

COMPATIBILITY OF IEC61850 EDITION 1 AND EDITION 2 IMPLEMENTATIONS

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ABSTRACT

Currently numerous substations worldwide feature IEC 61850 Edition 1 communication standard. Edition 2 of IEC 61850 was released in 2011 in order to cover new applications and improve interoperability. Users and vendors expect compatibility of both editions in order to safeguard invests in systems and product developments. The paper shows the differences of the editions and presents how compatibility can be achieved in practical use cases. In form of a user guideline the findings for compatibility are summarized.

INTRODUCTION

In 2004 the first edition of IEC 61850 was introduced as communication standard for substation automation [1]. Since then IEC 61850 has succeeded across the board in the market and represents the basis for state-of-the-art substation automation systems. Edition 2 was released in 2011 [2] – products with appropriate IEC 61850 edition 2 functionality will be available shortly after its release. Worldwide users and vendors have done remarkable invests in IEC 61850 technology. Therefore users and vendors expect comprehensive compatibility between the two editions of IEC 61850 in order to safeguard their investments.

In the following section an overview on the differences of edition 1 and 2 of IEC 61850 is given. This includes the motivation for the new edition as well as aspects which impact the backward compatibility and means to keep the compatibility.

The subsequent section presents how compatibility is affected in respect to parallel operation of edition 1 and edition 2 based devices. Besides runtime communication, also engineering aspects are affected. From an end-user perspective, practical relevant use cases are discussed.

As use case scenario, a substation automation system with typical applications like GOOSE interlocking and remote control is analyzed. Based on the discussion of these use cases, the requirements for communication services, data modelling and engineering capabilities are derived.

As a result of the use case analysis, a compatibility mode for edition 2 is introduced. For a better understanding the compatibility mode is presented in form of an end-user guideline. This guideline is intended, to give end-users a practical advice, which communication and data modelling capabilities should be supported by IEC 61850 edition 2 devices and tools. It also describes how the compatibility

mode can be beneficially integrated in the IEC 61850 engineering workflow.

DIFFERENCES OF IEC 61850 EDITIONS

Motivation for Edition 2

There are several reasons for the evolution of the IEC 61850 Standard to get a second edition. Interoperability projects were largely successful but have shown that there still was some place for interpretation when implementing the IEC 61850 first edition. Interoperability issues that were discovered during those tests were posted as TISSUES – Technical Issues – under www.tissues.iec61850.com. The editors of the standard had committed to provide a solution or simply an answer to the issues. Some of those issues were classified as “may cause interoperability problems” and other as “do not impact interoperability of the devices” therefore were collected as new features to be included in a second edition of the standard. The acceptance of the IEC 61850 as well as the flexible data model concept and its ACSI interface defined in the IEC 61850 – 7 – 2, have also motivated other domains to cooperate with the TC 57 WG 10. The IEC 61850 part 7 – 420 includes the modelling of the DER domain (TC 57 WG 17) to the collection of the IEC 61850 logical nodes, the part 7 - 430 includes the modelling of the Hydro domain (TC 57 WG 18). Joint meeting were held and the common modelling information were moved to the IEC 61850 part 7 – 4. New CDCs – Common Data Classes - were necessary to implement the requirements introduced by the new domains. Additionally, an amendment was produced to provide an interoperable solution for statistical and historical data within the data model. A second amendment defined the object modelling for the Power Quality applications. Furthermore, the TC 57 WG10 dealt with NWIPs – New Work Item Proposal – to extend the needs of the interoperable communication within the power system automation. As an example, the TR (technical report) IEC 61850 – 90 – 1 defines the inter substation communication. All these efforts needed to be gathered within a new edition of the standard, making amendments and technical reports normative.

Technical Differences

The following paragraphs will present some of the technical differences that may impact the backward compatibility explaining their motivation and means to keep the compatibility.

References:

Addresses of objects within the IEC 61850 standard are

called references. There are used in many different contexts: for reading or controlling an object, for listing it within a so called DataSet. A reference is available for every object of the object directory, and therefore also to access its leaves. The edition 1 limited the references to 65 characters. The edition 2 has extended the references up to 129 characters. There are two user defined positions within the reference: the Logical Device Name (LDName up to 64 characters in edition 2), and the Logical Node prefix and instance identifier (up to 12 characters in edition 2), see figure 1.

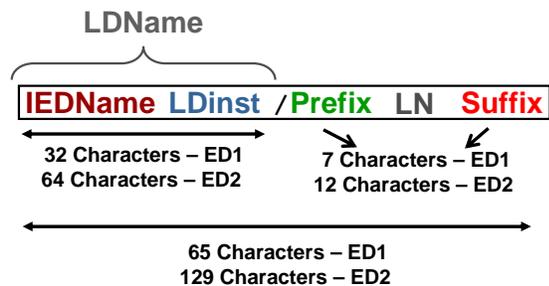


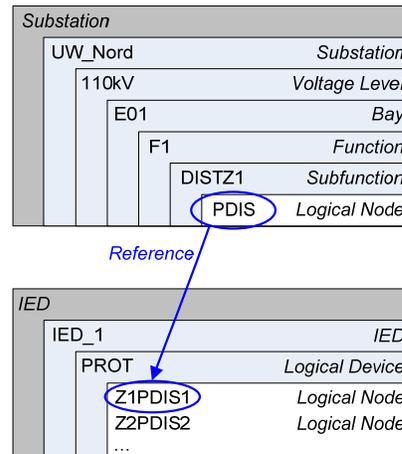
Figure 1: Principle of object reference

References are used for instance in GOOSE (Generic object-oriented substation event) configuration and telegrams to GOOSE subscribers as well as in Reports telegram to clients. Backward compatibility is granted as soon as the references used do fit in the 65 characters foreseen by the first edition. It is then the duty of the commissioner to take care that the user defined fields within the references remains short to fit the edition 1 requirements. Of course, IED tools and System Configuration tools, knowing the interoperability concern could check automatically that the user-defined fields remain in the limit when backward compatibility is necessary.

Flexible naming:

Flexible naming is a feature that was fully introduced within the edition 2. It relays on the addresses scheme that is being used. Edition 1 already introduced within the IEC 61850-6 – Engineering – two ways of addressing objects within a substation: either with the product naming (i.e. the root of the address is always the IED were the object/indication is located) or the functional naming (i.e. the root of the address is given by the substation topology). The functional naming however needed further mean to become fully available within the edition 2 – see Figure 2.

The only way to grant backward compatibility within mixed project is to keep the IED naming for all the devices that are GOOSE publishers, to make sure all the subscribers, independently of their edition will be able to process the information. Here again, IED tools and System Configurator tools, knowing the interoperability concern could disable the functional naming when backward compatibility is necessary



IED Naming:
IED_1PROT/Z1PDIS1
 Functional Naming:
UW_Nord110kVE01F1/DISTZ1PDIS1

Figure 2: Principle of functional naming with resulting example IED and functional naming reference [3]

Schema Version 2.0:

A new XML schema has been released with the second edition of the standard. The new schema includes of course new services and new functionality for enhancing the substation description. However, the schema can not be used for schema validation of the SCL of an edition 1 substation project. The only way to keep backward compatibility is that the edition 2 engineering tools (IED tools as well as system configuration tool) support both schemas. They shall have an export function (ICD, IID, SCD files) in each SCL version, and shall be able to import files from each SCL version.

New Logical Node Class:

As introduced previously, the edition 2 introduces new Logical Nodes since the standard has extended its domain from the substation automation to the power system automation. In edition 1, private Logical Node definitions were already allowed within the concept of name spaces. Here the name space definition of those new Logical Nodes will be IEC 61850-7-4:2010 instead of IEC 61850-7-4:2003. Therefore, most of the edition 1 implementation shall be able to support those new Logical Node classes when their Data Object are communicated over the wire (Report/GOOSE), but without knowing the semantic of them or of their Data Objects.

New CDCs: common data classes:

As mentioned previously, the edition 2 has introduces new Common Data Classes to fit the requirement of new domains or new functionality introduced in the standard. For example, the class HIST – histogram – has been added to follow the Power Quality requirements.

HST class						
Data attribute name	Type	FC	TrgOp	Value/Value range	M/O/C	
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)					
DataAttribute						
zstatus						
hstVal	ARRAY 0..maxPts-1 OF INT32	ST	dchg, dupd			M
q	Quality	ST	qchg			M
t	TimeStamp	ST				M
configuration, description and extension						
numPts	INT16U	CF		0 < numPts ≤ maxPts		M
hstRangeC	ARRAY 0..maxPts-1 OF Cells	CF	dchg			M

Figure 3: Part of the new CDC HST (Histogram) in IEC 61850-7-3 ed.2

Most of the edition 1 implementation will not be able to deal with those classes since the structure and associated functionality is totally unknown. Backward compatibility on GOOSE level / Report level will be achieved only if no Data Object that uses those new Common Data Classes is involved in the communication (GOOSE / Report). It is the responsibility of the user when configuring the Data Exchange to make sure that none of this Data Object are members of the transmitted telegrams. Here again, IED tools and System Configuration tools, knowing the interoperability concern could disable those objects for communication when backward compatibility is necessary.

USE CASE SCENARIOS

Basic Configuration

For the description of the use cases a basic configuration is introduced (see figure 4). In an IEC 61850 SAS a substation controller is used for the application for HMI, substation logic, gateway to the control center, archiving of faults and other central functions..

The IED at the bay level (bay controller, protection relays) are installed for the decentralized control and protection functions. This configuration requires different communication services.

The performance of the communication between IED at bay level is affected by short transmission time and high reliability, dependability and availability. Here IEC 61850 provides the time-optimized service GOOSE what is based on a direct mapping on Ethertypes of layer 2 .

For the date exchange to the substation controller event driven, cyclic and interrogated communication services are used.

Therefore mainly the IEC 61850 communication service “Information Report” is the best choice to exchange information to the SC, what is implemented as client-server communication based on TCP/IP and MMS.

For influencing of the data objects, e.g. for controlling the process outputs or to adopt the settings on changed operational needs, the direct write communication means is applicable. These are also based on TCP/IP and MMS services.

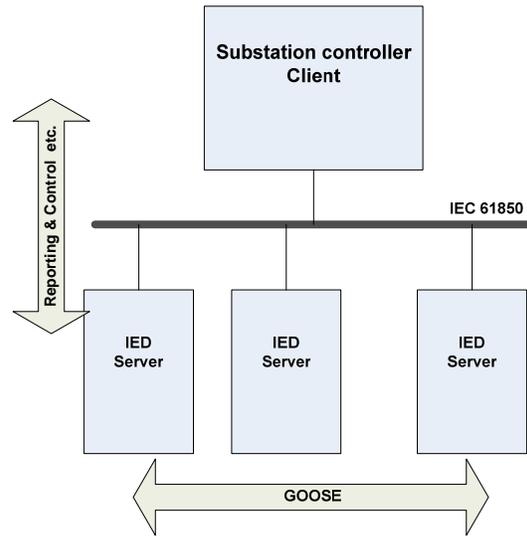


Figure 4: Basic scenario - configuration example

Use Cases

The main question regarding the migration of substation automation systems from edition 1 systems to edition 2 is the possibility of so-called mixed configuration. This scenario could happen when an installed systems should be extended by an IED for a separate bay or when an IED should be replaced.

Two specified use cases are relevant in practical operation:
 1) Replacing of an edition 1 device by one of edition 2
 2) Adding an edition 2 bay device into a edition 1 system.
 Using the edition 2 features of this new device by the substation controller.

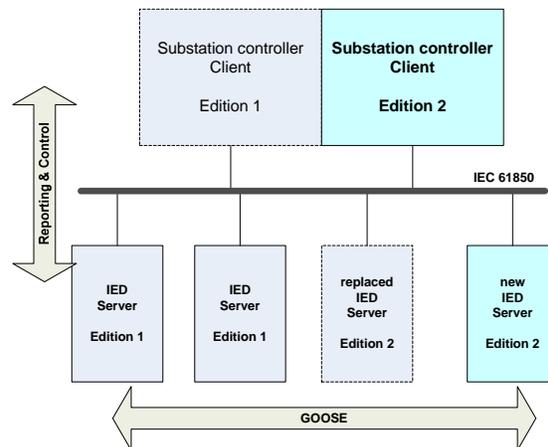


Figure 5: Use cases 1) and 2) for mixed configuration

In the context of this paper the first use case is defined by the following characteristics:

- The existent IED which should be replaced is of edition 1, the new IED supports edition 2. The GOOSE communication links to the other bay controllers or

protection devices are configured according edition 1.

- The substation controller exclusively supports edition 1.

The second use case is characterized by:

- The new IED is modelled with new data objects according edition 2 in order to provide additional data about functions or process information acc. edition 2.
- Prior existing IED according edition 1 as well the new IED according edition 2 should have communication links to the substation controller.
- The new IED should receive or send data from or to other IED on bay level by GOOSE. These other IED communicate on basis of edition 1.

Based on the characteristics of both use cases the following requirements can be derived:

- The substation controller (IEC 61850 client) should be able to accept all possible data from edition 1 as well from edition 2. The substation interface has to recognize if there is connected an edition 2 or an edition 1 device.
- If the IEC 61850 client is not able to communicate with edition 2 devices (may be it cannot process references longer than 65 characters), than the new or replaced device should fall back in "edition 1-behaviour". It means the device should be configured without extensions from edition 2.
- The IdName attribute of Logical Devices as necessary part of the flexible naming concept may not be used. So only the product naming like in edition 1 is the only way for addressing the data objects.
- The engineering workflow should base on both editions (schema 1.4 and schema 2.0). So it is necessary that engineering tools support a smooth engineering workflow.

COMPATIBILITY MODE

Engineering Workflow

Regarding the previous introduced use cases, the existing SAS were configured through system configuration tools based on edition 1 (SCL schema 1.4). Hence for the integration of an edition 2 IED into an edition 1 environment, the system configuration shall base on edition 1 (see Figure 6).

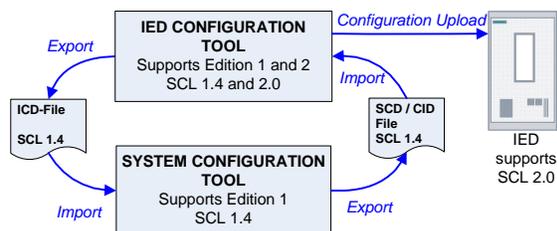


Figure 6: Workflow for integration of edition 2 IED in

edition 1 systems

Consequently IED configuration tool of the edition 2 device shall support both editions (SCL schema 1.4 and 2.0). All configuration file exchange shall apply to SCL schema 1.4. Configuration upload is a local matter, since this can be proprietary or done via a CID file.

Guideline to ensure compatibility

For a better understanding of the compatibility mode, the following guideline is intended to assist users in choosing appropriate devices and tools for supporting the presented use case scenarios.

Devices and tools of edition 2 shall support

- Reduction of object designation lengths to max. 64 characters
- Use of IED naming for edition 1 GOOSE subscribers and reporting clients
- Export and import interfaces according SCL schema 1.4
- Exclusive use CDCs according to edition 1

For usability reason, at best devices and tools feature a dedicated edition 1 mode. This special edition 1 mode can help the user in choosing the correct parameters and avoids mis-parameterization which may result in incompatibility.

CONCLUSION

The introduction of edition 2 of IEC 61850 reveals challenges for parallel operation of edition 1 and 2 devices in a common substation automation system. Under consideration of specific differences of the editions and applying a compatible engineering workflow, a compatibility mode can be defined. This compatibility mode is the basis to allow users the maintenance and the extension of existing edition 1 substation automation systems without upgrading complete systems to edition 2. This safeguards invests in IEC 61850 edition 1 technology.

REFERENCES

- [1] IEC 61850: "Communication networks and systems in substations", Edition 1, 2004.
- [2] IEC 61850: "Communication networks and systems for power utility automation", Edition 2, 2011.
- [3] Dawidczak, H.; Englert, H.: "Template based engineering of substation automation systems with the IEC 61860 functional naming concept", Power System Computation Conference, Glasgow, 2008.