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A Sequential Value Correction heuristic for a bi-objective two-dimensional bin-packing

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Abstract

In this work we address the orthogonal non-oriented two-dimensional bin packing problem where items are equipped with due-dates and the bi-objective function takes into account both the number of used bins and the maximum lateness of items. We propose a sequential value correction heuristic that outperforms the benchmark algorithm specifically designed for the same problem, and we finally give some insight on the structure of the Pareto-optimal sets of the considered classes of instances.

Keywords: Bin packing, Scheduling, Heuristics

1 Introduction

The Bin Packing (BP) is a well-known combinatorial optimization problem [12]. The two-dimensional basic version (2BP) calls for packing a given set I of n rectangular *items*, described by positive integer widths $w_1, \ldots, w_n$ and heights $h_1, \ldots, h_n$, into the minimum number of identical rectangular *bins* of size $W \times H$, with $W \geq w_i$ and $H \geq h_i$, $i = 1, \ldots, n$. In general, a packing is feasible if items are completely contained within bins and do not overlap to each other, but a number of further pattern restrictions have been investigated in the last decades, e.g., see [16] for a comprehensive classification. In this work

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we focus on the case, known as the *orthogonal non-oriented* BP (2RBP), where the edges of items must be parallel to the edges of bins and 90° rotation of items is allowed.

The two-dimensional BP arises, together with its cutting counterpart, in several real world applications such as truck loading and warehousing in logistics, or cutting optimization in manufacturing. Application of 2BP can be also found in the telecommunications field: in [10] the authors model the downlink subframe allocation problem in Mobile WiMAX technology as a 2BP where items are group of data packets and bins represent slots of time and frequency.

Bin packing solutions, although optimal with respect to the bin allocation efficiency, may be not attractive when the solution quality also depends on the way items are allocated over time: when bins are packed in sequence and the allocation of each item $i \in I$ can be regarded as a task that is due by a date d_i, also the optimization of typical scheduling objective functions such as weighted tardiness, number of tardy jobs or maximum lateness can be of interest. Indeed, scheduling issues in packing problems are recently receiving an increasing attention. The authors of [2] and [15] propose Integer Linear Programming formulations for the minimization of the number of bins and the weighted tardiness in the one-dimensional cutting stock problem, whereas the minimization of a convex combination of number of bins and maximum lateness has been investigated in [1].

In this paper we consider the bi-criteria 2RBP problem with due-dates (2RBP-DD) described in [5]. We assume, as in [5], that the packing of each bin requires a given constant time P and that the completion time C_i of each item allocated to the k-th bin in the sequence is equal to kP, i.e., we suppose that items are released only when the packing of the relevant bin is completed. The bi-objective function takes into account both the number z of used bins and the maximum lateness $L_{max} = \max_{i \in I} L_i$, where $L_i = C_i - d_i$ defines the lateness of items i. A Sequential Value Correction heuristic (SVC-DD) for the 2RBP-DD problem is described in Sec. 2 and improved dual bounds for the single objective functions are proposed in Sec. 3. Finally, in Sec. 4 the non-dominated solutions obtained by SVC-DD are analysed and compared with the benchmark reported in [5].

2 A SVC heuristic

The underlying idea behind a sequential value correction algorithm for BP is quite simple: given a *pseudo-price* p_i for each item $i \in I$, bins are packed sequentially, each one with the items not yet allocated that maximize the