Local Intelligence for a Customer Energy Management System equipped with Smart Breakers

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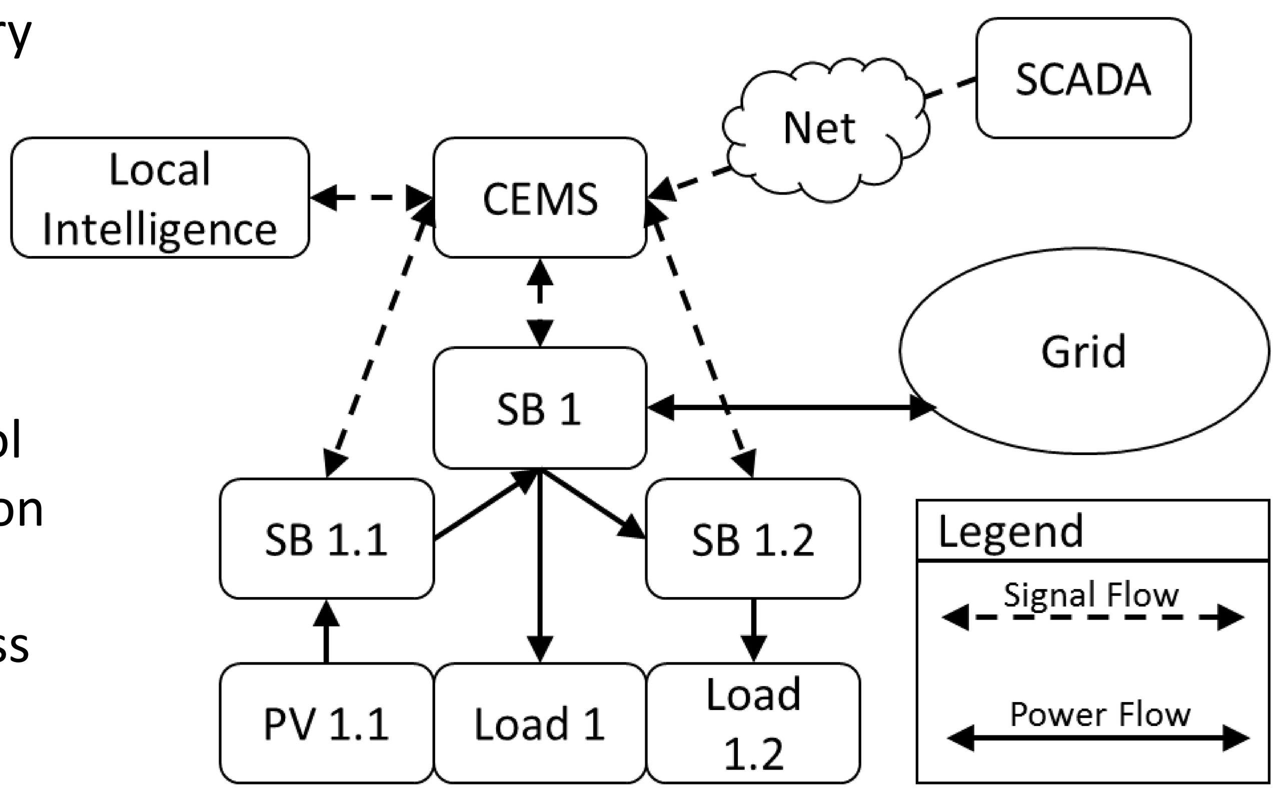
Motivation and Overview

The electricity grid of the future needs to be smart to react to the technological changes caused by increased distributed energy generation and increased consumer demands due to new technologies, like electric vehicles. To address this, advanced energy management systems need to monitor and control the power grid in new ways and on varying levels. One important aspect in this development will be the integration of distributed Customer Energy Management Systems (CEMS) into the control process. We aim to show the challenges and opportunities involved in such an approch, with focus on our recent development steps regarding the systems local intelligence.

System Setup

This is an exemplary setup showing a Customer Energy Management System (**CEMS**) connecting the Supervisory Control and Data Acquisition (**SCADA**), a **Local Intelligence** process and various **smart breakers** (SB), controlling local producers, e.g. a **photovoltaic system** (PV) and local consumers.



Components

SCADA

- Transmits **power** and **voltage** bandwidth **restrictions** from DSOs[1] and ISOs[2]
- Functionalities:
  - **Traffic light** schema for grid requirements
  - **Emergency shedding** for blackout prevention
  - Distributed producer impact via **Q(U)** configuration

CEMS

- **Central integration** point for all components
  - Local intelligence
  - User interface (Angular JS)
  - Smart breakers
- OpenMUC as **communication** framework with many protocols
  - IEC 61850 / IEC 62351
  - SunSpec
  - SGIP
  - EATON ECI TCP

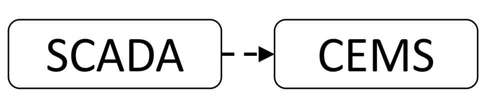
SB

- **Smart** Breaker
- Developed by EATON
- **Wireless** communication
- **Hybrid** switching

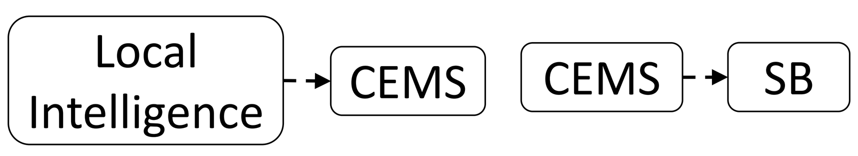
Local Intelligence

- Under active development
- Still simple **reactive** behavior
- Implemented in Java

Communication



IEC 61850 based communication with certificate based encrypted secure tunnels as promoted by CHP-ready alliance as **IEC 62351**

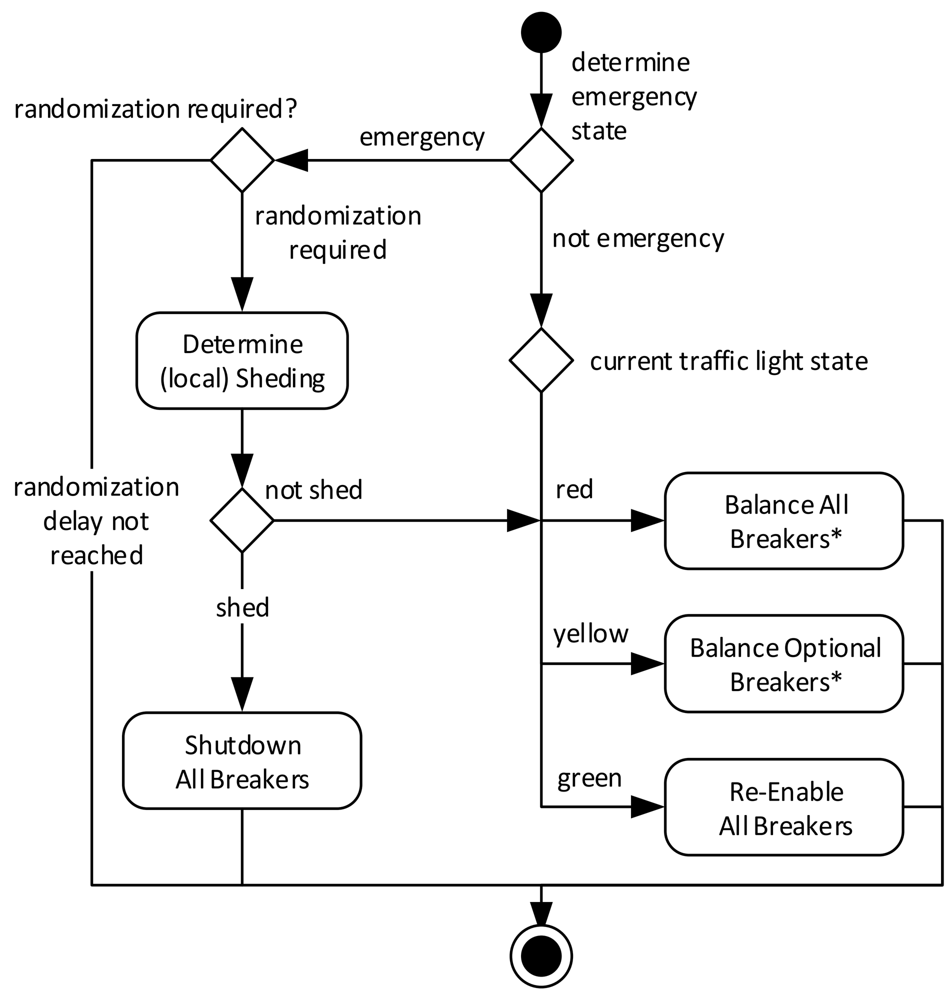


Custom communication drivers for **OpenMUC** communication framework (implemented in Java, using OSGi for driver integration)

[1]Distribution System Operator
[2]Independent System Operator

This work is based on findings of the project Integration of Innovative Distributed Sensors and Actuators in Smart Grids – Project iniGrid (Project no. 845018), commissioned as flagship project by Österreichische Forschungsförderungsgesellschaft mbH (FFG) as part of e!MISSION.at 4th call for proposals.

Local Inteligence



- Implemented as OpenMUC device in Java 8
- Development based on interdisciplinary inputs
- Distinguishes between optional and essential producers/consumers
- Based on usage scenarios from domain specialists

Usage Scenarios

Self Consumption Optimization

- Maximize usage of locally produced energy
- Adhere to ISO and DSO production/ consumption restrictions
- Reduces strain on energy grid
- Ecological and economical benefits

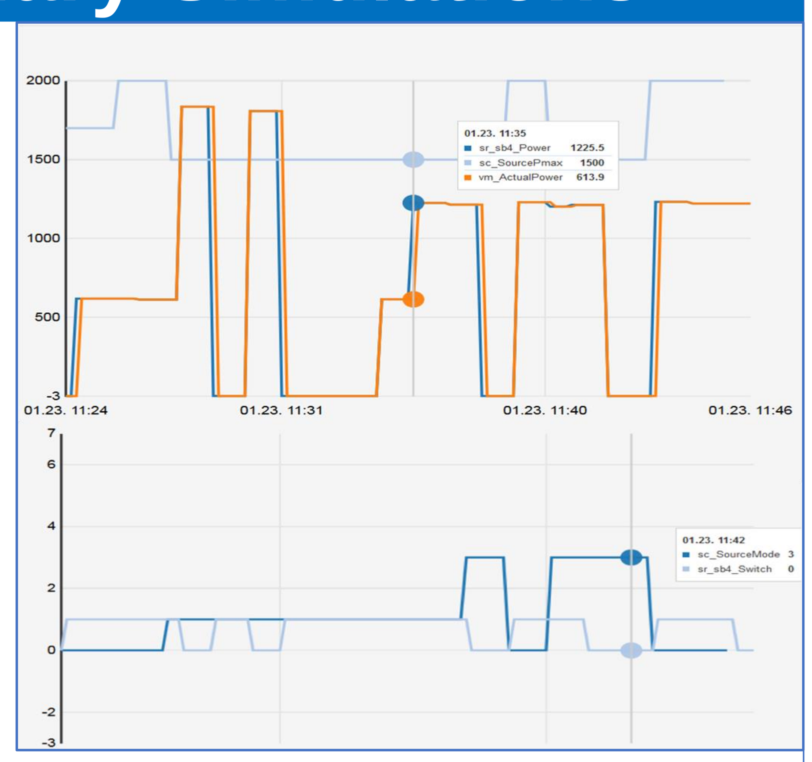
Priority Lists

- User ranks SBs depending on importance for system operation
- Separate priority lists for consumers and producers
- Coupled with predefined consumption estimations (to avoid oscillation effects)
- Allows definition of optional and non-optional devices by user

Communication Loss

- Different fallback mechanics for different loss scenarios
  - SCADA lost: Stick to ‘yellow’ traffic light and switches optional loads if required
  - Local sensors lost: replace missing values with estimates (e.g. sum smart breaker measurements to replace smart meter values)
- Alert local administrator to check communication equipment for non-critical failres (e.g. router unplugged, SIM card not paid)

Successful Preliminary Simulations



Adhere to Consumption Limits

- Randomized SCADA limits within boundaries
- CEMS disabled/enabled consumers as expected to minimize bandwidth violations

Emergency Load Shedding

- Simulated emergency shutdown signal with percentage
- Distributed determination of affected CEMS (without further communication)
- (Open) Challenge during shutdown sequence for hierarchical SBs: Uncontrolled disconnection if breaker hierarchy is not respected

Automated State Estimation

- Simulated medium voltage sensor in secondary substation
- Automated state estimation for medium voltage variations
- Bandwidth violations successfully detected and status automatically adjusted
- Automatic adaptions for PVs (via Q(U)) possible, but not yet realized