A relax-and-fix heuristic for the three-dimensional bin-packing model with transportation constraints

C.Paquay
HEC-ULg, QuantOM
cpaquay@ulg.ac.be

M.Schyns
HEC-ULg, QuantOM
M.Schyns@ulg.ac.be

S. Limbourg
HEC-ULg, QuantOM
Sabine.Limbourg@ulg.ac.be

December 18, 2013

Our problem is to pack a set of boxes into a selection of containers of various shapes. This problem belongs to the family of cutting and packing problems, which represent a key topic in operations research. We can label it as a three dimensional Multiple Bin Size Bin Packing Problem (MBSBPP) using the typology defined by [5]. Indeed, this is an input minimisation problem for which the dimensions of all objects are fixed, the small items being strongly heterogeneous and the assortment of large objects, i.e. the containers, weakly heterogeneous. Since our problem is a packing problem in three dimensions, it therefore also belongs to the family of Container Loading Problems according to the definition given in [1].

In this work, we extend the definition of the MBSBPP to include the situations in which the large objects may be truncated parallelepipeds. This is of particular importance in the field of air transportation. In this context, containers are called unit load devices (ULD). A ULD is an assembly of components consisting of a container or of a pallet covered with a net, so as to provide standardised size units for individual pieces of baggage or cargo, and to allow for rapid loading and unloading ([4]). ULDs may have specific shapes to fit inside aircraft.

Our first aim was to provide a mathematical linear model for this problem ([2]). This model takes into account the following set of constraints: the geometric constraints (the boxes lie entirely and without overlap inside the containers) the container weight limit (the total weight of the contents of a container cannot exceed a defined capacity), the orientation constraints (boxes can rotate inside the containers), the load stability, the load-bearing strength or fragility of items and the weight distribution within a container. As announced, we also take into account the specific shape of the containers.

This model has been implemented in Java, using CPLEX library, and tested this model on small instances. It includes a 3D interface that allows us to display the results from different angles and to zoom in and out.

Our next step is now to develop a constructive heuristic in order to start with a good initial solution. We choose to try the relax-and-fix method developed in [3].

Acknowledgement This work was partially funded by the Interuniversity Attraction Poles Programme initiated by the Belgian Science Policy Oce (grant P7/36).

References

[1] Bortfeldt, A. and G. Wäscher (2013). Constraints in container loading - A State-of-the-Art Review. *European Journal of Operational Research 229*, 1–20.

[2] Paquay, C., Schyns, M., and Limbourg, S. A Mixed Integer Programming formulation for the three dimensional bin packing problem deriving from an air cargo application. Submitted to *International Transactions in Operational Research*.

[3] Pochet, Y. and L. A. Wolsey (2006). *Production Planning by Mixed Integer Programming*. Springer Series in Operations Research and Financial Engineering.

[4] Limbourg, S., Schyns, M., and Laporte, G. (2011). Automatic Aircraft Cargo Load Planning. *Journal of the Operations Research Society* (0), 1–13.

[5] Wäscher, G., H. Haußner, and H. Schumann (2007). An improved typology of cutting and packing problems. *European Journal of Operational Research 183*, 1109–1130.