Demonstration of Agent-Based Control of Active Power Distribution Grids

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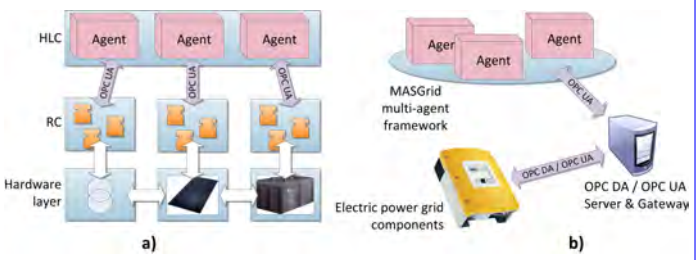
Motivation

- Future electric distribution grids (Smart Grids) require sophisticated control methods
- Autonomous, scalable and extensible control system necessary for handling large numbers of grid components
- Multi-Agent Systems (MAS) are generally considered as a promising technology for handling Smart Grids
- This work demonstrates the first implementation of a MAS-based power distribution control system in a small-scale laboratory power distribution grid at ICCS/NTUA

Automation Agent architecture

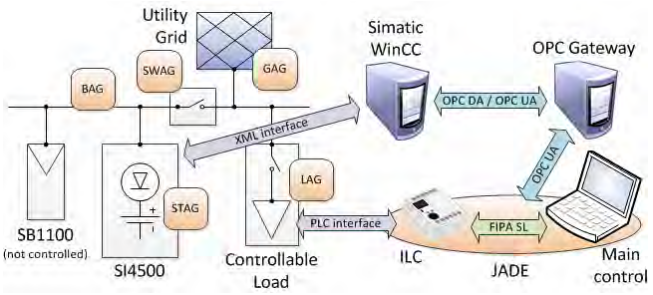


Layered automation agent architecture (a) and generalized experimental setup (b).

- To simplify the design, a generic architecture is introduced
- The High-Level Control (HLC) incorporates an ontology-based model for representing the physical environment and to enable advanced reasoning about its state
- The Reactive Control (RC) is located at the physical device to directly control the hardware and carries out its functions under real-time constraints

Experimental setup

- Sunny Island Bi-Directional Battery Inverter SI4500
- Sunny Boy PV InverterSB1100
- Intelligent Load Controller AN-ILC-03 & 100W control. load
- Simatic WinCC SCADA and OPC Server v7.0
- Unified Automation UaGateway v1.2.3
- JADE agent development environment



Experimental setup. In the course of the test case it is assumed that the load is on the same electrical grid segment as the Sunny Island, as opposed to the actual wiring.

Acknowledgements

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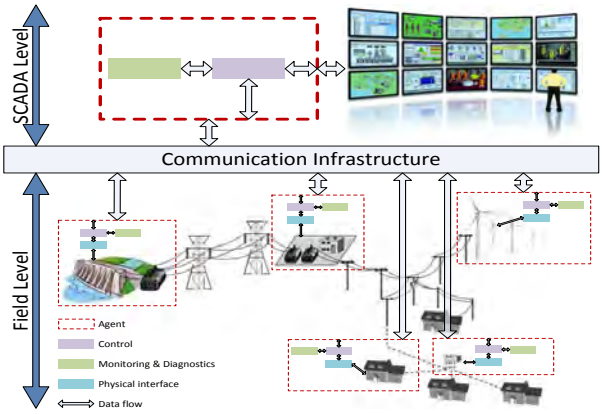
System architecture



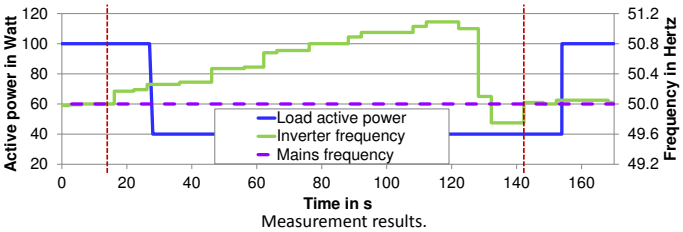
Hierarchical division of the power system control.

- The power system control is split into two levels:
  - The SCADA Layer carries out global tasks like grid optimization and reconfiguration (work in progress)
  - The Field Layer contains the Automation Agents (AAG) which represent the physical grid devices: busses (BAG), lines (LNAG), generators (SAG), loads (LAG), storages (STAG), grid (GAG), switches (SWAG)
- The BAGs carry out the main control functions, whereas the other agents only inform respond to their assigned BAGs

Test case

- The control system manages the battery inverter and the load using appropriate agents (see *Experimental Setup*)
- The control system receives a signal to set the microgrid into islanding mode and performs the necessary measures
- During islanding, the load should only consume a predefined minimal power in order to conserve the batteries
- In grid connected mode, the load can consume its maximum power while the battery inverter recharges the batteries

Results



Measurement results.

- At about time=14s, the inverter switches into island mode
- The Bus Agent requests the Load Agent to reduce the consumed power to a given minimum afterwards
- Until the grid reconnection around time=141s, a frequency shift due to power droop control of the inverter is observed
- After reconnection, the load again consumes its max. power

Outlook

- Implementation of advanced power management functions based on power flow equations
- Testing of scalability and behavior of the control system on a simulated large-scale distribution network
- Implementation of grid optimization algorithms

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