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

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1 Purpose of the STSM

The aim of the STSM was to start to work with the group of Matteo Fischetti on new MIP techniques for branch-and-cut approaches to deal with very large-scale problem instances. The main problem considered to test these new techniques is the Steiner tree problem (STP). There exists already a very large amount of literature for this problem, but some instances have remained notoriously hard and/or unsolved for over a decade after publication, see, e.g., instance sets PUC or I640 from the well-established benchmark-set `SteinLib`[1] [4]. Moreover new very-large and hard to solve instance sets with real-world applications have also appeared recently, see, e.g., [5]. It should be noted that the problem also proves to be quite resistant against branch-and-cut approaches, the most successful exact methods use tailored combinations of lower bounding procedures, heuristics and problem reduction techniques, see [1, 6]. Variants of the STP like the prize-collecting STP, or the node-weighted STP, are also part of our investigation.

2 Description of the work carried out during the STSM

The STSM was used to learn about the state-of-the-art in MIP techniques for branch-and-cut and to adapt and implement them for the STP. These methods include local branching and proximity search, which are both techniques where Matteo Fischetti was involved in the original work [2, 3]. Thus this STSM was a great opportunity for me to learn about these approaches. A heuristic based on variable fixing and different branching strategies were also implemented. Furthermore, we experimented with constraints, which remove non-optimal feasible solutions from the feasible region. A careful combination of these techniques, taking into account the problem structure of the STP, allowed our implementation to obtain a better feasible solution than the best published one for of the unsolved instances from `SteinLib`. Since we only considered a small set of instances for testing so far, our implementation may provide better feasible solution for other unsolved instances from `SteinLib` or may be even able to solve some of these instances to optimality. Aside from this, a new Lagrangian approach for the prize-collecting STP was also discussed.

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[1] http://steinlib.zib.de/showset.php?PUC

3 Future collaboration with the host institution

This STSM was the starting point of our joint work and further research visits are already in the planning stages.

4 Foreseen publications

It is planned to publish our obtained results for the STP in a paper. Moreover, the discussed Lagrangian approach for the prize-collecting STP may also result in a publication.

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

Sent by Matteo Fischetti.

References

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[4] T. Koch, A. Martin, and S. Voß. *SteinLib: An updated library on Steiner tree problems in graphs*. Springer, 2001.

[5] M. Leitner, I. Ljubic, M. Luipersbeck, M. Prossegger, and M. Resch. New real-world instances for the steiner tree problem in graphs. Technical report, ISOR, University of Vienna, 2014.

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