INSA Rennes, 4GM- Programmation mathématique avancée et applications

Projet Julia : Bin packing problem by branch-and-price

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Problem description :

Consider a company that wants to solve the problem of how to load its trucks with the products that will be sent to its customers. Let the set of trucks be given by $T = \{1, \ldots, t\}$ and the set of products to ship given by $P = \{1, \ldots, p\}$. We will assume in the following that each truck has a volume of V, and the volume of each product is given by v_p for $p \in P$. To simplify things further we will assume that we can load a truck with any set of products S such that the total volume of the products in the set is smaller than the volume of the truck, *i.e.*, $\sum_{p \in S} v_p \leq V$. The company wants to be able to send all the products to its clients with a minimum number of trucks (it is assumed that t is sufficiently large so that all the products can be sent with at most t trucks).

This problem is known in the operations research literature as the bin packing problem. The objective of this project is to implement the branch-and-price algorithm for the bin packing problem, and test its performance on various instances from the literature.

Organization :

The project will be done in groups of 2 or 3 students, and is **to be delivered before May 18th 2020**. Each group will be expected to deliver their code as well as a technical report detailing their work, and do a 15-minute presentation. It is strongly advised that each group find a weekly work schedule in order to advance in a timely and consistent manner.

Instances :

A number of instances, called the Falkenauer instances, for the bin packing problem can be found here. The structure of each instance file is described therein, and a link for access to the instance files are provided. You should develop a parser and define the appropriate data structures to be able to read and store these instances.

Further instances and many references for the bin packing problem can be found here. This source also contains a link to the optimal solutions of all of the instances presented therein (including the Falkenauer instances). It may therefore be a great source of reference to verify your implementation.

Expected work :

The minimum requirement for the project is to implement a correctly working branch-and-price algorithm for the bin packing problem. To this end, each group is expected to verify their implementation with multiple instances and with a mixed integer programming solver (using a classical integer programming formulation of the problem), or using the optimal solutions given through this link. You are free to choose among the three different options proposed during the course for handling the branching constraints.

Once you have a correct implementation you may consider the following improvements :

- Develop and implement a heuristic to obtain an initial feasible solution
- Implement a dynamic programming algorithm/heuristic to solve the subproblems
- Develop and implement heuristics to find feasible solutions throughout the algorithm
- Explore different node processing rules/branching variable selection rules

You may also consider numerically comparing different implementations of the algorithm based on the three options of handling the branching constraints.

You should compare the numerical performance of your final algorithm to that of an integer programming solver.

Going further :

There are many aspects of the column generation and branch-and-price algorithms that have not been covered during the course. Notably, the stabilization techniques, strong branching and diving heuristics are among those methods that are behind a successful implementation of the branch-and-price algorithm. Groups that will research one or more of these topics and incorporate them to their implementation will earn bonus points on the project.