Graph-Theoretic Algorithm for Nonlinear Power Optimization Problems

In this talk, we study a general mixed-integer nonlinear optimization problem using a convex relaxation named semidefinite programming (SDP). The existence of a rank-1 matrix solution to the SDP relaxation enables the recovery of a global solution of the original problem. We propose a graph-theoretic technique to sparsify the optimization problem of interest such that its SDP relaxation will have a guaranteed low-rank solution. We also discuss the implications of this technique. For instance, we show that the IEEE 300-bus system is already so sparse that the SDP relaxation of every security-constrained unit-commitment optimal power flow problem defined over this network has a matrix solution with rank at most 11 which would reduce to 3 after applying our sparsification method. This helps find a near global solution to the original optimization problem by approximating the low-rank SDP matrix with a rank-1 matrix. In this talk, we also derive a single number for each power network that shows the complexity of solving a nonlinear optimization over that network.