Enhanced lab-based testing methods and tools

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Laboratory integration obstacles

- Electrical power grids are mature infrastructures and have been extensively standardised. There is no standard for what constitutes a smart grid laboratory or what its primary purpose should be. Consequently, the use of ICT systems, the underlying architectures and the availability of interfaces is subject to large variations between facilities.
- Smart grid laboratories are complex infrastructures. They have some unique properties which distinguish them from many other technical installations of comparable complexity.
  - Experimental nature of the installations
  - Changing user groups
  - Evolving configurations
- Finding common ground when simply talking about laboratory integration can already be a challenge

Issues addressed in ERIGrid

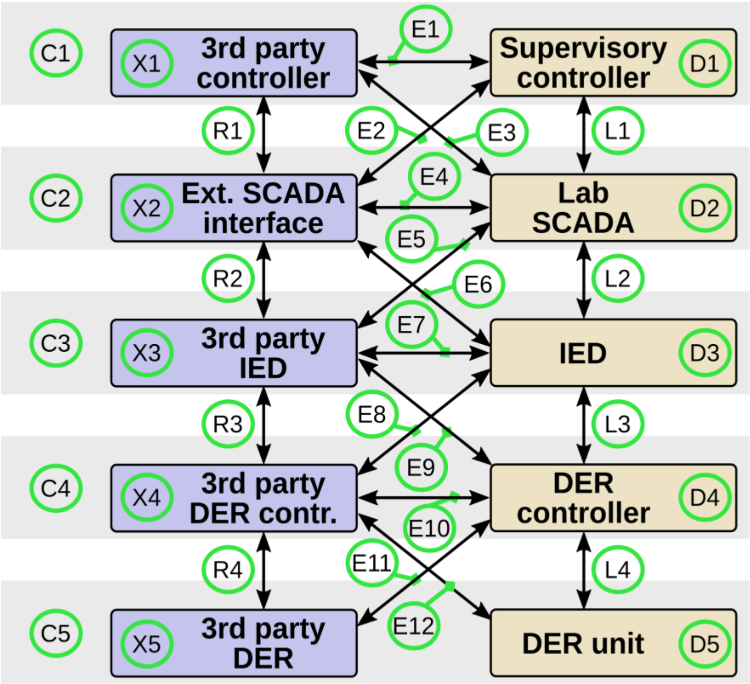
- Generic reference model for control hierarchies, interfaces and data flow in smart grid laboratories
- Documentation of controller deployment procedures
- Uniform naming of signals and objects
- Documentation of complex DER behaviour

The need for a generic reference model

- The availability of communication interfaces between the different parts of a laboratory determines to which degree the laboratory 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 laboratory capabilities which tend to focus on the performance of the electrical power equipment
- 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

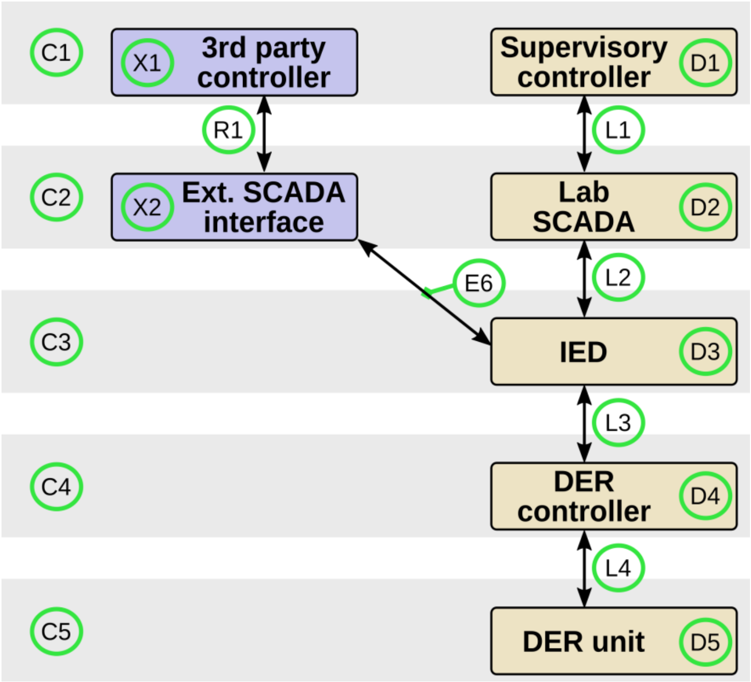
Generic reference model Description

- 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



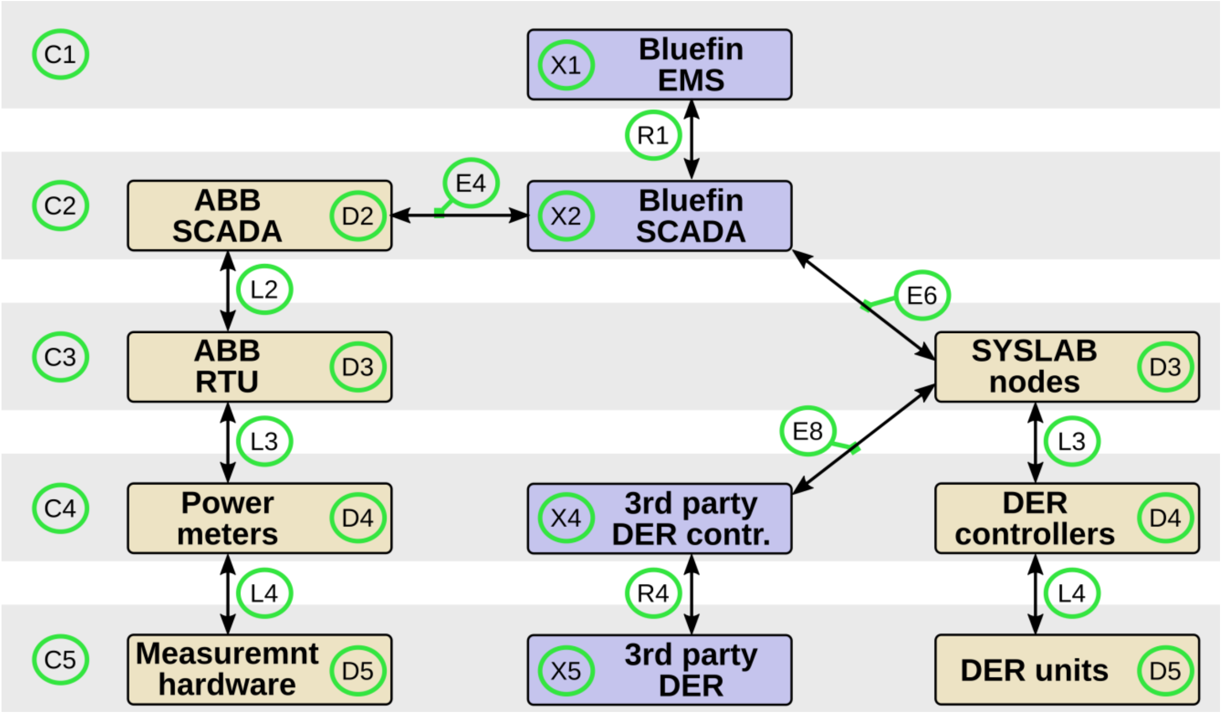
Generic reference model Example AIT SmartEST

- A third-party system-level controller (e.g., power balancing control) is directly interacting with DER units in the lab through a gateway/IED
- The la internal SCADA system is used for the configuration of the experiment, but not during the execution phase



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)



Controller deployment procedures

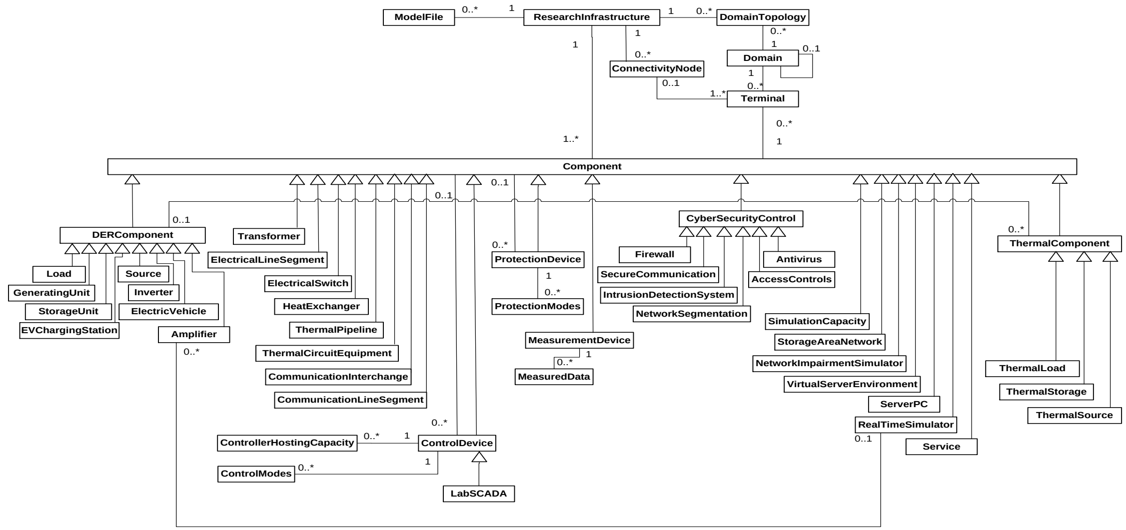
- Deploying controllers – software or hardware, from the unit level to the system level – is important for many types of smart grid testing
- It is very difficult for an outside user or research partner to gain an overview of the exact capabilities of a laboratory with respect to controller deployment. 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

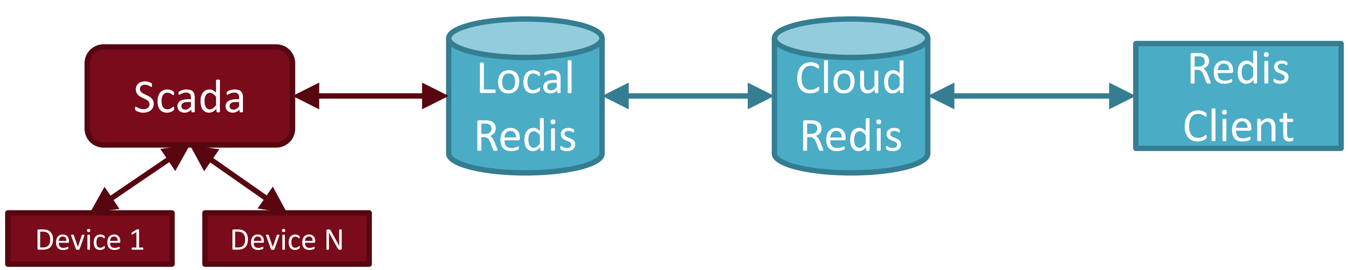
- The partner labs have been developed from very different architectural viewpoints, resulting in different ways of modelling information
- Establishing a harmonized object and signal naming convention is necessary for machine-to-machine communication between labs
- Existing standards lack flexibility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

Signal and object naming

- Object naming application (ERIGrid laboratory database)



- Signal naming application: JaNDER



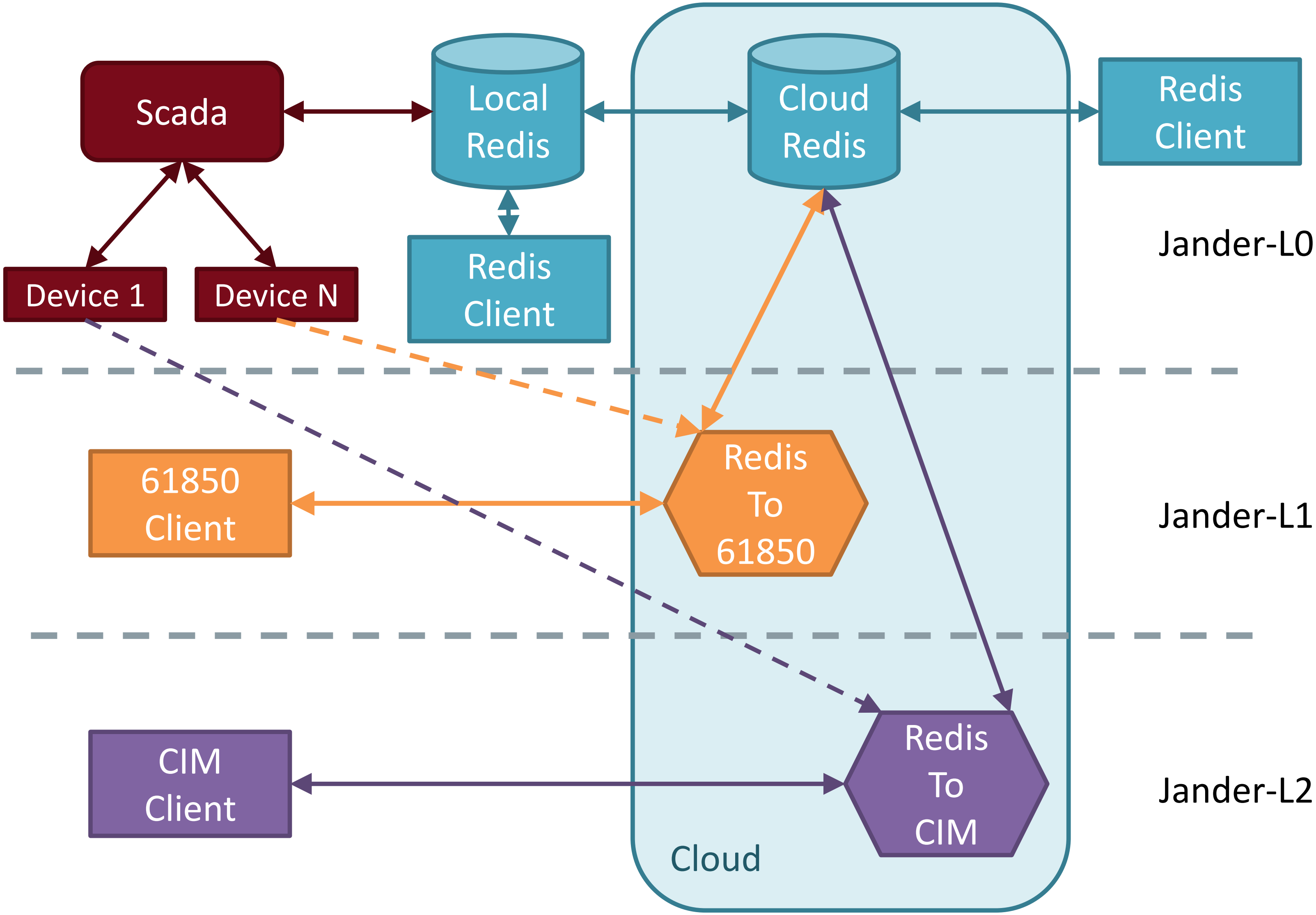
Complex DER component behaviour

- Lab equipment, in particular DER units with embedded controllers, often exhibits complex and undocumented behaviour when operated during experiments. Available 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.

Real-time data exchange (JaNDER)

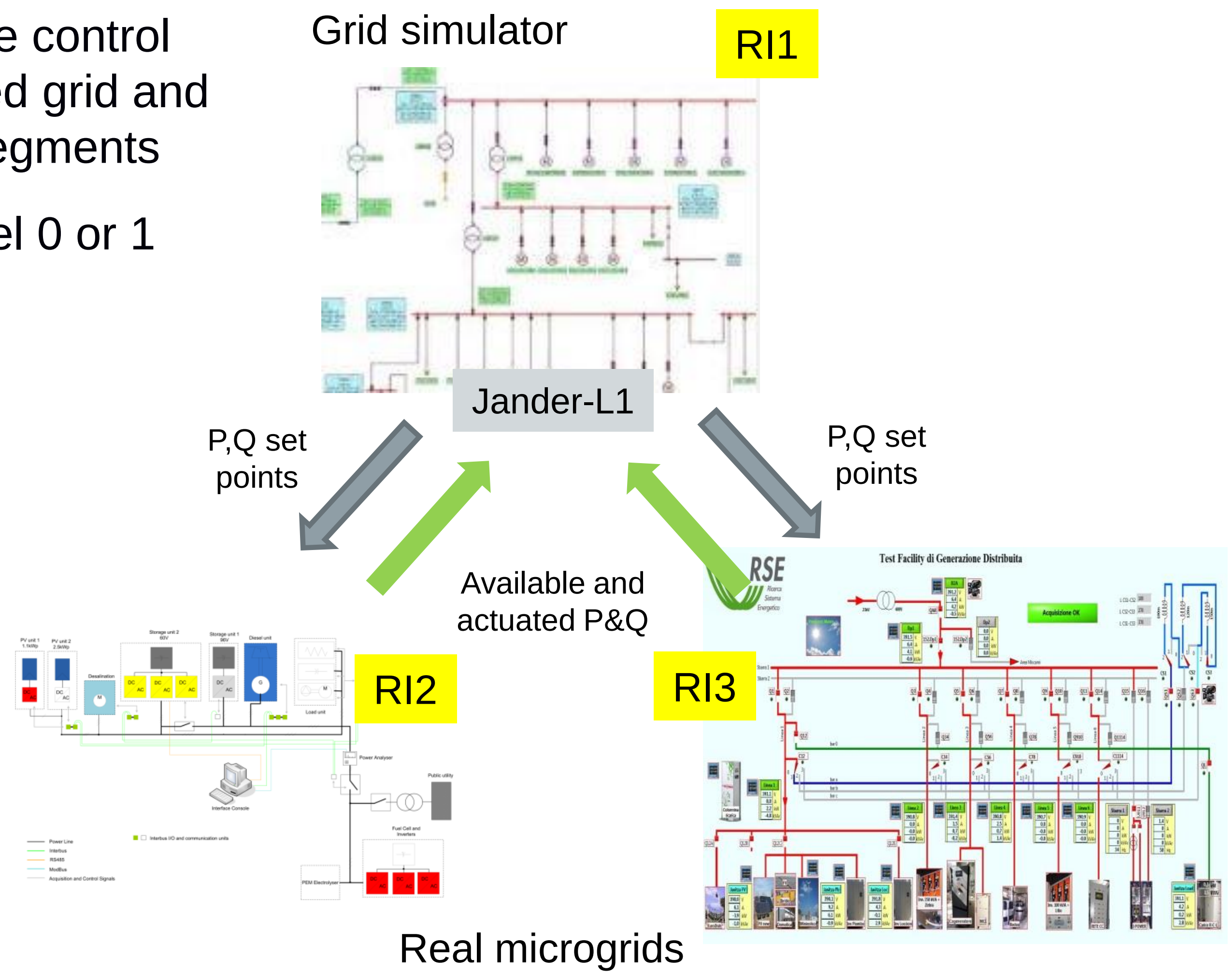
- JaNDER (Joint Test Facility for Smart Energy Networks with Distributed Energy Resources)
  - Proof-of-concept of real-time data exchange between lab facilities developed during the FP7 DERri project
- DERri version of JaNDER had several shortcomings which ERIGrid will address
  - Installation effort (e.g. requirement for firewall changes)
  - Lack of official multi-lab test cases in DERri
  - Limited participation by partners
  - No context information beyond raw real-time data
- All participating labs will be integrated into a Virtual Research Infrastructure (VRI), enabling their participation in implementing the three ERIGrid multi-research infrastructure test cases

Three JaNDER service levels



JaNDER application example

- Coordinated voltage control between a simulated grid and two physical grid segments
- Using JaNDER level 0 or 1



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