Study Committee B5

PS3 – Integration of intelligence on substation

Paper B5-10906

Engineering process and tools to support the specification, configuration, qualification and operation of substations based on IEC 61850 over their whole lifecycle

T.COSTE, A.DEHOUCK, Q.LEBOURG, K.KAMGA, B.GEORGES

EDF R&D FRANCE

Motivation

EDF will be engaging the refurbishment of its PACS systems over the next few years, in particular its substations at the transmission and distribution voltage level, based on the new standards and digital technologies aiming a single architecture for both voltage levels and at the same time maintaining older generations of substations.

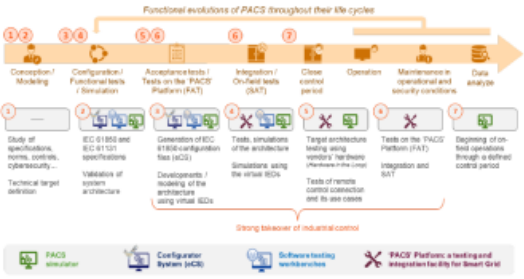
EDF therefore has the challenge of mastering its PACS in order to optimize :

- Integration, deployment (CAPEX) and maintenance (OPEX) cost,
- Industrial performance of the power grid as well as the electricity quality,
- Security of Information System, including their data
- Security and resiliency of the system facing cyber-threats,
- The industrial sustainability of products (interchangeability, maintainability),
- The internal skills and know how.

The EDF's engineering process is designed to tackle new stakes emerging from a context in full transformations: The PACS domain undergoes several transformations on both technological and business aspects. In that context, EDF observes three types of stakes that he uses as framework for his engineering process

Method/Approach

To achieve these stakes, EDF has defined an engineering process covering the entire life cycle of its systems :



EDF's engineering process consists of 7 interrelated steps that cover the entire PACS life cycle :

- **Step 1** define the functional scope of the PACS to be conform of the protection schema of the power network.
- **Step 2** starts once the functional perimeter is well defined. It composes of the IEC 61850 specification and modeling of the protection and automation functions identified during the step 1.

EDF's engineering process, based on a top down approach in accordance with the standard, adds a specific phase making it possible to describe its own libraries representing the electrotechnical elements of substations.

- **Step 3** is a stage to first define the PACS's architecture, therefore the allocation of functions in IEDs, and the communication network (LAN). From this step, the IEC 61850 files can be generated in order to define the specification (SSD) and the configuration (SCD) of the PACS (IED). These work are achieved using a key tool developed by EDF, named the eCS, which is a system configurator (SCT) for IEC 61850 PAC. EDF keeps control of its functional requirements, data model, which ensure the interoperability or even interchangeability between system suppliers.

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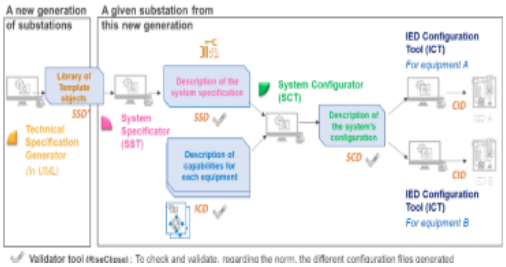

- **Step 4** enables to check specification and configuration using simulations and tests. More precisely, the IEC 61850 simulator ensures that the PACS's architecture and exchange interfaces comply with all the functional requirements.
- **Step 5** starts when the virtual architecture has been verified and validated. It allows checking the functional behaviour expected from protection and automation functions using the predefined exchange interfaces.
- **Step 6 and 7** are conventional steps, respectively for the FAT and the SAT. Once these steps are successfully passed, the commissioning and maintenance can be started.

Experimental setup & test results

To support steps 1 to 6, EDF set up in 2021 an IEC 61850 laboratory in Paris-Saclay that enables to check specifications and test entire substation's PACS. Thanks to this platform, it is possible to install and connect IEDs from different manufacturers, then test them alone or in interoperable environment. In addition, different configuration tools can be evaluated there, such as the IED configuration tools (ICT) from manufacturers, the EDF home-made configuration tool (eCS) or independent configuration tools.
To allow a comprehensive testing environment, the laboratory is leveraging on a test bed based on both an IED 61850 simulator under development and an OPAL-RT real time simulator that activates on-demand EDF's tests playbooks. Such a R&D laboratory is a key asset for EDF IEC 61850 strategy.

EDF's eCS (evoluted Configurator System) encompasses several configuration and validation tools within a unique modular solution, and is a key tool of the engineering process:

This tool is used by EDF to implement the complete IEC 61850 SCL configuration process for substation PACS. It is based on client/server architecture for a more effective collaboration work. One of the main advantages is that the tool has a shared library or database such as for the typical library objects
This IEC 61850 configuration tool is made of five modules offering a full set of functions that, together, enable to mutualize and ensure consistency of the various configurations required by protection, automation and control systems.

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- **The technical generation specificator, developed in UML is an additional step compare to traditional process**, that allows to create specific objects such as Transformer bay, Switchgear bay etc… It can be seen as a library gathering descriptions of all components of PACS for a given substation project developed in UML.

- **The system specificator** component will use as input the specific objects defined with the technical generation specificator in order to generate the SSD file of the corresponding specification. This file represents the single line diagram (SLD) and all logical nodes needed. We implement the standard top down process with the system specificator which generates the SSD file imported by the system configurator.

- **The system configurateur** based on standard top down approach. It import both SSD and ICD file from equipment to generate the SCD file, which will be imported in the ICT tool.

- **RiseClipse** is a component to verify the conformity of SCL files. This Open Source tool developed by EDF following part 6 of IEC 61850 series with rules developed from OCL1 technology.

Conclusion

The choice to develop EDF system configurator was motivated for different reasons. The main advantage for EDF is the possibility of describing all network objects in the form of a reusable library developed in UML, which is the language used by the IEC to describe the IEC 61850 standard. This makes it possible to inherit changes to the standard without impacting the code of the system configurator. eCS is suitable for multiple IEC 61850 use cases for EDF, such as substation, DER and RTU with optimized time to market. Having a unified engineering process, we believe that we can significantly reduce the configuration time of a substation and optimize the maintenance costs by a client/server architecture.
The simulator tool is important because it should save precious time both by a more accurate interpretation of the requirements between the specifier and the manufacturer and a verification process upstream of the FAT and SAT.
Some improvements of the IEC 61850 standard have been identified in particular using the top down approach which will be proposed to the IEC.