Resolution of mixed-variables problems in LocalSolver

Olivier Rigal
LocalSolver
36 Avenue Hoche, 75008 PARIS
e-mail : origal@localsolver.com

1 Context

LocalSolver is a model-and-run mathematical optimization solver combining different operations research techniques [2]. It uses a local search heuristic but also linear programming and non-linear programming.

We study the resolution of mixed-variables optimization problems. Those problems are the ones which use products of combinatorial and continuous variables. They appear for instance in production planning problems where a boolean variable activate the production and a continuous variable decide on the quantity produced.

We limit the study to the problems where, when the combinatorial affectation is fixed, the remaining continuous sub-problem is linear. A classic local search approach has poor performance on this type of problem, because it is ill-adapted to the processing of continuous sub-problems.

2 Resolution method

The resolution method implemented in LocalSolver consists in adding a reparation phase after each local search move. Specifically, at each iteration, a local search move modifies the combinatorial affectation in the current solution. Then, the combinatorial variables are fixed, and we try to repair the continuous part of the problem. This repair consists in solving at the optimum the continuous and linear sub-problem thanks to the simplex algorithm. After that, all of those modifications are evaluated and accepted or rejected by the LocalSolver heuristic.

This resolution method combines the strong performance of local search approaches on purely combinatorial problems and the simplex algorithm which can solve linear continuous problem in a short time. This method has already been tested on specific problems like the Unit Commitment Problem [3] and the Inventory Rooting Problem [1]. The implementation of the method inside LocalSolver has made it more generic because it can now be applied to a large range of mixed-variables problems.

3 Improvement of the method

3.1 Acceleration of the descent

With a naive implementation, we remark that a large proportion of the resolution time is spent to solve the continuous sub-problems. To limit this phenomenon, a range of check was implemented to detect quickly some sub-problems which will not improve the current solution. For instance, we use the Farkas Lemma that gives an unfeasibility certificate of a linear continuous problem. Those certificates are exploited to detect infeasible sub-problems.

3.2 Targeting of variables

Another improvement of the method consists in a better targeting of the combinatorial variables to modify in the local search moves. In order to do that, we use the data provided by the simplex algorithm. When the current solution is unfeasible, we use the Farkas certificate to direct the local search towards a feasible solution. When the current solution is feasible, we use the dual data to improve the optimal value of the sub-problem.

4 Results

The method provided a marked improvement in the performance of LocalSolver for different class of problems. Those improvements are particularly important for the Network Design Problem for which we generated a set of instances. Another class of problems that we tested is the Inventory Rooting Problem. We used the Inventory Routing over a finite periodic planning horizon of the OR Library [1]. On those instances, a medium improvement of more than 25% can be observed after 5 minutes of optimization.

Références

[1] T. Benoist et F. Gardi *Randomized Local Search for Real-Life Inventory Routing*, Transportation Science, 2011

[2] F. Gardi, T. Benoist, J. Darlay, B. Estellon, et R. Megel. *Mathematical Programming Solver Based on Local Search*, Wiley, 2014.

[3] F. Gardi et K. Nouioua. *Local Search for Mixed-Integer Nonlinear Optimization : A Methodology and an Application*, Springer Berlin Heidelberg, 2010

1. http ://people.brunel.ac.uk/ mastjjb/jeb/info.html