Source: Yuan et al., 2021

- "Picker-less" picking system

Contrary to the aforementioned recommendations, "Picker-less" picking is a proposed idea of a fully automated system where machines take charge of the picking part, fully eliminating human intervention in the order picking process. Such frameworks are still in heavy development, but have been realized in advanced warehouses with minimal human staff required.

CONCLUSION

Order picking is regarded as the most important warehousing activity. The lead time of an arbitrary order in the system is an important measurement of the efficiency of an order picking system. The faster the order can be picked, the sooner it can be ready for shipment and the higher service level the warehouse can provide. Mixed-shelves storage is an important factor that will influence the warehouse operations efficiency.

Beyond these specific systems, we see some emerging general trends in e-commerce warehousing that require further scientific consideration.

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