IEC 61850 Working Group Activity

2017 Summary

2017 TECHNICAL UPDATE

IEC 61850 Working Group Activity

2017 Summary

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THE ELECTRIC POWER RESEARCH INSTITUTE (EPRI) PREPARED THIS REPORT.

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Abstract

The purpose of this report is to document and report on the yearly progress of Technical Committee 57 Working Group 10 in support of the IEC 61850 standard.

The IEC 61850 standard is applicable to Power Utility Automation and is modified by activities performed by Working Group 10 (WG10) under the auspices of Technical Committee 57.

Keywords
IEC 61850
Working Group
Configuration
Testing
Role Based Access
Profile

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Section 1: Introduction

Background

The purpose of this report is to document and report on the yearly progress of Technical Committee 57 Working Group 10 in support of the IEC 61850 standard.

The IEC 61850 standard is applicable to Power Utility Automation and is modified by activities performed by Working Group 10 (WG10) under the auspices of Technical Committee 57.

The International Electrotechnical Commission's Technical Committee 57 is responsible for Power Systems management and associated information exchange. IEC TC 57 develops and maintains International Standards for power systems control equipment and systems including EMS (Energy Management Systems), SCADA (Supervisory Control And Data Acquisition), distribution automation, teleprotection, and associated information exchange for real-time and non-real-time information, used in the planning, operation and maintenance of power systems. [1]

The IEC 61850 standard suite encompasses the following relevant applications:

- Energy Management Systems
- Distribution Management Systems
- Distribution Automation
- System Automation
- Distributed Energy Resources
- AMI
- Storage
- Electric Vehicles

The specific parts to the standard are as follows:

Table 1-1
IEC 61850 Standard Parts [2]

Standard Part	Title
IEC 61850-1:	Communication networks and systems in substations – Part 1: Introduction and overview
IEC 61850-2:	Communication networks and systems in substations – Part 2: Glossary
IEC 61850-3:	Communication networks and systems in substations – Part 3: General requirements
IEC 61850-4:	Communication networks and systems in substations – Part 4: System and project management
IEC 61850-5:	Communication networks and systems in substations – Part 5: Communication requirements for functions and device models
IEC 61850-6:	Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs
IEC 61850-7-1:	Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models
IEC 61850-7-2:	Communication networks and systems for power utility automation - Part 7-2: Basic information and communication structure - Abstract communication service interface (ACSI)
IEC 61850-7-3:	Communication networks and systems for power utility automation - Part 7-3: Basic communication structure - Common data classes
IEC 61850-7-4:	Communication networks and systems for power utility automation - Part 7-4: Basic communication structure - Compatible logical node classes and data object classes
IEC 61850-8-1:	Communication networks and systems for power utility automation - Part 8-1: Specific communication service mapping (SCSM) - Mappings to MMS
IEC 61850-9-2:	Communication networks and systems for power utility automation - Part 9-2: Specific communication service mapping (SCSM) - Sampled values over ISO/IEC 8802-3
IEC 61850-9-3	Communication networks and systems for power utility automation - Part 9-3: Precision time protocol profile for power utility automation
IEC 61850-10:	Communication networks and systems in substations - Part 10: Conformance testing

In recent years WG10 has held three meetings annually mostly in Europe, but also in the USA and elsewhere. In 2017, the three meetings were held as follows [3]:

- Geneva, Switzerland on February 20 – 24, 2017.
- Seoul, Korea on June 18 - 22, 2017.
- New Orleans, Louisiana, USA on October 23 – 27, 2017.

Key Topics by Meeting

Geneva, Switzerland

- IEC Central Office Presentation
- IEC 61850 Interoperability Test 2017
- Deterministic Networking for Protection & Control
- IEC 61850-10-3: Functional testing of IEC 61850 based systems
- Basic Application Profiles (BAPs) using IEC 61850
- Task Force on Function Modeling in SCL (System Configuration Language)
- Task Force 90-11 – Logic Modelling
- Part 90-12: Wide Area Network Engineering Guidelines
- IEC 61850-80-5: Guideline for mapping information between IEC 61850 and IEC 61158-6(Modbus)
- IEC TR 61850-90-20: Guideline to redundancy systems
- New Task Force IEC 61850-90-21: Modelling Travelling Wave Fault Locator

Seoul Korea

- IEC 61850 Interoperability Test 2017
- Deterministic Networking for Protection & Control
- IEC 61850-10-3: Functional testing of IEC 61850 based systems
- Basic Application Profiles (BAPs) using IEC 61850
- Task Force on Function Modeling in SCL (System Configuration Language)
- Task Force 90-11 – Logic Modelling
- Part 90-12: Wide Area Network Engineering Guidelines
- Task Force 90-14 – Using IEC 61850 for FACTS, HVDC and Power Conversion data modeling
- IEC 61850 90-16: Device Management System
- IEC 61850 90-19: Role Based Access Control

- IEC 61850-80-5: Guideline for mapping information between IEC 61850 and IEC 61158-6(Modbus)
- IEC TR 61850-90-20: Guideline to redundancy systems
- New Task Force IEC 61850-90-21: Modelling Travelling Wave Fault Locator
- IEC 61850-6-2: HMI Task Force

New Orleans, Louisiana, USA

- Update from ENTSO-E
- Update on IEC status of web publishing of code components
- IEC 61850 Interoperability Test 2017
- IEC 61850 90-13 Deterministic Networking for Protection & Control
- IEC 61850-10-3: Functional testing of IEC 61850 based systems
- Basic Application Profiles (BAPs) using IEC 61850
- Task Force on Function Modeling in SCL (System Configuration Language)
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- IEC 61850 90-16: Device Management System
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- IEC 61850-80-5: Guideline for mapping information between IEC 61850 and IEC 61158-6(Modbus)
- IEC TR 61850-90-20: Guideline to redundancy systems
- New Task Force IEC 61850-90-21: Modelling Travelling Wave Fault Locator
- IEC 61850-6-2: HMI Task Force

Proposed Meetings for 2018

The currently proposed meeting locations and schedule for 2018 is as follows:

- February 12-16, 2018 in Sochi, Russia
- June 11-15, 2018 in New York, NY USA
- October 8-12, 2018 in Saclay (near Paris) France

IEC 61850 Interoperability Test 2017

The purpose of the Interoperability Test is to provide an environment that allows for "implementation" and standard improvement as well as learning. Implementations may be products or prototypes at the discretion of the vendor. With the intent to look for and cause failures. It is through analysis of the failures that the standard, implementations, and industry will be improved. It also gives a neutral technical snapshot of the products and tools to document (by confirming/informing/extending) the interoperability issues mentioned by some end-users such as ENTSO-E, Entergy, and SCE. The event was well attended by over 200 participants including both vendors and witnesses and took place on October 14-19, 2017 in New Orleans, Louisiana.

Figure 1-1
Troubleshooting during the interop

The tests results won't be available for a few months, but preliminary results indicate that the technology has improved. However, there are some issues with the tool used to configure the technology.

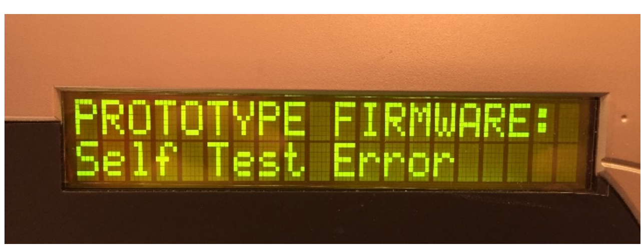

Figure 1-2
Typical Display during the Interop

Besides the Interoperability Test there was a UCA 61850 Boot Camp on October 13-14, 2017. It was a training opportunity for consultants, utilities, academics, and other interested parties and provided a hands-on experience to prepare for witness participation. The agenda includes the following: Project Management, Standard Overview, Designing Resilience, 61850 Field Testing, and NERC CIP and 61850.

Section 2: Key Topic Summaries

In this section progress summaries for key topics considered by the working group are presented.

How to Handle Role Based Access for IEC 61850

The group discussed the issue of role based access control (RBAC) and was cautious about "changing" what a vendor does within their products. Each vendor needs to accommodate the group security roles. Each device needs to be able to dynamically handle the changes to certificates as each one gets updated or generated. It will result in a more difficult process for the utility to handle all of the different roles. The process is similar to what WG15 is proposing. There was extensive discussion on the expected difficultly and the different roles that need to be accommodated with the certificates.

A Working Group Task force has been created and identified key liaisons with WG15 and WG17. There were presentations on security architectures and boundaries of the work scope. A key decision was made not to declare RBAC attributes within SCL. However, this still needs further clarification. There is a need to differentiate between how the roles / privileges are configured versus how the roles / privileges are exchanged or declared.

Some features that were discussed:

- Everyone who has access to engineering tools should not have the capability to change roles/privileges.
- An information flow use case needs to be described.
- A key principle is that users should not have to enter the same information twice.
- A user must have the means to review the configured system, including the RBAC details, without having visibility to sensitive information (passwords, etc.).

It was proposed and the group agreed to use XACML at this point but is open to other suggestions. Fundamentally a XACML profile is needed and the XACML must reference SCL as security should not be exposed in SCL. Lastly, the area of responsibility for each user is required.

Two use cases are to be developed. One that will indicate the need for roles and reasons based on LN group. The other is to indicate the need for hierarchical area of responsibility.

One of the interesting issues facing the 61850 RBAC work is how to properly reference SCL information (e.g. Logical Node Instances, DOs, FCDs, and FCDA) in order to allow rights to be assigned. Originally, it was believed that we could utilize Xpath syntax to provide the referencing. However, after trying to make this work, over several weeks, it was concluded that if it can be made to work it is complicated and they are not sure that they have the expertise to accomplish it.

It is clear that xpath can easily reference an IEDName in an SCL file. The query string might look something like:

> “//scl:IED[name=’xxx’]”

You can even get to a particular LN by transitioning through AccessPoint, Server, LDevice results in something like:

> “//scl:IED[name=’xxx’]/scl:AccessPoint[name=’S1’]/scl:Server/scl:LDevice[inst=’LD0’]/scl:LN[prefix=” && lnClass=’RDRE’ && inst=’1’].

Once you get this, you need to find the lnType attribute value and then start an iterative and painful xpath through the DataTypeTemplate section.

The task force recognized that this complexity might be able to be made to work, but it forced them to take a step back and look at the requirements that have been developing within the use cases.

Need to be able to specify down to a leaf, FCDA, FCD, or DO level of a specific

IEC 61850 already provides a simplistic mechanism for specifying this. It is the ObjectReference Construct.

<LDName>/<prefix><lnClass><inst>.<DOName>.<FC>.<DAName>….

Where LDName could be either <IEDName><LDInst> or just the value of the ldName attribute (Functional naming).

This would be the proposed syntax for specific instances. It would also be suggested that we always use the <LDinst> construct, to remove some of the complexity from moving things around in the Single Line Diagram.

Need to be able to specify wildcard reference

There is an implicit requirement to allow the specification of things at a non-instance level. As an example specifying access to all Mod DOs regardless of the LN, LD, or IED that it is located in.

Consider the use of a regex like expression.

Example 1: Any LNClass:

^.*.*RDRE.*$

Example 2: Any Mod DO:

^.*.RDRE.*.[.]Mod.*$

Example 3: Any DA of Mod that is ST FC:

^.*.RDRE.*.[.]Mod.ST.*$

Example 4: Restriction to a particular LDName

^herb1\/.*.RDRE.*.[.]Mod.ST.*$ where herb1 is the LDName.

In conclusion, it would appear that a restricted syntax regex would provide all of the filtering capability required.

Deterministic Networking for Protection & Control

The idea of Deterministic Networking for Protection & Control (P&C) was first presented at the meeting in Cathedral City, CA. Approximately ten members formed an ad hoc task force. They have proposed using IEEE 802.1 Time-Sensitive Networking (TSN) for P&C applications, however, only when there is a problem with current technology should new technology be chosen. The group indicated that we need to balance the push and pull of technology. There should be more of a pull for technology, rather than a push. The objective is to reference IEEE TSN. There was a request for a liaison to IEEE 802.1 and IEC TC65 WG15. It was determined that we can start the work within TC57 due to the expertise, but TC65 Industrial-Process Measurement, Control and Automation will need to still get involved for industrial applications. Both TC's must be involved. It is expected that other domains will also reference this technology such as transportation.

Existing use cases under consideration by the Ad Hoc team are: (More will be added in the future)

- Network Optimization
- Multi-service capabilities
- Network topology and redundancy

- Ease of use in engineering and network configuration
- Network security
- Synchrophasor traffic on the station bus
- TSN and SV over process bus
- TSN and GOOSE over process bus

The task force has agreed to extend the scope of the document at the October meeting. The new title: Deterministic Networking Use Cases for Power System IED communication based on IEC 61850. Now WAN Use Cases, such as Substation-to-Substation, Substation-to-Control Center, Tele-Protection and others are now in scope. Also utility WAN use cases and requirements that are available and requirements that are available will be included in the document. Lastly, coordination with IETF DetNet efforts are recommended.

The proposed report topic outline follows:

- Introduction, scope, and objectives
- Application requirements
    a. Performance, high-availability
    b. Use of deterministic networking in WAN based use cases
- Non-functional requirements
    a. Multi-Service considerations (utility input)
    b. Network availability
    c. Flexible network topology and redundancy
    d. Network convergence with all other non-critical traffic
    e. Network optimization
    f. Usability (ease of use in engineering and network configuration)
    g. Cyber Security
- Use Case Scenarios
    a. Synchro-Phasor traffic on the station bus
    b. TSN and SV over Process Bus
    c. TSN and GOOSE over Process Bus
- Benefits and improvements for existing applications and future development in Power System IED communication based on IEC 61850

Limitations of existing technologies

Numerous substations are operating reliably daily in the world, complying with the application requirements and with the communication requirements expressed in IEC 61850-5. Communication outside of the substation is also able to meet these goals using analogue or TDM transmission.

IEC 61850-5 defines the transfer time as the delay between the time at which a sending application asks for transmission and the time the receiving application is notified, excluding any processing delay in the application. Network transfer time is always inferior to the application-to-application transfer time. IEC 61850-5 does not specify the transfer time as a worst-case value which would require deterministic transmission, but rather as a design goal or best-effort value.

NOTE The jitter performance in IEC 61850-5 was introduced for the specific purpose of teleprotection over telephone lines. Since this technology is being replaced by sampling with a global time reference, this can be considered a legacy issue.

An IED cannot be tested for the transfer time. The transfer time has to be observed for a given substation network between any two applications. The transfer time is measured under "normal conditions", that is, in absence of network reconfiguration and with a traffic load corresponding to a substation operating normally, possibly considering (simulated) burst traffic originating from severe electrical disturbances. The influence of other traffic such as video streaming is considered negligible, but it is not deployed in fielded substations.

Network engineers tend to oversize the network to secure sufficient bandwidth under all circumstances for critical transfers, in particular for message classes Type 1, Type 1A and Type 1B (transfer time TT4, TT5 and TT6), allowing several classes of traffic to share the medium.

Some manufacturers prefer to dedicate a network to the IEC 61850 traffic, which includes the GOOSE, SV and MMS traffic, as well as the traffic used for file transmission (e.g. event recording), time synchronization (e.g. SNTP, PTP) and network management (e.g. SMTP). Other manufacturers prefer to deploy a second network for file transfer, engineering and other substation functions. This second network can be used for non-operational traffic, e.g. video camera transmission or (corporate) internet access. Sometimes, even a third network is deployed in the substation for the non-operational traffic.

The coexistence of these different traffics on the same wire is a challenge. The condition is that the bandwidth be sufficient for all applications. While VLANs allow to separate different classes of traffic, they do not increase the available bandwidth. Priorities only allow some traffic to reach destination within a given deadline with a higher probability, but priorities cannot guarantee that data be always delivered within a given deadline, since even the highest priority data can be delayed by network congestion due to low-priority traffic being transmitted in bridges and routers.

In fact, priorities are useless without means to reserve network resources from end to end. Schemes exist in wide area network, for instance RSVP, but they fall short from assuring a maximum bound on the delivery delay, as would deterministic networks.

Improvements in networking communication when applying deterministic communication

A deterministic network overcomes the limitation of priority-based networks by enforcing a network-wide resource reservation. This ensures that a certain class of traffic has a reserved slot under all circumstances and traffic patterns, as in the former TDM networks or some field busses.

This simplifies considerably the task of the network engineer, since critical data will always be delivered in time regardless of the network load. Other classes of traffic can be added, for instance video streaming, file transfer, voice, etc. with less concern, provided the remaining bandwidth is sufficient for these applications.

If bandwidth is sufficient, only one network can support the whole traffic.

Costs of deterministic networking

Deterministic networking is an end-to-end property, it can only be provided if all network elements in the chain behave deterministically. Therefore, an interoperation of deterministic and non-deterministic networks is difficult, only a best-effort can be provided if non-deterministic elements are present, defeating the purpose.

Deterministic networking is a condition, but not a guarantee of deterministic data delivery between applications. A deterministic transmission requires that the sending applications have a limited production rate and themselves behave deterministically. Therefore, applications must be written so that their production rate is limited to a maximum contractual value.

Deterministic networking implies a cyclic transmission at least at the rate of the maximum delay. If a data must be received within 3 ms (TT6), at least every 3 ms a slot for its transmission must be reserved (but due to synchronisation with the application a shorter cycle is needed).

Deterministic networking changes the paradigm under which some data are transmitted. For instance, it makes little sense to send GOOSE data upon events if their transmission slots are anyhow reserved. It would be more efficient to send the GOOSE data cyclically in every slot, avoiding the current tedious mechanism of repeating three time the same message.

Deterministic networking reduces network bandwidth. Resource reservation implies that the network is idle while it could transmit low-priority data to account for the possibility of a high-priority transfer. The only situation in which deterministic networking enhances bandwidth is when cyclic data such as SV are transmitted using every available slot continuously, and deterministic transmission allows organization of the cycles so as to reserve contiguous spans for low priority traffic.

Deterministic networking requires that all network elements support determinism, i.e. all IEDs must participate in maintaining this property. This implies that the current substation elements must be entirely replaced by a new generation of deterministic IEDs, switches, bridges and routers. This implies some hardware changes, for instance if a networking technology requiring frame pre-emption is used. Hardware support will also be needed to reduce the communication controller load since more traffic is expected. This also means changes to the application on the IEDs, since application will be required to limit their transmission rate to a certain value and they must be able to cope with the maximum traffic.

Cascading networks (for instance with a LAN for each voltage level and a process bus) can be challenging unless all networks use the same basic period and are kept in lock-step. Otherwise, synchronization of LANs with different periods increase the transfer time, introducing a significant jitter.

To reap the benefits of deterministic networking, a class of devices must be developed according to an IEC 61850-8-x specification. These devices will have additional properties necessary to manage determinism.

Deterministic networking requires a new approach to network engineering. The network engineer must identify data requiring deterministic transmission, know the production rate of the applications (and possibly the application cycle) and the processing rate of the network nodes. Tools have to be adapted to identify data requiring deterministic delivery and compute the worst-case delay based on this information.

The determinism-related properties of the devices must be introduced in the device description (ICD) and in the substation configuration description (SCD). Extensions for the object model (IEC 61850-7-x) and SCD are necessary.

A migration phase from the current best-effort technology to the deterministic technology is needed. Therefore, the costs of introducing the deterministic technology are quite high and must be weighed against the benefits, e.g. avoiding to deploy a second network in parallel with the operational network.

User Feedback

This task force primarily addressed two key topics in New Orleans

- Issues from Interoperability Test (IOP)
- Feedback IEEE H30

The results from the IOP were assigned as follows:

Responsible Party	Number of Items
Working Group 10	33
Implementation Issues	12
Test Case Issues	5
UCA Testing Committee	2
Other	3
Working Group 15	3

In the case of the Working Group 10 items 4 were closed, 13 assigned to a task force for consideration, 5 were in discussion and 11 were complete awaiting IEC consideration.

The following items were presented on behalf of the IEEE Power System Relay Committee - H30 - IEC 61850 User Feedback Forum:

- Allow simultaneous multi-user configuration - Agreed that the point : Analysis based on the process in part 6. Input from Deepak and other utilities.
- Reduce/avoid import/export of SCL files by user - Avoid import/export is not achievable because exchange is needed. Reduce import/export should be possible. The goal is to eliminate human interaction in such process.
- Configuration - Version management and configuration management.
- One file per IED, is it possible? - One of the goals is not to duplicate information. This is related to the point related to import/export of SCL files by user.

For all these requests it was agreed they will be addressed by the AdHoc engineering task force.

SCL Function Modeling

The group completed modelling exercises with mapping of functions and equipment to conducting equipment.

- Three winding transformer
- Breaker and a half scheme

There was a discussion on "why do we need functional modelling?" Functional Modelling provides the following:

- Need proper definition of a function
- Clear distinction between process structure (Primary process) and Functional Structure.
- Functions are hierarchically structured.

- Functions are containers for LN's
- Functions have different kinds of relationships
  - Relationships to conducting equipment
  - Relationships to physical IEDs
  - We have different types of relationships that need to be considered, and a hierarchal relationship is only one type.
  - Keep the function close to the conducting equipment
- Functions can be associated on every level of the primary process
- Functional association to conducting equipment is preferred

There are also Classifications of Functions. These are:

- Protection
- Automation
- Measurement
- Supervision
- Control

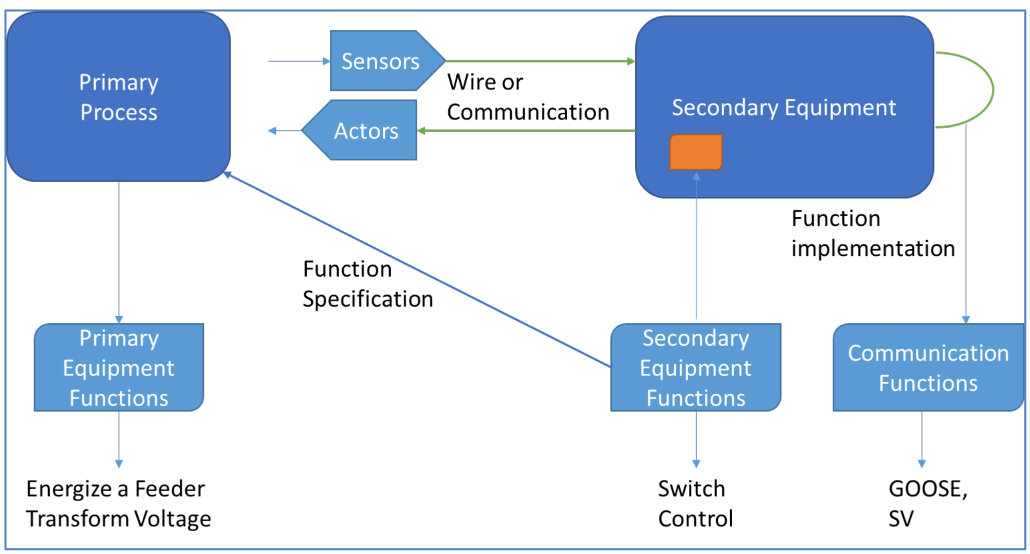

Figure 2-1
Generalized Process

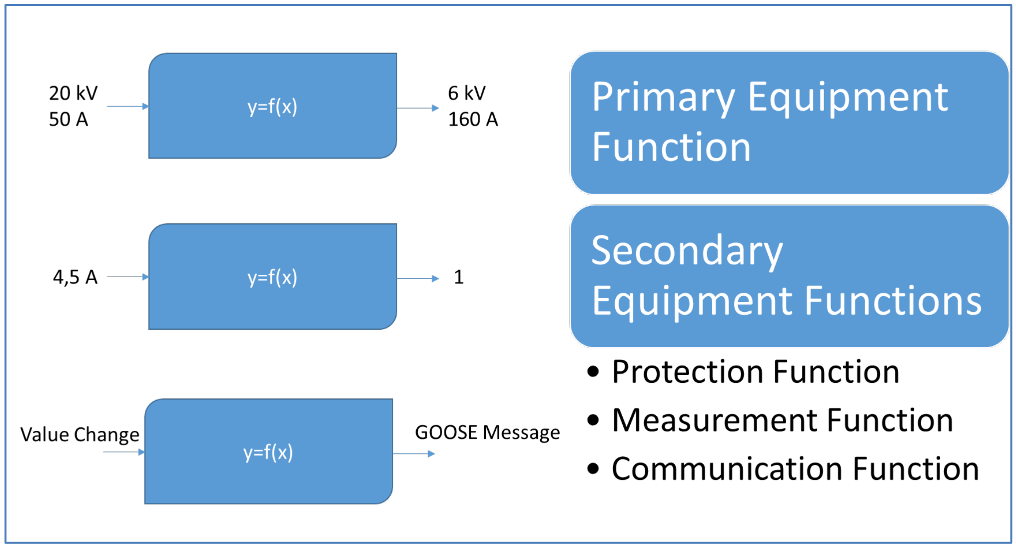

Figure 2-2
Function Examples

Function Types

- Abstract Function - Exists only “on paper” without Input /Output reference
- Specified Function - Is associated to an existing Primary Process context.
- Implemented Function - Is implemented in a physical device and is connected to physical inputs and outputs.

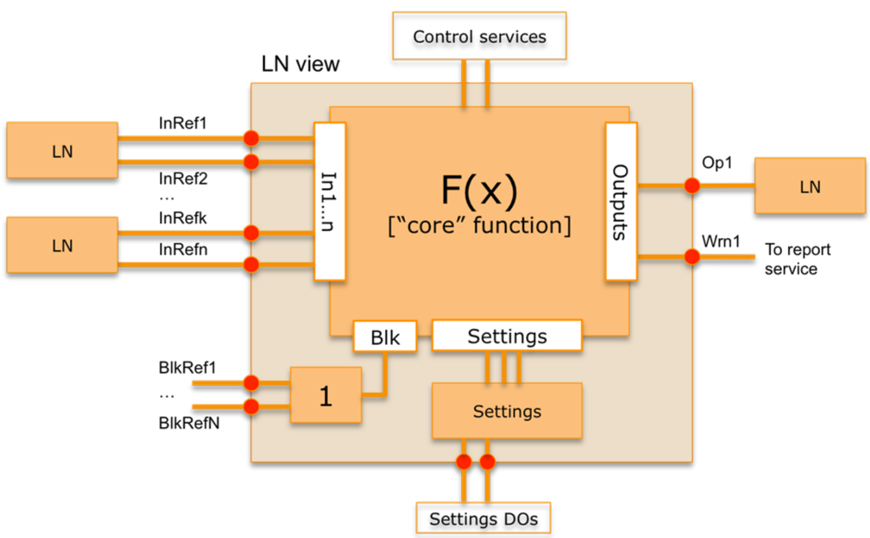

Figure 2-3
LN View of Functions

The draft standard is in final editing by the task force.

Guideline for defining Basic Application Profiles using IEC 61850

The primary goal of defining a profile is to improve interoperability for the data exchange between elements to achieve the functions as specified in the specific use of the standard. A secondary goal of defining a profile (BAP) can also be used to improve efficiency in engineering.

The functional specification of the BAPs is based on 7-500 - Use of logical nodes for modelling applications and related concepts and guidelines for substations. The BAPs are already completed for three use cases. They are:

- Interlocking
- Reverse block
- LTC

This task force is only providing examples of how BAP's are to be created, and not defining an "algorithm" of an application, which is outside the scope of work. They are not defining how the function is to perform, but only defining the required inputs.

The update from the New Orleans meeting was that the group needs to finish the 2nd draft for comments and distribute it to national committees for comments.

IEC 61850-80-5: Guideline for mapping information between IEC 61850 and IEC 61158-6(Modbus)

Although many manufacturers already implement Modbus-IEC 61850 conversion functions, the associated mapping is not guaranteed to be interoperable. To provide an IEC 61850 compliant data model, consistent and unified information exchange mapping between existing Modbus interfaces and IEC 61850 is required.

Two primary use cases are being addressed. The first is the mapping between a Modbus RTU (server) and an IEC 61850 client. The second is the mapping between an IEC 61850 IED (server) and Modbus client.

Mapping aspects included are:

- conceptual architecture;
- general mapping requirements;
- the mapping of CDC, ASCI;
- the architecture of a gateway used for exchanging and requirements for embedding mapping configuration information into IEC 61850 SCL and Modbus Device Profile.

This approach addresses a selection of features, data classes and services of the two standards.

During the last comment cycle for the document 208 comments were received. These are being addressed and the current plan is for the document to be submitted for review by mid-2018.

Part 7-7: Machine processable format of IEC 61850-related data models for tools.

The purpose of this IEC 61850 technical specification provides a way to model the code components of IEC 61850 data model (e.g., the tables describing logical nodes, common data classes, structured data attributes, and enumerations) in an XML format that can be imported and interpreted by tools. The following main use cases will be supported:

Generation of SCL data type templates for system specification or ICD files. One sub-use case is the generation of LNodeTypes for replacing GGIO.

- Validation of SCL data type templates.
- Definition of private extensions by following the rules of the standard.
- Adapting rapidly the whole engineering chain as soon as a new version of IEC 61850 data model (an addendum, a corrigenda or a Tissue) affects the content of the standard.
- Provide tool-neutral textual help to users of tools on the data model contents.
- Supporting multi-language publication, i.e., enabling the expression of the data model in different languages, through a machine processable format.

The purpose of this proposal is limited to the publication of the XML format which should support the data model part of any IEC 61850 related standard and the publication of code components themselves will be part of the related IEC 61850 part.

Part 90-20: Guideline to redundancy systems

This task force will determine how to model redundancy systems within the IEC 61850 domain and provide a guideline on implementation possibilities. There exist different kinds of redundancy system applications, which might require addition to the IEC 61850 standard. Therefore a description, documented as use cases, of the various redundancy systems is needed to identify different requirements for e.g. performance, architecture and modelling.

It is expected that the report might eventually include:

- definition of new logical nodes, e.g. for representation of redundancy schemes and supervision of redundant IEDs
- definition of new functional specifications for applications and application supervision (e.g. "alive supervision")

- guideline of communication possibilities with and between redundancy systems
- implications for the engineering process for substations containing redundancy systems
- extensions to SCL
- extensions to basic communication principles of IEC 61850

Introduction to redundancy concepts

In engineering, redundancy is usually understood as the duplication of critical components or functions of a system with the intention of increasing the dependability. Adding redundancy typically increases the cost and complexity of a system design but might be considerd in order to meet other system requirements. Different forms of redundancy exist, including:

- Standby Redundancy
  - Cold Standby redundancy
  - Warm standby redundancy
  - Hot standby redundancy
  - Active-Active redundancy (load balanced)
- Modular Redundancy
  - Dual Modular redundancy
  - Triple Modular redundancy
  - 1:N redundancy
- Network redundancy
  - RSTP
  - MSTP
  - Dual homing
  - Dual IP and duplication of the network
  - PRP
  - HSR

Use Cases

Currently there are four use cases considered by the task force. They are as follows:

- Redundant Clients
- Service on demand
- Calculation of logic plans
- Regulation

Redundant Clients

In the redundant clients use case, two IEC 61850 client entities (contained in same or different IED) connect to the same server entity and have the same data reported. Thus, both clients receive the same data during normal operation. An internal redundancy management does the coordination between the clients. In the case that both clients are communicating actively with the server (modular redundancy) a voter takes the decision which information is forwarded to / received from the consuming application. The used voting algorithm is an implementation issue and depends on the application.

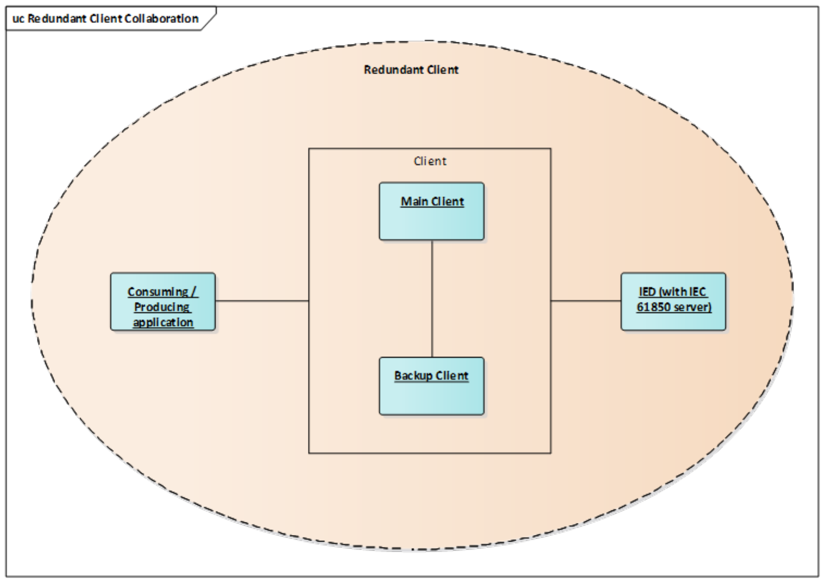

Figure 2-4
Redundant clients collaboration diagram (Example)

Service on demand

In the Service on demand use case, a human user or a technical entity wants to perform a service request. Executing the service requests involves other, possibly redundant, subsystems.

The control function of a circuit breaker from a control center is used as an example. The substation SCADA system is redundant and the bay controller IED is redundant. The underlying redundancy mechanisms must ensure that the control request is executed even when a single failure occurs.

Figure 2-5 shows the collaboration diagram for the service on demand use case. The Main and Backup entities of the SCADA application perform the same function and form the 'Substation SCADA' application. In the same way the Main and Backup IED perform the same function and together build a logic IED. , where x can be number 1 to N.

Each application may implement its own redundancy mechanism according to clause 4.2 or 4.3.

The ‘Substation SCADA’ application must support the communication mode required by the IED application. This may require knowledge of the of the redundancy mechanism implemented in the partner application.

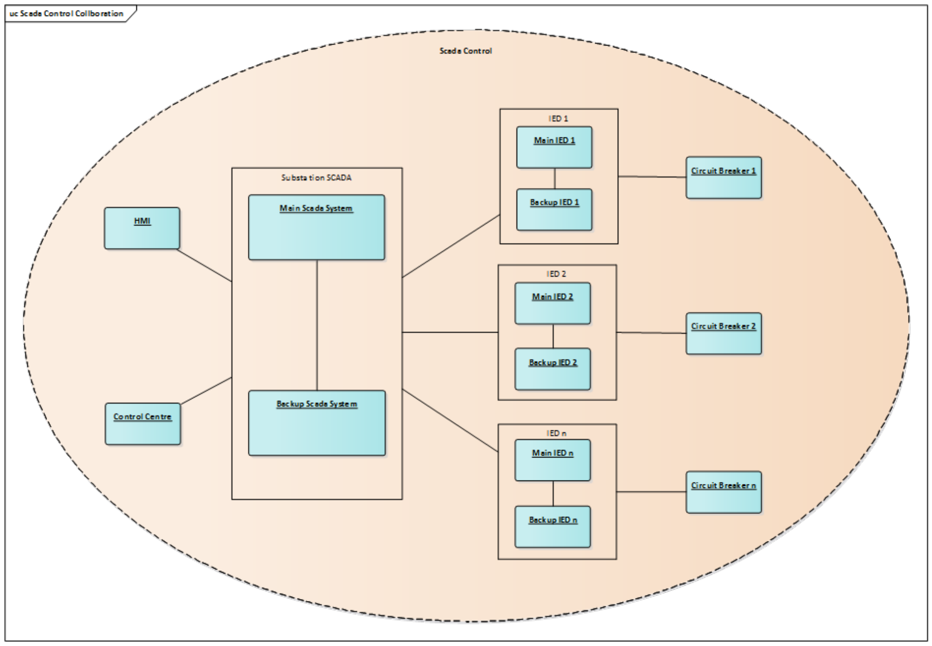

Figure 2-5
Service on demand collaboration diagram (Example)

Calculation of logic plans

In the calculation of logic plans use case, typically a technical system triggers the execution of a logic plan calculation. Executing the logic plan calculation use case involves other, possibly redundant, subsystems. Logic plan calculation is typically done by a programmable logic controller (PLC).

Figure 2-6 shows a generic collaboration diagram of the logic plan calculation use case. Both PLC entities perform the same function and form the ‘PLC’. The PLC entities can be located on the same or different IEDs. The underlying redundancy mechanisms must ensure that the calculated output is available even when a single failure occurs.

Depending on the kind of applications controlled by the PLC, different redundancy schemes can be applied to this use case:

- Hot – Standby Redundancy
- Dual Modular Redundancy

In case of Hot – Standby Redundancy both PLC entities calculate the logic result, but only the result of the Hot PLC is forwarded to the process output. In case of Dual Modular Redundancy also both PLC entities calculate the logic result, the voter then decides which result is used for the process output. One rule for the voter could be to use only the first calculation result in case of relative commands (e.g. tap position raise) and block the second calculation result. Another rule for the voter could be to forward both results to the process output (e.g. circuit breaker on). In a third, case the voter could wait for a short time (1 ms to 100 ms) that both PLC entities provide the same result, before forwarding it to the process output. Future IEC TR 61850-90-11 standard provides several use cases for programmable logic applications.

The IED configuration tools must ensure that the logic plans for the PLC entities are identical.

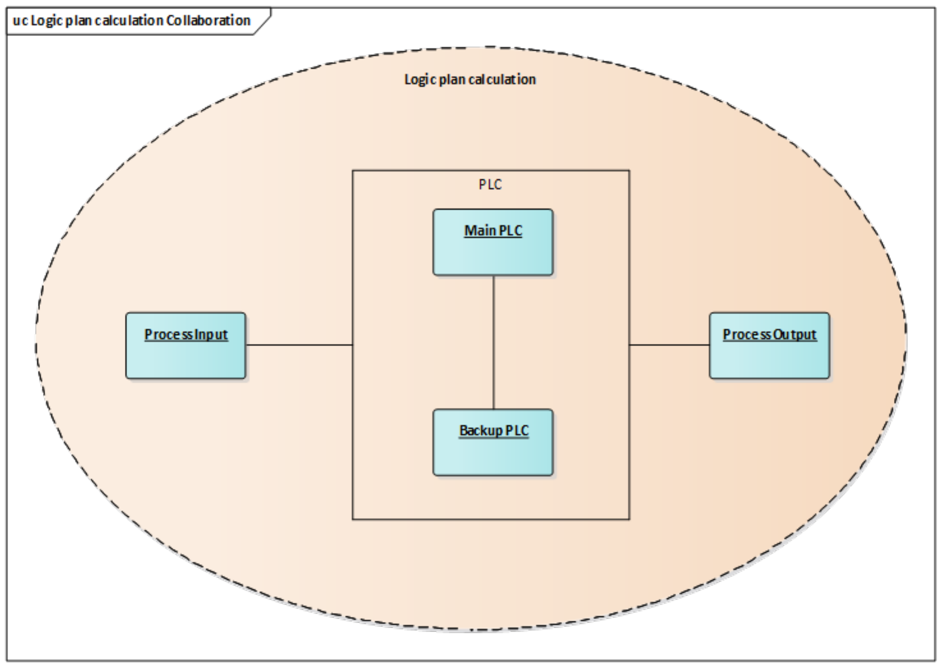

Figure 2-6
Logic plan calculation collaboration diagram (Example)

Regulation

A regulation function permanently / periodically delivers outputs to the process based on inputs from the process according to a settable / varying goal set from some client. In this case both RS IEDs should 'know' the set (same) goal.

If the results are 'relative' commands, then only one application IED should run at the time, as else too many 'relative' adjustments (e.g. tap changer raise / lower) commands are given.

The control and regulation application functions are redundant, they execute in parallel but the event and commands/orders are only in operation in control functions within the active controller.

The redundancy is tightly related to the supervision system. When any severe malfunction occurs in the control part, a switchover between the systems is initiated. Such error situation can also be detected by the protection functions that can indicate that there is an error in the operation of the power process.

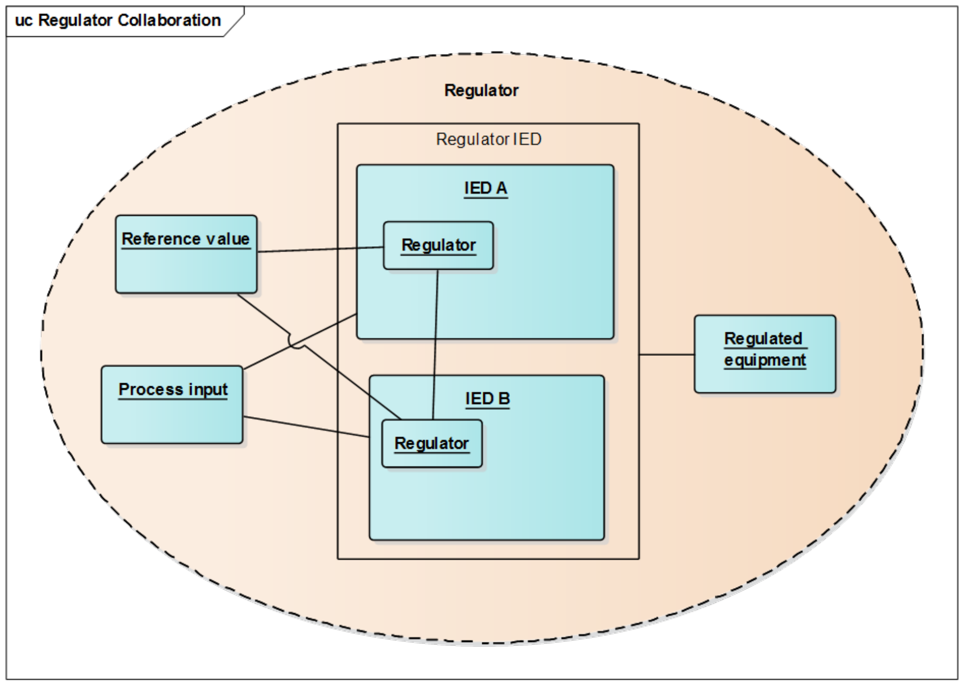

Figure 2-7
Example Block diagram of redundant voltage regulation

Part 90-4: Network engineering guidelines

The growing success of the IEC 61850 series calls for guidelines for engineering Ethernet networks. The IEC 61850 series specifies the basic requirements for the networks but not how to achieve them. Instead, the 61850 series of standards focus on data modelling and the interchange of that data, leaving out physical interconnection details that are nevertheless needed for full interoperability.

This Technical Report provides definitions, guidelines, and specifications for the network engineering of IEC 61850 based substation automation.

This report addresses issues such as Ethernet technology, network topology, redundancy, traffic latency and quality of service, traffic management by multicast and VLAN, network-based clock synchronization and testing of the network. It does not address network based security.

The report is based on existing standards for semantics, services, protocols, system configuration language and architecture. It is based on work done by: IEC TC57 WG10 (Power system IED communication and associated data models) and IEC TC57 WG 15 (Data and communications security), IEC 61918 (Industrial communication networks – Installation of communication networks in industrial premises), IEC 62439 (Industrial communication networks - High-availability automation networks), the IEEE 802.1 Working Group and IEC 61588 (Precision clock synchronization protocol for networked measurement and control systems), the UCA International Users Group 9-2LE, the IEEE Power System Relaying Committee (PSRC), and contributions of different companies.

The contents of this Technical Report are coordinated with the Working Groups producing IEC 62439, IEC 62351 and with the IEEE PSRC.

Furthermore, it focuses on engineering a local area network limited to the requirements of IEC 61850 based substation automation. It outlines the advantages and disadvantages of different approaches to network topology, redundancy, clock synchronization, etc. so that the network designer can make educated decisions. In addition, this report outlines possible improvements to both substation automation and networking equipment and addresses the most critical aspects of IEC 61850 such as protection related tripping over the network.

The report addresses in particular the multicast data transfer of large volumes of sampled values (SV) from merging units (MUs). It also considers the high precision clock synchronization and "seamless" guaranteed transport of data across the network under failure conditions that is central to the process bus concept.

Revision Update from New Orleans

IEC TR 61850-90-4 was published in 2013 with stability date 2016. The revision IEC TR 61850-90-4 Edition 2.0, specifically and additionally to Edition 1.0 brings new contents listed below without changes of the original structure and most of the contents of the first edition.

- Replacement of the automatically generated SCD objects in §19.4 by the aligned and simplified bridge and clock objects, keeping the same UML automation generation model;
- Adaptation of the description and figures in §19 (Bridge and port object model) to reflect the changes;
- Rewriting of the clock section (§14) to reflect the adoption of IEC/IEEE 61850-9-3 instead of the original profile and to explain the engineering of boundary clocks.
- Corrections, actualization of standard references and figures.
- Possible inclusion and actualization of use cases.

Revision was started 2017-08-11

IEC 61850 90-16 - Device Management System

The System Management standardization context includes adjustable and upgradeable equipment in order to face tomorrow issues and the necessity for the equipment to adapt to the evolving and growing cybersecurity threats. This equipment need to be patched, updated and reconfigured, and this has to be able to be done locally or remotely due to their great number. This is the cornerstone of System Management (SM)

System Management functionalities need to be managed by the operator through a vendor independent Information System and thus the SM exchanges need to be standardized. As these are to be applied to IEC 61850 compliant equipment, these functionalities need to be integrated in the standard.

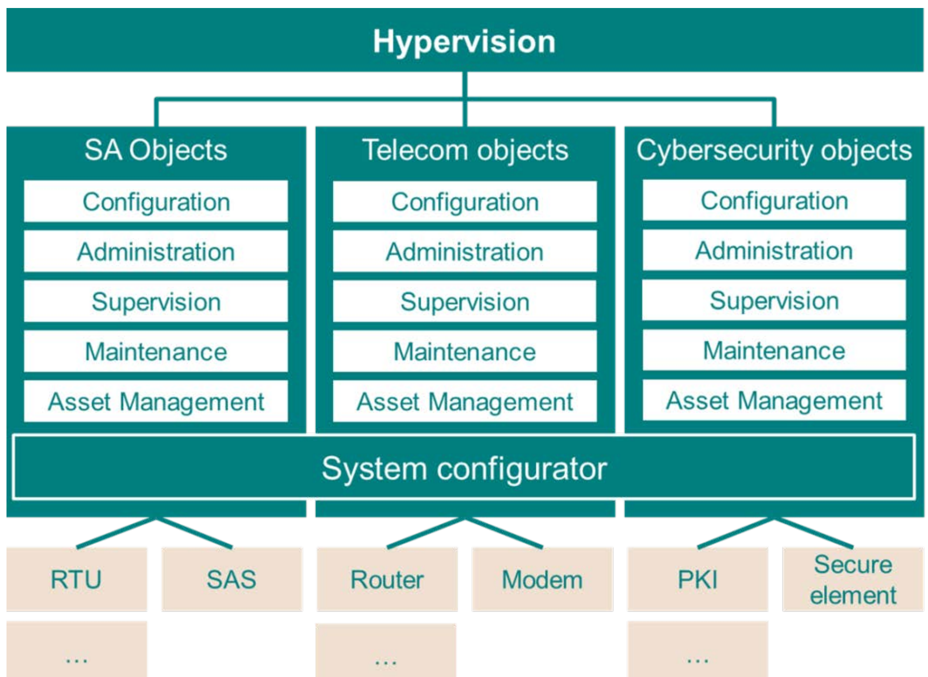

Figure 2-8
System Management Task Force scope

Proposed IEC 61850-90-16 outline

- FOREWORD
- INTRODUCTION
- 1. Scope
- 2. Normative references
- 3. Terms and definitions
- 4. Automation systems life-cycle
  - 4.1 Overview

4.2 IED life-cycle

4.3 Cybersecurity elements life-cycle

4.4 Communication systems life-cycle

5. Business Use Case

5.1 General context

5.2 Enable Automation System to perform operational functions in best conditions

6. Configuration System Use Cases

7. Administration System Use Cases

8. Supervision System Use Cases

9. Maintenance System Use Cases

10. Asset Management System Use Cases

11. System Architecture

IEC 61850-1-2 - Guidelines on extending IEC 61850

Scope - This document is targeting any 61850 users including standardization bodies that consider IEC 61850 as a base standard within their scope of work but also wants/needs to extend it.

The document identifies the high-level requirements and required steps in achieving such extensions of IEC 61850 and provides guidelines for the individual steps.

The proposed Document structure:

- Scope
- Definition
- Cases of extension
  - Namespace extensions and associated rules
    - Domain namespaces
    - Product standard namespaces
    - Transitional namespaces
    - Private namespaces
  - IEC 61850 profiles for domains
  - Mapping of IEC 61850 data model to other protocols at CDC level
- What to extend in IEC 61850 ?
  - Basic requirements (technical, editorial, IP, …) and checking
  - IEC 61850 Flexibilities

    - Allowed flexibilities per extension cases
- The main activities to extend IEC 61850

61850-90-12 - Wide Area Network Engineering Guidelines

The following WAN applications have been consolidated or already implemented

- Teleprotection: Legacy and L2-based , MPLS-based , Emergency backup wireless access for MV protection
- WAMPAC: Legacy and IP-based
- Generation and transmission EMS/SCADA including 90-2: Hydro/wind power telecontrol , SCADA/Maintenance MV/LV SCADA
- WAMS (transmission, distribution): Dynamic oscillation monitoring
- Distribution applications: DAS-FLISR , Microgrid protection using satellite
- Customer-side applications (smart metering, DR, DER, DLC, etc.): Cloud application, Metering
- CMD and maintenance: IoT application, Fault location
- Market, B2B (ISO/TSO/DSO/Customer), etc.

Additional WAN technologies addressed:

- PLC
    - Narrowband PLC
    - Broadband PLC

  Supplemental descriptions to Ed. 1
- Wireless access technologies
    - LoRa, Wi-SUN
    - 5G, LTE
    - DMR

  With upcoming applications promising for utilities such as IoT and cloud applications
- Deterministic networking technologies briefly addressed referring to 90-13 (core document), if applicable
- Network management issues briefly addressed referring to 62351-7 (MIB), 90-16 (system management) and 90-4 (communication equipment LN), if applicable
- Network migration
    - From TDM to packet-switched: Drivers, considerations, concepts, etc.

Part 90-14: Using IEC 61850 for FACTS (Flexible AC Transmission Systems) and Power Conversion data modelling

This part of IEC 61850 specifies the information model of devices and functions related to systems of power utility automation, specifically related to FACTS (Flexible AC Transmission Systems) and Power Conversion applications.

The IEC 61850-90-14 information model standard utilizes existing IEC 61850-7-4 logical nodes where possible, but also defines specific logical nodes where needed.

- Covers communication between control system of FACTS, HVDC and Power Conversion and SCADA and HMI systems.
- Includes the data model for FACTS, HVDC and Power conversion devices
- Does not cover Protection relays
- Does not cover process bus
- Does not cover valve communication

Section 3: Conclusion

When attending the individual working group meetings and sitting in the meeting room during the sometimes drawn out discussion on a specific narrow topic can be painful, it usually benefits the process in assuring that the best possible outcome is concluded given the facts presented at the time.

Topics Advanced

Across the course of 2017 the following topics have advanced:

- The handling of Role Based Access for IEC 61850
- Applicability of Deterministic Networking for Protection & Control
- User Feedback - issues and concerns of the user community
- SCL Function Modeling
- Guideline for defining Basic Application Profiles using IEC 61850
- IEC 61850-80-5: Guideline for mapping information between IEC 61850 and IEC 61158-6(Modbus)
- Machine processable format of IEC 61850-related data models for tools.
- Part 90-20: Guideline to redundancy systems
- Part 90-4: Network engineering guidelines
- IEC 61850 90-16 - Device Management System
- IEC 61850-1-2 - Guidelines on extending IEC 61850
- 61850-90-12 - Wide Area Network Engineering Guidelines
- Part 90-14: Using IEC 61850 for FACTS (Flexible AC Transmission Systems) and Power Conversion data modelling

2018 Meeting Schedule

The proposed meeting schedule for 2018 is as follows:

Week of	Location
February 12-16, 2018	Sochi, Russia
June 11-15, 2018	New York, NY USA
October 8-12, 2018	Saclay (near Paris) France

Section 4: References

[1] "POWER SYSTEMS management and associated information exchange," 22 September 2016. [Online]. Available: http://tc57.iec.ch/index-tc57.html.

[2] International Electrotechnical Commission, "International Electrotechnical Commission - Core IEC Standards," 22 September 2016. [Online]. Available: http://www.iec.ch/smartgrid/standards/.

[3] UCA International Users Group, "IEC TC 57 > Wg 10 - Sharepoint," [Online]. Available: http://iectc57.ucaiug.org/wg10/default.aspx. [Accessed 3 November 2016].

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