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DECISION SCIENCE TECHNOLOGY

CASE STUDY

PROCESS RE-ENGINEERING VIA MATH-OPTIMIZATION AND SIMULATION TECHNOLOGY APPLIED TO AN INTENSIVE PICKING DISTRIBUTION CENTER IN THE RETAIL INDUSTRY

Keywords: Process re-engineering – Warehouse optimization – Picking/packing - Distribution – Warehouse – 3PL 4PL

Abstract

For retailers and 3/4PLs, the distribution centers (DC) are one of the most strategic points of the supply chain. World-class company management of the processes and activities in DC makes a significant difference in the net annual profit. Think of the billions tied up inventory passing through the DC daily, 1-3% improvements in efficiency are tremendous.

Excellent management starts with good engineering and design of the physical and logical aspects of the DC.

In this paper we will discuss how a major food retailer improved their operational performance via holistic reengineering of their processes using math-optimization and stochastic & dynamic simulation modeling.

The following contents, refer to a real case, names used in this paper are hidden.

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THE CONTEXT

The case refers to a Retailer "MyRetail Ltd" serving from one of their Distribution Center (DC) about 450 Stores. The DC treats more than 10.000 SKU including food and non-food items.
The SKU's have a wide range of different behaviour in terms of rotation and characteristics as well as a good percentage of them are subjected to intensive seasonality.
The DC is managed by a 3PL Logistics provider. The relation between MyRetail and the 3PL is regulated by a multi-year (SLA) contract where the economics are linked to productivity.
The annual operations cost of the DC in terms of labour is about 11.0m $ per year.

THE PROBLEM

A recent market shift has triggered the need for a structural change between the 3PL logistic provider and its client MyRetail. The 3PL was claiming of a reduction in productivity due to changing of the operational conditions required by MyRetail's new requirements. On the discussion tables between the firms were new products introductions in the assortments and increasing of store campaign promotions, which affect the inventory flow and processes.

On the other hand the Operation Manager at MyRetail, claims that the 3PL quality of Unit Load Devices (ULD or pallets) sent to the stores are dropping. Stores of MyRetail claimed pallets containing wrong mixes of products, pallets with unappropriated shapes or weigh combinations (heavier boxes squeezing other boxes, etc.).
After a validation, by MyRetail of the productivity "of the handling processes " and some revisions of the contracts to match the requests of the 3PL provider, there was not any chance to further decrease the logistic costs, nor the possibility to accomplish the economical requests of the 3PL. So the MyRetail Operations Manager was forced to look for a different and structural process solution.
After a couple of meetings, they outlined an incremental re-engineering roadmap. The backbone of this roadmap was an advanced analytical approach, paramount to understand and improve the outcome of the warehouse processes with the goal based on performance and thus cut operating costs.

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The main numbers:

- 10.740 products
- warehouse surface: 62.000 sq.mt (667.000 sq ft)
- Class A/B/C classification of item: 20% / 65 % /15%
- # of shifts: 2 x 8 hours
- # of pickers per shift: 50
- # of operators: 18
- Average # of pallets shipped per day with picking process: 1800 /day
- Served customers: 450
- # of working day/week: 6/7

THE SOLUTION APPROACH

After a preliminary assessment and evaluation of the main data (operational costs, productivity, saturation of the space, etc.), the team and the Operations Manager identified which levers consider, to reduce costs.
In the warehouse, MyRetailer was using two-ways lines with U-Pick. One of the new options to consider was the switch Z-Pick and one-way. This option would have increased the safety with-in the warehouse and this, apart from the costs aspect, was one of the element to considers because, new acquisitions of stores, were increasing the flows in the distribution center and consequently the traffic in the aisles.
Another alternative that the Operations Manager was open to considering was a Multi-Orders Picking process scheme.

Last but not least, there was the option to seriously improve Slotting management. The slotting was manually adjusted 2 times per year but with significant time efforts of the warehouse manager and his team. Moreover, the slotting was managed only considering main elements like respecting the category and the rotation of the products. There was a strong feeling by MyRetailer, that acting on creating a new slotting policy, they could improve both picking and packing performance and the quality of the pallets shipped.
All these possibilities have to be technically verified and evaluated economically before moving them in the real world.
To manage all the above new scenarios, it was agreed on dynamic simulation model of the DC, with a set of parametric logic (optimizers) to handle correctly the improvement levers – it was the best solution. The tool: Ublique Warehouse Simulator MyRetailer and Ublique team worked on the standard template to collect the large amounts of data, necessary for the models. It was been decided to start with the data of 2 significant weeks of the DC operations as chosen by MyRetailer.

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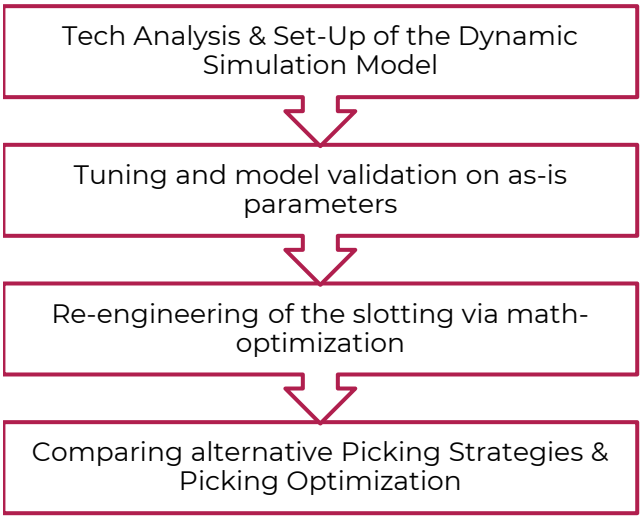
The roadmap for the analysis phase includes the following milestones:



From the engagement process, it was evident and agreed by MYRetail that an advanced warehouse model using mathematics and dynamic simulation focused on improved slotting and picking procedures could solve the problems caused by the market shifts and reduce costs. Why?

The combinations of these technologies called Prescriptive Analytics can provide the highest possible predictions and process evaluations as compared to simple WMS or ERP "reporting only type" systems.

Math modeling with simulation offer compounded "what-if analysis" using Big Data for My Retail to gain insights into solving the problem, whereas regular reporting type business systems offer, limited insights on complex problems.

The Dynamic Simulation model

The scope of the model is to reproduce the picking process with a high level of adherence to the real situation. This means that the simulator must be able to map, with a high level of detail, what really happens. So the model must reproduce the movement of the picking operators, and all the activities absorbing time, like print labels, merging pallets, re-conditioning some pallets etc. A sample top view animation of the warehouse simulation is below.

Layout and network in the simulation model.

The main inputs for the simulator, like in the real DC, are the daily orders transmitted by the stores. Not all the stores are served every day and the ordered quantity changes on a daily basis product by product. The picking is organized based on the transportation schedule, in particular, based on how in specific days more customers are linked to the same truck and the scheduled departure time of the truck for that day.

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All these elements are considered in the model and, most of all, the model must include a detailed management of the warehouse slotting and picking strategy. Finally, an added benefit of the simulation is the animation portion of the warehouse, viewing the picking and packing operation helps sell the concepts and new processes to the warehouse managers and it shifts supervisors as to "why" the processes need to be changed.

Technical tip:

There are several ways to model the same process. These alternatives include a different level of details used by the modeling engineer to represent logic, physical components as well as data. For example, the working of a picking list can be simply modeled by saying the picking list will keep operators busy for a time depending on the number of products to pick. This is feasible and is a good approach in some situations but absolutely not in others. For example, if we need to understand how a different slotting impact is on the productivity, we need to capture this effect molding the real position of the single item.

In other words, the level of details must be consistent with the response that the simulation (or optimization) model must provide.

When the level of details to be included in the simulation (or optimization) model increases, and the data used by these models become more complex, is hard and time intensive to start developing models.

For this reason in this project, it has been used Warehouse Simulator, including, vertical standard pre-built model-templates, which are able to map all the picking processes and Ublique is able to standardize the data model to feed the simulation model and to provide advanced math-optimization logic. Even more: the framework of Ublique Warehouse Module permits an automated portion of the building of the simulation model.

TUNING AND MODEL VALIDATION FOR THE AS-IS SCENARIO

In order to evaluate the possible process improvements deriving from different slotting policies, a new and different strategy such as adding different forklifts, more labour, etc., a baseline comparison is needed by the modeler. When possible, it is a good technique to use the as-is situation as baseline. This also permits the modeler to tune the parameters ensuring the coherence between the real-world and the modeled-world. This was the case for the MyRetail retailer.

Using the standard template provided by Ublique engineers, the MyRetail Operation Manager has committed to collecting of the following data to be used for the analysis.

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The set includes:

- real-orders dataset for a period of x weeks,
- detailed layout,
- current slotting,
- time for the basic operation like pick a standard box and put on the pallet, or print a liable etc.,
- parameters to reproduce the as-is picking strategy,
- number of operators/forklifts per type per shift duration of the working shifts.

The following table shows some of the standard operation time:

Elementary Activity	Time (sec)
Single-case pick form pick-level 0	8
Multi-case pick form pick-level 0	6
Single-case pick form pick-level 1	12
Single-case pick form pick-level 1	9
Final pallet adjustment	30
Pallet wrapping	40
Max standard forklift velocity	6.5 Km/hours

The model reproduced the physical warehouse including aisles, sections, levels, and positions, directions and includes the network with all the distances. The network is used by the virtual-operators in the simulator to move from one point to another. For example: to move from one pick-location to another or, at the end of the picklist, to move to the closer printer station, and then to the dock where the pallets are loaded into the truck. The performance has been evaluated considering also the as-is slotting. The satisfaction of the Operation Manager showed clearly when he saw that the actual productivity measured in the field, with the 3PL was the same as that calculated by the optimization and simulation model. The main as-is KPI are showed below.

KPI	Value in the as-is scenario
Cases/hour picked	142
Total distances per day & week of pickers	1477 km/day
Total volume shipped per day	N/A
# of shipping picking-pallets	9876
Average working time per picking list	21.60 minutes
Utilization of the pickers team	70%
Quality Index of produced pallet (*)	1.64(Category Groups/PL)
Total picking time	3479 Hours
Total distances	8867 km/week
% of moving time / pick time	52% / 48%

(*) this is a KPI that consider how goods of same category /sub-category are split on more pallets or mixed in the same pallet. The max value is 100%.

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RE-ENGINEERING THE SLOTTING VIA MATH-OPTIMIZATION

Why did the MyRetail Operation Manager dedicate a high effort to their slotting policy? After reviewing the simulation model via various **"what-if scenarios"** he was able to "connect the dots": his slotting strategy could improve productivity as well as service levels. When there are several products of different nature (category and sub-category), seasonality, changing of the merchandize assortments, that means a certain number of SKUs will exit and new products have entered in the assortment, that is they need space in the warehouse. For this reason, is NOT easy to manage the slotting.

So, slotting is one of the significant control variables available in the hand of the warehouse manager for process and cost improvements.

The key questions that the Operation Manager asked to the model-engineers was: how can we define a good slotting? How can we compare the goodness of one slotting versus another? What is the objective we want to reach changing the slotting? All good questions.

To answers to these questions let's consider what slotting policies influence:

1. first of all, there could be basic reasons to position certain products in dedicated areas of the warehouse for example, during the summer some type of chocolate must go in a controlled temperature zone or flammable product must stay in a specific restricted area, or product of high economic value must be within a controlled zone where only some staff might access. So if a flammable item is, for any reason, not in the flammable zone, we could call it bad process or anomaly.

2. The sequence of products in the aisles might impact the quality of the pallet (or ULD) the picker is creating. For example, if heavy objects are placed before light ones, the picker not only will have more difficulty in positioning the SKUs on the pallet (= more time) but also there will be the risks that more delicate boxes and products can be damaged. Again, another "anomaly"

3. If there are fast-moving products, probably compacting them in a certain zone will contribute to increasing the picking productivity (a "good process") but if the density of pickers will become too high in that zone this will limit the benefit (another anomaly).

4. If we have some products with really similar packaging (eg. same brand, same colour etc.) and these products are positioned in adjacent locations the picker has a higher probability to make mistakes exchanging one product from another and he not recognizing the mistake (unless each product is scanned), another "anomaly" example.

The previous exemples show that the Operation Manager should limit the "anomalies" to improve productivity, which leads right to the bottom operational budget line.

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Using an XLS spreadsheet "ordering" products to define the slotting makes quickly evident the difficulties: we have contemporarily multiple nature of "anomalies" to avoid and these can also contract each-other and most of all we have a limited space and some physical constraints to respect.

It's clear that they needed sophisticated logic that permits them to define the bad processes and position the products efficiently so to minimize these "anomalies." Not all the "anomalies have the same importance, for example if a product with a box of 10 Kg is positioned after a product of 8 Kg it's not as bad like if it was positioned next to a box of 0.5 kg.

Using the same set of orders, after a classification of the "anomalies" their relative importance with Ublique has created some alternative slotting policies.

The new optimized slotting configuration then is an input to create new simulation scenarios and the performance compared with the as-is.

Several optimization scenarios comparisons have been created with slotting oriented to improve the efficiency of the picking and slotting much more oriented to the service level. The difference between one scenario and the other is the set of parameters enabling/disabling the rules and their priority.

Technical tip:

To optimize the slotting means to find a good compromise among the multiple desires (optimization objectives) and constraints.

This, first of all, requires quantitative criteria to measure the goodness of a certain solution. In Ublique this is done via the concept of "rules" and "anomalies". A rule is a set of SKU criteria that has to be respected in the model. The rules might have a different level of importance (priority level) and anomalies might have a different level of severity. Ublique via a structured process permits users to minimize the global intensity of the anomalies, this means to optimize the slotting respecting the objective of the warehouse manager expressed by the concept of the rules. It has to be noted, that Ublique does not care about the single product only the overall slotting, that is the total intensity of all the anomalies possible and present.

It also has to be highlighted that, even in an optimized slotting environment, that might contain residual anomalies due to physical constraints. Just to give a simple example, if we want a product to stay in the zone with the others of its same category and in this zone, there are no more than 200 locations available the product #201 has to be moved somewhere else (which as a whole, creates the minimum impact on the global level of the anomalies-intensity).

Technological tip:

The data used to create the optimization scenarios with Ublique are only partially the same needed to the dynamic simulator. Indeed, if in the simulator model we need the goods flow (of orders), the information to model movements and picking process,

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and information to characterize the resources, in Ublique the set of information need is to describe the categories, the items and the locations, the compatibilities and incompatibilities and the rules to be respected.

The output is the optimal link product-location and a set of KPI reporting the number of anomalies per type and severity.

COMPARING ALTERNATIVE PICKING STRATEGIES & PICKING OPTIMIZATION

Once the slotting policy has been created the next agreed-upon step of the road map with MyRetailer was to evaluate alternative picking strategies.
The most significant analysis time was addressed to

1. Compare U-Pick versus Z-Pick
2. Evaluate the impact of switch to bi-direction to one-direction way in certain high traffic zone of the warehouse
3. Evaluate the benefit in terms of productivity applying a multi-order picking.

This activity had two steps:

1. by Ublique module to create a different set of picking lists from the same set of orders. The different optimization scenarios refer to a different set of parameters (defining the strategy). The output of the optimization scenarios is the picking lists to be used in the simulation model.
2. By the Ublique Warehouse Simulator; the different picking strategies have been simulated obtaining the KPI in terms of productivity, utilizations as well as traffic, timing.

SCENARIOS COMPARISON AND GLOBAL RESULTS

The scenario analysis had a particular focus on evaluating the effect of a single lever (slotting, picking strategies) in order to evaluate the single effect respect the organization change and eventual costs.

For example what passing from U-Pick to Z-Pick, and what if we enable the multi-order picking? What is the effect of a certain slotting policy respect the current? Once the single components have been evaluated what from the business point matter is the combination total benefit playing the multiple levers that are reasonable to play.

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