Enhanced lab-based testing methods and tools

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Laboratory Integration Obstacles

- Power grids are mature infrastructures and have been extensively standardised
  - No standards for smart grid labs or what there primary purpose should be
  - Consequently, the use of ICT/automation systems (architectures, interfaces, etc.) is subject to large variations between facilities
- Smart grid labs are complex infrastructures with unique properties
  - Experimental nature of the installations
  - Changing user groups
  - Evolving configurations
- Finding a common ground when talking about lab integration can be a challenge

SmartEST Laboratory at AIT

Smart metering communication platform at TECNALIA

Issues Addressed in ERIGrid

- Generic reference model for control hierarchies, interfaces and data flow in smart grid laboratories
- Documentation of complex DER behaviour
- Documentation of controller deployment procedures
- Uniform naming of signals and objects

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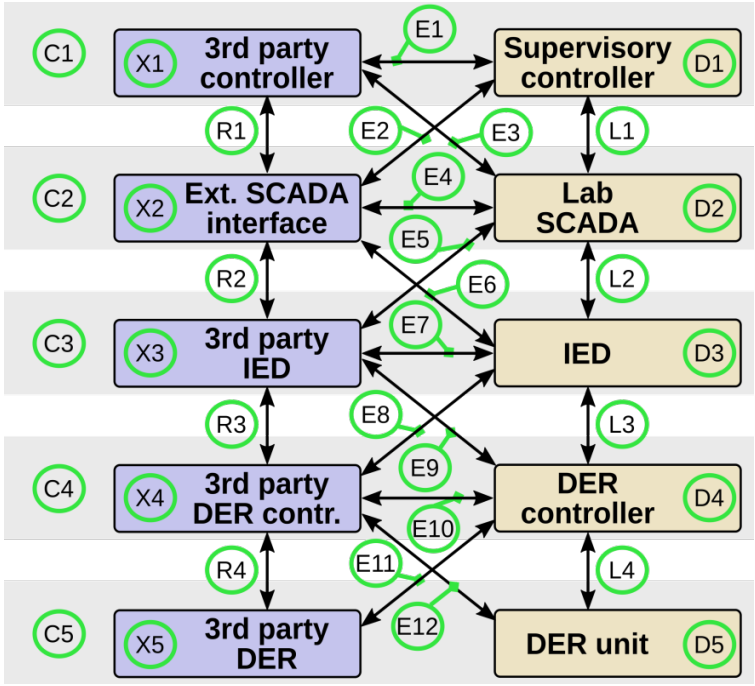
Need for a Generic Reference Model

- Status quo
  - Availability of communication interfaces between the different parts of a lab determines to which degree the lab presents itself to the user as a collection of hardware components or as an integrated system
  - The automation and control aspects are often missing from descriptions of lab capabilities which tend to focus on the performance of the power equ.
- A one-size-fits-all model is complicated because
  - A wide range of automation levels/concepts is found among partner labs
  - Ad-hoc automation for individual experiments is not uncommon
  - Automation may involve communication between lab components and/or between the lab and third party equipment (under test)
  - The automation may be considered as infrastructure, as part of the system under investigation, or a combination of both

Generic Reference Model Description

- The model abstracts away from individual devices, controllers, protocols etc. as well as time, in order to focus on classes of controllers and interfaces
- Definition of five hierarchy levels at which control functionality may be deployed (both internal to the lab & external)
- Definitions of 20 communication interface locations
- Use cases for 12 interfaces between lab installations and external systems
- Partner examples of concrete experiment configurations



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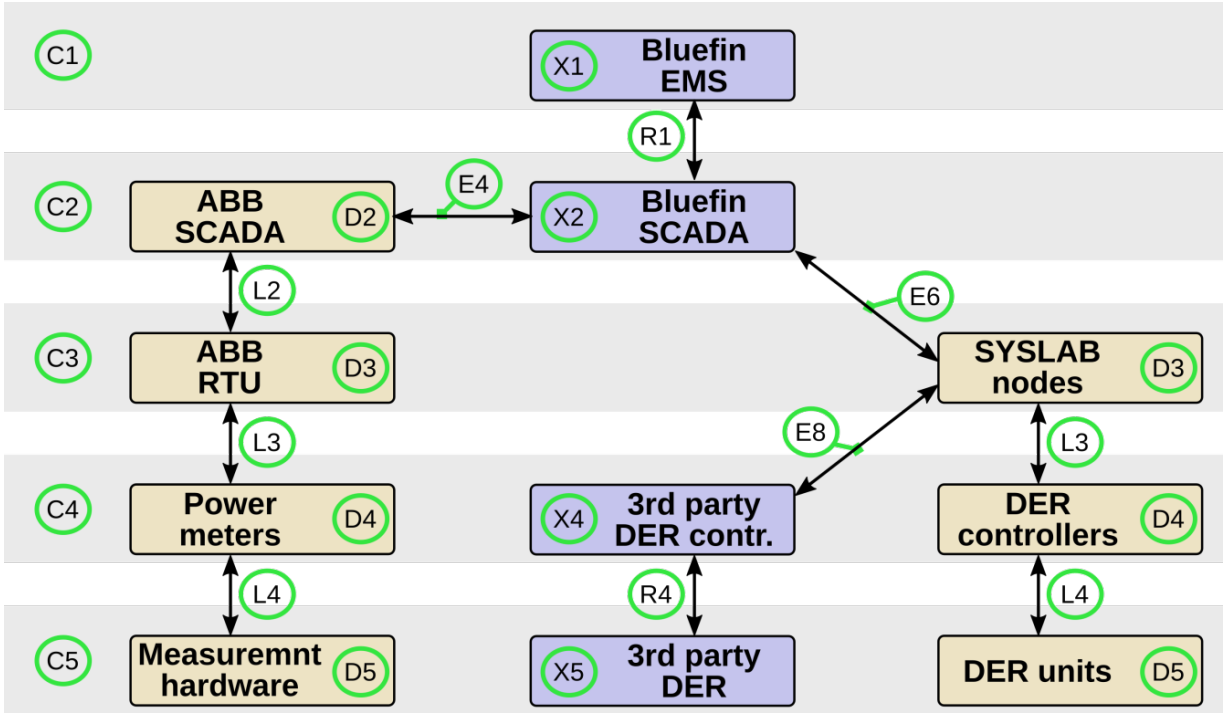
Generic Reference Model
Example DTU SYSLAB & Electric lab

- Performance evaluation of a third-party smart grid automation system
- Augmentation of a low automation host lab (DTU Electric lab) with components and control infrastructure from a highly automated lab (DTU SYSLAB)



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Complex DER Component Behaviour

- Lab equipment (esp. DER units) often exhibits complex and undocumented behaviour when operated during experiments
  - Documentation often focuses on the operation under standard conditions
  - Examples include deratings, internal limits, safety circuits, alternate operating modes, functions added as part of laboratory integration etc.
- The productive use of a particular component often relies on unofficial knowledge associated with experienced lab staff – sometimes a single person
- ERIGrid conducted a survey of examples across partner labs, the results can be seen as a first step towards a more systematic documentation


RSE face-to-face converter


SysTec of Fraunhofer IWES

Controller Deployment Procedures

- Deploying controllers – software or hardware, from the unit level to the system level – is important for many types of smart grid testing
- It is very difficult for an outside user or research partner to gain an overview of the exact capabilities of a laboratory with respect to controller deployment. This complicates the selection of a suitable facility for an experiment.
  - Uniqueness of the individual laboratories
  - Many possible interaction patterns
  - Policies and safety/stability concerns (an interface exists, but it should not be used)
- Survey of controller hosting capabilities across partner labs
  - Physical capabilities
  - Interfaces
  - Procedures

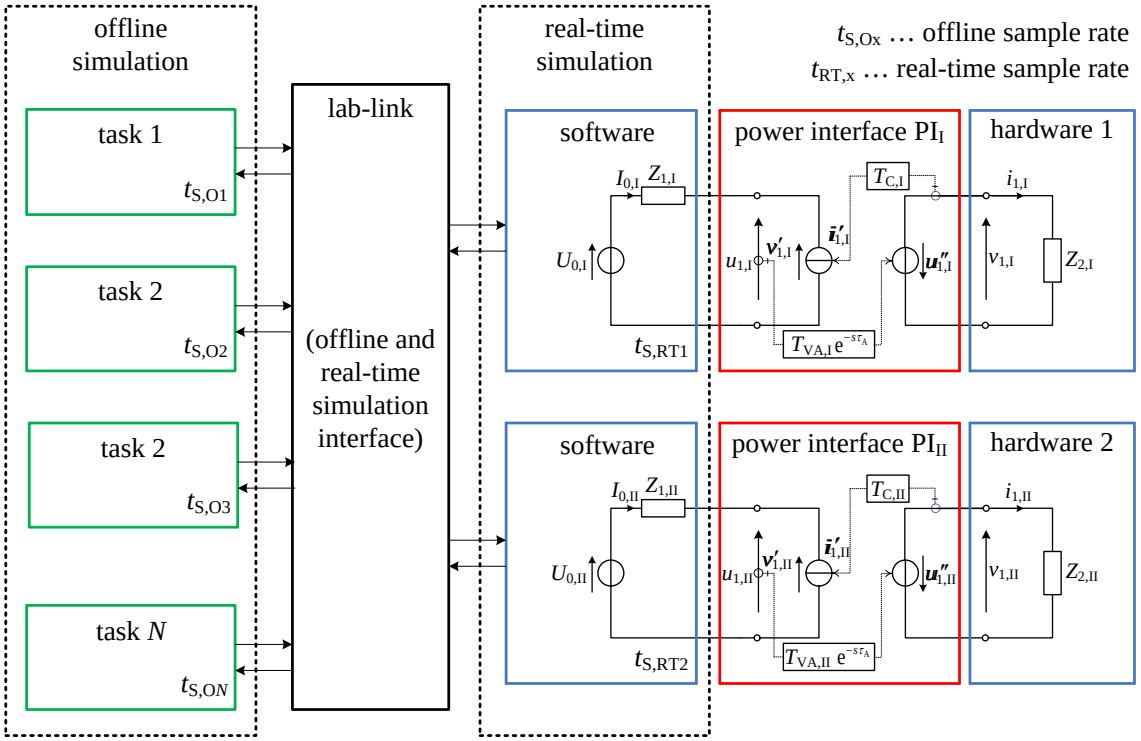
Signal and Object Naming

- The partner labs have been developed from very different architectural viewpoints, resulting in different ways of modelling information
- Establishing a harmonized object and signal naming convention is necessary for machine-to-machine communication between labs
- Existing standards lack flexibility
  - Lab-specific description of primary hierarchy (physical, electrical, automation based, information based, etc.)
  - Additional domains (control, communication, etc.)
  - Unambiguous description of components which belong to multiple hierarchies and/or multiple domains

- ERIGrid has developed naming conventions suitable for the detailed description of static (objects) and dynamic (signals) data in smart grid laboratories.

Coupling Co-Simulation and Real-Time Hardware-in-the-Loop (HIL)

- Cyber-physical (multi-domain) approach for analysing and validating smart grids on system level
- Improved validation and testing methods with focus on co-simulation & HIL

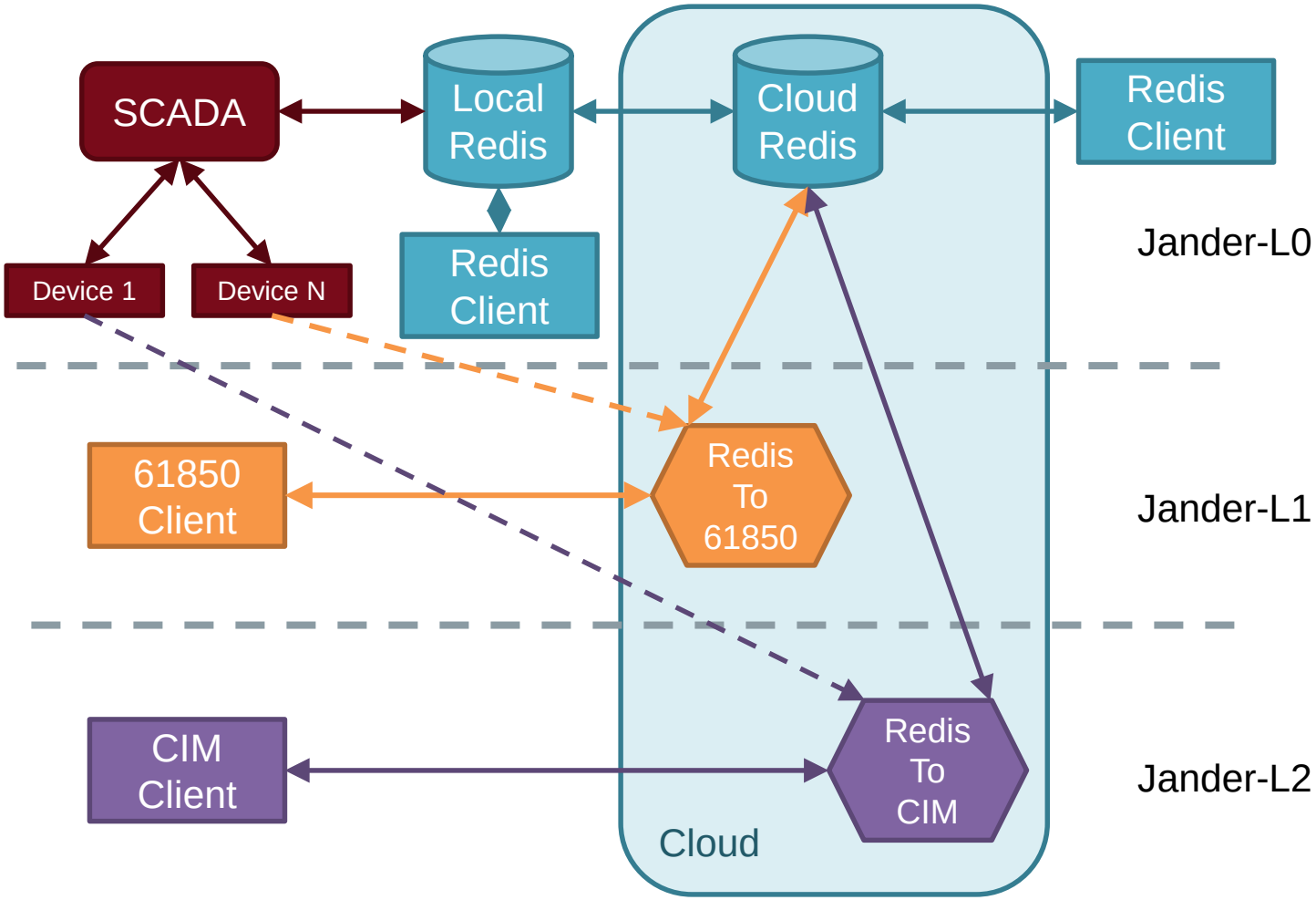


Connecting Smart Grid Labs
Real-Time Data Exchange via JaNDER

- Joint Test Facility for Smart Energy Networks with DER (JaNDER)
  - Result from FP7 DERri
  - Proof-of-concept of real-time data exchange between lab facilities

- Several shortcomings of DERri JaNDER version (addressed in ERIGrid)
  - Installation effort (e.g., requirement for firewall changes)
  - Lack of official multi-lab test cases in DERri
  - No context information beyond raw real-time data
- Virtual Research Infrastructure (VRI)
  - Integration of all ERIGrid participating labs
  - Virtually integrated pan-European smart grid research infrastructure

Connecting Smart Grid Labs
JaNDER Architecture



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Connecting Smart Grid Labs
JaNDER Example

- Coordinated voltage control between a simulated grid and two physical grid segments
- Using JaNDER levels L0 or L1