Optimal Grid Design for Cyber-Physical Resiliency
Los Alamos National Laboratory (LANL)

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Objective

- Optimal placement of trust-worthy nodes and secure quantum links in order to minimize the impact of cyber-physical attacks on the power grid.

Schedule

- 10/2017-10/2020
- Key deliverables and dates expected/met
- A design-support software tool that can help decision makers in adopting evidence-based investment strategies

Total Value of Award: $450K
Funds Expended to Date: 24%
Performer: LANL
Advancing the State of the Art (SOA)

- Current SOA consists in linearizing power flow equations leading to weak approximations and sub-optimal investment decisions.
- We will rely on exact mathematical models of the alternating current power flow equations proven to be sufficiently accurate.
- We will implement realistic models on how the grid reacts to adversarial attacks.
- Decision makers will have mathematical optimality guarantees when it comes to investing in building high-cost quantum channels and trustworthy nodes.
- With a flexible and reliable software tool that can optimize over the AC power flow equations, decision-makers can formulate and solve any decision-support problem.
Challenges to Success

Build a scalable modeling tool for optimal grid design

• We are developing Gravity, an open-source, scalable modeling framework with state-of-the-art performance on AC power flow optimization.

Understanding the interdependency between communication and physical layers

• Collaborating with SCADA experts to understand and model these interdependencies

Formulating the underlying mathematical optimization models and designing scalable algorithms

• We have an initial formulation based on multi-stage mixed-integer nonlinear programming and initial solution techniques inspired by alternating attacker-defender algorithms.
Major Accomplishments

- Literature review and first mathematical formulation
- Implementation of AC power flow models in *Gravity*
- Development of convex relaxations for AC power flow equations (needed to provide optimality guarantees)
- Connecting *Gravity* to state-of-the-art mathematical optimization solvers.
Collaboration/Technology Transfer

Plans to transfer technology/knowledge to end user

- Targeted end user: Investment Decision Makers in Grid Operators

- What are your plans to gain industry acceptance?
  - Compare our formulations with state-of-the-art power flow simulation tools, e.g., GridLAB-D
  - Reach out to industrial partners and test our algorithms on realistic data
Next Steps for this Project

Approach for the next year or to the end of project

- Formulate the multi-stage attacker-defender problem in Gravity

- Develop scalable algorithms for solving the problem