Extreme families of warehouses

Introduction

In this case study, I will discuss and compare four different ‘families’ of warehouses. All of them concern traditional warehouses in the sense that they contain physical resources, but differ in the way they are organized. The goal is to identify the underlying properties that distinguish them and certain organizing principles corresponding to those properties. Since there are immensely many warehouses with just as much configurations and property values, the focus will be on some of the most extreme cases, which will accentuate the differences in property values and organizing principles.

What is being organized?

One of the most important properties that define to what family of warehouses an instance belongs to, is the type of physical product that is being stored and organized. Four categories of resources are analyzed that require completely different organizing systems: consumer goods, raw production materials, spare parts, and perishables (such as food or flowers). These four categories have a major influence on the design principles within a warehouse, as the goals and constraints that come with them are completely different. Regardless of the type of resources in a warehouse, another two-split can be made in the ‘thingness’ of the resources. On the one hand, the individual, physical items that are in the warehouse are organized: products are allocated to a location in the warehouse, stored there, potentially moved around and eventually retrieved and shipped to its destination. These kinds of operations concern specific instances of resources. On the other hand, warehouse managers keep track of several resource descriptions at the Stock Keeping Unit (SKU) level. This includes measuring collection properties such as inventory levels of each product, expected demand, and performance indicators such as availability levels. This distinction comes with the observation that the single instances are physical resources that are mostly organized as such. Their key resource descriptions are about their physical location in the warehouse and their destination. The more abstract notion of SKUs on the other hand, are digital resource descriptions that describe at an aggregated level what is going on with the separate instances. The harmony between the two plays a key role in the operations of any warehouse.

Why is it being organized?

The four identified resource categories have a structural relationship with the goal they are organized for. Clearly, consumer goods and perishables are organized by (online) stores so that they can be sold for a profit. Spare parts on the other hand, are organized to be sure they are available when needed. Suppliers of high tech machines have agreements with their clients over the amount of up-time of the machine and if a component breaks, a replacement should therefore be immediately available. Raw materials have a similar goal, they should be available so that the production planning can be executed.

By going one layer deeper, another notion of ‘why’ can be identified, and that is about why resources are organized a certain way or to a certain granularity. What properties make organizing the resources
necessary? Two main features are identified: the amount of units coming in and going out (volume) of the
warehouse and the amount of different SKUs (mix) in the warehouse. Consider a spare parts warehouse.
There are often (tens of) thousands of different components in a warehouse, while demand for a component
can be as low as one or two units a year. On the other hand, a raw material storage for a manufacturer of
chemical products contains only a few different types of oil, but tons of the stuff is flowing in and out every
day to keep production going. Obviously, these two warehouses do not use the same organizing principles.
Consumer goods warehouses, like those of Amazon for example, often have a both high mix and high volume.
Perishables typically have medium to high mix and high volumes, but another distinguishing feature comes in:
they have a limited shelf life and have to be thrown away if not sold in time. Hence it is even more
expensive to have too much inventory. The notions of mix and volume help answer the question ‘why is it
being organized?’ by providing the reasons sophisticated organizing principles are needed. In a warehouse
with a lot of traffic, congestion of order pickers and reach trucks can easily arise, preventing on time deliveries.
Similarly when a lot of different SKUs are stored and the ones you need most often are far away from the
loading dock, that is not an efficient operation. Summarized, the ‘why’ of organizing in a warehouse is to
be able to satisfy the mix and volumes of orders. At the SKU level, the the most important decisions to
be made are inventory levels and procurement decisions. Obviously the expected demand forms the basis
of these decisions. The decision is however influenced significantly by the variability of the demand. If we
cannot predict demand very accurately, we say there is high variability and safety stocks are used to absorb
higher levels of demand. How much safety stock is used, depends on very first feature highlighted in this
section: the primary goal of keeping stock. If this goal is selling products to consumers, the costs of not
having enough stock is usually relatively low, as this incurs only some missed profit. When organizing for
availability, such as with spare parts and raw materials, the cost of not having stock can be immense, as
this means production cannot proceed. For example, if a lithography machine at a chip manufacturer like
intel or AMD breaks down, this costs tens of thousands of dollars per hour. Even if the part is immediately
available, a single breakdown costs millions. Now imagine if the part is not available.

How much is it being organized?
In every warehouse, resource descriptions at the SKU level, such as inventory levels and expected demands,
are tracked. These descriptions are crucial to make daily operating decisions like placing orders and esti-
mating lead times. It depends however on the types of resources if they are also carefully managed at the
individual instance level. Components of high tech machines have a unique product number so every unit
- with its maintenance history, the machines it has been part of or must become part of, and the current
state of the component - can be distinguished. When organizing perishables, you must be able to distinguish
between different brands of food and keep track of expiration dates and place of origin to be able to guaran-
tee safety, but there is no need to do this on a more granular level than that. For non-perishable consumer
goods, such as books or DVDs, such granularity is not needed at all.

When is it being organized?

Basically warehouses are continuously organized during its operating hours. Incoming supply is entered into
the information system and the physical products are organized by placing them at the most suitable or
most efficient location in the warehouse. The next movement of a specific unit is when an order comes in.
The required products are picked/collected from the warehouse, packed and shipped to the client. Hence,
products are organized both on the way in and the way out. Meanwhile, at the SKU level, there are either
continuous or periodic measurements of inventory levels so that it can be determined how much should be
ordered or produced.
Table 1: Properties of the four analyzed warehouse families.

<table>
<thead>
<tr>
<th>Case</th>
<th>e-commerce</th>
<th>perishables</th>
<th>spare parts</th>
<th>raw materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>volume</td>
<td>high</td>
<td>high</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>mix</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>goal</td>
<td>sales</td>
<td>sales</td>
<td>availability</td>
<td>availability</td>
</tr>
<tr>
<td>variability</td>
<td>high</td>
<td>low</td>
<td>high</td>
<td>low</td>
</tr>
</tbody>
</table>

How is it organized?

The properties of the four warehouse families are summarized in Table 1. Using this, common organizing principles will now be tied back to these properties. The spare parts warehouses are the only family considered to have low volumes. This allows them to be organized by frequency: by putting the most used items in convenient locations, picking efficiency is increased. Doing this in a high volume warehouse would lead to congestion and would thus not be a usable principle. Similarly, because of the low mix of resources in a raw materials storage, it is acceptable for a part of these resources not to be accessible, meaning resources can be stored more densely/space efficient. In any of the other ‘families’ this wouldn’t work because that would mean certain SKUs cannot be retrieved.

Concerning organizing the collection of resources, the goal you have for your resources determines whether it is acceptable to be out of stock when an order comes in. So if the goal is ‘sales’ the principle used for determining inventory levels and make procurement decisions, is to hold an amount equal to the expected demand and balance the costs of unsold resources and missed profits to adjust this number a little. When the goal is availability, the costs of having a shortage are usually immense, either for the company itself or for its customers, and thus an almost perfect availability score should be reached (often captured in service contracts). This is done by using safety stocks; holding an additional amount of inventory on top of the expected demand.

The preferred main organizing principles for any warehouse can thus be determined using these four properties. The attached artifact provides a visual guide to determining these principles.

Where is it being organized?

The case study limits to in-warehouse organization of resources. The locations or network of warehouses, or other parts of the supply chain are out of scope.
### Families of warehouses
A guide to their determining their organizing principles

#### Organization of physical (instances of) resources in the warehouse

<table>
<thead>
<tr>
<th>Storing and retrieving</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>- All locations accessible</td>
<td>- Dense storage</td>
</tr>
<tr>
<td>- Organize by frequency</td>
<td>- Limited access acceptable</td>
</tr>
<tr>
<td>- Traditional aisle layout</td>
<td>- Create flow: in, storage, out</td>
</tr>
<tr>
<td>- Easy</td>
<td>- Automation</td>
</tr>
<tr>
<td>- Automation</td>
<td>- Separated retrieval and picking</td>
</tr>
<tr>
<td>- Random allocation to avoid congestion</td>
<td></td>
</tr>
</tbody>
</table>

#### Organization of the collection of resources

<table>
<thead>
<tr>
<th>Determine inventory levels</th>
<th>Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Forecasts are accurate:</td>
<td>- Variable demand:</td>
</tr>
<tr>
<td>- Inventory levels follow forecasts</td>
<td>- Balance cost of excess product vs missed profits</td>
</tr>
<tr>
<td>- Just-In-Time methods</td>
<td>- Use safety stocks to ensure availability</td>
</tr>
</tbody>
</table>

### Sales

- Forecasts are accurate:
  - Inventory levels follow forecasts

### Goal

- Variable demand:
  - Balance cost of excess product vs missed profits

### Availability

- You know what you need and when:
  - Just-In-Time methods

- Use safety stocks to ensure availability