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USE OF FILL-AND-ROTATE ALGORITHM FOR INCREASING THE STORAGE CAPACITY

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ABSTRACT: *Warehouse operations are much more complex than when they appear at first glance. Profi ling (partitioning) of products and orders leads to a potential multitude of warehouses inside the warehouse. The paper presents an algorithm for increasing storage capacity in modern warehouses.*
KEY WARDS: *warehouses, storage capacity, storage area.*

I. Introduction

Warehouses are places where materials and goods are stored [1]. Depending on the market demand, many operations such as loading distribution, packaging, marking, commercial conversion consolidated cargo forming are completed. Warehouses could be considered as a distribution channel for goods and materials. They could also be considered as an "insurance" against various difficulties in distribution channels and disruption of material flows in already established distribution chain.

Warehouses [5] accumulate material resources, which are necessary for dampering the volume fluctuations of demand and supply. They are also very important for synchronizing system from the producers to the customers or material flows in technological production systems.

II. Exposition

Warehouses can serve different roles within the larger organization. For example, a stock room serving a manufacturing facility must provide a fast response time. The major activities would be piece (item) picking, carton picking, and preparation of assembly kits (kitting). A mail-order retailer usually must provide a great variety of products in small quantities at low cost to many customers. A factory warehouse usually handles a limited number of products in large quantities. A large, discount chain warehouse typically “pushes” some products out to its retailers based on marketing campaigns, with other products being "pulled" by the store managers. Shipments are often full and half truckloads. The warehouse described here is a small, chain warehouse that carries a limited product line for distribution to its retailers and independent customers.

The purpose of the warehouse is to provide the utility of time and place to its customers, both retail and individual. Manufacturers of office supplies and furniture are usually not willing to supply products in the quantities requested by small retailers and individual customers. Production schedules often result in long runs and large lot sizes. Thus, manufacturers usually are not able to meet the delivery dates of small retailers and individuals. The warehouse bridges the gap and enables both sides, manufacturer and customer, to operate within their own spheres.

Modern big warehouse is a complex technical facility which consists of multiple interconnected elements. It has a fixed structure and performs a number of functions in the transformation of material flows, also in the accumulation, processing and distribution of goods among consumers. Moreover, because of the variety of parameters, technological and volume-planning solutions, equipment design and characteristics of the diverse nomenclature of processed goods stores belong to complex systems. At the same time the warehouse itself is only an element of a system, which is on a higher level in the logistics chain. This position determines the main technical requirements to the warehouse system. It also determines the goals and criteria for its optimal function and the conditions for cargos processing.

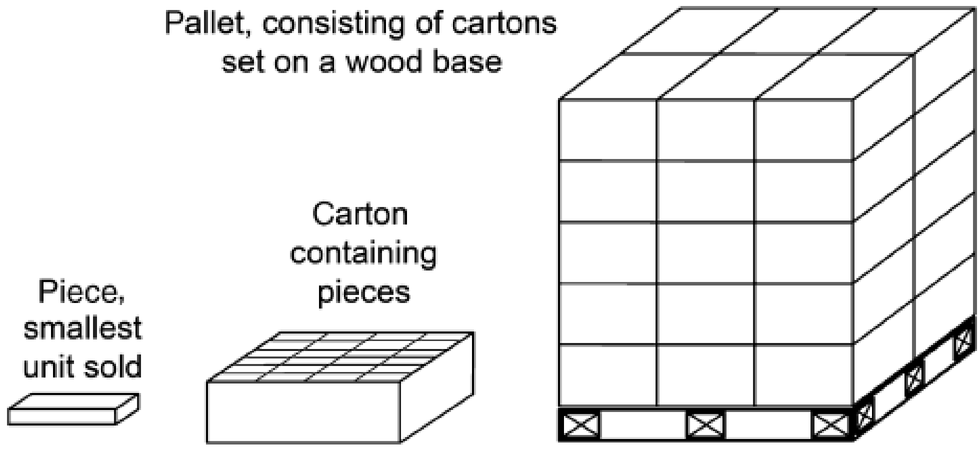

Fig. 1. Load types.

Products are sold by the warehouse as pieces, cartons, and on pallets. Figure 1 shows the relationships among these load types. Individuals usually request pieces; retailers may also request pieces of slow movers, products that are not in high demand. Retailers usually request fast movers, products that are in high demand, in carton quantities. Bulky products like large desktop storage units may be in high enough demand so that they are sold by the warehouse in pallets. Furniture units are also sold on pallets for ease of movement in the warehouse and in the delivery trucks. The typical dimensions of a piece is 10 × 25 × 3.5 cm, with a typical volume of 0.875 liters. A carton has typical dimensions of 33 × 43 × 30 cm, with a typical volume of 42.6 liters. Thus, a typical carton contains 48.7 pieces. The typical dimension of a pallet is 80 × 120 × 140 cm, with the last dimension being the height. The pallet base is about 10 cm high, so the typical product volume is 1.25 m^3, corresponding to 29.3 cartons [3]. The pallet base allows for pickup by forklift truck from any of the four sides. Products in the pallet reserve storage area (see Fig. 2.) are assigned locations using a shared storage concept, with the more active products located closer to the receiving or shipping dock

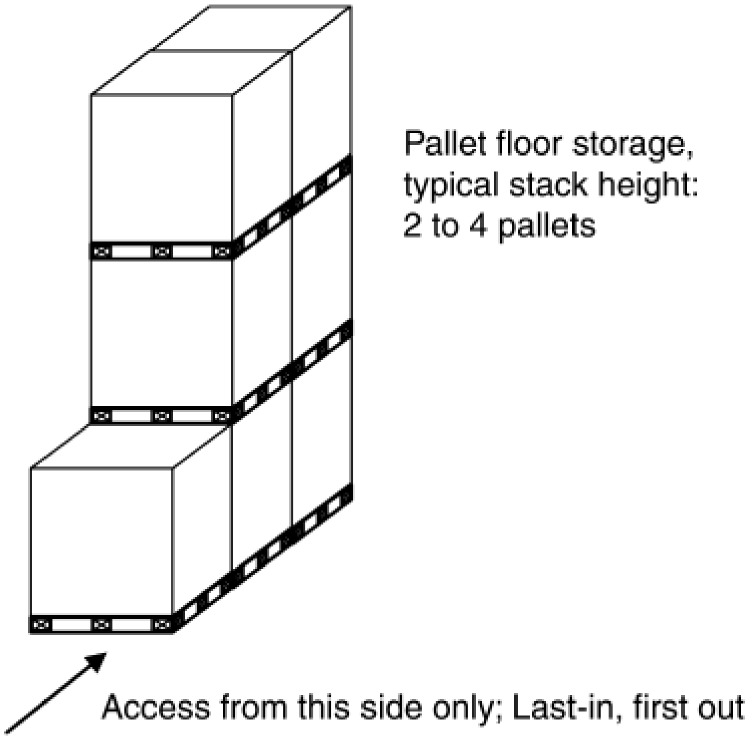

Fig. 2. Pallet reserve storage area, fl oor stacking

The high cost and limited availability of real estate near population centers - where most businesses would like to locate often forces firms to make the most of smaller facilities. In large cities it is common to find multi-level department stores, parking lots, all efforts to make better use of space.

Effective space utilization has long been a theme in material logistics and transportation as well. For example, ports must make the best use of limited acreage to store empty and full containers and other cargo; shipping and trucking firms must maximize freight per vehicle in order to reduce the total costs of transportation; and distributors strive for high utilization of warehouse space to decrease total facility and operating costs.

An automated form of dense storage is deep bulk storage, in which pallets are stored several deep in an automated handling system (Figure 3).

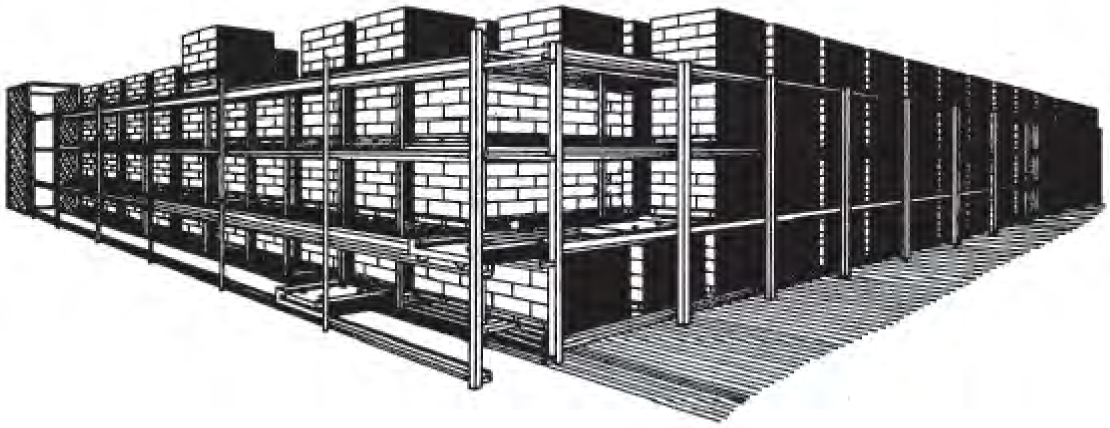

Figure 3: An automated deep bulk storage system.

Storage system has Very High Density (VHD) when it is sometimes necessary to move interfering items in the system in order to gain access to desired items. Generally speaking, double-deep pallet rack has very high density because one might have to move a pallet to retrieve the one behind it, but single-deep pallet rack does not, because every pallet is accessible directly from an aisle. Deep-bulk systems also have very high density, as do many container yards in ports, where containers are sometimes stored several units deep, and perhaps several units high.

If aisle cells are the same size as cells containing items, and so aisles have the same width as items. For many automated systems this is a reasonable assumption, but for other systems those involving forklifts in particular aisles are wider than items to allow the transporter to maneuver. Should wider aisles be necessary, there are at least two options. If aisle width is approximately an integer multiple of the width of a storage cell, we can redefine “cell” to mean the integer multiple and proceed as before. An alternative is simply to “stretch” the aisles to required width and then fill in newly created storage space with items.

Figure 4 shows three example layouts: single-, two-, and three-deep, from left to right.

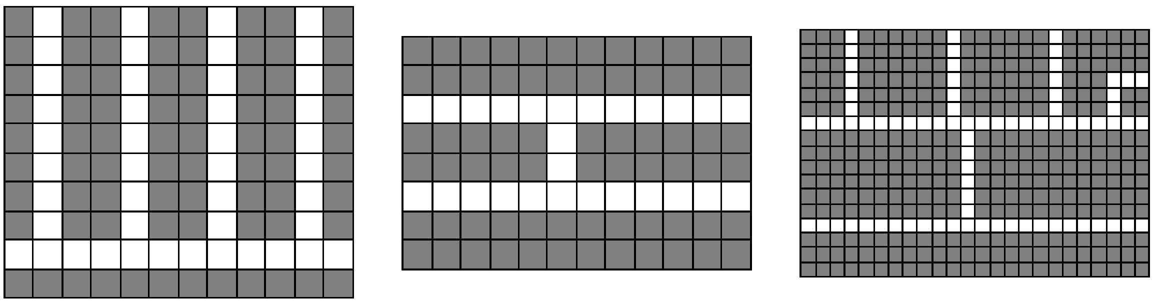

Figure 4: Example layouts

If we use algorithm, which is called Fill-and-Rotate, is based on a simple labeling procedure and a series of rotations of the grid (Figure 5):

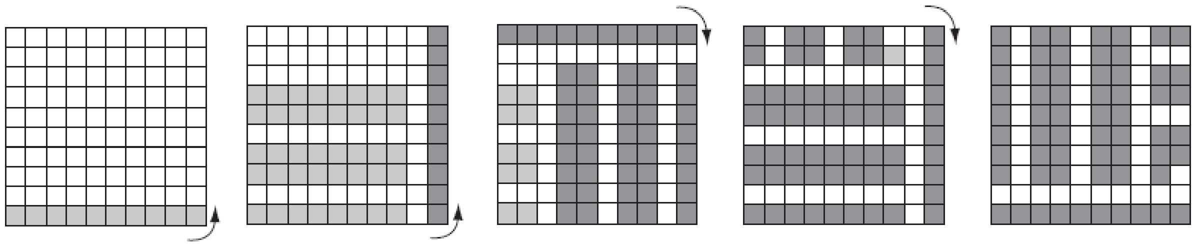

Fig.5: The Fill-and-Rotate algorithm applied to a 10 × 10

The best layouts for Very High Density storage spaces have a definite structure: items should be arranged in several aisles connected by a single cross aisle. For certain combinations of length, width, and lane depth it is best to arrange a slightly different region on one side to compensate for the lack of divisibility between the parameters.

III. Conclusion

The storage density in a space can be no greater and this bound is asymptotically tight as the storage space gets large. Logistics might use this as a rule of thumb when designing storage spaces that will be faced with the need for high density. This simple result can be used in other contexts as well for parking lots

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