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Mitigating Against a Succession of Hidden Failure Accelerants Involved in an Insider Threat Sequential Topology Attack on a Smart Grid

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Keywords: Cyber; supply chain vulnerability; insider threat; zero-day type vulnerabilities; hidden defects/failures; protection system hidden failure; sequential topology attack; cascading failure; blackout; resiliency; control signal energy cost; artificial intelligence

Abstract: Protection System Hidden Failures (PSHF)-induced sequential events have been shown to have higher impact and greater likelihood of being sequenced to major outages. Hence, a pragmatic mitigation approach is to intervene in the outage-related successive event stream. From a cyber perspective, as pertains to the power grid, PSHF are comparable to a Zero-Day attack (a.k.a. "0-Day"); accordingly, adequate mitigation is not yet in place. This problem is particularly interesting because of the involved paradox; although widely accepted to be comparable to a 0-Day, some form of a priori architected mitigation is crucial so as to prevent a major outage. This can be construed as contributory toward resiliency. Accordingly, a pseudo-inverse approach is taken to the optimal controllability problem (in this case, non-optimal controllability is sought, particularly in the case of an Insider Threat Paradigm or ITP) as a form of mitigation. In essence, the maximal optimal Control Signal Energy Cost (CSECopt) and reduction of the diffusion of malicious Control Signals (CS) and/or Augmented CS (ACS) is sought. The described problem space is non-trivial, as Efficient Controllability Problems (ECP) have been shown to exhibit Non-deterministic Polynomial-time Hardness (NP-Hard), and likewise, countermeasure non-ECP are NP-Hard. This paper advances matters by leveraging a bespoke Machine Learning (ML) paradigm, comprised of a multi-Convolutional Adversarial Neural Network (CANN) Module and Particle Swarm Optimization (PSO)-based Enhanced Reinforcement Learning (RL) Component (ERLC), to better orchestrate Defense Circuit Breakers (DCB) and leverage ML-based Protection Relay Selection (MLPRS) for more optimal Grid Re-configuration (DGR) so as to better obviate a PSHF-based ITP Sequential Topology Attack (STA). Although previously thought to be a High-Impact, Low-Frequency (HILF) event, PSHF studies have shown that the associated distribution has an unusually fat tail; by endeavoring to reduce the fat tail, a principal contribution of this paper is to lessen the impact of the involved event.

Pages: 9 to 18
Copyright: Copyright (c) IARIA, 2022
Publication date: November 13, 2022
Published in: conference
ISSN: 2519-8599
ISBN: 978-1-61208-996-6
Location: Valencia, Spain
Dates: from November 13, 2022 to November 17, 2022

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