technische universität dortmund

Fakulty for Electrical Engineering and Information Technology

Institute of energy systems, energy efficiency and energy economics

Bachelorthesis/Masterthesis

Date: 7th April, 2025

Requirements Analysis and Development of a User Interface for Operating a Smart Grid Using Edge Computing and Digital Twins

Distribution networks are playing an increasingly important role in electrical energy systems. On one hand, the feed-in to medium and low-voltage networks from decentralized energy generation systems is increasing. On the other hand, the electrification of the mobility and heating sectors is placing additional strain on the grids, which in extreme cases can result in voltage band violations or line overloads. Due to these and other factors, such as the increasing variability of electricity consumption, so-called smart meters are being installed at customer sites to monitor grid conditions. Additionally, local substations are being equipped with measurement technology to gather information about the thermal load on individual network segments.

This measurement-based monitoring of medium and especially low-voltage networks results in a paradigm shift in the operation, planning, and maintenance of these grids. Whereas the grid was previously managed based on experience and rules, future operations will be data-driven. For this, connecting static, grid, and real-time data is essential. Digital twins are therefore being developed to provide a “single source of truth” for describing assets. These digital twins can be run on edge devices in local substations and must be monitored in an event-driven manner by central control room personnel. However, due to the diversity and scale of local grids, traditional monitoring concepts used for high and extra-high voltage networks reach their limits.

This thesis will begin with a literature review of the current state of science and research on control systems for the active operation of medium and low-voltage networks. Based on this, a requirements analysis will be carried out to identify the core components of such a system. Following that, a system will be developed and evaluated in a real-time simulation in the Protection and Automation Laboratory using exemplary application cases.

The proposed structure for the thesis is as follows:

- Literature review on digital twins in the power and electricity sectors as well as in Industry 4.0, and on concepts and solutions for user interfaces for monitoring and operating medium and low-voltage networks
- Formulation of requirements for the user interface and translation into a software architecture
- Development of the software architecture in interaction with a digital twin developed at the ie3 institute
- Identification and definition of relevant use cases and evaluation metrics
- Design and setup of a laboratory environment for validating the user interface in the defined use cases
- Experiment execution, analysis, and optimization

After completing the thesis, the results are to be presented in a final presentation.

This thesis is now available as a Bachelor’s/Master’s project for Industrial Engineering, Electrical Engineering and Information Technology (ETIT) students, Automation and Robotics, and Sustainable Energy Systems.

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