AIT Austrian Institute of Technology

Smart Grid Lab Automation using 4DIAC and IEC 61499

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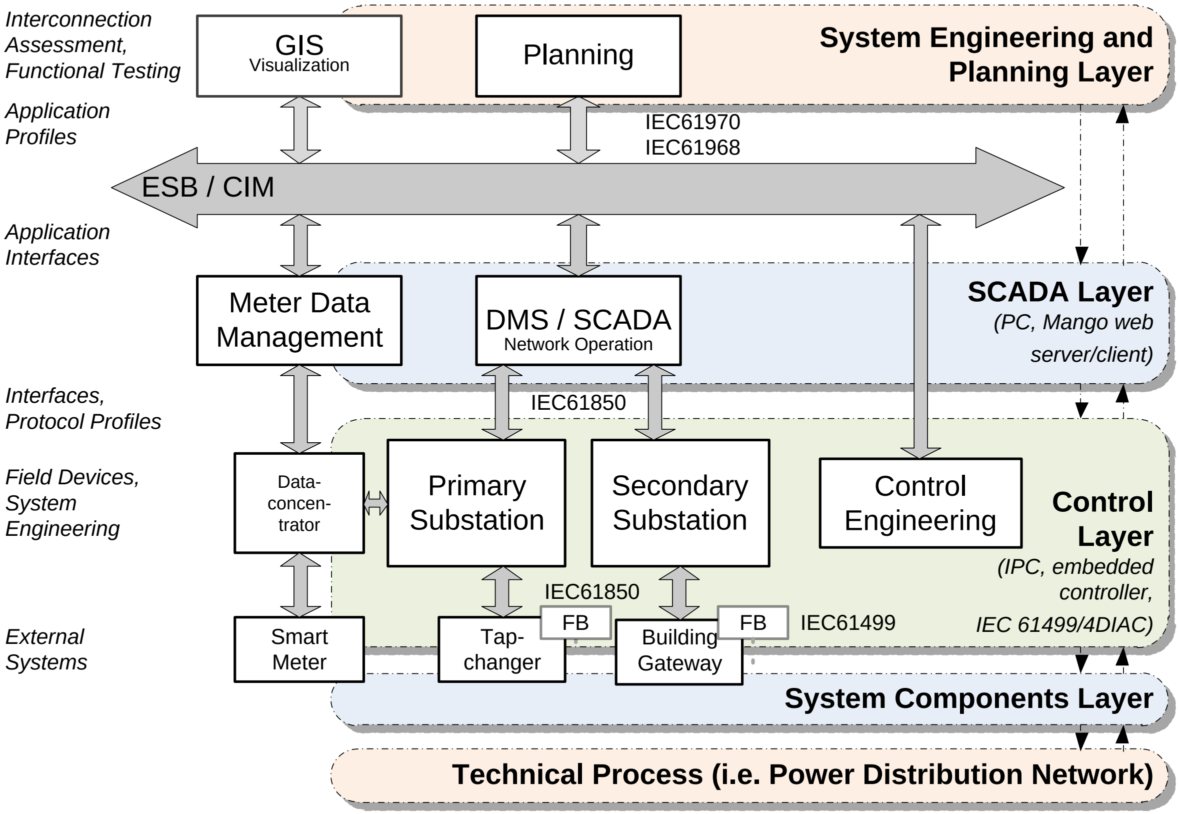
Content

- Background and Motivation
- Design and Validation Environment
- System Design
- Implementation Using 4DIAC
- Example Application (RLC Tuning)
- Summary and Conclusion

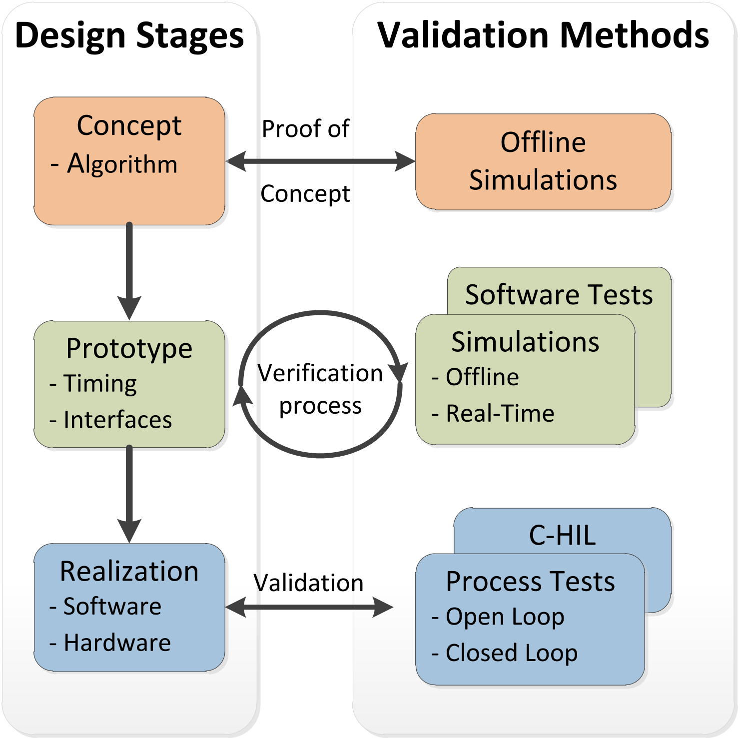
Background and Motivation

- Smartness requires awareness, i.e., knowledge about what is currently happening in the surrounding system
  - Measurements
  - Widespread communication
  - Intelligent control
- Collaboration between stakeholders
- International standards
  - Development
  - Research



Background and Motivation

- Design stages & validation methods for development of Smart Grid components
- Concept
  - Offline simulations
- Prototype
  - Offline and real-time simulations
  - Software tests
- Realization
  - Process and hardware tests
- Challenge
  - Environment based on international standards for development and validation of Smart Grid components



Design and Validation Environment

Motivation and Introduction

- The integration of renewable energy resources and distributed generation into the current power grid is a major problem
  - → A paradigm shift from a centralised to a distributed energy generation
- More intelligence needed to cope with the new challenges, i.e. control, communication and automation strategies
- Environment for design, simulation and validation of new Smart Grid automation and control concepts needed
  - → Concept for environment integrating possibilities for simulation as well as real hardware tests

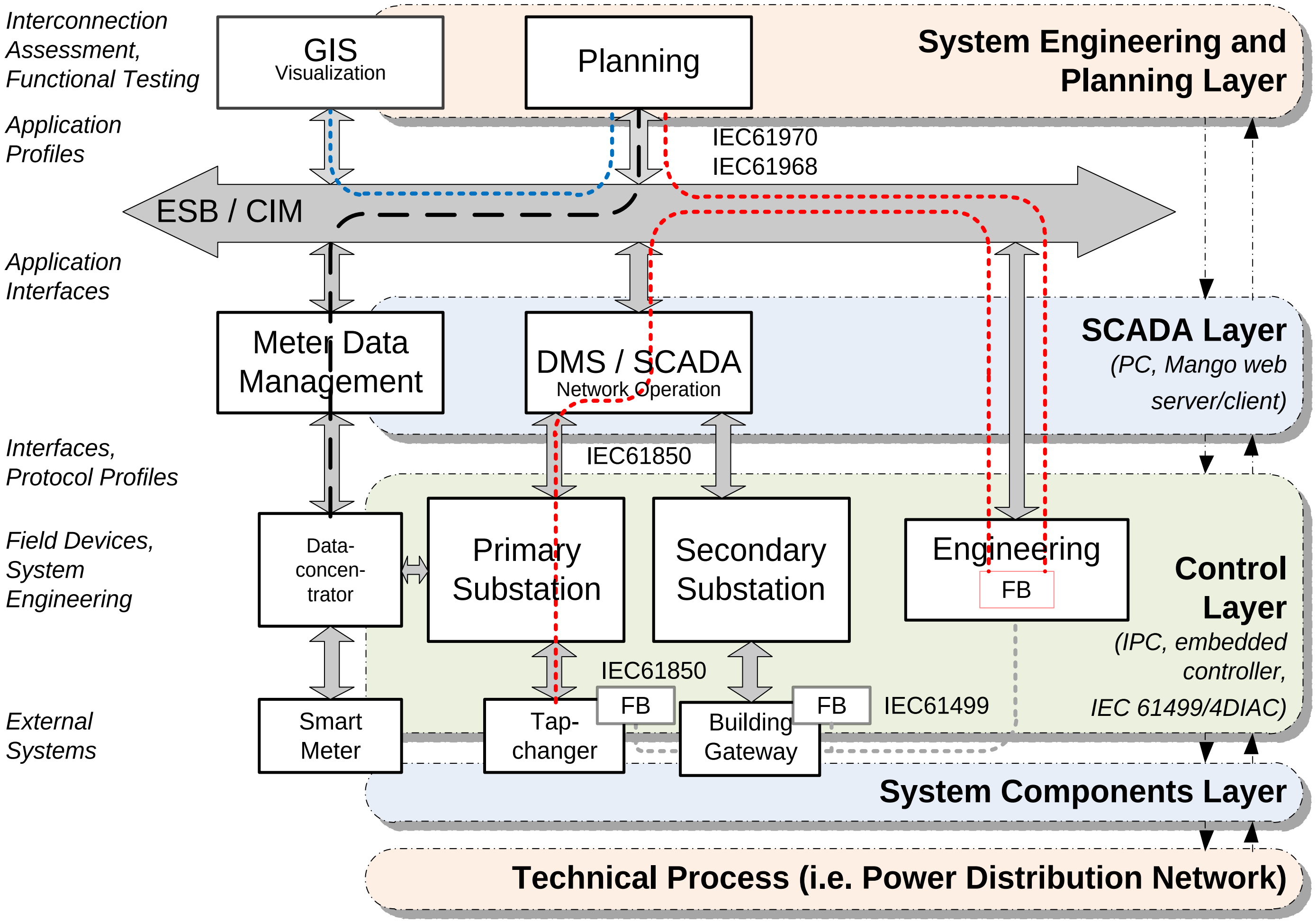
Design and Validation Environment

Main Requirements

- Hardware Requirements
  - Flexibility
  - Scalability
  - Hardware independence
- Software and Application Requirements
  - Configurability
  - Portability
  - Application Distribution
- Simulation Requirements
  - Offline simulation
  - Real-time simulation
- Open and Standard-Compliant Implementation
  - Interoperability
  - Open communication interfaces
  - Free & open source approaches

Design and Validation Environment

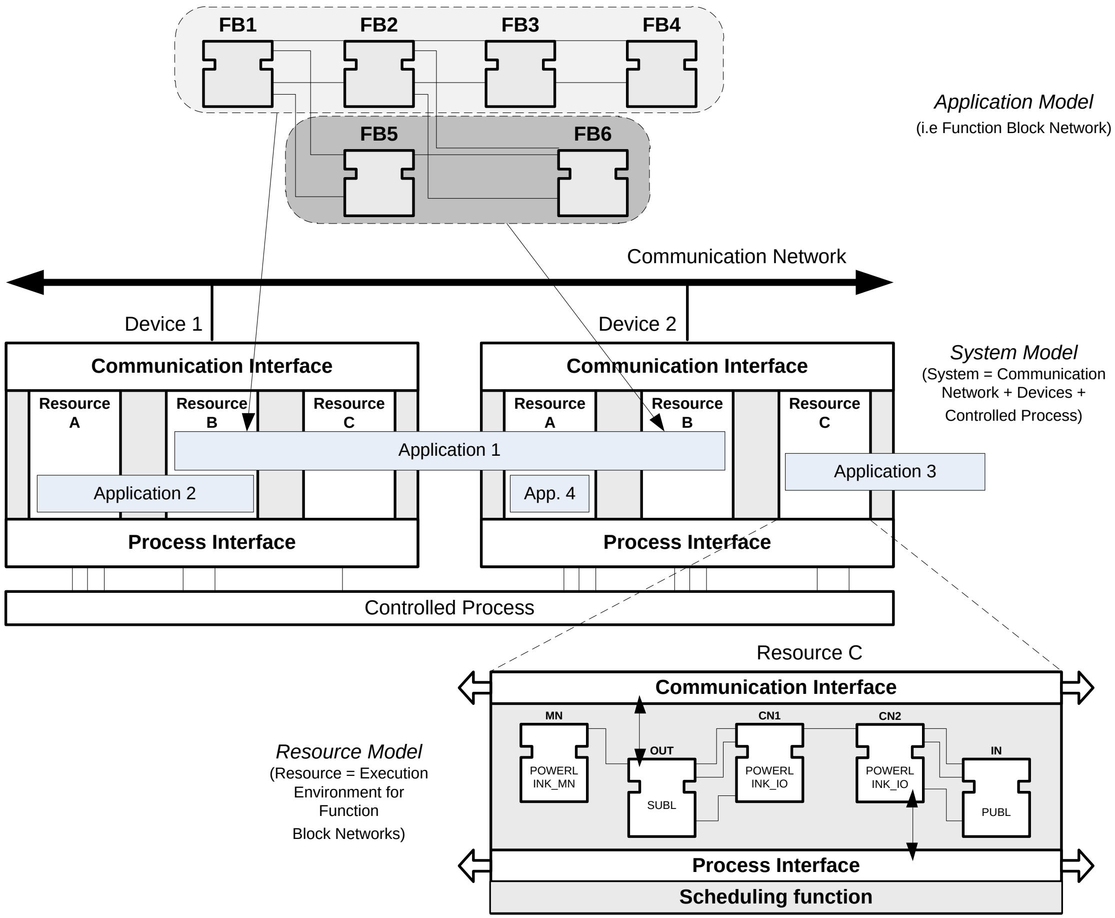
Main Idea and Concept



Design and Validation Environment

Why IEC 61499 and 4DIAC?

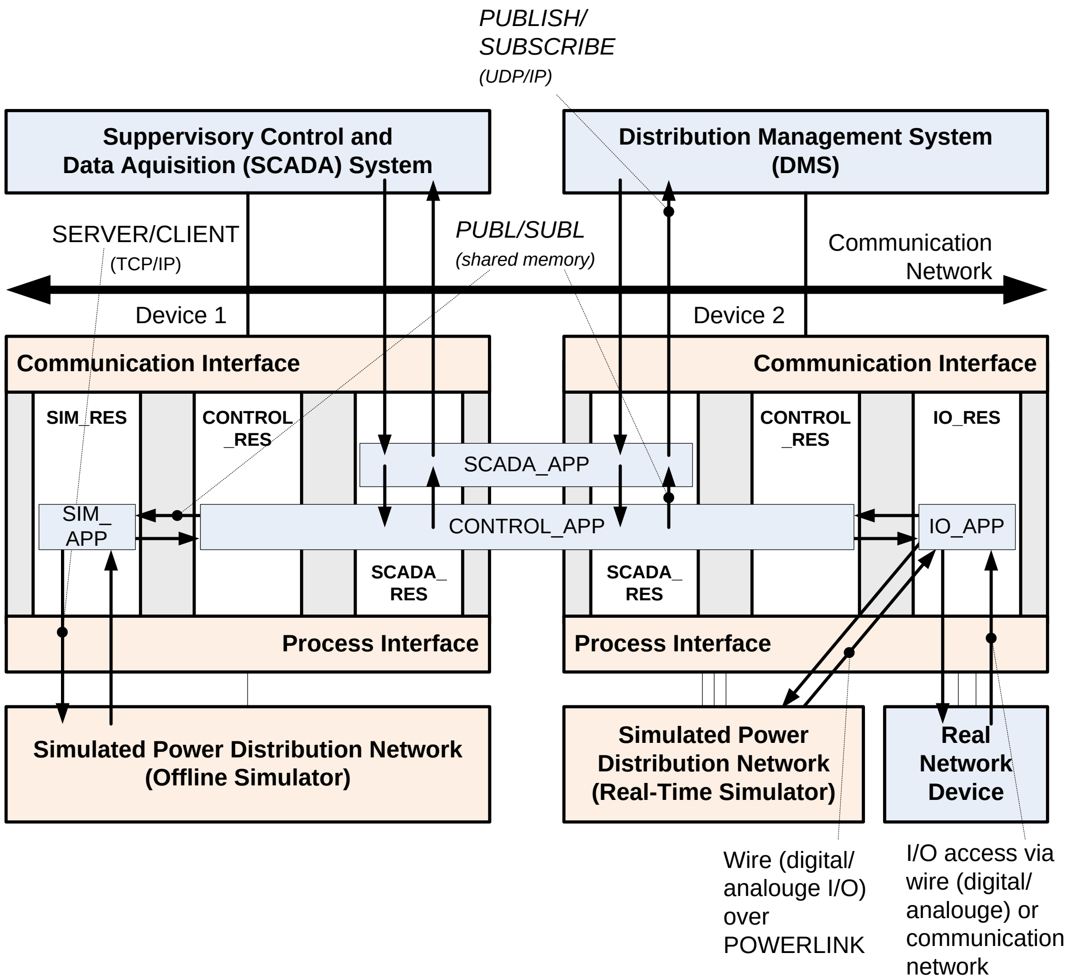
- Engineering Process
  - Devices
  - Resources
  - Applications and subapplications
- Generic Interfaces
  - Communication Interface
  - Process Interface
- Controlled Process



Design and Validation Environment

Basic Concept Based on IEC 61499

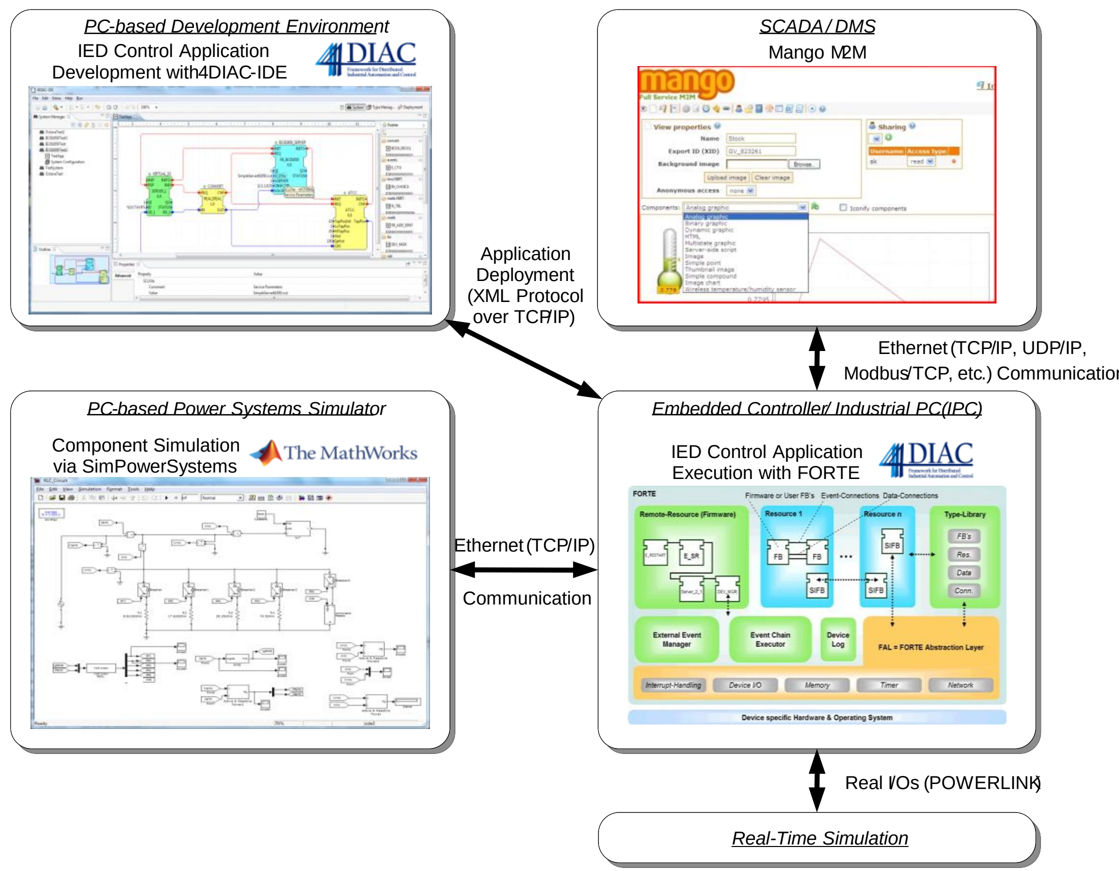
- Interconnection of multiple systems
  - SCADA
  - DMS
  - Simulators
  - Controllers
- Independent applications
  - Control application
  - Communication application(s)



Design and Validation Environment

Visualisation and Simulation Tools

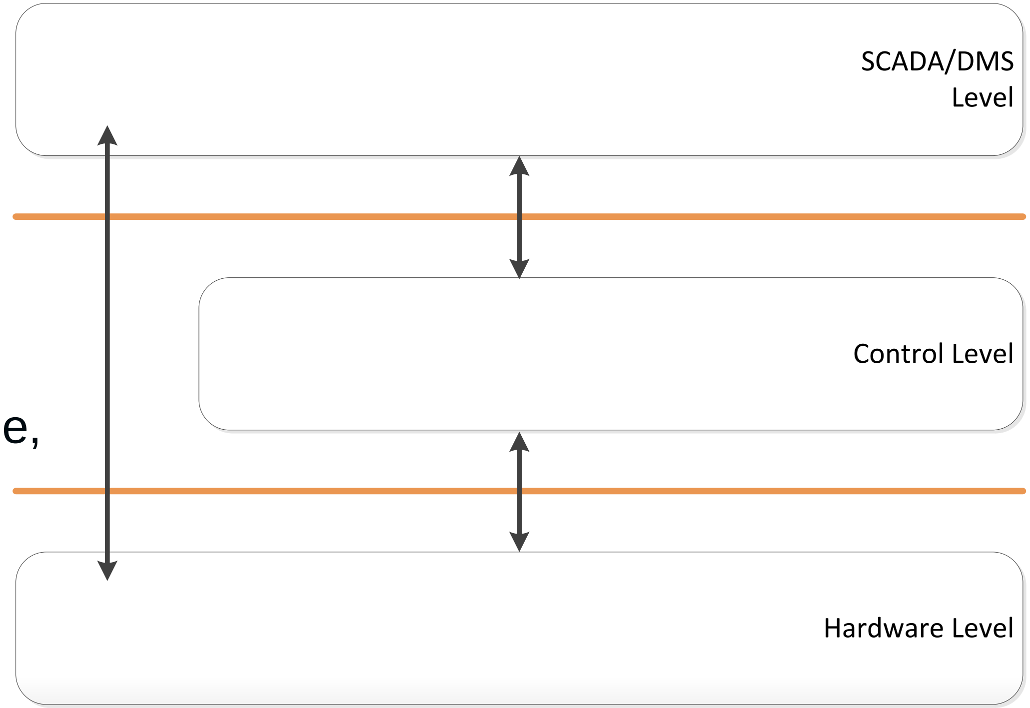
- SCADA for visualisation
  - ScadaBR
- Simulation Tools
  - Matlab/Simulink
  - DIgSILENT / PowerFactory
  - OpalRT (real-time)



System Design

Control Layers

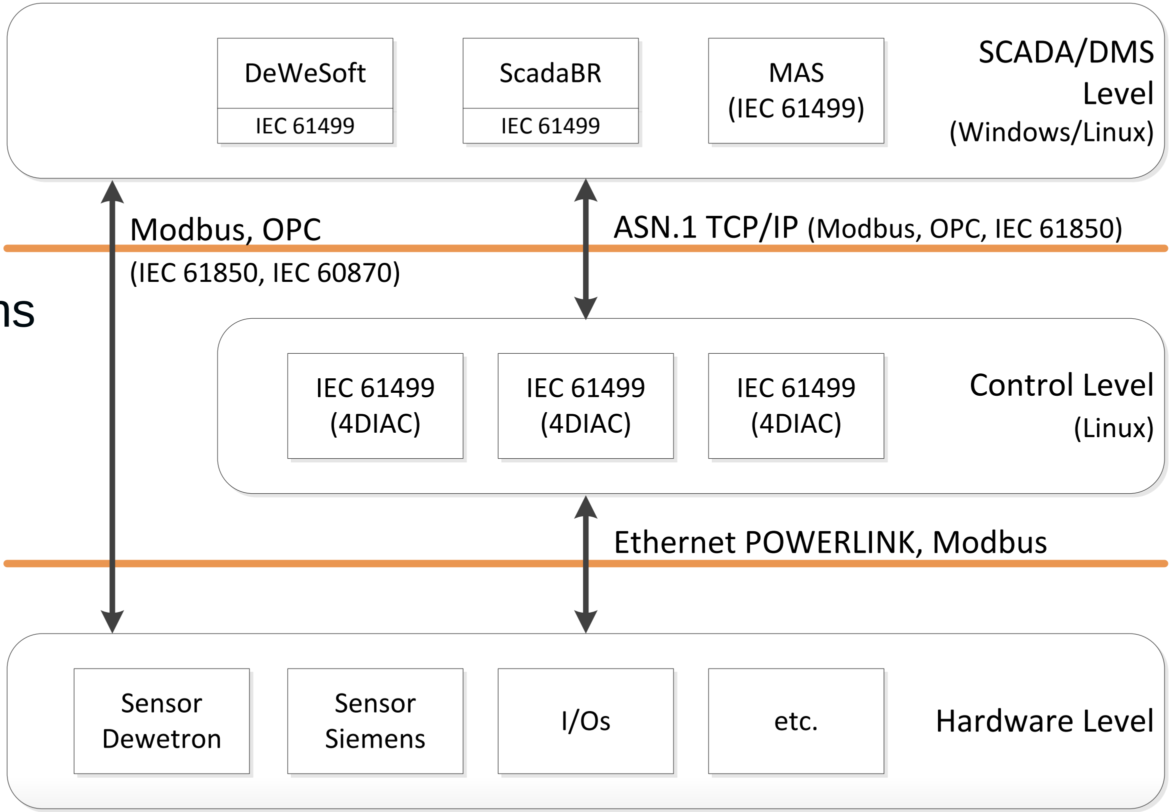
- Hardware Layer
  - Proprietary hardware
  - No access to software
- Control Layer
  - Basic control functionality
  - Software alterations possible, but not necessary
- SCADA Layer
  - Superior control functions
  - Alterations straightforward



System Design

Layer Components and Communication

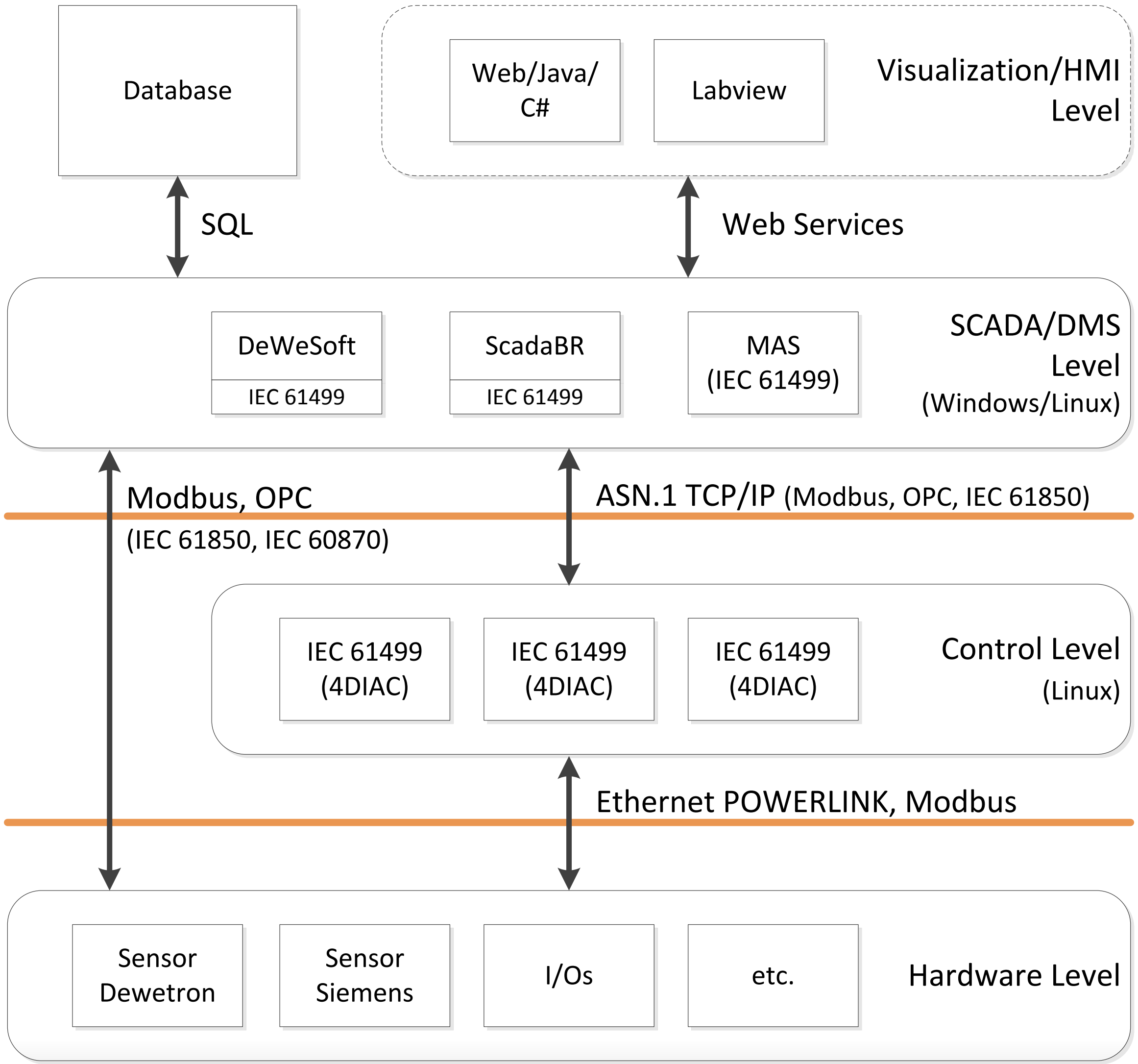
- Fix components
  - Sensors, I/Os
- Main control components
  - IEC 61499 applications
  - ScadaBR
- Additional components
  - Multi-Agent-System
  - ...



System Design

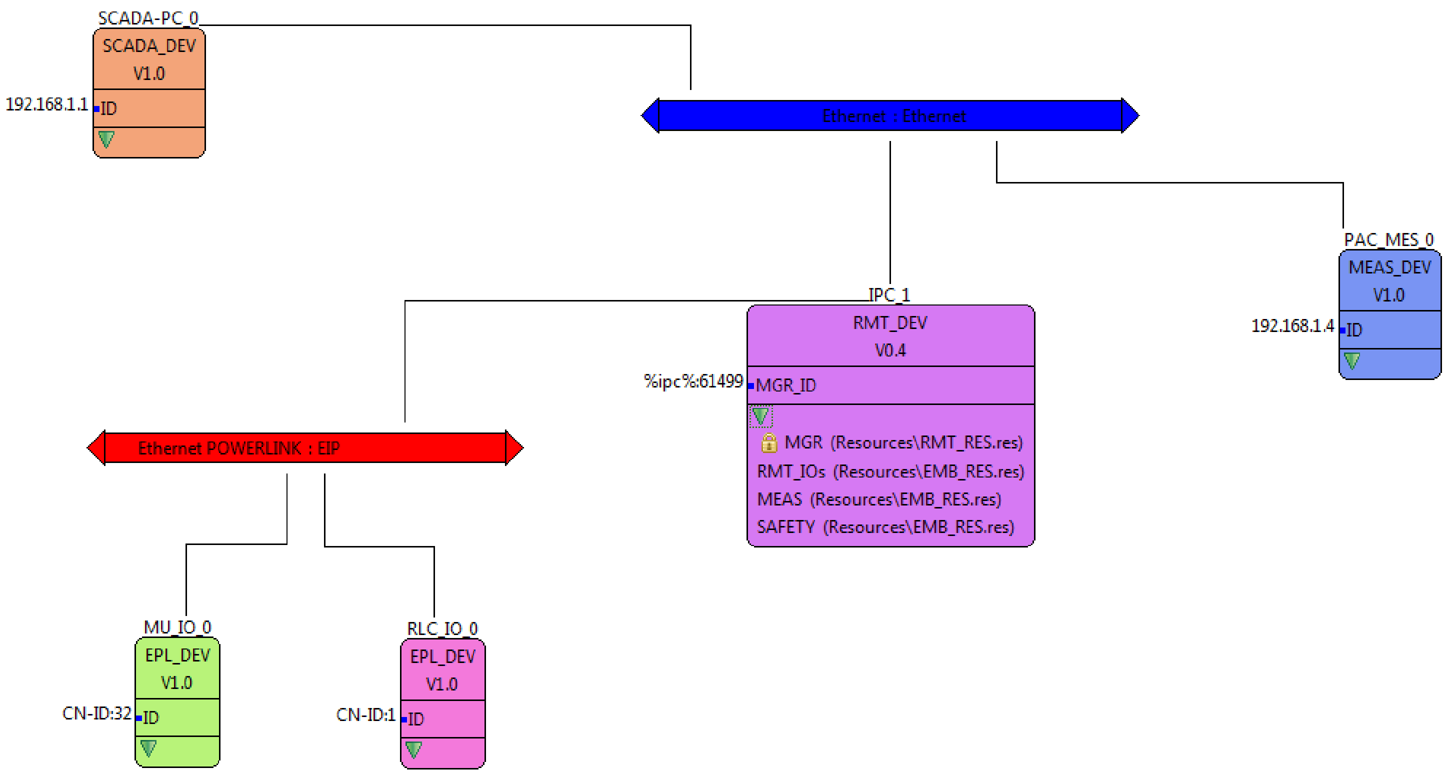
Extensibility

- Database
  - MySQL
- Visualization
  - Web Service interface
- High-level control applications



Implementation using 4DIAC

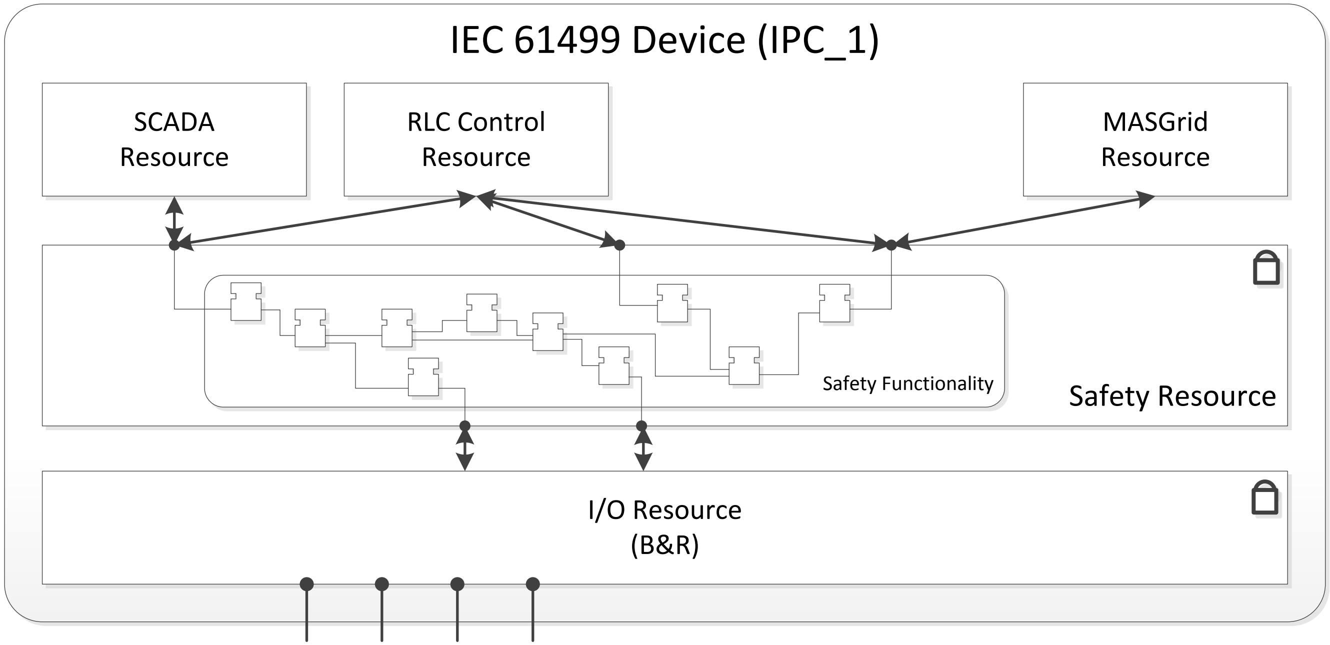
System Configuration



Implementation using 4DIAC

Control Level Implementation using 4DIAC

- IEC 61499 device for laboratory control
- I/O and Safety Resources are locked in the device



Implementation using 4DIAC

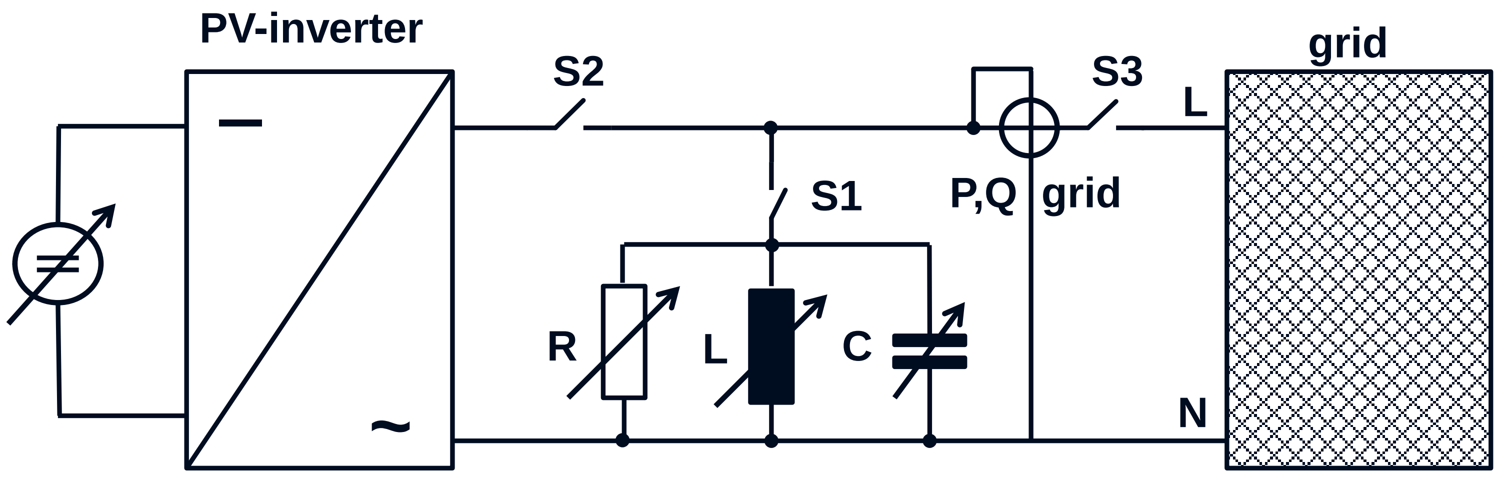
Communication Protocols

- Communication protocols were added to 4DIAC
- Implementations as network layers
  - Modbus
  - OPC
- Implementation with standalone function blocks
  - Ethernet POWERLINK

RLC Tuning for PV-Inverter Islanding Test

Implemented Test Case: Inverter Test Stand

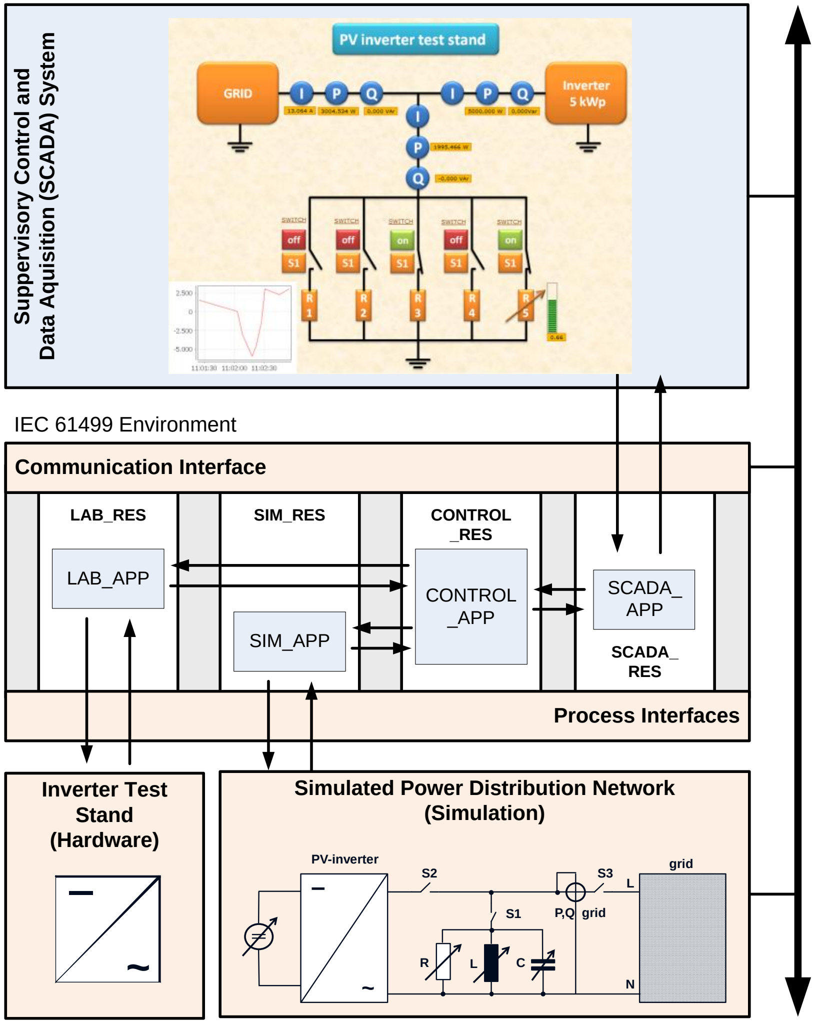
- Implemented Case Study: Control of AIT PV-inverter Test Stand
  - RLC tuning for PV-inverter islanding test (VDE 0126)



RLC Tuning for PV-Inverter Islanding Test

Implemented Test Case and Simulations

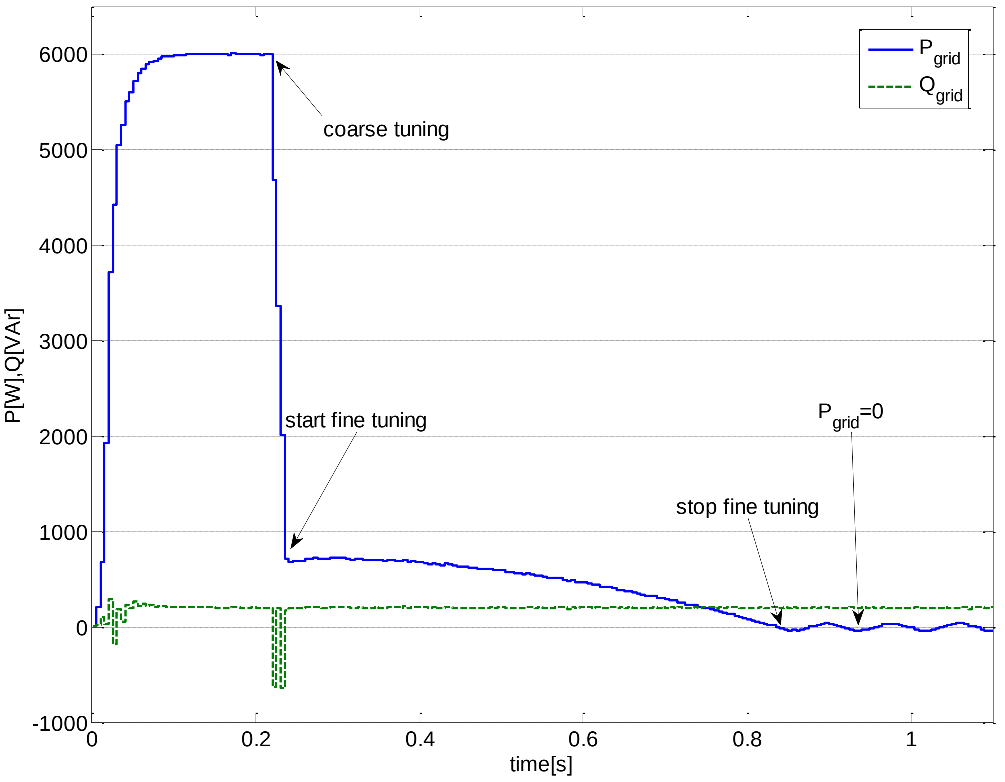
- Inverter Test Stand
  - Real Hardware
  - Simulation model using Matlab/Simulink
- SCADA/HMI Implementation
  - Using ScadaBR
- IEC 61499 Control Implementation
  - Tuning of RLC load
  - Coarse and fine tuning



RLC Tuning for PV-Inverter Islanding Test

Implemented Test Case: Simulation Results

- PV-Inverter Characteristics
  - 6 kW active power output
  - 200 VAr reactive power output
- Only tuning of R load
- Tuning of L and C loads similar



Summary and Conclusions

- Development of a validation and test environment using open source tools
  - Enabling simulation and hardware tests
  - Connection possibilities for multiple technologies
- 4DIAC and IEC 61499 is used as a core technology to enable this
- Proof-of-concept has currently been shown
- This concept will be integrated into the new research and test laboratory

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