THE IEC 61850 IN THE PORTUGUESE DISTRIBUTION SUBSTATIONS: CONTEMPORARY CHALLENGES AND POSSIBLE SOLUTIONS

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ABSTRACT

Interoperability may be defined as the ability of intelligent electronic devices (IED's) to exchange and use information correctly. Although the IEC 61850 standards define a consistent methodology for interconnecting IEDs in substation using LAN based technologies to promote interoperability, this ability to exchange information correctly is not always achieved between different IED's from different manufactures. This paper reports the assessment of IED's, featured with IEC 61850 standards and connected to the same communication network from different manufactures. Different interoperability tests are performed and the difficulty and challenges to exchange and receive information is also reported. Possible solutions on the XML schema to generate a compliant SCL file as well as the way to scale up the standardization of the substation project is also explored and discussed in this paper.

INTRODUCTION

Distribution System Operators (DSO) worldwide seek for service quality, financial performance, flexibility, reliability and thus more capacity to monitor and control all primary equipment in a substation. The IEC 61850 standards may help the DSO to archive their objectives leading the implementation of substation communication networks into a new paradigm. The Portuguese DSO has also taken advantages of the IEC61850 standards to seek for interoperability, free configuration and hopefully long term stability to the substations. Moreover, it is expected easy expansion of systems with future-proof protocols and data structures could be applied across a wide range of interconnection technologies towards standardizing Portuguese substations. Thus, it is expected that the power substations continue to improve quality of service along with cost reduction.

When implementing the IEC 61850 standards at the different power substations, it is expected that communication network architecture becomes equal between these substations rather than being unmatched because of incompatible equipment made by different manufacturers. As the communication network architecture between distinct substations becomes standardised, the Portuguese DSO expects that the equipment made by different manufacturers communicates between them. Therefore it would be easier and less costly to integrate equipment made by different manufacturers.

Interoperability may be defined as the ability of IED's to exchange and use information correctly. Although the IEC 61850 standards define a consistent methodology for interconnecting IEDs in substation using LAN based technologies to promote interoperability, this ability to exchange information correctly is not always achieved between different IED's from different manufactures. This paper reports the assessment of IED's, featured with IEC 61850 standards and connected to the same communication network from different manufactures. Vertical interoperability test is performed and the difficulty and challenges to exchange and receive information is also reported. Possible solutions on the XML schema to generate a compliant SCL file as well as the way to scale up the standardization of the substation project is also explored and discussed in this paper.

IEC 61850 PRACTICAL IMPLEMENTATION: UTILITIES' CHALLENGE

The IEC 61850 specifies the substation configuration description language (SCL) based on extended markup language (XML) format for configuring and engineering the substation automation (SA). The SCL defines the station single line diagram, function allocations, mandatory/optional and extensible data, services, communications and configuration parameters. The objective of SCL is to have a common description of SA exchanged between different manufacturers.

IEC 61850 specifies then the SCL based on XML format for configuring or engineering the SA system. The SA system with IEDs consists of distribution and control system configuration of the substation, and the number of IEDs through communications performs the functions of monitoring, measurement, control, and protection. The IEC 61850 based IEDs are configured with the communication network and communication system means to configure the IEDs. In other words, the engineering process is the construction and setting the interfaces between IEDs or IEDs and HMI in substation.[1-3]

Using IEC 61850 schema files, the configuration tools create, edit, and save the SCL file depending on its purpose, which can be classified on the following types: IED Capability Description (ICD), Substation Configuration Description (SCD), Configured IED Description (CID), among others. HMI data obtained from the parent to the user to perform monitoring and control and it makes IEC 61850 based dataset to create and delete the data, and get the event messages, and also supports the engineering

process allowed download, upload and search of files with a service of IEDs . The engineering process with conventional tools is effective to the communication between IEDs for the same manufacturer but is not actually so good if the utility uses the third-party products, although the rationale behind IEC 61850 is to achieving communication interoperability as well as functional integration and advanced engineering in multi-vendor systems. The software from one manufacturer cannot be used by other manufacturer. This make the systems operators need to have a capability to facilitate of IED configuration tools in order to perform the engineering process of SA system according to the product's manufacturers. [3-5]

INTEROPERABILITY TESTS AT THE PORTUGUESE DSO

At the present time, the Portuguese DSO as a substation operator has not yet indicated to its IEC suppliers a specific guidance for the IEC 61850 SA solution. This means, the IEC 61850 manufactures apply to their product their own solutions and no a standardize solution imposed by the DSO. Therefore, the solution may be too dependent on the manufactures, with the difficult to standardize the engineering process to SA to the other projects or to apply fully interoperability between IED's. [3,6]

Figure 1 illustrates different engineering tools from different IED's manufacturers and used in the interoperability testes performed in this work.

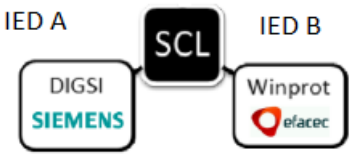

Figure 1 – IED's software configuration tool from different manufacturers.

The proprietary software of each of those manufacturer in Figure 1 allows the configuration of communications in the substation, both vertical or horizontal communication. For vertical communication, the IED's IP (Internet Protocol) adress is set and for horizontal communication, the content of the sent or received Generic Object Oriented Substation Event (GOOSE) messages are defined.

Vertical Interoperability Test

Two different IEDs were used to perform the vertical interoperability test carried out. It was replaced one IED from one manufacturer to the equivalent from the other manufacturer, both IED in compliance with IEC 61850 and approved by the Portuguese DSO. The substation database was updated. Both IEDs are in the same Local Area Network (LAN) as shown in **Figure 2**.

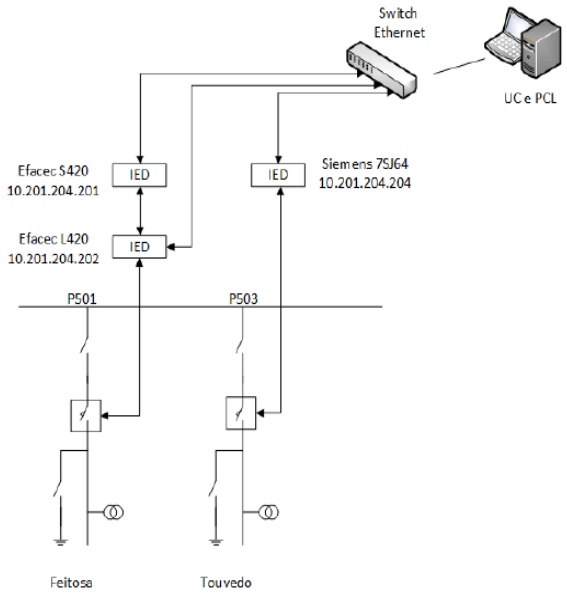

Figure 2 – Substation scheme under the vertical interoperability test.

Figure 3 shows the result of the communication trace from the vertical interoperability test. As it can be seen there is a continued existence of an error in the communication when the Central Unit (CU) tried to communicate with the new replaced IED.

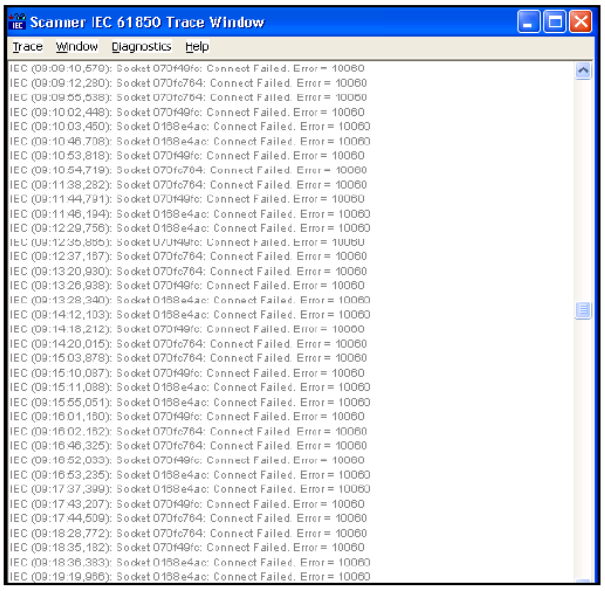

Figure 3 – Communication trace from the vertical interoperability test.

The difficulty of the vertical interoperability may reside on the generic names that were assigned to the IEC 61850 Standard's dataset, such as the names of the Logical Nodes

(LN), instead of the appropriate descriptive names. Table 1 shows, as an example, the same assigned LN in the Centre Unit (CU) by both IEDs manufacturers.

Table 1 – The IEC 61850's tags by two different IEDs manufacturers at a Portuguese substation

Central Unit	MAX I> INST	MAX I> TEMP
	QPPPG-5501-PRI1I	QPPPG-5501-PRI1T
IED B	PFDPTOC2STStr	PFDPTOC2STOp
IED A	IED_224PROT$PIOC1$Str	IED_224PROT$PIOC1$Op
IEC 61850	PIOC	PTOC

As a specific LN is not specific for the IEC standard and the DSO do not specific either, each IED manufactures gives different names and solutions. Sometimes defining LN for generic reference GGIO (Generic process I/O). It is easily found that are too many GGIOs implementing protection, command and control at the Portuguese SA avoiding simplicity and product development process.

Vertical interoperability test and possible way to standardization and scale up

An IED A from one manufacturer it was connected to a Control Unit from manufacturer B. Then, it was update the UC's database and to reconfigure IED A.

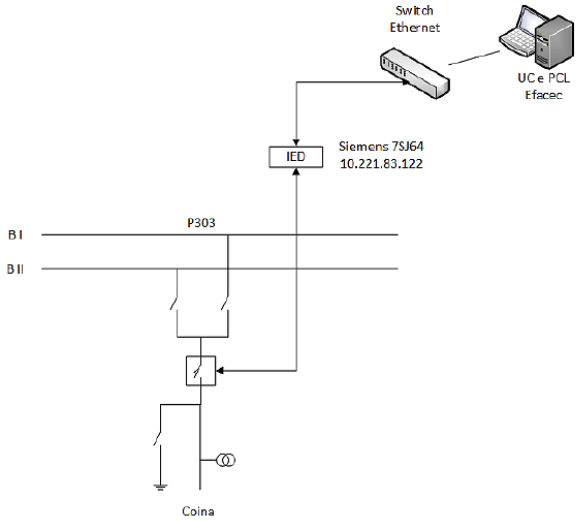

Figure 4 - Substation scheme used for the test.

Figure 5 illustrates the communication trace between IED from manufacturer A and UC from manufacturer B.

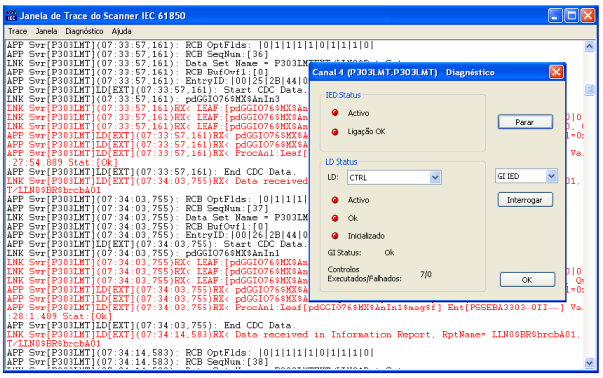

Figure 5 - Communication trace from the performed tests

Comparing this trace with the one in Figure 3, is possible to see that there is effectively an exchange of information between the level 1 and level 2 of the substation, despite the fact the devices being from different manufacturers. The database updated and the IED reconfiguration consisted of using Generic LNs (GGIOs or pdGGIOs) instead of specific LNs as shown in **Table 2**.

Table 2 - Comparison of IEC 61850's tags after integrating the Siemens's IED with the Efacec's CU.

Central Unit	MAX I> INST	MAX I> TEMP
	PSSEBA3303-PRI1I	PSSEBA3303-PRI1T
IED A	pdGGIO29STSPCSO18$stVal	pdGGIO29STSPCSO23$stVal
IEC 61850	PIOC	PTOC

Good Engineering Practices

After updating the database, the procedure that allowed the integration of a new and different IED manufacturer can be summarized in the following sequence:

(1) Open the substation project with the own IED configuration manufacturer software;
(2) Configure the IP, in the 'Object Properties' option;
(3) (in this particular case) Confirm that the project's MLFB matches the device's MLBF (the MLFB refers to the protection device's model in this specific IED manufacturer);
(4) Confirm Voltage and Current transformer ratio;
(5) Download the new configuration to the IED and confirm/update the firmware version of IEC 61850 as well as to confirm/update the UC's, to confirm/update the firmware version of the IEC 61850 protocol's file that accompanies the ethernet switch.

Horizontal Communication at the Portuguese SA

With the goal of achieving the interoperability between equipment from different manufacturers, the IEC 61850

Standard specifies a configuration language, a data format and the data mapping on the communication layer of the Open System Interconnection model 1 (OSI) among other specifications. The Part 8 of the IEC 61850 Standard, proposes Generic Object Oriented Substation Event (GOOSE) messages characterized by the way Publisher/Subscriber where information is distributed in a unicast, multicast or broadcast way. That is, messages can be received by a single, several or all IEDs (subscribers) and they can use it or not.

At the moment, the Portuguese DSO has not yet implemented any functionality for verifying the horizontal interoperability. The configuration of each IED was made individually instead of having the possibility to perform in the system configuration tool, regardless the equipment involved. Although, different manufacturers are able to exchange GOOSE messages with each other, the unavailability of equipment yet capable of monitoring the communications between IEDs from different manufacturers, it has delayed conclusions in this aspect.

SUMMARY

Achieving communication interoperability within the IEC 61850 SA is possible but functional integration and advanced engineering is still not straightforward, at least in multi-manufactures systems. The main cause of non-interoperability between IEDs from different manufacturers may be that the data do not follow the hierarchical organization as defined in Part 7-2 of the IEC 61850 Standard or the functional organization defined in the same part of the standard. The IEC 61850 Standard is not strict, allowing different interpretations of the manufacturers. Additionally, the lack of transversal equipment and engineering tools to various manufacturers, does not allow the GOOSE messages configuration in order to achieve a proper operation between IEDs from distinct manufacturers. It would be the ideal to have a tool oriented by the IEC 61850 Standard to allow and support all the IEC 61850 settings, ensuring the desired interoperability.

Aiming to maximize the benefits of the IEC 61850 Standard, a possible solution to be adopted by the DSO, can be the definition of specifications of the IEC 61850 at project level, as is already done in other areas. So that, the Portuguese DSO IEC 61850's SCL, in order to define its own IEC 61850 functional specifications in such a format that could be imported by manufacturers' configuration tools.

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