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Smart Grid Test Management Platform

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Bachelor's Thesis

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Introduction

- Test platform based on the Mosaik simulation framework
- Written primarily in Java
- Allows testing of Smart Grid components
- User defined Smart Grid topologies
- Java based API for simulators

Smart Grids Testing/Simulation Concepts

- **Emulation** (integrated or co-simulated): emulated component mimics the real world hardware counterpart
- **Co-simulation**: orchestrate simulations running by different means
- **Real-time simulations**: the real time expectation that the simulator needs to fulfill to interact with external components (hardware or software)
- **Hardware in the loop (HIL)**: used to develop complex real-time embedded systems in which some components are real hardware, whereas others are simulated

Thesis Goals

- Provide an environment for Smart Grids testing which can allow
    - Testing of different SG scenarios and topologies
    - Testing of SG devices in a virtualized grid
    - Evaluation of proposed SG deployments in small and full scale
- Provide an easy to use and extend SG platform for education of students in the SG domain
- Implement and extend the SG lab model proposed by Katarína Hrabovská in her Master’s Thesis

Test Platform: Features

- Define SG topology (layout of simulation entities)
- Define test pass criteria
  - Measure acceptable range (voltage, pressure, …)
  - Simulator defined, separate test evaluator
- Observe and log simulation state at each step
  - Observe measures
  - Determine at which step/time the test failed or parameters went out of maximum range

Mosaik

- Smart Grid co-simulation framework, written in Python
- Discrete time step simulation
- Allows integration of various simulators into a centrally controlled one
- Simulators can be HiL / RT / software
- Defines Smart Grid layout and simulation scenarios
- Mosaik synchronizes individual simulation timeframes
  - Certain components can run in realtime
  - Others can run slower than RT with variable step size

Platform details

- Users can input simulation data:
  - Grid topology
  - Simulator data flows
  - Initial configuration
- Platform auto-injects several properties to make simulator integration easier

Java Simulator API

- Created Java API for adding new simulators
  - Base classes containing most of the required behavioral functionality
  - User only has to implement interfaces with hardware simulators and translate requests between HW and Mosaik’s requests
- <50 LoC for most basic software simulator
  - Ex: Input adder

Sample Use Case: Power usage over time

- One key challenge of power distribution is predicting power usage over time
- Most renewable energy sources have highly variable power output based on changing environmental conditions
- Energy production is simulated by several nodes, each in a different location
- Power consumption is simulated by Mosaik HouseholdSim
  - Houses and other consumers are connected to the power grid
  - Energy surplus or deficit is measured throughout a simulated time period
- Can be used to predict energy requirements for a city, what time additional power plants need to switch on to supplement renewable energy
  - Predicting this data in advance leads to more robust and reliable power grid

Future Work

- Log synchronization after test run from simulators to central server
- Better hardware error detection support, improved incident generation
- Domain Specific Language to describe: connection and model details, test pass criteria (measures)
- Web interface covering all implemented functionality
- More sample simulators

Thank you for your attention!