WAREHOUSE DESİGN

Lecture Note #9

Storage systems

- There are two kinds of storage systems for packages:
  - **Static,** including stacks, racks (conventional, drive-in, drive-through and cantilevers), multilevel shelvings, lockers and drawer cabinets;
  - **Dynamic,** such as mobile racks, storage carousels, live pallet racks and push-back racks.
- **Stacks** Palletized load units are stacked in blocks separated by aisles, whose width depends on the kind of machinery used for movement.
- **Conventional racks** Conventional racks allow direct access to all the load units and therefore are particularly suitable for storing large volumes of single items.
- **Drive-in or drive-through racks** These are systems similar to conventional stacks, with the difference that a suitable structure is used to support the palletized load units (so that problems of product superimposition are avoided). This system is useful for storing homogeneous products, in particular seasonal ones, and reduces potential damage to the packages.

Identification systems

- These are systems for the codification of packages inside the warehouse by means of codes that can be scanned by automatic devices.
- The codification of the packages is of fundamental importance for the computerized management of the warehouse.
- The main identification systems are: bar codes, logistic labels and smart tags based on radiofrequency technology (radiofrequency identification, or RFID).

Bar codes

- The bar code is the optical conversion of a numerical or alpha-numerical code which is used to identify a package. This optical conversion is represented by means of an alternating sequence of vertical bars and spaces

Logistic labels

- The logistic label records information, both in legible format (characters, numbers and graphic elements) and in the form of a bar code, also regarding the entities involved in material-handling operations as suppliers, shippers and customers.

Smart tags

- These are the main components of an automatic identification system that is based on RFID technology and is known as an RFID tag or transponder

An RFID tag can be active or passive

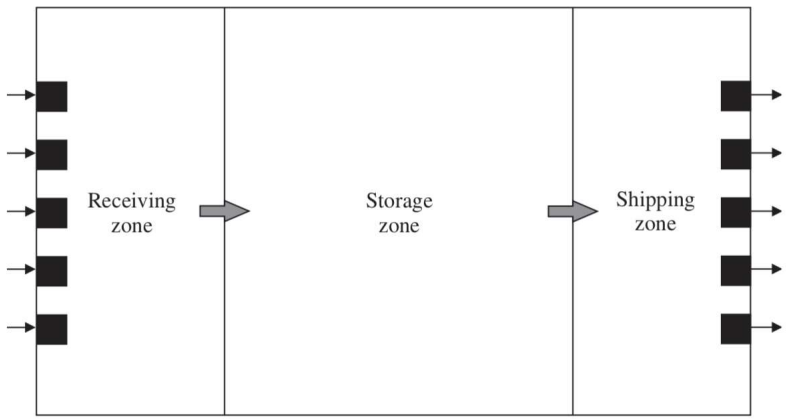
- **Passive tags**, which are more economical and widespread, are made up of an aluminium or copper antenna, a memory microchip and a support for the protection of this chip. They do not have a battery and require no maintenance.
- **Active tags** are more sophisticated electronic devices. Provided with an internal battery that powers them and that enables very great transmission distances to be achieved (over 400m in the open for some models), they are equipped with a very complicated electronic system that allows the application to be customized on the basis of individual requirements.

Choice of warehouse layout

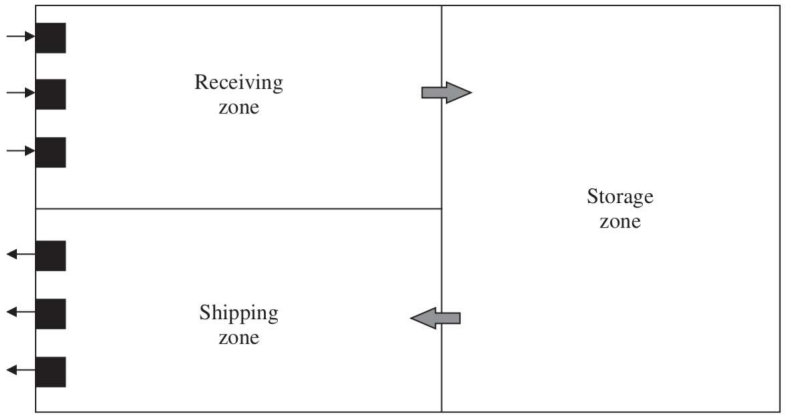
- The choice of warehouse layout involves sequentially solving two decision-making:
  - it is first necessary to determine the arrangement of the warehouse zones where the warehouse activities take place (warehouse layout problem),
  - and then size and organize each of the warehouse zones (internal layout problem).

- **The receiving zone** is the area where the qualitative-quantitative control of checked-in packages, the preparation of the load units to be stored and the updating of the inventory are carried out.
- **The storage zone** is the area where the packages are stored. It is sometimes divided into a remote reserve zone (RZ), where the large load units coming from the receiving zone are stored, and a small-sized rapid access storage zone (pick zone (PZ)), from which the packages are retrieved for the formation of outgoing load units.
- **The shipping zone** is the area where the operations of the outgoing load units checking, assembly and packaging and of the shipping documents for the transport preparation take place.

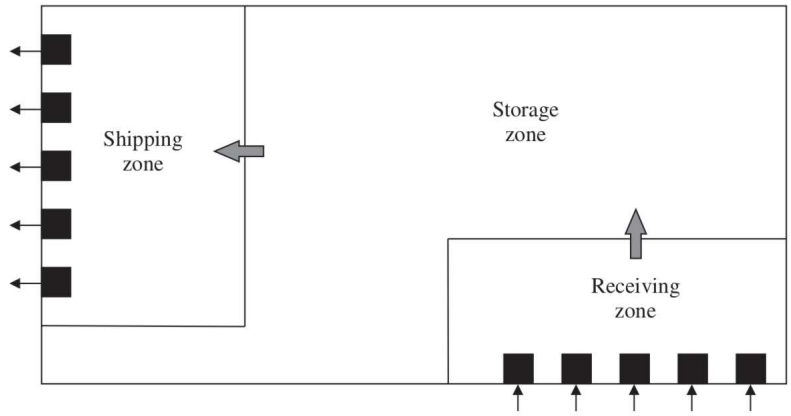
Flow-through warehouse layout



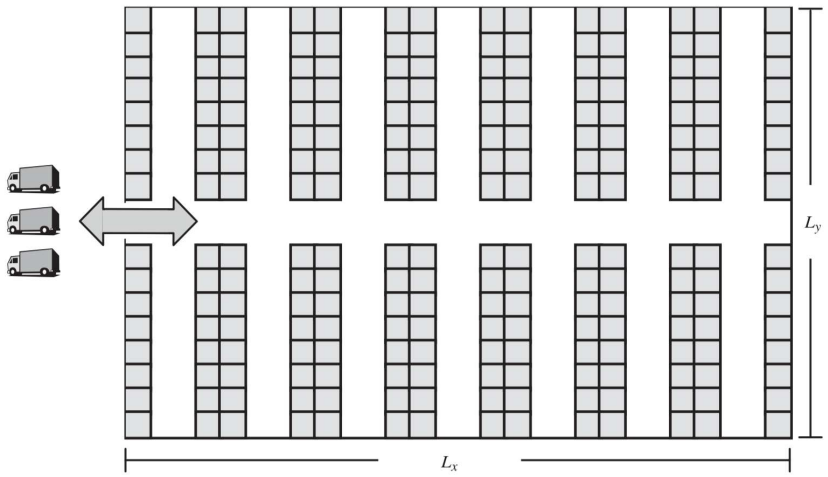
U-shaped warehouse layout



Hybrid warehouse layout



Determining length, width and height of a storage zone



Determining length, width and height of a storage zone

- m be the required number of stocking positions
- α_x and α_y the occupation of a unit load (e.g. a pallet or a cartoon) along the directions x and y
- w_x and w_y, the width of the side aisles and of the central aisle
- n_z the number of stocking zones along the z-direction allowed by the storage technology
- v the average speed of a picker.
- The decision variables are
- n_x , the number of storage locations along the x-direction,
- n_y, the number of storage locations along the y-direction.

- The extension L_x of the stocking zone along the direction x is given by the following relation

$$L_x = (\alpha_x + \tfrac{1}{2} w_x) n_x,$$

- where, for the sake of simplicity, n_x is assumed to be an even number. Similarly, the extension L_y is

$$L_y = \alpha_y n_y + w_y.$$

Therefore, under the hypothesis that a handling operation consists of storing or the retrieving a single load, and all stocking points have the same probability of being accessed, the average distance covered by a picker is: $2(L_x/2 + L_y/4) = L_x + L_y/2$. Hence, the problem of sizing the storage zone can be formulated as follows.

Minimize

$$(\alpha_x + \tfrac{1}{2} w_x) \frac{n_x}{v} + \frac{\alpha_y n_y + w_y}{2v}$$

subject to

$$n_x n_y n_z \geqslant m$$
$$n_x,\ n_y \geqslant 0,\ \text{integer},$$

Hence,

$$n'_y = \sqrt{\frac{2m(\alpha_x + \frac{1}{2}w_x)}{\alpha_y n_z}}.$$

Finally, replacing n_y in Equation (5.6) by the n'_y value given by Equation 5.8, n'_x is determined:

$$n'_x = \sqrt{\frac{m\alpha_y}{2n_z(\alpha_x + \frac{1}{2}w_x)}}.$$

Consequently, a feasible solution $(\bar{n}_x, \bar{n}_y)$ is

$$\bar{n}_x = \lceil n'_x \rceil \quad \text{and} \quad \bar{n}_y = \lceil n'_y \rceil.$$