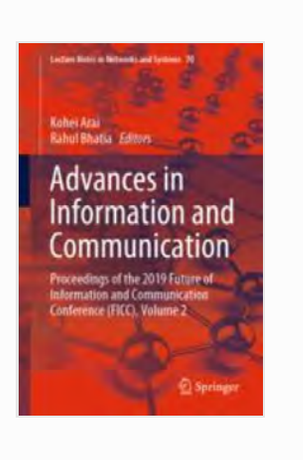

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A Potential Cascading Succession of Cyber Electromagnetic Achilles' Heels in the Power Grid

The Challenge of Time Synchronization for Power System Disturbance Monitoring Equipment in a Smart Grid Amidst Cyber Electromagnetic Vulnerabilities

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Abstract

The instantiation of various Phasor Measurement units (PMUs) at pertinent, disparate points across a smart grid facilitates certain insights. Time synchronization among the involved PMUs and other involved disturbance monitoring equipment (DME) is vital for situational awareness within the smart grid so as to avoid catastrophic failures, such as large-scale blackouts. Current PMUs often utilize Global Positioning System (GPS) substation clocks for time synchronization. From a cybersecurity vantage point, this subjects the PMUs, and in turn, the entire involved smart grid, to various cyber electromagnetic vulnerabilities, such as GPS blocking/jamming, and spoofing. Current mitigation strategies are not yet robust enough and need buttressing. In this paper, an architectural schema is proposed, wherein a modified Best Master Clock Algorithm (BMCA) (equipped with a modified "Compare Unit") is executed along different pathways and then harmonized, via a modification of an N-Input Voting Algorithm (NIVA). A modified Fault Tolerant Average Algorithm (FTAA) is then applied against the results of the various NIVAs so as to determine a Master Clock Group (MCG). Variants of sync integrity protection mechanisms (SIPMs) were utilized prior to the final confirmation of the Grand Master Clock (GMC) election and prior to any time information being utilized and/or syndicated for data synchronization and/or event correlation purposes.

Keywords

Phasor measurement unit (PMU) | Smart grid | Time synchronization | Disturbance monitoring equipment (DME) | Situational awareness | Large-scale blackouts | Global positioning system (GPS) | Cyber electromagnetic vulnerabilities | Timestamping | Best master clock algorithm (BMCA) | Data synchronization | Event correlation

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