Question 2.01: What are the challenges in the development of digital substations and how to address the problems caused by the digitalization?

In the past two decades, the policy of RTE has been to purchase "turn-key" integrated Protection Automation and Control Systems (PACS) from several vendors, according to a set of specifications. RTE has now launched the R#SPACE project aiming at an industrial rollout of fully digital, IEC 61850 based multi-vendor PACS. This project is motivated by several constraints and evolutions experienced by RTE over the last years, including increased insertion of Renewable Energy Resources (RES), limited flexibility, delays and high development costs in case of evolution of substation level functions, demand to extend remote maintenance and administration of PACS, and the need to interface Low Power Instrument Transformers and other communication HV equipment via IEC 61850 process bus.

In the definition phase of the R#SPACE project, it became clear that there are components which should be purchased and others which should be developed internally. It also became clear that every purchased component could (and probably should) be purchased independently, thus making R#SPACE a multi-vendor and multi-component system by construction.

For R#SPACE, the position of RTE is thus that of a system integrator charged with the definition of the interoperability framework of the new PACS, including the configuration, data models and cybersecurity.

In this context, several challenges associated to an industrial rollout of fully digital PACS need to be addressed by the project:

Interoperability

It is necessary to guarantee complete interoperability between all the IED participating in the functional protection chain. The specifications, based on of IEC 61850 and IEC 61869-9, to achieve this interoperability have been formulated taking into account the experience feedback from the "Postes Intelligent" Rte project. The IED concerned are the Stand Alone Merging Unit (SAMU), the IED hosting the protection function and the Binary I/O IED (BIOI).

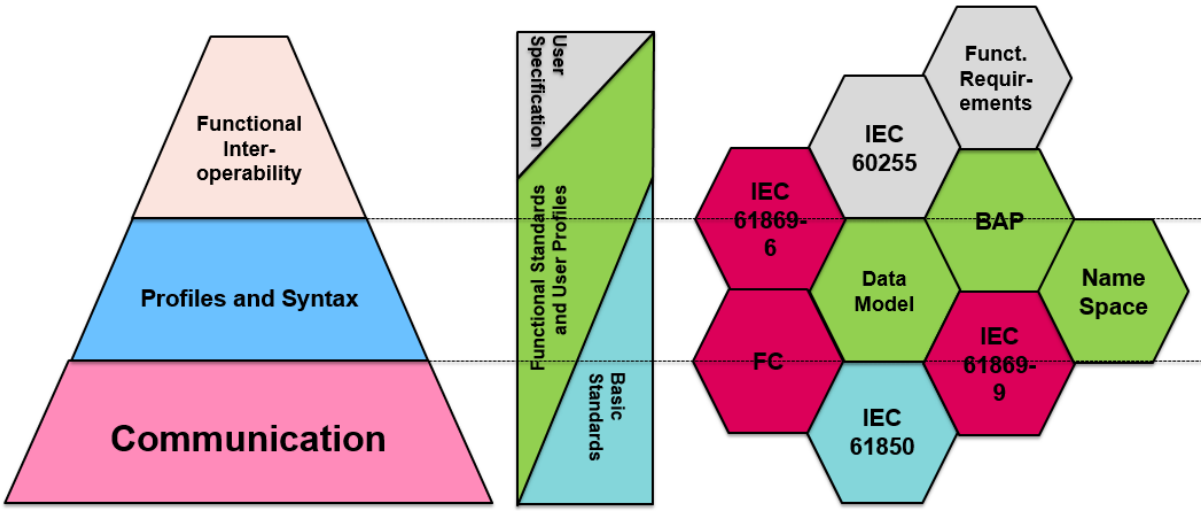

Figure 1 Conceptual Interoperability levels

In order to achieve a complete operational interoperability between two components or functions, several levels of interoperability need to be addressed [3][4], including (see Figure 1):

- **Communication interoperability** is covered by IEC 61850.
- **Profiles and Syntax**: Functions communicating which others also need a common understanding about the meaning of the different Data Objects. In some cases, the general

definition offered by IEC 61850 is not sufficient and needs to be completed by profiles or data models.

- **Application level interoperability** is covered by functional specifications.

Figure 2 [4] highlights the different features required to achieve operational interoperability, in particular, the use of standard or user profiles (e.g. BAP (Basic Application Profile) and data models needs to be coordinated between the components of the functional chain implemented in the different IEDs. In the approach defined by Rte, PACS, functions are represented as Logical Devices. For each function, the inputs need to be associated either to an input terminal or to a DO subscribed from another LD. Each interoperability feature needs to be tested.

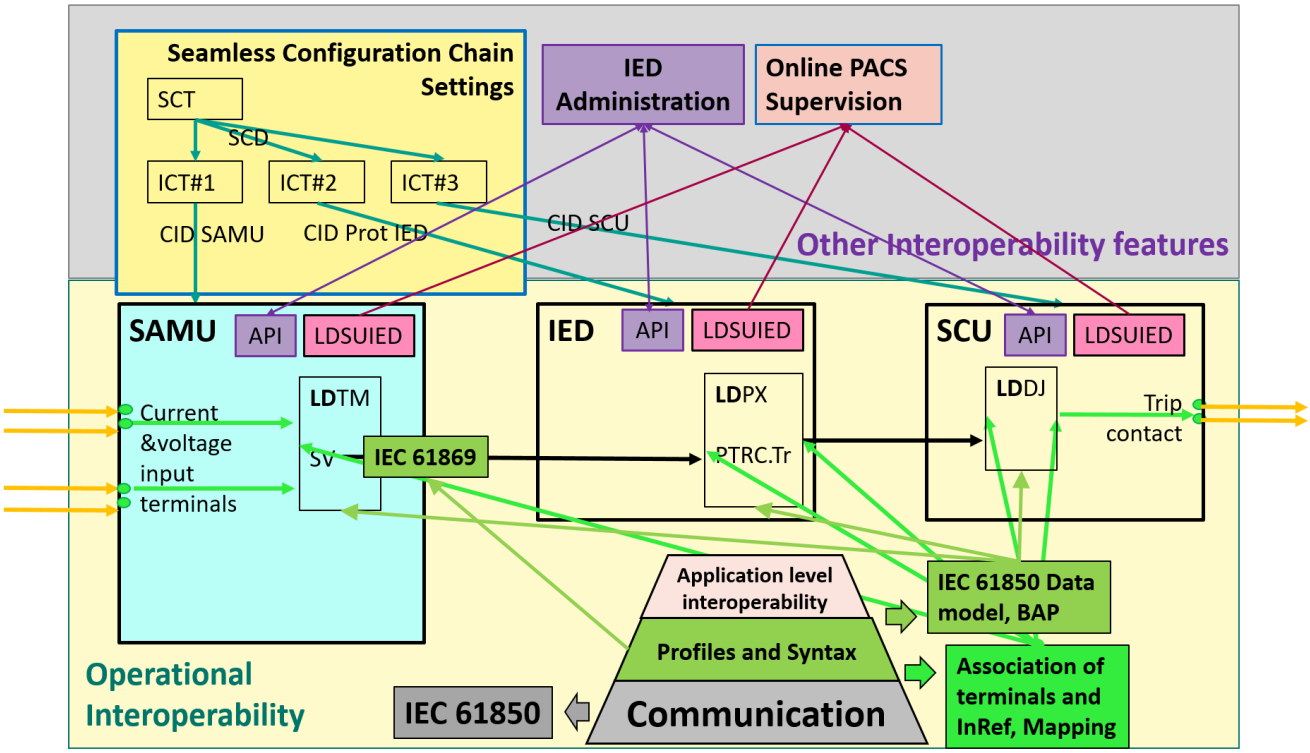

Figure 2 Operational and non-operational interoperability features of a functional chain

Seamless engineering process and system management

Figure 2 also indicates different features belonging to non-operational interoperability. For a PACS composed of IEDs from different manufacturers, an industrial scale deployment requires interfaces for those features complying with a common specification. It is not possible to manage the initial configuration, the tests and the maintenance stage by manually addressing each IED using its proprietary IED configuration and administration tool. It must be possible to implement a seamless top-down configuration and administration process. This requires the interfaces for

- IED Administration, which is used in particular to download updates for configuration, settings and functions. In R#SPACE, the implementation of an API for these functions is required.
- IED Supervision. This can be based on existing IEC 61850 LN. In the R#SPACE data model, this information is grouped in a specific LD. It includes hardware and communication supervision of the IED.
- The support of a top down engineering and use of end-user profiles.

Virtualisation

From the first phase of R#SPACE, substation level functions are implemented in a virtualised structure. This includes the telecontrol gateway, the SCADA, firewalls and substation level functions. Whereas the existing off the shelf technology enables virtualisation of real-time or close-to-real time PACS functions, care has to be taken regarding environmental constraints. Many off the shelf servers are designs for IT

applications and environments and may not have a sufficient EMC or temperature immunity required for an installation in conventional kiosk or cubicles.

The virtualised PACS functions have to interface in the same way as functions implemented in IEDs, leading to specific requirements for administration, supervision and the IEC 61850 communication interfaces.

Also, there are specific constraints for real-time applications that need to be met and the different components to be integrated in the virtualised structure should be packaged in a way that limits the size of memory and the number of different operating systems.

Finally, optimisation regarding the implementation has to take into account the availability constraints of the hosted functions. Some need 100% availability with hot stand-by, for others a short-time interruption of service of service is acceptable. This has a direct impact on the resources of the virtual structure used for the different functions, in particular the number and sharing of processor cores.

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