The three-dimensional rectangular Multiple Bin Size Bin Packing Problem with transportation constraints

A case study in the field of air transportation

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According to the International Air Transport Association and Air Transport Action Group, 51.3 million metric tons of goods were transported by airlines in 2014. To transport luggage, freight and mail, special containers, called Unit Load Devices (ULD), are used. The method of loading packages into ULDs represents a key element for cargo safety and aircraft weight and balance, as well as for the economy of airline companies.

This thesis aims to solve the problem of packing a set of boxes into containers of various shapes without wasting loading space. The goal is to select the best set of ULDs to pack all the boxes achieving a minimum unused volume. As for all the packing problems, geometric constraints have to be satisfied: items cannot overlap and have to lie entirely within the bins. The richness of this application is to manage additional and common constraints: the bin weight limit, rotations, stability and fragility of the boxes, and weight distribution within a ULD. In practice, this problem is manually solved with no strict guarantee that the constraints are met.

First, the problem is formulated as a mixed integer linear program. As this problem is NP-hard, it opens the way to heuristics. A second approach makes use of the formulation to apply three matheuristic methods, combining exact approaches and heuristics. Third, a tailored two-phase constructive heuristic is developed for this specific problem; it aims to find good initial solutions in short computational times. These approaches contain parameters that have been tuned using the `irace` parametrisation technique. For the experiments, several instances have been created on the basis of a box data set which stems from a real world case.