STSM: SCIP for Vector Packing

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Filipe Brandão

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1 Purpose of the STSM

The purpose of the STSM was the analysis of SCIP on an arc-flow formulation for vector packing proposed in Brandão and Pedroso (2013). This analysis includes the study of the most effective components of SCIP on the formulation and the identification of good parameter settings.

Vector packing is a combinatorial NP-Hard problem with several applications, some of which are related to energy. For instance, on scheduling problems on cloud computing where there are tasks that need to be assigned to nodes in such a way that the number of nodes is minimized. Moreover, since the cardinality constrained bin packing problem can be solved as a vector packing problem, there is also another important application related to nuclear energy with the objective of optimizing the spent nuclear fuel deposition in deep repository (see, e.g., Zerovnik et al. 2009).

Improving the performance of SCIP on the arc-flow formulation for vector packing can be beneficial since currently on large models it is usually necessary to use commercial MILP solvers and SCIP with some refinements may be a good replacement for the commercial solvers.

2 Work report

Several components of SCIP were analyzed during this STSM. We started by identifying that strong branching (the default branching rule) was not the best branching rule for the arc-flow formulation since it requires the solution of several LP problems and the model is sometimes difficult for LP due to the high number of variables and constraints. According to several experiments, the best branching rule on SCIP for the arc-flow formulation seems to be inference branching. Moreover, the node selection strategy that seems to work best is depth first search with periodical selection of the best node.

The time spent on presolving was reduced since it has little effect on the model and the cutting planes were disabled since the formulation is already very strong and hence the computation of cutting planes on these models is in most instances a waste of time.

Since the arc-flow formulation is a very strong formulation and hence it is usually easy to prove optimality, the most difficult part is to find feasible solutions. We therefore increased the time spent in heuristics in order to spend more time looking for solutions. The heuristics that seem to be more effective on the arc-flow formulation are Feasibility Pump, RINS and DINS. Some simple diving and rounding heuristics also seem to be effective.

After the identification of the most effective components of SCIP on the arc-flow formulation, its performance improved a lot and now it is more competitive with other solvers. On a small dataset composed by 45 instances, the average run time decreased from 20 seconds to 10 seconds and the number of solved instances (within a five-minute time limit) increased from 32 to 41. The geometric mean of the run time decreased from 1.48 to 0.93. Nevertheless, there is still some work to do in order to reach a performance closer to the performance of commercial solvers.

The collaboration with the SCIP developers was fundamental to perform this case study. Considering some improvements on SCIP that can still take some effort to do, the collaboration with the host institution will certainly continue after this STSM.

References

Brandão, F., Pedroso, J. P., 2013. Bin Packing and Related Problems: General Arc-flow Formulation with Graph Compression. Technical Report DCC-2013-08, Faculdade de Ciências da Universidade do Porto, Portugal.

Zerovnik, G., Snoj, L., Ravnik, M., 2009. Optimization of Spent Nuclear Fuel Filling in Canisters for Deep Repository. Nuclear Science and Engineering 163 (2), 183–190.