

Study Committee B5

Protection & Automation

Paper ID_10677

Reaping the benefits of new standards editions for better integration of intelligence in IEC 61850 digital substations

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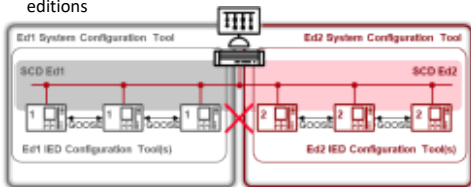
Motivation

- Increased digitalization of substations increases the complexity of IEC 61850 systems
- To effectively deploy such systems, the involved IEC 61850 devices as well as engineering and testing tools need to fulfil increased requirements.

Mixing of IEC 61850 editions

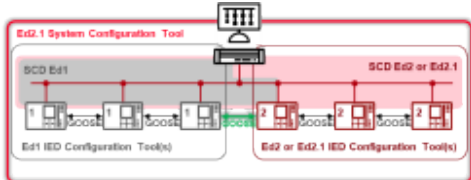
Past: Separation of Ed1 and Ed2

- Systems had to be split in an Ed. 1 and an Ed. 2 part
- This hindered communication between IEDs of different editions

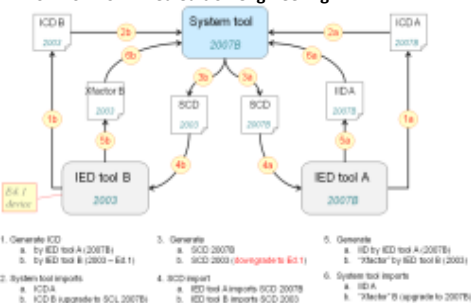


Present: IEC 61850 Edition 2.1, up- and downgrading rules

- Communication between legacy and new devices, respecting the abilities and limitations of both versions
- Defined workflows to engineer data exchange between different edition IEDs

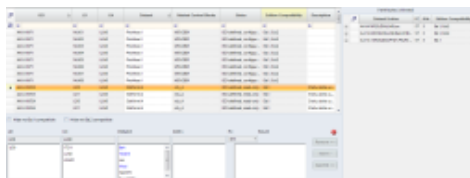


Workflow for mixed edition engineering



Edition 1-Edition 2 mixed engineering with different SCL versions and one SCT (IEC 61850-6 Ed.2.1)

System Configuration Tool with Edition compatibility verification



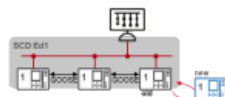
Indication of edition compatibility of datasets and their content

Use cases

Even if Ed.2.1 enables mixing of editions, it does not make sense in all use cases:

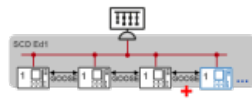
IED replacement in edition 1 substation

- Use new IED running with Ed.1



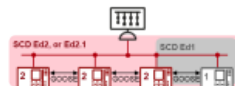
Bay extension

- For small extensions use Ed.1 if product in active life cycle



New system

- Use latest edition where possible, integrate Ed.1 devices where needed



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Continued

Digital substation engineering efficiency

- By moving from copper cables to GOOSE and SV data exchange, engineering and testing effort is shifted to the IEC 61850 tools.
- Efficient engineering and user-friendly documentation of the GOOSE and SV dataflow is vital to deploy digital substation projects and to enable safe and simple maintenance of process bus-based systems.

Client focused engineering

- Edition 2.1 of IEC 61850 parts 6 and 7-1 introduces a later binding approach using external references (extRefs). Using this approach, a “client focused” engineering workflow becomes possible.
- During IED configuration the engineer declares what GOOSE and SV inputs are required by the application.
- The system configuration tool creates then the required datasets and control blocks in the server IEDs.

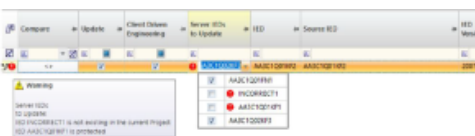
- Sometimes and for some users, it is more adequate to represent the dataflow in a table, like the well-established wire connection tables.
- This documentation is exported by the SCT after the dataflow engineering is completed.

Source	IED	LD, LN, DO, DA	Dataset	Dataset Description	Transmission Substation	VLAN	Destination IED	Access Point
Control IED	AAIC1Q01A	XC001.Pri	SPW4	For distributed interlocking	AA15WF01R	002	Control IED	55
Control IED	AAIC1Q01B	XC001.Sec	SPW4	For distributed interlocking	AA15WF01R	002	Control IED	55
Protection IED	AAIC1Q01C	OC4PTOCLOp	PrvA	For distributed protection	AA15WF02R	003	Protection IED	55

Simplified GOOSE dataflow documentation

Virtual LANs

- With the increasing complexity of the substation communication networks, whether in conventional or digital IEC 61850 substations, the usage of VLANs to guide substation traffic is increasing.
- Planning of the virtual networks in substation automation systems is today typically done manually with “paper and pencil”.
- As the system configuration tool knows all dataflow as well as communication topology, the VLAN calculation can be automated.



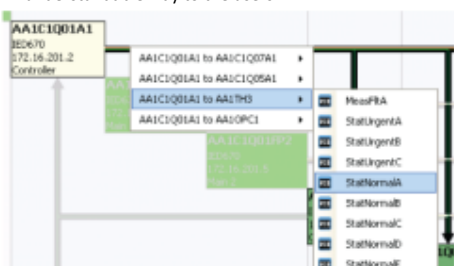
Update IED dialog of an SCT with consistency warnings for updating of server IEDs

Dataflow documentation

- Documentation of the GOOSE and SV dataflow shall be as simple as possible to enable also non-IEC 61850 experts to do efficient maintenance of digital systems.
- Because the SCD is the single source of truth for the system configuration and data exchange in the system, it is important, that it can be represented in an understandable way to the users.



SCT topology view, enabling VLAN calculation together with dataflow definitions



GOOSE dataflow from a control to other IEDs and to SCUs (Switchgear Control Units). Presented from SCD file by an IEC 61850 testing tool.

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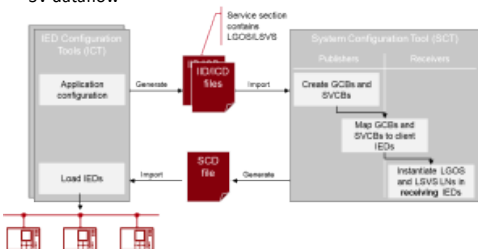
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System supervision

- Asset performance management for secondary assets is gaining increasing importance to optimally plan maintenance activities.
- Permanent supervision of all device and exchanged data plays an increasingly important role.

Supervision of GOOSE and Sampled Values

- Edition 2.1 clarified the workflow, to create LGOS and LSVS logical node instances to supervise GOOSE and Sampled Value reception by the receiving IED.
- The picture shows the approach, where the SCT instantiates the required LNs based on the GOOSE and SV dataflow

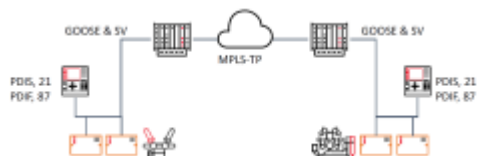


Workflow with GOOSE and SV supervision engineering in the SCT

Cyber security

- With the trend to more integrated substations and communication beyond substation boundaries, cyber security features gain increasing importance.
- IEC 61850 refers to IEC 62351 ("Power systems management and associated information exchange – Data and communications security").
- To increase security in document exchange or storing, it may be required, that SCL documents are signed. IEC 62351-11 defines how XML files can be secured by signing or encryption.
- IEC 61850 refers to IEC 62351-6 for introducing Layer 2 security for GOOSE and SV. From engineering perspective important is for example the McSecurity service capability.
- With this information, the SCT can define for each GOOSE and SV control block, whether it shall be sent as encrypted, signed or without security.
- Encryption is a must for routable R-GOOSE and R-SV that are transmitted between substations.

- Because the required key management solutions as per IEC 62351-9 are not yet available, standardized and secured transmission of GOOSE and SV between substations is not given.
- Therefore, real-time communication solutions between substations using proxy-gateway or tunnelling across the wide area network, are preferable alternatives.



Linde protection with GOOSE&SV transferred with proxy-gateway approach, taking care of cyber security and quality of service.

Testing

- Cyber security, but also other system design aspects have an impact on the testing of IEC 61850 substations. Testing tools need to...
 - support the relevant Edition 2.1 features.
 - analyze real and simulated data concurrently.
 - handle certificates for TLS connections
 - indicate replayed packages as per Ed.2.1

Further, VLAN segregation needs to be considered when analyzing or simulating traffic.



GOOSE analysis with detected replayed packages marked as "x"

Conclusion

- Through continuous evolution of IEC 61850 and IEC 62351 standards the PAC systems can be engineered more and more efficiently, with better quality and increased security.
- To deploy the advancements in substation products and systems, it is important that relevant conformance test procedures and certifications are in place.
- Conformance certification not only enables interoperability, but it is also the minimum requirement to deploy substations that can be maintained and extended across their lifetime.