Standardizing Protection Systems with Flexible Naming Extensions of IEC 61850 Functions

Benton Vandiver III, Peter Rietmann, ABB Inc.

Abstract - The paper identifies how substation automation systems using IEC 61850 can be engineered and deployed in a standardized and efficient way using flexible naming extensions. This facilitates interoperability between different vendor IEDs and other substation automation systems.

This allows a standardized way that a utility can engineer their substation automation systems with a model that they are always familiar with bringing standardization, efficiency, and time savings in the substation automation engineering process and throughout its entire life-cycle.

Index Terms – Protection systems, IEC 61850, substation automation, flexible naming.

1 Introduction

One challenge with the engineering of IEC 61850 systems has been that, users were dependent and tied to the IEC 61850 model defined by the IED vendor. While being IEC 61850 compliant, various vendor models could still be slightly different and this required users to adapt to each of these 61850 model structures.

Let's introduce a flexible naming concept which allows the user to use their own utility specific IEC 61850 model tags and then map the data to different vendor's IEC 61850 product models. This utility specific model will then be visible in all IEC 61850 communications without affecting the vendor specific models or any other aspects of the IEDs. This allows a standardized way that utilities can engineer their substation projects and automation systems with a model that they are always familiar with.

Flexible naming enables interchangeability of different vendor IEDs and yet maintains a consistent interface to the utility defined IEC 61850 model and thereby can standardize the substation engineering process and the substation's product life-cycle.

2 The Challenge

The IEC 61850 standard has achieved a de-facto status in substation protection, automation, and control (PAC) systems. Its popularity is driven from a modern sustainable standard and achieving inter-operability between vendor compliant devices. However one challenge with the usage and engineering of IEC 61850 systems has been that users were dependent and bound to the IEC 61850 model of the vendor's IEDs they used. (Compliance doesn't mean identical)

For many engineers this exposed limitations on the application of IEC 61850 functions and features when engineering their substation PAC systems across multi-vendor devices. In order to achieve a harmonized view of the system irrespective of the IED's used, the use of flexible naming extensions of the IED's attributes, data objects, and logical nodes could provide the user a next level of freedom to define their own internal utility standards consistent with IEC 61850 models.

3 Key Concepts

To overcome the challenge and provide flexibility to the utility engineer, a consistent mapping concept between the utility standard model and complaint IEC 61850 model is needed. The flexible naming extension concept allows the user to do just that, use their utility specific names and tags for their internally defined models complaint to IEC 61850 rules and then consistently map that data to any vendor IED with complaint IEC 61850 models.

This concept is implemented in a current IED engineering tool (abbreviated FPN) where the user IEC 61850 data model that is imported via an SCD file is viewed beside the vendor's IED IEC 61850 data model. This in principle provides the user a look-up table between the different naming definitions and provides a simple way to map between them.

The actual mapping process, which is to bind the mapping to the IED's IEC 61850 data model, can actually be performed at several levels: the attribute level, the data object level, or the logical node level. Because of the nature of the SCL, a template can be easily made to support the mapping process from the utility SCD file to the vendor SCD or ICD file. It can even be harmonized and applied to several IEDs in a project in a quick and efficient way using templates.

FPN User Interface

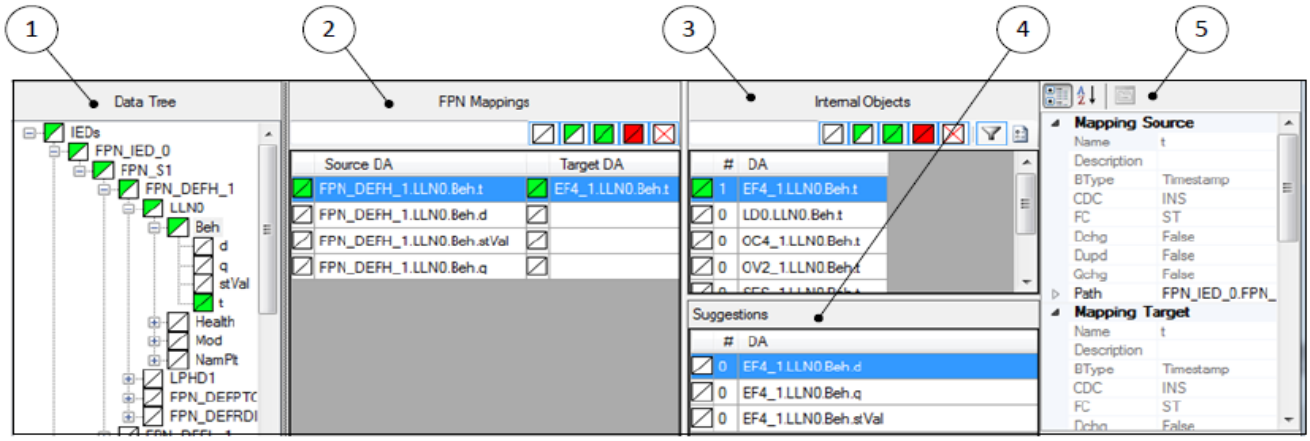


Figure 1: User interface for the FPN engineering tool

4 The Mapping Process

To begin the mapping process, the user IEC 61850 data model (which is a substation level SCD file) is imported into the FPN engineering tool. This SCD file normally contains the predefined report control blocks and data sets, with signal assignments from the customer IEC 61850 data model. The mapping tool user interface is available with simple and clear user process windows as shown in Figure 1.

The Data Tree (1) displays the (FPN) IEDs and their SCL data model down to the data attribute (DA) level. The IEDs displayed in the data tree are filtered based on the current selection in the project plant structure.

The FPN mappings list (2) displays the FPN objects based on the current selection in the data tree. The list may display either IEDs or DA's. The FPN object's name is displayed in the column on the left and the name of the mapped vendor internal object is displayed in the column on the right.

Internal objects list (3) displays the vendor internal objects. The list may display either IEDs or DA's. When displaying the data attributes, the list will also contain information on how many times the vendor internal data attribute is mapped with an FPN data attribute.

Object properties window (5) displays properties of objects currently selected in the FPN Mappings and Internal Objects lists. The properties are mostly read-only and cannot be modified by user by definition.

The Suggestions list (4) displays the vendor internal data attributes that the FPN Mapping Tool suggests to be mapped with the FPN data attribute currently selected in the FPN Mappings list.

Figure 2 shows the clear separation between the data structures (the left based on customer IEC 61850 data model and on the right based on the vendor IED - IEC 61850 data model). With drag-n-drop of the signals, they can be mapped easily one to the other and bound within the context of a single template and IEC 61850 SCD file via a private section.

(It would be advantageous in the future if this method of naming extensions was formalized in IEC 61850 so that all tools and files could benefit from the same mappings and bindings.)

The data mapping can be easily performed using the drag-n-drop method on the Attribute level, DO level where all the underlying attributes are mapped or even at the LN level and here all the underlying DO and their attributes are mapped. The more conformant to IEC 61850 utility SCD file the easier the mapping since it can be applied at the LN level and all the sub-hierarchical DO and DA will be automatically mapped.

IEDs that cannot or does not need to be mapped can be excluded from the mapping concept. Excluded IEDs will be ignored when determining whether or not the mapping of all IEDs is complete.

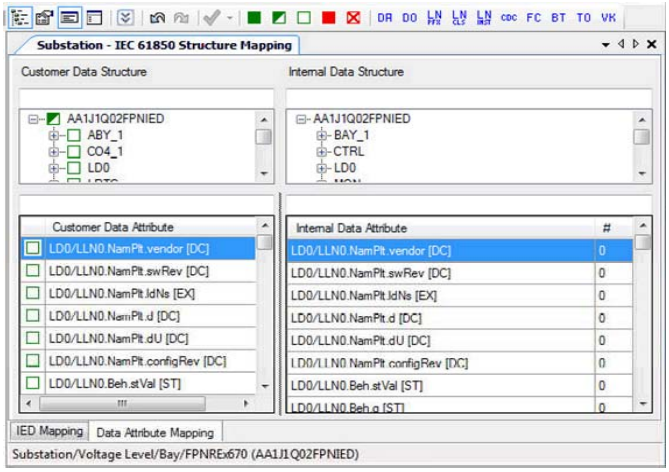


Figure 2: Flexible naming extensions with FPN mapping tool

Data attribute mapping means that each utility data attribute in the FPN model is mapped with a corresponding data attribute in the internal IED model, that is, the real device in the substation. The mapping status is indicated visually. It can be seen what utility data attribute is mapped to what IED internal data attribute and how many utility data attributes are mapped to an IED internal data attribute.

Data attribute mapping is complete when all data attributes of the utility FPN IED, which are not excluded from the mappings, are mapped with an IED internal data attribute. The data attribute mapping must be complete in order to be able to write to the IED. Data attribute mapping is broken if any of the data attributes - FPN or IED internal – that are mapped, does not exist in the SCL database.

In order to guide the user a visual system can be employed where a symbol shown beside the signal (DA/DO/LN) indicates the status of the mapping as provided in Figure 3.

The FPN mapping tool displays the FPN data objects and IED internal data objects in separate lists and pre-maps the data objects based on several criteria to find the best match for example name, CDC, LN class, contained data attributes and their types, names etc. If the tool was not able to pre-map all of the data objects or guessed some of the mappings wrong, user can fix and complete the mapping before accepting it.

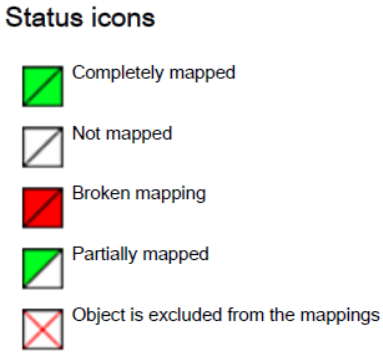


Figure 3: Status of signal mapping

Once the data mapping is completed it can be written to the IED using the engineering tool. The mapped signals reported to IEC 61850 clients, published reports, and datasets are based on the customer specific IEC 61850 data model tags. The IED's data model signals are in essence hidden using the flexible naming signal mapping. The result is the end user is now exposed to a harmonized and familiar signal set based on internal names and tags they commonly use day to day, including all IEC 61850 communications without the IED's specific internal nomenclature.

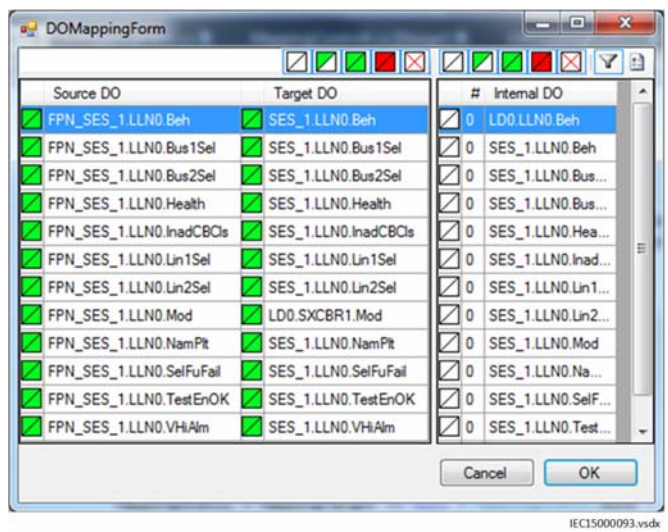


Figure 4: Pre-Mapped Data Objects

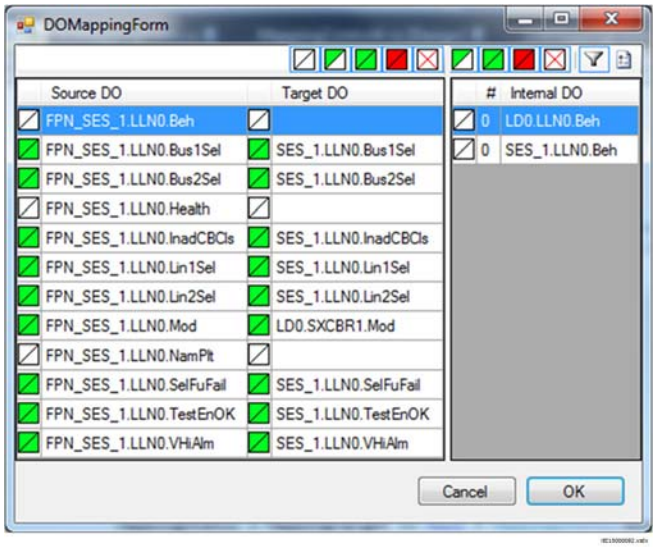


Figure 5: Completed Data Object Mapping

5 Templates and Reports

It is possible to create a template of an IED's data attribute mapping and store it for reuse. The template contains a description of the data attribute mapping between two IED SCL models. All mapping templates created are stored in a template library. The template library is not specific to a project but it is common for all projects. Templates in the library can be managed/used in the following ways:

- Delete, Export, Import selected templates
  - Export - single or multiple template files
  - Import - single or multiple template files
- If a template being imported already exists in the library, the user will be prompted whether to overwrite the existing one.
- Delete, Export, Import a project's template(s)

The mapping templates are also used by the SCL configuration tool to translate the internal data references in the signal library to the FPN references. Because the SCL configuration tool needs to know what template to use to resolve the internal data references, the template information must be included in every FPN IED's SCL data as a "private element."

Naturally a concise report consisting of a cross-reference list of the FPN objects, vendor IED, and data attribute/signal mappings is advantageous for the documentation of the standards process. A sample table is shown in Figure 6.

FPN DA / Signal	IED internal DA	Signal Name in IED
LD_A.QB1CSWI.Pos.stVal	LD_A.QB1CSWI.OpOpn.general	SCSWI: 1.POSITION.stVal
LD_A.QB1CSWI.BlkCmd.stVal	LD0.SCSWI1.BlkCmd.stVal	SCSWI: 1.CMD_BLK.stVal
LD_A.QB1CSWI.OpOpn.general	LD0.SCSWI1.OpOpn.general	SCSWI: 1.EXE_OP.general

Figure 6: Cross reference sample table in report

6 Conclusions

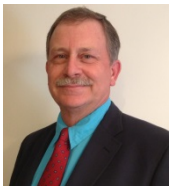
Flexible naming extensions enables the user to easily map the IED's IEC 61850 data model to a customer defined equivalent IEC 61850 data model. This offers significant flexibility and efficiency in engineering substation PAC systems and establishing reliable PAC standards internal to the utility environment. With the abstract mapping of the utility IEC 61850 data model to the IED, flexible naming extensions enables interchangeability of IEDs at the visible communication interface level by simply importing the utility SCD file, applying the saved mapping template for the new IED and downloading that mapping to the new IED.

7 References

[1] ABB 670 series 2.1 IEC, Engineering Manual, 1MRK511 355-UEN

[2] 2016-June-30, "Flexible product naming", J. Menezes, L. Frisk, K. Hagman, ABB AB, Sweden

8 Biography



Benton Vandiver III received a BSEE from the University of Houston in 1979.

He is currently the Regional Technical Engineer for ABB in the Southeast Region located in Houston, TX. A registered Professional Engineer in TX, he is also an IEEE / PSRC senior member. He was with Houston Lighting & Power for 14 years, with Multilin Corp. for 4 years as Project Manager and with OMICRON electronics for 22 years in various sales, marketing, and technical roles. He has authored, co-authored, and presented over 95 technical papers and published numerous industry articles.