COST Action TD1207

Short Term Scientific Mission Report

(STSM Ref. Num. COST-STSM-TD1207-26522)

"Robust Optimization for Uncertain Unit Commitment Problems
with Quadratic Cost Function"

General info

- **Proposer:**
  Dr. Fabio D'Andreagiovanni (Senior Researcher)
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  - DFG Research Center MATHEON, Technical University Berlin, Berlin, Germany
  - Einstein Center for Mathematics Berlin (ECMath), Berlin, Germany
  - Istituto di Analisi dei Sistemi e Informatica, Consiglio Nazionale delle Ricerche (IASI-CNR), Roma, Italy

- **Host:**
  Dr. Claudia D'Ambrosio (Senior Researcher)
  - Centre National de la Recherche Scientifique (CNRS), France
  - Laboratoire d'Informatique de l'X (LIX), Ecole Polytechnique, Palaiseau, France

- **Period:** 22.03.2015 - 28.03.2015

Purpose of the STSM

The main purpose of the short term scientific mission has been to establish a new collaboration about robust optimization of power systems between the mission proposer, Fabio D'Andreagiovanni, and the mission host, Claudia D'Ambrosio, aimed to find new synergies between the respective knowledge of theory and applications of Robust Optimization and of Mixed Integer Non-Linear Programming (e.g., [1, 3, 4]). The main scientific purpose has been to start a detailed study about the computational behaviour of realistic robust versions of the classical unit commitment problem, taking into account major sources of data uncertainty that naturally affect the problem.

More in general, the STSM has been aimed to establish a new research connection between the *Department of Optimization* of *Zuse Institute Berlin* (ZIB) and the *Laboratoire d'Informatique de l'X* (LIX) of *Ecole Polytechnique*.

Description of the work carried out during the STSM

We focused our attention on an uncertain version of the *Unit Commitment Problem* (UC) taking into account the uncertainty affecting the market price of energy. We have initially jointly analyzed the literature available about the problem, in particular referring to the recent survey [6]. Then we have identified a reference mathematical programming formulation of the UC that we have used as basis for our study. This formulation presents a quadratic cost function. Additionally, we have also included a strengthening of canonical minimum up and down time constraints that was proposed by Rajan and Takriti [5].

After having identified this basic formulation, we have derived a robust version of it according to the principle of Robust Optimization, considering cardinality-constrained uncertainty sets (see [2]).

During the visiting, D'Andreagiovanni has worked to develop a first code in C/C++ implementing the reference formulation. The code is interfaced directly with the commercial optimization solver IBM ILOG CPLEX through Concert Technology libraries. Currently, the code is under debugging and first experiments based on realistic instances are being executed to operate a first assessment of the computational performance of the reference formulation. On the basis of this first computational experience, we will decide how to continue the investigations, in particular identifying promising directions for developing new solutions algorithms improving the performance of CPLEX when used for the UC.

Description of the main results obtained

Besides having jointly reviewed the available literature about the use of robust optimization in uncertain unit commitment problems, we have:

1. derived a robust optimization formulation for the uncertain version of the unit commitment problem with quadratic costs that we have taken as reference;

2. developed a first C/C++ code to implement the robust optimization model for the unit commitment that we have derived;

3. executed preliminary computational experiments on realistic instances that will be analyzed and used as basis to decide how to proceed towards the development of more effective and efficient solution algorithms.

The activities done and the results obtained have followed the program of the mission that was submitted for funding approval.

Future collaboration with the host institution

Both the proposer and the host hope that the STSM will be the starting point of a more long-term cooperation about optimization of power systems between them and their two research institutions. A new visit of the proposer is expected to take place in 2015, possibly before the Fall. A visiting of the host at Zuse Institute Berlin is also expected before the end of the year.

Foreseen publications/articles resulting from the STSM

A critical objective of the ongoing collaboration is to derive new insights about the uncertain unit commitment problem that will be worth to be published in an international scientific journal and be presented at international conferences. Given the availability of new results by the submission deadline, the proposer and the host intend to present the first results of the joint work at the PGMO DAYS 2015 (October 2015, ENSTA Paris Tech, France), which is part of the *Gaspard Monge Program for Optimization and operations research* (PGMO) and is sponsored by the electric utility company EDF.

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

The confirmation was produced by the host researcher, Claudia D'Ambrosio.

Essential references

[1] T. Bauschert, C. Büsing, F. D'Andreagiovanni, A.M.C.A. Koster, M. Kutschka, U. Steglich: Network Planning under Demand Uncertainty with Robust Optimization, IEEE Communications Magazine 52 (2), 178-185, 2014

[2] D. Bertsimas, D. Brown, C. Caramanis: Theory and Applications of Robust Optimization, SIAM Review 53 (3), 464-501, 2011

[3] C. Büsing, F. D'Andreagiovanni: New Results about Multi-band Uncertainty in Robust Optimization. In: Klasing, R. (ed.) Experimental Algorithms - SEA 2012, LNCS, vol. 7276, pp. 63-74. Springer, Heidelberg, 2012

[4] C. D'Ambrosio, A. Frangioni, L. Liberti, A. Lodi: A Storm of Feasibility Pumps for Nonconvex MINLP, Mathematical Programming, 136 (2), 375-402, 2012

[5] D. Rajan, S. Takriti: Minimum Up/Down Polytopes of the Unit Commit-
    ment Problem with Start-Up Costs, IBM Research Report RC23628, 2005

[6] M. Tahanan, W. van Ackooij, A. Frangioni, F. Lacalandra: Large-scale
    Unit Commitment under uncertainty : a literature survey, 4OR-Q. J. Oper.
    Res., DOI: 10.1007/s10288-014-0279-y, 2015