Preserving Confidentiality of Sensitive Information in Power System Models

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Abstract:

The electric power grid is a critical infrastructure that is vulnerable to physical and cyber attacks. As a result, data describing grid topology and components is considered sensitive information. There is also increasing need to foster cooperation among the participants in microgrid-enabled electric marketplace. However, to maintain their economic competitiveness, the market participants are not inclined to share their sensitive information with other participants. Motivated by this need for increased cyber-physical security and economic confidentiality, the project is developing techniques to obfuscate sensitive design information in power system models without jeopardizing the quality of the solutions obtained from such models. In [1], we proposed a solution approach to hide sensitive structural information in the Direct Current Optimal Power Flow (DCOPF) problems. DCOPF are usually formulated as an optimization problem with linear constraints with either linear or quadratic objective. In this approach, the power system operator first obfuscates all the sensitive model information by applying a linear transformation that preserves the sparsity of the underlying formulation. The transformed problem is then sent to shared computing platform such as a cloud computer for solution. We prove that no one except the power system operator has the ability to recover the sensitive information from either the transformed problem and/or its solution. The solution is transferred back to power system operator who then applies a de-obfuscation transformation to recover the optimal solution to the original problem. We also that there is not much increase in the time required to solve the optimization. In [2], we showed that there exist linear transformations that transform any DCOPF into another DCOPF problem in such a way that the optimal solution of one gets mapped to the optimal solution of the other. This is advantages in scenario where a power system operator wishes to share his/her system model with researchers who are developing new approaches to efficiently solve the DCOPF problems. These researchers need "real" instances to verify effectiveness of their solution approaches but the power system operator has vested interest in ensuring confidentiality of sensitive information in his/her model. Instead of giving the researchers the original DCOPF, the power system operator can apply structure-preserving linear transfor- mation and make the transformed problem available to the researchers. In [3], we consider the challenge of masking sensitive information in AC Optimal Power Flow (ACOPF) problems. We show that ACOPF can be re-formulated as an optimization with quadratic constraints and quadratic objective. We show that another randomly selected ACOPF with the same number of buses, generators, and lines as the original problem serving as an encryption key can be used to linearly transform the quadratic programming formulation into another set of quadratic constraints that can be solved using shared computing platform without leaking any sensitive information in the original ACOPF. The transformation preserves the locally optimal solutions. As in the case of DCOPF, the operator can derive the solution to the original ACOPF from the solution to the transformed set of constraints using its knowledge of the encrypting ACOPF. Ongoing research efforts include multiparty privacy solutions to the power flow problems and evaluation of proposed methods using National Science Foundation's networking testbed called GENI.

References:

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2. A. R. Borden, D. K. Molzahn, B. C. Lesieutre, and P. Ramanathan, "Power system structure and confidentiality preserving transformation of optimal power flow problem," in Allerton Conference on Communication, Control, and Computing, Sept. 2013.

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