Storage Location Assignment in Fast Pick Area: A column generation approach

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1 Introduction

In internal warehousing logistics, the placement of the different items, i.e. SKU (Single Keeping Units), is one of the most impactful decisions on the performance of warehouse activities. The Storage Location Assignment Problem (SLAP) aims at finding an efficient assignment of the SKU to the storage locations. However, the storage decisions must be strongly connected to the routing of the order pickers, to assess the performances of an allocation. In this talk, we focus on the fast pick area (also called forward reserve), where the storage decisions change dynamically, with a very versatile demand. It is therefore interesting in this context to consider the problem with full information on the demand over a time horizon, with a *pick-by-order* structure, where all the items of one order are picked altogether.

2 Related literature and motivation

In the related literature, the Storage Location Assignment Problem (SLAP) has been extensively studied, almost only with class-based storage and frequency information on SKU. Most of the state-of-the-art models have been designed to be easy to implement and to tackle industrial-scale instances. Various solutions methods have been proposed in the form of policy-based heuristics [3]. However, the *pick-by-order* feature, where all SKU of one order are picked altogether in one route, is often not considered with exact distances in mathematical programming, because of the class-based storage organisation. Furthermore, recent work has been made on the integration of storage and routing decisions, but mostly with simulation methods [2]. Few attempts have been made at tackling the problem with full information on demand and order structure [3], and even less with exact methods, the article [1] being the only example to the best of our knowledge. The aforementioned paper focuses on complexity analysis, and solve the problem with a dynamic programming approach. The paper [4] studies a very similar problem, and developed a heuristic algorithm to tackle industrial-scale instances. It accounts for the full information about the by-order structure of the demand, applied to high-level warehouses. Its numerical results are competitive compared to the state-of-the-art class-based methods.

Having a highly-constrained and combinatorial structure, the SLAP problem presents a strong academic interest to get a more thorough comprehension of the interactions between the layout, storage and routing decisions. This version of the SLAP problem was proven NP-hard in the strong sense, even in very simple cases [1], therefore it is particularly challenging for exact methods. It also has a practical interest to model fast pick areas, where the storage assignment changes dynamically in a very versatile context. In fast pick areas, the storage decisions are thus posed at the operational level, and the picking policy gets a bigger impact.

3 Extended formulation

In this talk, we introduce a novel non-linear formulation for the storage location assignment problem, accounting for the *by-order* structure of the demand. The proposed formulation presents a highly-structured constraint matrix, which is prone to decomposition methods. The Dantzig-Wolf reformulation is applied to the SLAP, leading to an integer linear program, which presents the advantages of being independent from both: **(i)** the warehouse layout, and **(ii)** the chosen routing policy for order pickers. The aforementioned two aspects are convexified in the subproblems. The proposed extended formulation is tackled by a column-generation algorithm, with a decomposition of the pricing problems. Preliminary results are encouraging and show a major improvement of the dual bound between a compact mixed-integer formulation and the extended one. Further work is ongoing to further tighten the dual bound, with several families of valid inequalities under study. Future work is planned ahead to integrate the column generation algorithm in a competitive Branch-and-Price-and-Cut solution method.

References

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