technische universität dortmund

Fakultät für Elektrotechnik und Informationstechnik

Institut für Energiesysteme, Energieeffizienz und Energiewirtschaft

Master Thesis for X

Development of a Virtualized Laboratory Setup to Enable Testing of an AI-Driven Anomaly Detection Algorithm in Smart Grids

The operation of modern transmission power systems is characterized by a high degree of automation and extensive use of digital control and monitoring infrastructure. Extending comparable levels of automation to distribution and low-voltage grid levels requires a significant increase in communication interfaces and data exchange. While this ongoing digitization enables advanced control strategies and improved system efficiency, it simultaneously increases the exposure of power systems to cyber threats, data manipulation, and communication failures.

Consequently, the reliable detection of anomalies in measurement and control data becomes a critical requirement for secure power system operation. Data-driven approaches, including machine-learning-based anomaly detection methods such as those implemented in the EnerGuard pipeline, represent promising tools to address these challenges. In addition, control and protection algorithms must be systematically evaluated with respect to their robustness against corrupted, delayed, or maliciously manipulated data.

The objective of this thesis is to enhance the existing virtualized laboratory to enable simulated cyber-security tests. For this purpose, each physical component of the Smart Grid Technology Laboratory is recreated virtually in terms of its electrical properties and communication protocols. The digital twin is then tested and compared with its physical counterpart. Optionally, the EnerGuard anomaly detection pipeline will be evaluated and benchmarked with respect to its detection capability and reliability under the considered scenarios.

The work can proceed as follows:

- Familiarization with the topic, literature review, and requirements analysis about virtualized power system components, communication and testing procedures
- Setup of digital twins of each laboratory component
- Implementation of a testing system and scenario definition
- Evaluation of the virtualized laboratory platform in comparison to the laboratory equipment
- Documentation of the results

Schedule:

- Start of the thesis work in Dortmund as soon as possible

At the end of this thesis work, the results achieved shall be presented to wider audience along with open discussions.

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