Report on the Short-Term Scientific Mission at Tilburg University (30.4 – 6.5.2016)

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This report concerns the second part of the short-term scientific mission to Tilburg University in the first week of May, 2016. The overall goal of the three week long visit was to establish a collaboration between the researches from FAU and Tilburg University in order to study challenging two-stage robust optimization problems that occur in energy networks.

In the first two weeks of the collaboration, different approaches to tackle potential driven networks with potential functions under uncertain scaling were proposed. We discussed important special cases like tree structured networks with potential uncertainty as well as demand uncertainty. Our focus then shifted to simple general networks with a small number of cycles (typically one or two). Since our approaches for the tree-like networks were not applicable anymore, a new strategy using polynomial optimization was considered. As the problem admits a very natural algebraic representation, using polynomial optimization is a logical next step for this type of problem. In this setting, two approaches were discussed.

The first idea deals with certifying infeasibility of a given uncertain potential driven network problem. The tools of polynomial optimization approximate the real, generally non-convex, problem by a series of convex relaxations that are exact at the limit. Because of computational constraints, it is unpractical to consider more than the first few elements of this series. Due to the relaxation property of polynomial optimization, a solution of our proxy problem correctly identifies infeasibility, but has no implications for a feasible uncertain problem.

The second idea was developed during the last week of my visit. It seeks to complement the first approach by giving a certificate for a feasible potential driven network flow problem under box uncertainty. Robust feasibility can be reduced to a set containment problem after a projection step. After projecting out all original variables, a problem in the uncertain parameters remains which can then be checked for feasibility via a set containment approach.

The last days of the short-term scientific mission were dedicated to the concretization of the set containment idea together with Prof. Dr. Juan Vera. During our discussions,

new and previously unknown observations (e.g. non-convexity) regarding the feasible set of the problem were made. Using a connection between the direction of the flows along the network's arcs and the uncertainty set, we were able to further simplify the problem and partition it into a number of subproblems. By exploiting these observations, we were finally able to transform the projection step into an equivalent problem which can be solved with polynomial optimization.

In the upcoming months, we will continue our collaboration with Tilburg University on the subject. Areas of future reasearch include the extension of the set containment approach to general networks with any number of cycles as well as more complicated uncertainty regions (e.g. ellipsoids). Some practical demonstrations of the models and a possible publication of the developed approaches is also part of our agenda.