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TECHNICAL REPORT

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Communication networks and systems for power utility automation – Part 7-500: Basic information and communication structure – Use of logical nodes for modeling application functions and related concepts and guidelines for substations

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 7-500: Basic information and communication structure – Use of logical nodes for modeling application functions and related concepts and guidelines for substations

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IEC TR 61850-7-500, which is a technical report, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
57/1817/DTR	57/1865/RVDTR

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61850 series, published under the general title *Communication networks and systems for power utility automation*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

This part of IEC 61850, which is a technical report, shows the use of Logical Nodes as defined in IEC 61850-7-4 for application functions in the substation domain. IEC 61850 defines Communication Networks and Systems for Power Utility Automation, and more specifically the communication architecture for subsystems like substation automation systems. The sum of all subsystems may also result in the description of the communication architecture for the overall power system management. The defined architecture provides in IEC 61850-7-x both a power utility-specific data model and also a substation domain specific data model with abstract definitions of data objects classes and services independently from the specific protocol stacks, implementations, and operating systems. The mapping of these abstract classes and services to communication stacks is outside the scope of IEC 61850-7-x and may be found in IEC 61850-8-x and in IEC 61850-9-x.

IEC 61850-7-1 gives an overview of the basic communication architecture to be used for all applications in the power utility domain. IEC 61850-7-3 defines common attribute types and common data classes related to all applications in the power system domain. The attributes of the common data classes may be accessed using services defined in IEC 61850-7-2. These common data classes are used in this part to define the compatible data objects classes.

To reach interoperability, all data objects in the data model (IEC 61850-7-4, IEC 61850-7-3) need a strong definition with regard to syntax and semantics. The semantics of the data objects are mainly provided by names assigned to common logical nodes and data objects they contain as defined in IEC 61850-7-4, and dedicated logical nodes are defined in domain-specific parts (IEC 61850-7-x) e.g. for hydro power control systems in IEC 61850-7-410. Interoperability is reached with minimum effort if as many as possible of the data objects are defined as mandatory. Because of different philosophies and technical features, some data objects, especially settings, were declared as optional in this edition of the standard. After some experience has been gained with this standard, this decision may be reviewed in the next edition of the relevant parts of the standard.

A data object with full semantics is only one of the elements required to achieve interoperability. Standardized access to the data objects is defined in compatible, power utility and domain specific services (see IEC 61850-7-2). Since data objects and services are hosted by devices (IED), a proper device model is also needed. To describe both the device capabilities and the interaction of the devices in the related system, a configuration language is also needed as defined in IEC 61850-6 by the System/Substation Configuration description Language (SCL).

A lot of functions in power systems are complex combinations of local Logical Nodes in one IED, or distributed Logical Nodes in many IEDs linked by a dedicated data exchange. For some functions different solution concepts exist resulting in different implementations. Depending on the kind of differences they may result in increased requirements for system integration engineering tools or, in the worst case, destroy interoperability. The goal of this informative document is to show the most common application of Logical Nodes in modelling simple and complex application functions, to improve common understanding in modelling and data exchange in general, and finally to stimulate implementations which support in any case interoperability.

The data model of IEC 61850 i.e. the Logical Nodes (LN) contain only the data provided by the application functions described but not the source where the data which are needed as input for the application functions are from. This gap is also closed in this document either expicitely by naming the input data or implicitely by showing the connections between the different LNs used.

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 7-500: Basic information and communication structure – Use of logical nodes for modeling application functions and related concepts and guidelines for substations

1 Scope

This part of IEC 61850, which is a technical report, describes the use of the information model for devices and functions of IEC 61850 in applications in substation automation systems, but it may also be used as informative input for the modeling of any other application domain. In particular, it describes the use of compatible logical node names and data objects names for communication between Intelligent Electronic Devices (IED) for use cases. This includes the relationship between Logical Nodes and Data Objects for the given use cases. If needed for the understanding of the use cases, the application of services is also described informatively. If different options cannot be excluded they are also mentioned.

The modelling of the use cases given in this document are based on the class model introduced in IEC 61850-7-1 and defined in IEC 61850-7-2. The logical node and data names used in this document are defined in IEC 61850-7-4 and IEC 61850-7-3, the services applied in IEC 61850-7-2. The naming conventions of IEC 61850-7-2 are also applied in this document.

If extensions are needed in the use cases, the normative naming rules for multiple instances and private, compatible extensions of Logical Node (LN) Classes and Data Object Names defined in IEC 61850-7-1 are considered.

IEC 61850-7-5 describes in examples the use of logical nodes for modeling application functions and related concepts and guidelines in general, independently from any application domain respectively valid for all application domains in the electric power system (substation automation, distributed energy resources, hydro power, wind power, etc.). This document describes in examples the use of logical nodes for application functions in substation automation including also line protection between substations. It also implies some tutorial material where helpful. However it is recommended to read IEC 61850-5 and IEC 61850-7-1 in conjunction with IEC 61850-7-3 and IEC 61850-7-2 first.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60255-24/IEEE C37.111:2013, *Measuring relays and protection equipment – Part 24: Common format for transient data exchange (COMTRADE) for power systems*

IEC 61588, *Precision clock synchronization protocol for networked measurement and control systems*

IEC TS 61850-2, *Communication networks and systems in substations – Part 2: Glossary*

IEC 61850-5:2013, *Communication networks and systems for power utility automation – Part 5: Communication requirements for functions and device models*

IEC 61850-7-1, *Communication networks and systems for power utility automation – Part 7-1: Basic communication structure – Principles and models*

IEC 61850-7-2:2010, *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 61850-7-4:2010, *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 (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3*

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/IEEE 61850-9-3, *Communication networks and systems for power utility automation – Part 9-3: Precision time protocol profile for power utility automation*

IEC 61869-9, *Instrument transformers – Part 9: Digital interface for instrument transformers*

IEC 62271-3, *High-voltage switchgear and controlgear – Part 3: Digital interfaces based on IEC 61850*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61850-2 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
application functions
functions which perform a dedicated task in the utility automation system to allow the control, protection, monitoring and supervision of the power system in a given domain such as substation automation

3.1.2
domains
well-defined areas in the utility automation system respectively in the power system

3.1.3
use cases
samples for application functions or for a set of interacting ones to performing a dedicated task

3.1.4
1-out-of-n control
state of the substation control when only one of the n switches in the substation is allowed to be controlled (opened or closed) at the same time

3.2 Abbreviated terms

The abbreviated terms of IEC 61850-7-3 and IEC 61850-7-4 will be used. The following terms are listed since they need to be highlighted or are missing in the referenced parts.

AIS	Air insulated substation
ARC	Autoreclosure
BIED	Breaker IED means process near circuit breaker controller same as CBC
CC	Control Center used as more generic term instead of NCC (Network Control Center)
DCC	Process near disconnector controller IED according to IEC 62271-3 instead of SIED (switch IED)
CBC	Process near circuit breaker controller IED according to IEC 62271-3 instead of BIED (breaker IED)
ESC	Process near earthing switch controller IED according to IEC 62271-3 instead of SIED (switch IED)
GIS	Gas insulated substation
GOOSE	Generic Object Oriented Substation Event according to IEC 61850-8-1
GPS	Global Positioning System (US)
HMI	Human Machine Interface
IED	Intelligent Electronic Device
ITL	Interlocking
LV	Low Voltage
MMS	Manufacturing Messaging Specification
MU	a) Merging Unit used for process near IED sampling analogue measurement of current and voltage, performing A/D conversion and merging data from different measurement points in one or many SV streams as far as applicable b) Merging Unit used as LD name containing LNs for analogue data like TVTR and TCTR
SBO	Select before Operate
SCSM	Specific Communication Service Mapping
SER	Sequence of Event Recording
SIED	Switch IED means process near disconnector/earthing switch controller same as DCC and/or ESC
SV	Sampled values data stream according to IEC 61850-9-2

4 Basics of substation automation with IEC 61850

4.1 Architecture

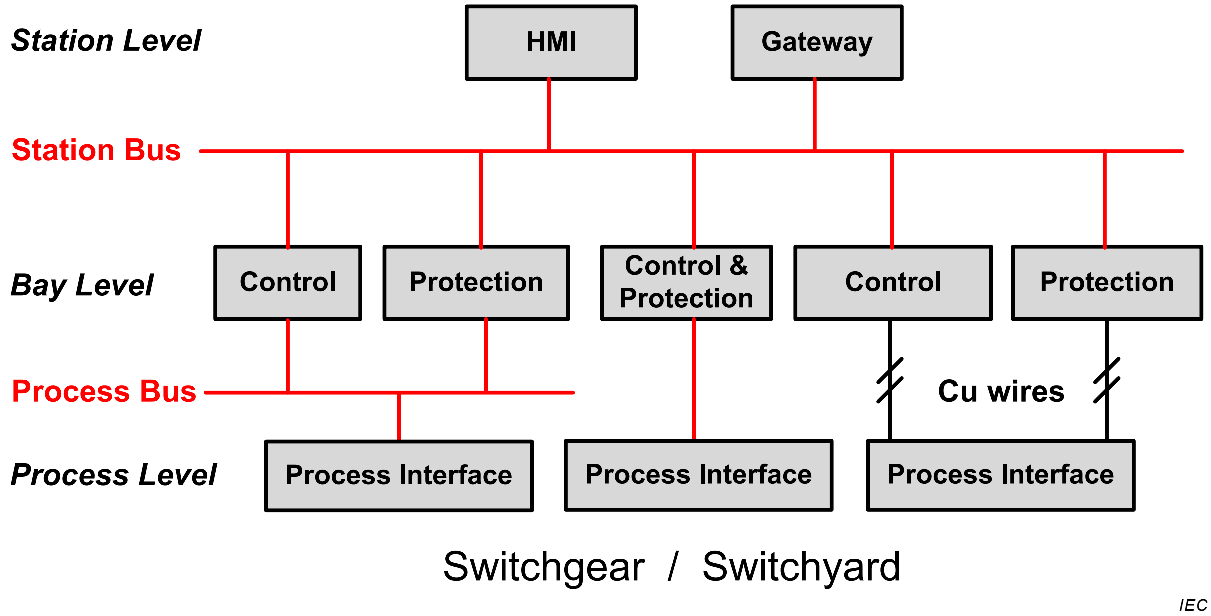

Figure 1 – Architecture of a substation automation system

The architecture example given in Figure 1 describes the most common implementation of substation automation systems with station level, bay level and process level. The boxes (Intelligent Electronic Device: IED) are the containers for the functions. The communication between the levels are named station and process bus. The naming refers to the physical allocation of the communication systems between the levels only and not to a functionality which is discussed below. Based on the common allocation of functions to station (including HMI and Gateway), bay and process level IEDs the following definitions apply:

- The station bus is the communication network between station level devices (station computer, gateway, etc.) and the bay level IEDs (protection, control, monitoring devices etc).
- The process bus is the communication network between bay level IEDs (protection, control, monitoring devices etc) and the process level interface for switchyard devices (breakers, disconnectors, earthing switches, busbars, power transformers, current and voltage transformers, etc.).

4.2 Communication and relevance of bus definitions

IEC 61850 defines the object model, the communication services to access and to exchange the data, the engineering process and the mapping of the services onto a protocol.

All services are applicable for communication over both the above-defined station bus and process bus. Based on the common allocation of functions also a common allocation of services to the busses is assumed. Some allocations are very intuitive, i.e. the sampled value (SV) service runs over the process bus since the samples of current and voltage come from instrument transformers or sensors on the process level. However voltage samples representing the busbar voltage for the synchrocheck may come over the station bus.

Since the function allocation and, therefore, the allocation of data of the object model is not the same everywhere and not fixed regarding the evolution of substation automation over time, the terms “station bus” and “process bus” do not have an implementation-independent meaning. These terms do not exist in the title of any standard parts. They refer to the defined services only, i.e.

- IEC 61850-8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3 refers to the Client-Server communication and the GOOSE messages and
- IEC 61805-9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3 refers the transmission of sampled values.

Therefore, the terms “station bus” and “process bus” will be used only if they are of benefit for the reader of this document.

5 Summary of substation automation functions

5.1 HMI and related station level functions

Accessing the system

- Access control & access security management
- Access authority and access logging
- Operator access to the system: control, parameter switching, data retrieval
- Display of data and information: single line, alarm list, measurands
- Storage of data in the station computer: historical data, disturbance files
- Log management: archiving, sorting, etc.

5.2 Operational or control functions

Operating and supervising the system

- Operational control: switching devices, tap changer, LV devices
- Indication handling: switchgear position, etc.

- Event (SER) and alarm handling: recording, logging, acknowledgement (for alarms only)
- Parameter setting and parameter set switching: protection, ARC on/off, ITL override, etc.
- Data retrieval: setting, parameters, disturbance records, etc.

5.3 Monitoring and metering functions

Process/status data from the primary and secondary process/system

- Metering: revenue metering, operative measuring, calculation of U, I, P, Q, f, φ
- Power equipment and system monitoring: switchgear and transformer load, power quality
- Disturbance recording: Fault recording and fault location

5.4 Local automation functions (protection and others)

Performing local decisions without human intervention

- Protection: line, transformer, busbar, generator, level, impedance, differential protection, zero voltage protection, fault location
- Automation: local synchrocheck and autoreclosure
- Bay interlocking: blocking and release of circuit breakers, disconnectors and earthing switches

5.5 Distributed automation functions (protection and others)

Using global data for local decisions

- Distributed busbar protection