Solving the Two-Dimensional Bin-Packing Problem with Variable Bin Sizes by Greedy Randomized Adaptive Search Procedures and Variable Neighborhood Search

Andreas M. Chwatal[1] and Sandro Pirkwieser[1,2]

[1] Destion – IT Consulting, Vienna, Austria
[2] Vienna University of Technology, Vienna, Austria
{chwatal|pirkwieser}@destion.at

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Introduction. In this work we consider a special variant of a two-dimensional bin packing problem where a finite number of bins of different dimensions are given, and a given set of two-dimensional rectangular items must be packed into (a subset of) these bins. This problem obviously has many practical applications, e.g. in the wood, glass and metal industry. For this particular problem variant we require the solutions to be guillotine-cuttable, which means that it must be possible to cut the items from a blank (bin) by only straight slices. The items are allowed to be rotated by 90 degrees.

More formally, we are given a set of two-dimensional objects (items) $I = \{1, \ldots, i_{\max}\}$ with dimensions $w_i \times h_i$, for all $i \in I$ and a set of blanks or bins $B = \{1, \ldots, b_{\max}\}$ with dimensions $w_i \times h_i$, for all $i \in B$. For each blank $b \in B$ we are further given costs $c_b \in \mathbb{N}$. We assume the instances to be feasible, i.e. a feasible packing exists for the given set of items and blanks. The optimization goal is to find a feasible packing with minimum costs of the used blanks. Figure 1 shows an example of such a packing.

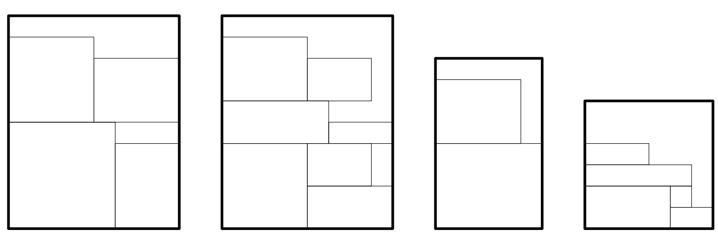

Fig. 1. Exemplary solution using three different bin types

Previous Work. Two-dimensional bin packing problems are a natural extension of the well-known one dimensional bin packing problem. A survey of related work is given in [1]. Whereas most of the according literature deals with problems where an infinite number of identical bins is given, also variants with different bin sizes have been considered. A first such attempt has been made in [2], but however no direct two-dimensional packing solution needs to be derived in this problem variant, but only resource constraints in two dimensions need to be fulfilled by the items packed to a particular bin. In [3, 4] the application of metaheuristics to a problem variant similar to the one considered in this work, however with uniform bin costs, has been investigated. In [5] the authors propose an exact algorithm based on column generation for the problem variant with variable costs and bin sizes and an unbounded number of each bin type.

Algorithms. The subject of this work is to outline an algorithmic (metaheuristic) framework which is capable of solving large scale instances of the given problem fast and accurately, in order to be suitable for practical applications. Further requirements are that the algorithms should be able to be easily adopted to further problem variants with additional constraints, but also parallelizable in order to obtain higher execution speed.

For this reasons we consider solution methods based on *greedy randomized adaptive search procedures* (GRASP) [6] and *variable neighborhood search* (VNS) [7]. In the first step of GRASP a randomized solution construction is performed. Within each step a random choice from a limited set of good extension candidates is selected. The subsequently performed neighborhood search is based on the neighborhoods for the two-dimensional bin packing problem with identical bins proposed in [8]. These neighborhoods are also used within a VNS algorithm which uses increasingly larger neighborhoods to escape local optima.

Preliminary Results and Conclusions. First computational experiments confirm the effectiveness of the considered metaheuristics for the particular problem. For a comparison to existing work the instances provided by the authors of [3, 4] have been used. Detailed results of these experiments will be presented in the corresponding full paper.

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