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Experience of Implementation of IEC 61850 Standard in BE2704 Protections by EKRA

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The IEC 61850 standard is the key document for implementation of communication between protection IED and control center as well as communication of IEDs with one another.

The advantages of the standard are the following:

- support of Ethernet technology;
- international recognition;
- possibility to obtain lists of all information elements available in IED using standard means via self-description or via SCL-file;
- meaningful names to avoid shifting of identifiers when the program in the equipment should be updated.

It is these advantages that account for further implementation and development of the standard.

Some other advantages of the standard are often mentioned in literature. Among these are flexibility, openness to future change, free allocation of functions and their combination for different devices. The fact that the standard can be used in multiple areas is also considered an advantage. In addition to traditional vertical communication “control center – protection IED”, IEC 61850 standardizes horizontal communication between IEDs and can also be used for settings and for automatic substation design procedures.

Due to pursuit of more functionality however the quality of the standard itself is sometimes left aside. IEC 61850 is first of all the communication standard. The main purpose of creating any communication standard is to achieve interoperability between different systems. All the rest is secondary and shouldn't affect the realization of the major task. But even in well elaborated vertical communication “protection IED – control center” some problems may nevertheless occur.

1 TRANSMISSION OF EVENTS

The events are transmitted in IEC 61850 via report service. The reports are sent using report control block. The control block is used to set the report format, enable/disable transmission, general interrogation queries, etc. Reports can be buffered and unbuffered. The report control block is associated with a dataset. This dataset defines the list of signals assigned for events generation. As far as the data model is hierarchical, elements from different hierarchy levels can be added to datasets.

Traditionally, protections by EKRA have events recorder with buffer. Due to this it was decided to use the buffered report control block for the protocol.

The list of signals is traditionally defined in the events recording mask. Adding to the dataset structures containing value of binary signal, its quality and time will not always result in unambiguous correspondence. For example, ACT common data class contains signal “general”, three signals for

every phase and has one timestamp and quality field associated with all these signals. Thus, all four signals will simultaneously be added or removed in the events recording mask. In the initial analysis stage (i.e. after having read the standard) it was deemed unnecessary to implement the logic of simultaneously adding or removing data elements. Therefore it was decided to use the dataset consisting of final elements in data tree.

At the first attempt of communication with a SCADA-system it was found that it works only with unbuffered reports and it necessarily requires dataset with structures.

Therefore in theory at least 4 variants of absolutely incompatible implementations of the standard are possible in events transmission:

- unbuffered reports + structures
- unbuffered reports + final elements in data tree
- buffered reports + structures
- buffered reports + final elements in data tree

While types of reports supported can be seen in PICS(protocol implementation conformance statement), the elements that form the datasets can be determined only experimentally.

It turns out that in the area of events transmission IEC 61850 is more complex to configure than IEC 60870-5-103.

A standard should describe one method for implementation of a single function. The existence of several equivalent methods may result in two different conditions. On the one hand, vendors may divide into groups each supporting just one of the existing variants. In this case joint operation of devices of vendors of different groups becomes impossible and creation of the standard loses sense. On the other hand vendors could be forced to realize both ways of implementing the same function. Without actually adding any helpful functionality this results in more resources spent, need for configuration, selecting one of the variants.

There is an undocumented tendency today to use unbuffered reports for transmission of events and use structures as dataset elements. The post factum reasons can be found for such a condition. The dataset from final elements in data tree corresponding to binary signals recording mask does not have the quality field and timestamp. This is a drawback from the point of view of SCADA-system. The unbuffered reports are easier to implement than buffered reports.

In protections by EKRA the transmission of events can be realized using buffered or unbuffered reports; either final elements in data tree or structures can be selected for adding to dataset.

The datasets differ in creation method: pre-defined (configured) and dynamically created. Dynamically created datasets may be persistent or non-persistent. Non-persistent datasets are automatically deleted when association over which the dataset has been created is released or aborted. The simplest type is realized in our protections, which is pre-defined datasets that can be modified only with a specialized program. Fortunately, all clients we are familiar with support this type.

2 GOOSE MESSAGE TRANSMISSION

The standard defines two methods of direct data transfer between devices, that is, GOOSE and GSSE. This is another example of two methods used for implementation of the same function. GOOSE is a newer method of sending messages, was specially developed for IEC 61850. GSSE was present in UCA 2.0 standard - one of IEC 61850 predecessors. GOOSE as compared to GSSE has a simpler format (Ethernet compared to OSI protocol stack) and can transmit data of different types. It looks like GSSE was included in IEC 61580 for one reason: so that manufacturers with UCA 2.0 feature available could claim conformity to IEC 61850. Now GOOSE is used by all vendors for transfer of data between devices.

The datasets are used for lists of GOOSE data as in the case with reports. The requirements for GOOSE are however different. The time of processing GOOSE-messages must be as fast as possible; therefore it is logical to send as simple data types as possible. Usually the value itself is transmitted, while some vendors also add the quality field. The timestamp is normally not included in the dataset. One of the vendors in the first version of standard implementation used structures for transmission in GOOSE-messages, but in newer versions of devices of this vendor also only simple data types are transmitted.

The BE2704 series protections by EKRA transmit *boolean* data in GOOSE-messages. The received data types are *boolean*, *dbpos*, *integer*.

The established tendency exists only for discrete data transmission. Just few vendors now transmit analog data, and there is no established tendency in analog data transmission.

3 DATA MODEL

Logical nodes defined in the standard don't cover all functions necessary to describe a device. It is suggested to create new logical node classes in accordance with the rules defined in IEC 61850-7-4 (Ed.1). Newly-created logical node classes are not recognized by bay controllers of some manufacturers. Preparatory work was necessary despite the fact that all logical nodes and data are described in SCL file and their description is available via MMS.

4 OPTIONAL FUNCTIONALITIES IN THE STANDARD

The IEC 61850 standard does not specify strictly which functionalities must be implemented and which not. The only mandatory requirement is in fact the presence of SCL-file. The file must be accessible somehow and conform to current IED configuration. All other functionalities are not mandatory. The IED does not need to support horizontal data exchange between devices and may perform only as server. And, vice versa, it is possible that it supports only GOOSE and doesn't have server. The IED may support self-description through MMS-query GetNameList or it may provide just the SCL-file for obtaining the list of signals.

If you use a functionality specified in the standard, this functionality will not necessarily be used by other vendors. And, vice versa, in some SCADA-systems the functionality which is not mandatory in the standard may be implemented as obligatory.

Example 1

The names of logical nodes in data model are too generic. Therefore it is difficult to understand the function of a logical node without description. EKRA decided that a standard field dU be used for text description of signals in its BE2704 protections. However SCADA-systems do not read this field and do not display it. The only SCADA-system that can read this field is one Russian SCADA manufacturer with whom we were able to agree on this specification.

Example 2

The SCL-file was required when connecting to a SCADA-system. The control service had to contain the value of control model (ctlModel). It is not necessary to define field values in the SCL-file. Therefore it was impossible to predict this SCADA-system requirement.

5 CONCLUSION

1. Implementation of IEC 61850 in IED in full compliance with the standard doesn't guarantee that this IED will be able to communicate with every SCADA-system. Without preliminary interoperability tests it is impossible to say whether this IED will be able to work with a particular SCADA-system or not.
2. There is a need for an explicit description of typical use cases either in the standard itself or in some accompanying documents.