Scientific Report*
New MIP techniques for branch-and-cut approaches for large-scale problems, part II

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Host: Matteo Fischetti
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1 Purpose of the STSM

The aim of the STSM was to continue the work with the group of Matteo Fischetti, which started with a STSM in April this year. In this joint work, we focus on the Steiner tree problem (STP) and variants of this problem, to try to design new MIP techniques for branch-and-cut approaches to deal with very large-scale problem instances. The STP and its variants were chosen with the *11th DIMACS challenge* [1] in mind, which is devoted to these kind of problems. In particular, our focus was the prize-collecting Steiner tree problem (PCSTP), where both Matteo Fischetti and my PhD-advisor Ivana Ljubic are co-authors of one of the state-to-art papers [1].

2 Description of the work carried out during the STSM

We implemented three different dual ascent procedures for the PCSTP. Aside from lower bounds, these approaches also produce GSEC and cut inequalities. We use these inequalities in our branch-and-cut algorithm by either statically adding them in the beginning or by means of a cut-pool. Primal heuristics for the STP were also transformed to the PCSTP to complement our framework. Following the approach suggested in [2] for the Steiner tree problem, we also run the primal algorithms on the support graphs produced by the dual ascent algorithms. We then tested our branch-and-cut framework against the state-of-the-art algorithm from [1] (which is freely available online [2]). Our approach produces optimal solutions much faster most of the time and we were able to solve most of the unsolved instances from [1]. We also worked on a Lagrangian approach, which unfortunately was not competitive with our branch-and-cut framework.

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[1] http://dimacs11.cs.princeton.edu/

[2] http://homepage.univie.ac.at/ivana.ljubic/research/pcstp/

3 Future collaboration with the host institution

The current work is still ongoing and may result in further research visits. Moreover, some of the developed ideas may also be adapted to other problems in a future collaboration.

4 Foreseen publications

Right now we are preparing a paper for the workshop of the 11th DIMACS challenge. It is planned to expand this paper and to submit the expanded version to the special issue of *Mathematical Programming Computation* associated with the challenge.

5 Confirmation by the host institution of the successful execution of the STSM

Sent by Matteo Fischetti.

References

[1] I. Ljubić, R. Weiskircher, U. Pferschy, G. W. Klau, P. Mutzel, and M. Fischetti. An algorithmic framework for the exact solution of the prize-collecting Steiner tree problem. *Mathematical Programming*, 105:427–449, 2006.

[2] T. Polzin. *Algorithms for the Steiner problem in networks*. PhD thesis, University of Saarland, 2003.