

Communication Title: Several constructive heuristics for the three dimensional Multiple Bin Size Bin Packing Problem with air transportation constraints

Authors: C. Paquay¹, S. Limbourg¹, J.F. Oliveira² and M. Schyns¹

Affiliation: ¹University of Liege (ULg), HEC Management School, QuantOM

²INESC TEC, Faculdade de Engenharia, Universidade do Porto

Abstract:

The problem tackled here is the selection of containers in order to pack a set of cuboid boxes. The aim is to minimize the unused space inside the selected containers. The set of boxes is highly heterogeneous while there are few types of containers to select. This is a three dimensional Multiple Bin Size Bin Packing Problem (MBSBPP) in which, in addition to the geometry constraints, some additional constraints encountered in practical packing situations are considered: the container weight limit, the orientation constraints, the load stability, the load-bearing strength or fragility of the boxes and the weight distribution within a container.

Moreover, as the original problem is an air cargo application, we extend the definition of the MBSBPP to include situations in which the large objects may be truncated parallelepipeds. Indeed, in this context, containers are called Unit Load Devices (ULD) and may have specific shapes to fit inside aircraft.

The first approach was to develop a mixed integer programming formulation for this optimization problem and to solve it with branch-and-bound algorithm. This model has been implemented in Java, using CPLEX library, and tested on small instances. As expected, the computational times were rather important. Therefore, the aim of the current research is to develop set of constructive matheuristics based on that formulation.

Our first try is to adapt the Relax-and-Fix (R&F) heuristic which is an iterative procedure which decomposes a large-scale MIP problem into several easier subproblems in order to get an initial feasible solution for the original problem. The integrality restriction of some variables is relaxed in subproblems, reducing the computational times. Two other MIP-based constructive heuristics, inspired from the R&F heuristic, have also been developed adapted to our context. The Insert-and-Fix (I&F) heuristic relies on the idea to insert boxes step by step inside containers. In addition to this heuristic, the Fractional Relax-and-Fix (FRF) heuristic is based on the merge between the two previous methods: at each iteration of this algorithm, a set of boxes is inserted (as in the I&F) while a subset of their variables has the integrality restriction relaxed (as in the R&F). These three MIP-based constructive heuristics are compared to a greedy best-fit decreasing algorithm designed especially for this purpose.

Keywords: bin packing, air transport, matheuristics