MISOCP Relaxations for the Unit Commitment Problem with AC Power Flows

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Abstract

In short-term electrical power systems planning, there are two fundamental problems: Unit Commitment (UC) and Optimal Power Flow (OPF). Generally, these two problems are solved in a serial manner although the former contains a simplified version of the latter. In particular, the system operator solves the UC problem daily to decide which generators will be used for power generation in the next one or two days. Then, the OPF problem is solved in every 5-15 minutes to decide the amount of energy produced by each generator in order to satisfy the real time electricity demand.

There are two approaches to solving OPF problem: one uses the alternating current (AC) power flow equations, and the other one utilizes the direct current (DC) power flow approximation. Since AC power flow equations introduce nonconvexities, it makes the problem more challenging. Hence, the DC approximation of the power flow equations is generally used in the UC problem as a subproblem. However, this approach may lead to inaccurate generator commitment decisions, especially for congested power systems since it ignores the power losses in the network. Thus, solving the UC problem with AC power flow equations as a mixed-integer nonlinear program (MINLP) would be a better approach, however, there is only a limited number of studies in the literature utilizing this approach.

In this work, our approach is to solve the UC problem with AC power flow equations to find a feasible schedule for both generation commitment status and power generation amounts simultaneously. We develop a base algorithm which consists of two phases. The first phase of the base algorithm solves a mixed-integer second order cone programming (MISOCP) relaxation of the UC problem with AC power flow equations. In the second phase, the optimal solution of the MISOCP relaxation, which provides the generator commitment statuses, are fixed and a multiperiod OPF problem with AC power flow equations is solved using a local solver to find a feasible solution to the original MINLP. Hence, the algorithm outputs an upper bound in the second phase, and we compute its quality using the lower bound obtained in the first phase.

In the computational experiments, the base algorithm provides promising results for small-size instances. However, for bigger instances, the MISOCP problem becomes challenging to solve. Hence, we adopt a decomposition method and add valid inequalities originally derived for the UC problem with the DC power flow approximation. To obtain even better lower bounds, we strengthen the MISOCP relaxation by adopting the recent convexification approaches proposed for the SOCP relaxation of the OPF problem. These additions to the base algorithm have led to an enhanced algorithm, which has promising outcomes for solving the UC problem with AC power flow equations in an efficient manner, with more accurate solutions compared to the existing methods from the literature.

Keywords
Unit commitment problem, optimal power flow problem, mixed integer second-order cone programming, integer programming.

Biographies

Burak Kocuk is an assistant professor at the Industrial Engineering Program, Sabancı University. He obtained his BS degrees in Industrial Engineering and Mathematics, and MS degree in Industrial Engineering from Boğaziçi

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