Order Picking Optimization as a Service

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Popular summary

"Too much of current warehousing practice is based on rules-of-thumb and simplistic ratios" [1].

Warehouse optimization can be undeniably complex, but also relatable. Everyday routines, such as the order with which one carries out shopping errands, the distribution of items between two shopping bags, or where to store the keys and wallet in the house, have formal analogues in warehouse research (Section 1.3, 1.4, 1.5, respectively). For humans, optimization of such routines is often subconscious. A supermarket shopper, as well as a warehouse picker, have a basic notion of the difference between an "efficient" and "inefficient" routine. But this does not mean that they always follow the efficient routine. Instead, they tend to follow a routine lying somewhere between the efficient and inefficient. It has been developed over years and carries a substantial amount of inertia. Why change that which already works?

The sub-optimality of existing routines is apparent in the domain of complex systems, such as Warehouse Management Systems (WMS). It is often easy to spot weaknesses in a WMS. It may have taken years of development and difficult decisions to get it working, followed by specific patches for multiple other systems that it connects with. Later, when core developers have left, a challenge may be to keep it updated and operational. When new features are needed or something in it fails, subsequent updates include brittle dependencies, erratically drawn connections between modules and spaghetti-code. This is what reality often looks like when consultants are brought in to work on a WMS.

The situation is not much better in the domain of warehouse research. While researchers can publish on topics that sidestep some of the intricacies of real WMSs, contributions cannot answer all questions that lay-persons may be pondering. Questions on warehouse operations, including order-picking optimization, often lack simple answers. Traditional conceptions are challenged by lean manufacturing, cloud-services and automation. Do we even

need warehouses or research on them? Could retailers not ship directly to customers? Or could we reduce warehousing to *cross-docking*, a method aimed at eliminating the need for storage, by instead timing the arrival of shipment trucks and moving products directly between them at docking stations?

We may never have good answers to such questions, but that does not mean that warehouse research is meaningless. In this dissertation, we begin by discussing the problem of what a basic warehouse is and the types of activities that commonly occurs within it. This type of standardization is an important driver not only for research, but for industry as well, as we can only compare operational quality if we have a stable fundament on which to base the comparisons on. A significant portion of the work in this dissertation concerns standardization of common features that are used to represent order-picking problems. Order-picking is widely considered one of the costliest activities in warehouses, and its optimization is both deserving and receiving an increasing amount of public attention.

For our quantitative work, we propose optimization methods for three optimization problems related to order-picking: The Picker Routing Problem (PRP), the Order Batching Problem (OBP) and the Storage Location Assignment Problem (SLAP). Optimization methods are proposed within the context of Software-as-a-Service (SaaS), where they are made accessible to warehouses over the cloud.