IEC TR 61850-90-2

Edition 1.0 2016-02

TECHNICAL REPORT

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Communication networks and systems for power utility automation – Part 90-2: Using IEC 61850 for communication between substations and control centres

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CONTENTS

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-2: Using IEC 61850 for communication between substations and control centres

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IEC TR 61850-90-2, 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:

DTR	Report on voting
57/1578/DTR	57/1641/RVC

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

A list of all the 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 publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

Following the publication of IEC 61850, substations using IEC 61850 technologies have been implemented. The concepts of IEC 61850 are also used in applications outside of the substation such as distributed energy resources, hydro power plants and wind power plants. Therefore, IEC 61850 forms the foundation for a globally standardized utility communication network.

The object models and configuration language introduced by IEC 61850 provide new possibilities for the management of the automation system. A direct and seamless access from the control and maintenance centres to the IEDs of the substation automation system allows efficient data management of the overall control system.

The possibility of using IEC 61850 for communication between substations and control systems is mentioned in IEC TR 62357-1:2012 without any specification of how it will be used. The issue was evaluated in 2002 by a task force. The conclusion was that IEC 61850 is suitable, but may eventually require the following extensions:

- A new mapping of the communication services on a protocol suitable for wide area communication;
- Extensions of the data model to provide a control centre view of the substation. A further important benefit to users is the possibility of entering configuration information only once.

Currently, substation configuration information is available in the SCL and control centre configuration information is available in the CIM. The models have been harmonized, so that an automatic transfer of the information from one model to the other should be possible. New work will describe how that configuration information can be transferred between CIM and SCL. However, this document does not address the overall topic of CIM/IEC 61850 harmonisation. That will be addressed separately in the future technical report IEC TR 62361-102.

IEC 61850 was initially prepared for information exchange between the devices of a substation automation system. The concepts are now also used in other power system application domains.

This technical report provides a comprehensive overview of the matters that need to be considered in order to use IEC 61850 for information exchange between substations and control or maintenance systems. Areas that require extension of specific parts of the existing IEC 61850 standards will be incorporated in future editions of the affected part of IEC 61850.

A similar report discussing the use of IEC 61850 for communication between substations has been issued as IEC TR 61850-90-1.

The namespace of this technical report is “(Tr)IEC 61850-90-2:2015A”.

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-2: Using IEC 61850 for communication between substations and control centres

1 Scope

This part of IEC 61850, which is a technical report, provides a comprehensive overview of the different aspects that need to be considered while using IEC 61850 for information exchange between substations and control or maintenance centres or other system level applications. In particular, this technical report:

- defines use cases and communication requirements that require an information exchange between substations and control or maintenance centres
- describes the usage of the configuration language of IEC 61850-6
- gives guidelines for the selection of communication services and architectures compatible with IEC 61850
- describes the engineering workflow
- introduces the use of a Proxy/Gateway concept
- describes the links regarding the Specific Communication Service Mapping (SCSM)

This technical report does not define constraints or limitations for specific device implementations. There is no specific chapter for cyber security which is tackled when it is necessary. The model, for IEC TR 61850-90-2, provides security functions based upon the security threats and security functions found in IEC TS 62351-1 and IEC TS 62351-2. This technical report touches several security aspects with the following basic assumptions:

- Information authentication and integrity (e.g. the ability to provide tamper detection) is needed
- Confidentiality is optional

It shall be possible to provide information authentication and integrity in an end-to-end method, regardless of information hierarchies. The typical method to provide this security function is through some type of information/message authentication code. IEC 62351-4:2007 and IEC 62351-9[1] describe how authentication and integrity is achieved for IEC 61850-8-1. A later version of IEC 62351-4 will provide means to ensure end-to-end data integrity through Proxy/Gateways.

Beneath information authentication and integrity, information availability is an important aspect for telecontrol. This technical report provides redundancy architectures to enhance the availability of information in control and maintenance centres.

The scheme shown in Figure 1 gives an overview of the connectivity and the communication paths. In particular it indicates the principle to access directly or indirectly – via the Proxy/Gateway – to an IED. An application of security controls for substation to control centre communication can be found in IEC 62351-10:2012, 6.4.3. Thus, the substation automation system has to be considered inside a perimeter of cyber security. The access is totally checked by security access points (this document does not describe such a security access

[1] Under consideration.

point). The boundary of the electronic security perimeter is defined by the point, where the communication line leaves the perimeter of the substation over public ground. There might be more than one security access point, where separation of applications (e.g. control centre and maintenance centre) is required. When more than one client needs access to the same security access point information level access control, e.g. according to IEC TS 62351-8:2011, may be added. IEC TS 62351-8:2011 may also be used in other cases, where different access rights are required.

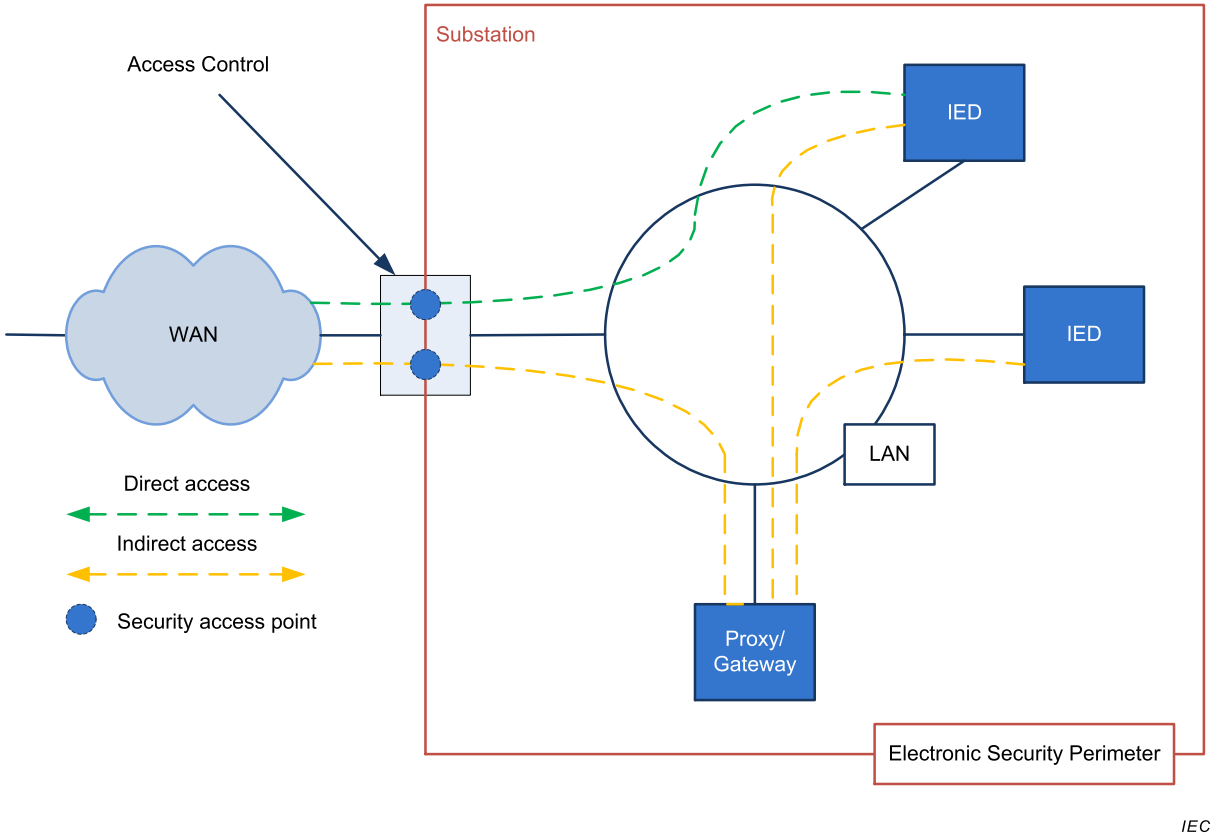

Figure 1 – Connectivity and communication paths of a substation

The majority of applications for which this technical report is applicable will use the services of MMS (ISO 9506) mapped to ISO/IEC 8802-3 frame formats, as described in IEC 61850-8-1:2011.

The primary application for the use of indirect access, as described in this technical report, will be for telecontrol applications. Nevertheless this technical report does not imply that the use of a Proxy/Gateway is required for telecontrol applications. Direct access may also be used for telecontrol applications where applicable and accepted by the customer.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60870-4:1990, *Telecontrol equipment and systems – Part 4: Performance requirements*

IEC 60870-5-103:1997, *Telecontrol equipment and systems – Part 5-103: Transmission protocols – Companion standard for the informative interface of protection equipment*

IEC 60870-5-104:2006, *Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles*

IEC 61158-6, *Industrial communication networks – Fieldbus specifications*

IEC TS 61850-2:2003, *Communication networks and systems in substations – Part 2: Glossary*

IEC 61850-4:2011, *Communication networks and systems for power utility automation – Part 4: System and project management*

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

IEC 61850-6:2009, *Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs*

IEC 61850-7-1:2011, *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 61850-7-3:2010, *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 61850-8-1:2011, *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 61850-9-2:2011, *Communication networks and systems for power utility automation – Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3*

IEC TS 61850-80-4, *Communication networks and systems for power utility automation – Part 80-4: Translation from COSEM object model (IEC 62056) to the IEC 61850 data model*[2]

IEC TR 61850-90-3, *Communication networks and systems for power utility automation – Part 90-3: Using IEC 61850 for condition monitoring diagnosis and analysis*[2]

IEC TR 61850-90-5:2012, *Communication networks and systems for power utility automation – Part 90-5: Use of IEC 61850 to transmit synchrophasor information according to IEEE C37.118*

IEC TR 61850-90-12:2015, *Communication networks and systems for power utility automation – Part 90-12: Wide area network engineering guidelines*

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2 To be published.

IEC 62056-6, *Electricity metering data exchange – The DLMS/COSEM suite*

IEC TS 62351-4:2007, *Power systems management and associated information exchange – Data and communications security – Part 4: Profiles including MMS*

IEC TS 62351-8:2011, *Power systems management and associated information exchange – Data and communications security – Part 8: Role-based access control*

IEC 62351-9, *Power systems management and associated information exchange – Data and communications security – Part 9: Cyber security key management for power system equipment*[2]

IEC TR 62351-10:2012, *Power systems management and associated information exchange – Data and communications security – Part 10: Security architecture guidelines*

IEC 62351-11, *Power systems management and associated information exchange – Data and communications security – Part 11: Security for XML Files*[3]

IEC 81346-1:2009, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules*

IEC 81346-2:2009, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 2: Classification of objects and codes for classes*

IEEE 1815-2012, *IEEE Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3)*

RFC 1122:1989, *Requirements for Internet Hosts – Communication Layers*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61850-2:2003 and IEC 61850-7-2:2010, as well as the following, apply.

3.1
control centre
place where a master station (SCADA, EMS, DMS, GMS, grid operator) receives and processes data coming from substations

Note 1 to entry: The control centre may also perform the functions of a maintenance centre.

3.2
maintenance centre
place from where maintenance, management of asset, disturbance analysis and metering are managed

3.3
Proxy/Gateway
IED containing an IEC 61850 server which services requests of its clients by forwarding requests to other servers through its IEC 61850 client

Note 1 to entry: A Proxy/Gateway optionally alters the client requests or the server's response and sometimes it may serve the request without contacting the specified server, e.g. by maintaining a process data image. In some

3 To be published.

cases the Proxy/Gateway has to reprocess the data to meet the requirements of the Control centre interface. In the context of IEC 61850 the Proxy/Gateway consists of both client and server interfaces. The incorporation of data from sources other than IEC 61850 could also be supported within the Proxy/Gateway but the description of this is outside the scope of this document.

3.4
substation
system consisting of a place where high voltage devices (circuit breaker, isolator, transformers) related to an electrical grid, facilities necessary for system security, control and communication (Proxy/Gateway, IED) are located

4 Abbreviated terms

For the purposes of this document, the abbreviated terms given in IEC TS 61850-2:2003, IEC 61850-7-2:2010 as well as the following apply.

ACSI	Abstract Communication Service Interface
BRCB	Buffered Report Control Block
CC	Control Centre
CIM	Common Information Model of IEC 61970 / IEC 61968
COSEM	Companion Specification for Energy Metering
DMS	Distribution Management System
EMS	Energy Management System
FACTS	Flexible Alternative Current Transmission System
GMS	Geographical Management System
GOOSE	Generic Object Oriented Substation Event
GSE	Generic Substation Event
HMI	Human Machine Interface
ICD	IED Capability Description
IED	Intelligent Electronic Device
ICT	IED Configuration Tool
IID	Instantiated IED Description
IP	Internet Protocol
LAN	Local Area Network
LD	Logical Device
LN	Logical Node
MMS	Manufacturing Message Specification (ISO 9506)
PIXIT	Protocol Implementation Extra Information for Testing
RCB	Report Control Block
RMS	Root Mean Square
SBO	Select Before Operate
SCADA	Supervisory Control and Data Acquisition
SCD	Substation Configuration Description
SCL	Substation Configuration Language
SCSM	Specific Communication Service Mapping
SCT	System Configuration Tool
SED	System Exchange Description
SGCB	Setting Group Control Block
SS	Substation
SSD	System Specification Description
SP	Setting (outside setting group)

SV	Sampled Value
TCP	Transmission Control Protocol
THD	Total Harmonic Distortion
TPAA	Two party application association
TR	Technical Report
WAMPAC	Wide Area Monitoring Protection And Control
WAMS	Wide Area Monitoring System
WAN	Wide Area Network

NOTE Abbreviations used for the identification of the common data classes and as names of the attributes are specified in the specific clauses of this document and are not repeated here.

5 Use cases and requirements

5.1 Use cases

5.1.1 Overview

Use cases describe typical communication functions envisaged for substation to control centre operation using techniques described in this document. These use cases include operational and engineering activities.

5.1.2 Actors

These are the actors that are used in the following use cases:

Name	Role description
User	Could be: • Control centre which is a place where a master station is located. The control centre (SCADA, EMS, DMS, GMS, grid operators) receives and processes data coming from substation. • Maintenance centre which is a place from where maintenance, management of asset, disturbance analysis and the metering are managed. • A local user which is a technician having to intervene on the substation automation system.
IED	A device that acquires and computes process data.

5.1.3 Use case diagram

Figure 2 shows a use case diagram for substation to control centre communication.

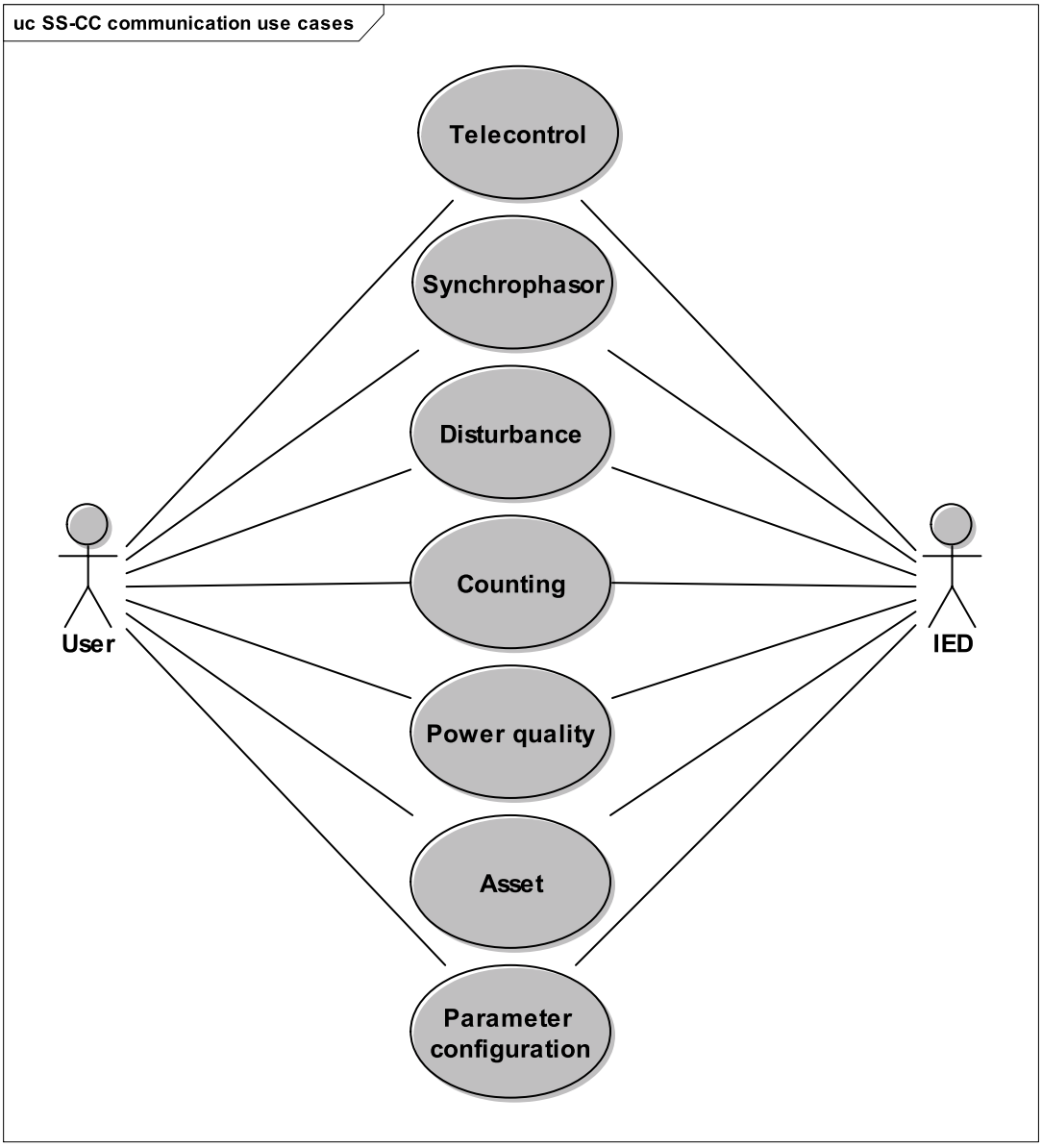


Figure 2 – Use case diagram for substation to control centre communication

5.1.4 Use cases

The substation to control centre communication includes the following main use cases:

Name	Service or information provided
Telecontrol	Sending and receiving Information: Typical applications include (non-exhaustive list): For supervision: • Status information of switchgear positions • Indications of warnings and alarms: o Status of the process/stations buses o Status of synchronization network and sources • Measurement values (voltages, currents, power, frequency) • General interrogation For control: • Remote control for power system devices and substations • Remote control of protection related functions (recloser, lockout relay) • Setpoint for transformers • Setpoint for FACTS devices • Control authority management
Synchrophasor	Information measured via mechanisms specified in IEEE C37.118.1 or similar used by applications such as state estimation, WAMS and WAMPAC. Transport of phasor data is done according to IEC TR 61850-90-5:2012.
Disturbance	Manage disturbance records in remote systems. Typical applications include (non-exhaustive list): • Transmission parameters • Records transmission • Transmission of status records • Delete of records
Counting	Manage integrated totals / energy accounting. Typical applications include (non-exhaustive list): • Transmission of integrated totals • Transmission of incremental information
Power quality	Transmission of all necessary information to manage specifically the power quality (frequency, current, current unbalance, voltage, voltage unbalance, voltage variation, etc.).
Asset	Transmission of all necessary information to manage power system resources (name plate, health, local operation, operation counter, etc.).
Parameter configuration	Transmission of parameter and configuration information (settings).

5.2 Telecontrol

5.2.1 General

The telecontrol (supervision) is used to report information of the primary equipment, secondary equipment and other information regarding the operational context to local SCADA systems and control centres.

Telecontrol includes the following use cases:

- For supervision:
  - Acquisition of status
  - Acquisition of measurement
  - Acquisition of alarms
  - General interrogation
  - Telemonitoring blocking
- For control:
  - Remote control
  - Sending setpoint
  - Control authority management

5.2.2 Constraints / assumptions / design considerations

All telecontrol communication is done through the Proxy/Gateway. Basic functionality required is listed below

- Periodic system data: status point, analogue points, quality flags, time stamps, protection events.
- Report by exception capability: status point, analogue points, quality flags, time stamps, protection events.
- Device control requests: on/off, trip/close, raise/lower etc. and setpoints. Includes mechanisms for interlocked controls and select before operate.
- Event reporting: Reporting to a client of error conditions and device state changes at a server.
- General interrogation: Transmission on request capability.
- Control authority management according to IEC TR 61850-7-500[4].

Availability of the system must fulfil the customer requirements.

5.2.3 Actors

The telecontrol use case requires the following actors:

Name	Role description
IED	Acquires and computes process data
Control centre	Receives and processes data

4 Under consideration.

5.2.4 Use cases diagram

Figure 3 shows a telecontrol use diagram.

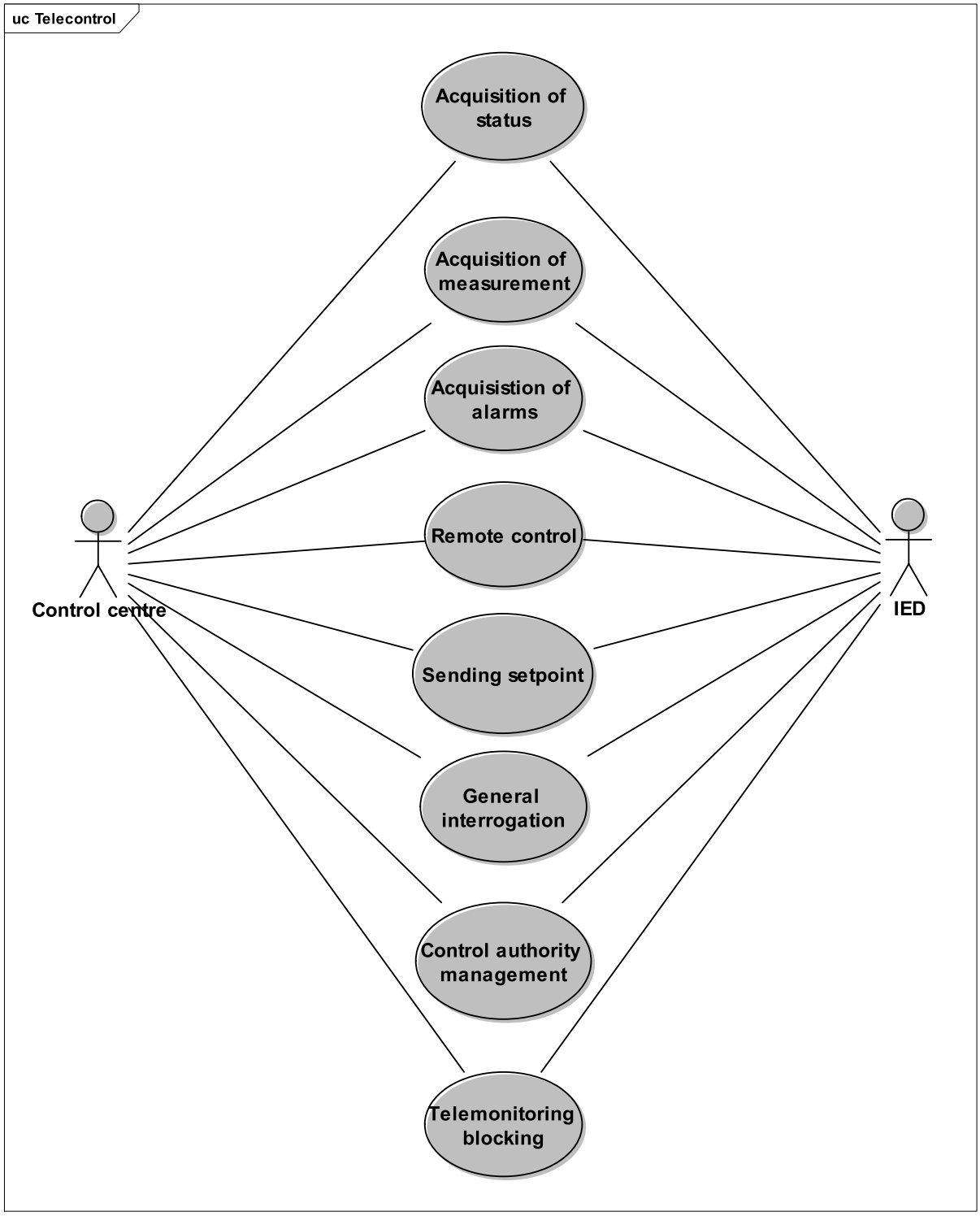


Figure 3 – Telecontrol use case diagram

5.2.5 Use case description

The telecontrol use case includes the following sub-use cases:

Name	Service or information provided
Acquisition of status	IED acquires the current status of a power system device (e.g. open, close…) and, if it has changed, sends the new status, cause of transmission, time stamp, etc., to the control centre.
Acquisition of measurement	• Sending Measurement on change IED acquires measurement (P, Q, I, V…) and, if it changed significantly (using dead band), sends it to the control centre. • Sending measurement cyclically IED acquires measurement (P, Q, I, V…) and sends it, cyclically (user configured), to the control centre.
Acquisition of alarms	IED receives alarms from substation equipment and sends them to the control centre.
Remote control	• Sending a direct command Control centre sends a command to a power system device to change its current position. • Sending a SBO command Control centre sends a command to a power system device to change its current position using SBO functionality.
Sending setpoint	Control centre sends a setpoint to a generator or to a tap changer transformer or FACTS.
General interrogation	Control centre issues a request to refresh the control centre database image of substation information.
Control authority management	Isolation of remote control for maintenance purposes.
Telemonitoring blocking	Temporarily disable the update of information from the substation, or a part of it, to the control centre.

5.2.6 Sequence diagrams

5.2.6.1 Acquisition of status

5.2.6.1.1 Acquisition and sending changed status

Use Case step	Description
Step 1	IED acquires status from devices.
Step 2	If the status changed, the status with time stamp, cause of transmission, etc. is sent to the control centre.

5.2.6.1.2 Sending spontaneous status changes

Use Case step	Description
Step 1	IED acquires an event (indication warning, status change…).
Step 2	The event status is sent with time stamp, cause of transmission, etc. to the control centre.

5.2.6.1.3 Constraints for acquisition of status

Table 1 summarizes the target communication delay and time accuracy (see IEC 61850-5:2013).

Table 1 – Constraints for acquisition of status

Constraint	Value [ms]
Maximum application -to-application time delay (see definition of transfer time t in 5.9.3.2)	1 000
Minimum time stamp resolution	1
Minimum time accuracy	10

5.2.6.2 Acquisition of measurement

5.2.6.2.1 Sending measurement on significant change

Use case step	Description
Step 1	IED acquires measurement value.
Step 2	If the measurement changed significantly (user configured) the measurement value is sent with time to the control centre.

5.2.6.2.2 Sending measurement cyclically

Use case step	Description
Step 1	IED acquires a measurement value
Step 2	The measurement is sent (optionally with time stamp) to the control centre cyclically (user configured).

5.2.6.3 Acquisition of alarms

5.2.6.3.1 Acquisition of single alarms

Use case step	Description
Step 1	IED acquires alarm state.
Step 2	Alarm system component notifies alarm to the control centre.

5.2.6.3.2 Acquisition of grouped alarms

Use case step	Description
Step 1	IED acquires alarm state.
Step 2	Individual alarms are grouped together (user defined) to a new alarm within the IED.
Step 3	Alarm system component notifies group alarm to the control centre.

5.2.6.3.3 Constraints for acquisition of alarms

Table 2 summarizes the target communication delay and time accuracy.

Table 2 – Constraints for acquisition of alarms

Constraint	Value [ms]
Maximum application -to-application time delay (see definition of transfer time t in 5.9.3.2)	1 000
Minimum time stamp resolution	1
Minimum time accuracy	10

5.2.6.4 Remote control

5.2.6.4.1 Sending a SBO command

Use case step	Service or information provided
Step 1	Control centre sends a selection to the IED for the object to be controlled (open or closed).
Step 2	After checking procedure, IED sends an acknowledgement.
Step 3	Control centre transmits control command to the IED.
Step 4	After checking procedure, IED sends an acknowledgement.
Step 5	IED issues the command to the concerned device.

5.2.6.4.2 Sending a direct command

Use case step	Description
Step 1	Control centre transmits control command to IED for the object to be controlled (open, closed, up, down, etc.).
Step 2	After checking procedure, IED sends an acknowledgement.
Step 3	IED issues the command to the concerned device.

5.2.6.4.3 Constraints for remote control

Table 3 summarizes the anticipated communication delay and time accuracy.

Table 3 – Constraints for remote control

Constraint	Value [ms]
Maximum application -to-application time delay(see definition of transfer time t in 5.9.3.2)	1 000
Minimum time stamp resolution	1
Maximum validity time of control command	60 000

5.2.6.4.4 Sending setpoint

5.2.6.4.5 Sending a SBO setpoint

Use case step	Service or information provided
Step 1	Control centre sends a selection to the IED for the object to be controlled.
Step 2	After checking procedure, IED sends an acknowledgement.
Step 3	Control centre transmits setpoint to the IED.
Step 4	IED sends an acknowledgement.
Step 5	IED issues the setpoint to the concerned device.

5.2.6.4.6 Sending a direct setpoint

Use case step	Description
Step 1	Control centre transmits setpoint to IED for the object (transformer, generator, FACTS, etc.) to be controlled.
Step 2	IED sends an acknowledgement.
Step 3	IED issues the setpoint to the concerned device.

5.2.6.5 General interrogation

Use case step	Description
Step 1	Control centre transmits general interrogation request.
Step 2	Proxy/Gateway transmits current value of all IED status recorded.

5.2.6.6 Control authority management

Use case step	Description
Step 1	The switching control authority of the substation is changed to local or station mode from within the substation for a part of the substation or the whole substation.
Step 2	The change of the switching control authority for the substation is reported to the control centre.
Step 3	While the switching control authority of the substation is in local or station mode commands from the control centre are not executed.
Step 4	The switching control authority of the substation is changed to remote mode from within the substation.
Step 5	The change of the switching control authority for the substation is reported to the control centre.
Step 6	Following this, control centre commands are accepted.

5.2.6.7 Telemonitoring blocking

5.2.6.7.1 Controlling telemonitoring blocking

Use case step	Description
Step 1	The telemonitoring blocking of the substation is enabled from within the substation for a part of the substation or the whole substation.
Step 2	Information is no longer updated to the control centre for the selected parts of the substation or the whole substation.
Step 3	The telemonitoring blocking of the substation is disabled from within the substation for a part of the substation or the whole substation.
Step 4	The current state of the previously blocked information is updated to the control centre.

5.2.6.7.2 Constraints for telemonitoring and telecontrol blocking

Each substation has one master control centre and can have secondary control centres. A secondary control centre has, at the maximum, the same rights than a master control centre. That means one secondary control centre cannot receive more information than the master control centre.

Table 4 shows in which state information will be forwarded within the substation and to the control centre.

Substation operation modes are:

Remote Substation is operated from control centre

Local Substation is operated from substation HMI

Inhibit Substation is operated from substation HMI and the Proxy/Gateway does not transmit any data, which could disturb the operation of the control centre

Bay operating modes are:

Remote Bay is operated from control centre or substation HMI

Local Bay is operated from bay level HMI

Inhibit Bay is operated from bay level HMI and the bay IED does not transmit any data, which could disturb the operation of the control centre or substation HMI

The transmission states in monitoring direction in Table 4 are:

Fwd Data is transferred to the next level

Blk Data is not transferred to the next level

Usr Data transfer depends on the operation mode of the user

The transmission states in control direction in Table 4 are:

Acc Command is accepted on this level

Rej Command is rejected on this level

Usr Command execution depends on the operation mode of the user

Table 4 – Forwarding of information depending on the operation mode

Destination	Substation IED							Bay IED								
Substation mode	From/To Master CC			From/To Secondary CC			Bay mode	From/To Substation HMI			From/To Master CC			From/To Secondary CC		
	Ind	Meas	Ctrl	Ind	Meas	Ctrl		Ind	Meas	Ctrl	Ind	Meas	Ctrl	Ind	Meas	Ctrl
Remote	Fwd	Fwd	Acc	Usr	Usr	Usr	Remote	Fwd	Fwd	Acc	Fwd	Fwd	Acc	Usr	Usr	Usr
							Local	Fwd	Fwd	Rej	Fwd	Fwd	Rej	Usr	Usr	Rej
							Inhibit	Blk	Blk	Rej	Blk	Blk	Rej	Blk	Blk	Rej
Local	Fwd	Fwd	Rej	Usr	Usr	Rej	Remote	Fwd	Fwd	Acc	Fwd	Fwd	Rej	Usr	Usr	Rej
							Local	Fwd	Fwd	Rej	Fwd	Fwd	Rej	Usr	Usr	Rej
							Inhibit	Blk	Blk	Rej	Blk	Blk	Rej	Blk	Blk	Rej
Inhibit	Blk	Blk	Rej	Blk	Blk	Rej	Remote	Fwd	Fwd	Acc	Blk	Blk	Rej	Blk	Blk	Rej
							Local	Fwd	Fwd	Rej	Blk	Blk	Rej	Blk	Blk	Rej
							Inhibit	Blk	Blk	Rej	Blk	Blk	Rej	Blk	Blk	Rej

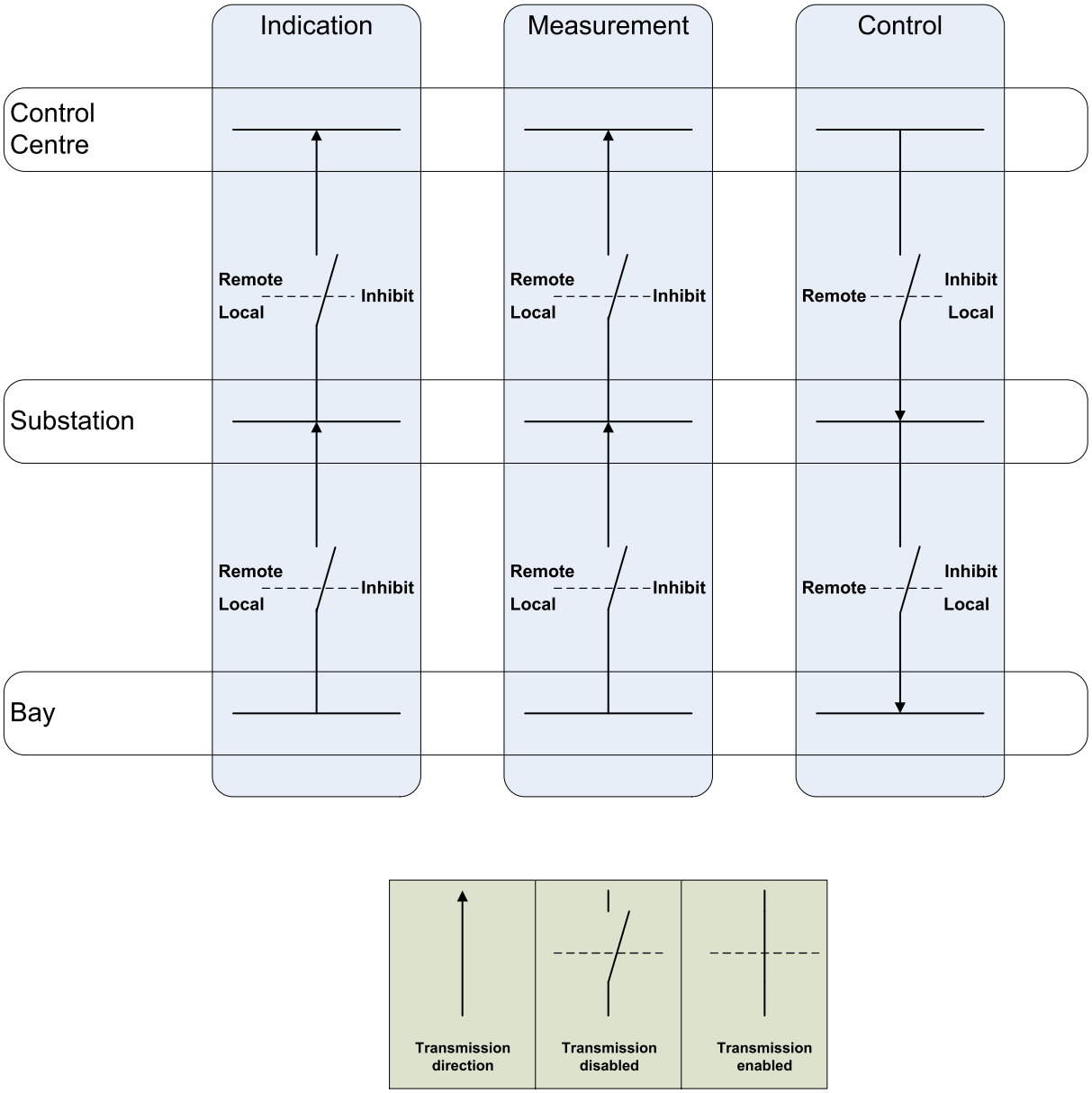


Figure 4 – Principle of data forwarding, depending on the operation mode

The arrows in Figure 4 indicate the direction of the data flow. An open switch indicates that data will not be forwarded. A closed switch indicates that data will be forwarded.

5.3 Synchrophasor

5.3.1 General

Synchrophasor communication can be used within a substation for synchrocheck or substation level state estimation, as well as between several substations and a centre which performs regional or network level alarms and stability calculations. Subclause 5.3.3 describes only those use cases which require a communication to a centre. The transmission of synchrophasor information is defined in detail in IEC TR 61850-90-5:2012.

5.3.2 Constraints / assumptions / design considerations

In the majority of the applications, the sources and sinks for the synchrophasor data are separated by large distances. In this context "large" means distances which extend essentially further than a typical local area network (LAN). See IEC TR 61850-90-5:2012, 5.2 for details.

5.3.3 Use cases

The following use cases of IEC TR 61850-90-5:2012 apply to this technical report:

- Situational awareness
- State estimation and on-line security assessment
- Archive data (event & continuous)
- Wide Area Controls
- Phenomenon assumption type WAMPAC
- Phasor Data Concentrator

The detailed descriptions of the use cases for the transmission of synchrophasor information are given in IEC TR 61850-90-5:2012, clause 5 and its subclauses.

5.4 Disturbance

5.4.1 General

The disturbance use case describes the transmission of disturbance or fault records from substations to remote systems.

5.4.2 Constraints / assumptions / design considerations

Disturbance or fault records are stored in individual IED and/or in a dedicated data concentrator with disturbance recording capability and/or in a Proxy/Gateway. The sources are referenced in the following as “storage device”.

5.4.3 Actors

The disturbance records use case requires the following actors:

Name	Role description
Maintenance centre	A place from where maintenance, management of asset, disturbance analysis and the metering are managed.
Storage device	IED, disturbance data concentrator or Proxy/Gateway which is able to store one or more disturbance records.

5.4.4 Use case diagram

Figure 5 shows a disturbance use cases diagram.

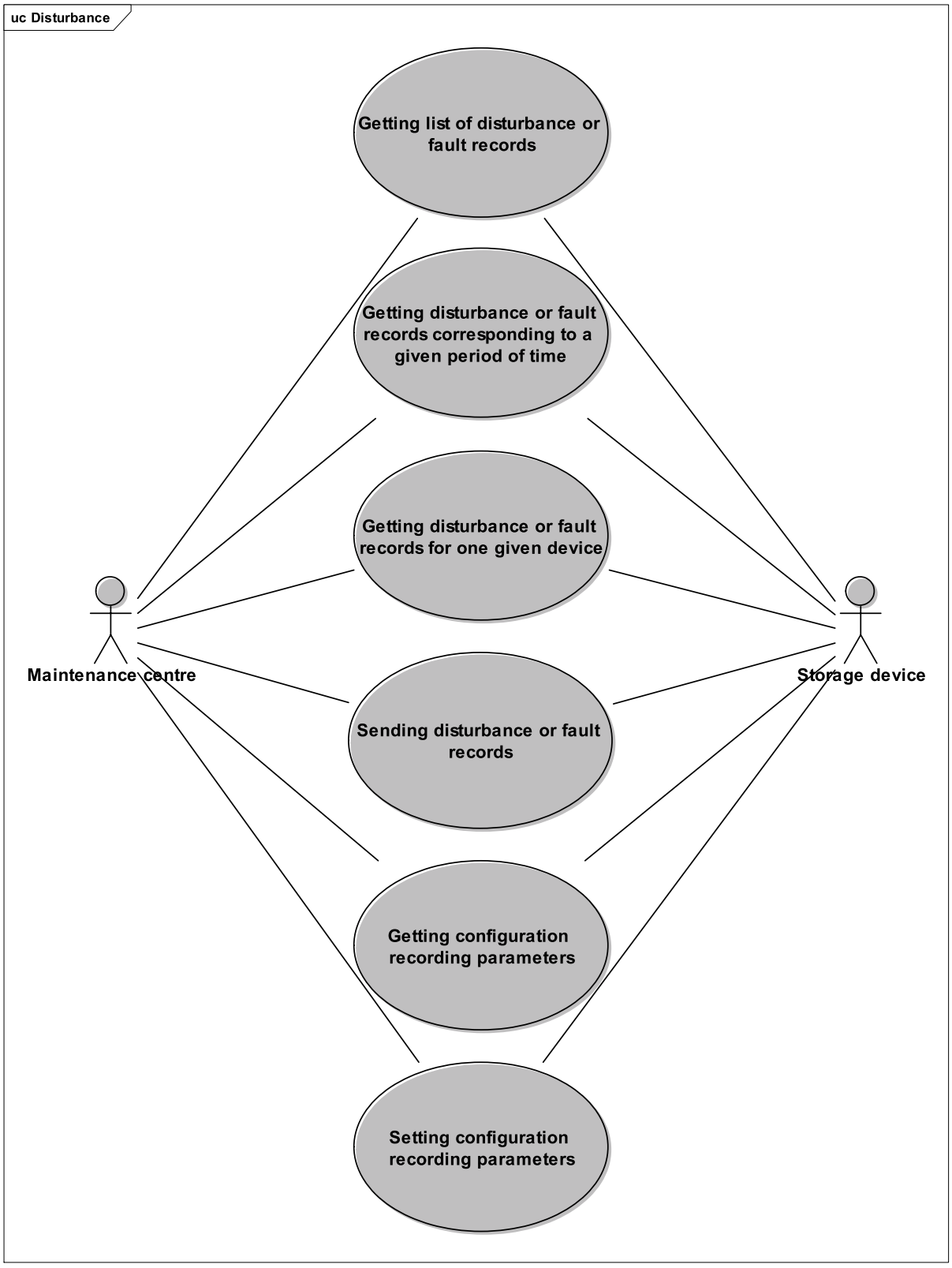


Figure 5 – Disturbance use cases diagram

5.4.5 Uses cases description

Name	Service or information provided
Getting list of disturbance or fault records	After received request from maintenance centre storage device sends the list of available disturbance or fault records. At least, the list should indicate for each file: • the concerned high voltage device, • the first sample time stamp, • the duration (disturbance records)
Getting disturbance or fault records corresponding to a given period of time	The maintenance centre sends a request including a given period of time to the storage device in order to get disturbance or fault records. Once received, the storage device sends related information.
Getting disturbance or fault records for one given device	The maintenance centre sends a request including one given high voltage device in order to get disturbance or fault records. Once received, the storage device sends related information.
Sending disturbance or fault records	The storage device sends disturbance or fault records to the maintenance centre.
Getting configuration recording parameters	After request from the maintenance centre, the storage device sends configuration recording parameters.
Setting configuration recording parameters	The maintenance centre sends configuration recording parameters to storage device.

5.4.6 Sequence diagrams

5.4.6.1 Getting list of disturbance or fault records

Use case step	Description
Step 1	Maintenance centre requests list of available disturbance or fault records.
Step 2	Storage device replies with list of available disturbance or fault records indicating for each file the information described above (please refer to uses cases description).

5.4.6.2 Getting disturbance or fault records corresponding to a given period of time

Use case step	Description
Step 1	Getting list of disturbance or fault records (refer to the first use case).
Step 2	Maintenance centre selects a period of time consistent with what is indicated in the list.
Step 2	Maintenance centre sends a request for the selected period of time.
Step 3	Storage device sends disturbance or fault records corresponding to the selected period of time.

5.4.6.3 Getting disturbance or fault records for one given device

Use case step	Description
Step 1	Getting list of disturbance or fault records (refer to the first use case).
Step 2	Maintenance centre selects a device indicated in the list.
Step 3	Maintenance centre sends a request for the selected device.
Step 4	Storage device sends disturbance or fault records corresponding to the selected device.

5.4.6.4 Sending disturbance or fault records

Use case step	Description
Step 1	Storage device stores new disturbance or fault record.
Step 2	Storage device sends disturbance or fault record to maintenance centre.

5.4.6.5 Getting configuration recording parameters

Use case step	Description
Step 1	Maintenance centre requests list of disturbance or fault recorders.
Step 2	Storage device sends list of recorders.
Step 3	Maintenance centre request to get configuration recording parameter from storage device.
Step 4	Storage device sends configuration to maintenance centre.

5.4.6.6 Setting configuration recording parameters

Use case step	Description
Step 1	Maintenance centre requests list of disturbance or fault recorders.
Step 2	Storage device sends list of recorders.
Step 3	Maintenance centre request to set configuration recording parameter to storage device.
Step 4	Maintenance centre sends configuration parameters to storage device.
Step 5	Storage device applies new parameters.
Step 6	Storage device confirms new parameters and sends one acknowledgement to maintenance centre.

5.5 Counting

5.5.1 General

Integrated totals are in IEC 61850 referenced as Binary Counter Readings (BCR).

5.5.2 Constraints / assumptions / design considerations

The meter is configured to send the metering data to the control and/or maintenance centre. The freezing interval, start time and the reset can be configured. Alternatively the metering data are stored locally in the device and retrieved later.

IEC 62056-6 COSEM used specifically for revenue metering might be considered in the future, pending on the ongoing work mapping COSEM to IEC 61850. This work will result in IEC TS 61850-80-4[5].

5 To be published.

5.5.3 Actors

The reading of counter values use case requires the following actors:

Name	Role Description
Meter	Measures, records physical quantities vacations for a fixed duration.
User	As defined in 5.1.2.

5.5.4 Use cases diagram

Figure 6 shows a counting use cases diagram.

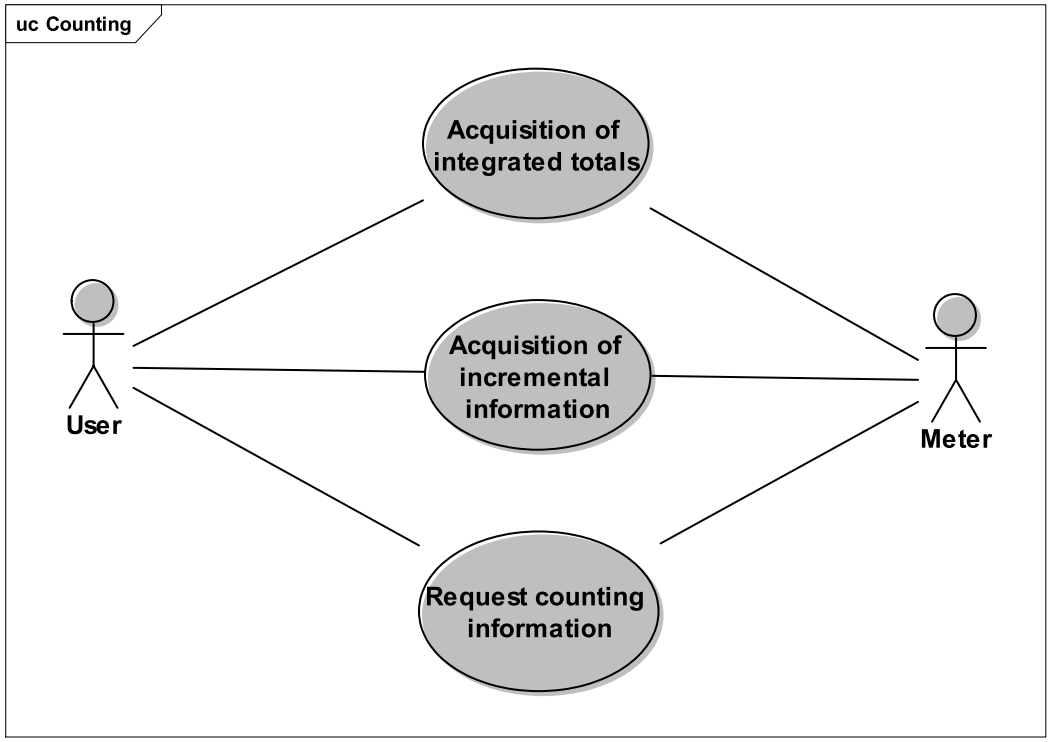


Figure 6 – Counting use cases diagram

5.5.5 Use cases description

Name	Service or information provided
Acquisition of integrated totals	Memorization of integrated totals and transmission to the maintenance centre.
Acquisition of incremental information	Memorization of integrated totals; reset of the integrated totals and transmission to the maintenance centre.
Request counting information	Memorization of integrated totals or incremental information. Locally stored in the device. Transferred to the maintenance centre on request.

5.5.6 Sequence diagrams

5.5.6.1 Acquisition of integrated totals

Use case step	Description
Step 1	Meter memorizes the integrated totals as pre-configured.
Step 2	Meter transmits the memorized integrated totals as configured using reporting mechanism.

5.5.6.2 Acquisition of incremental information

Use case step	Description
Step 1	Meter memorizes the integrated totals as configured.
Step 2	Meter resets the present integrated totals as configured.
Step 3	Meter transmits the memorized integrated totals as configured using reporting mechanism.

5.5.6.3 Request counting information

Use case step	Description
Step 1	Meter memorizes the integrated totals or incremental information as pre-configured.
Step 2	Meter stores the data locally and persistent.
Step 3	Maintenance centre requests memorized metered values (e.g. last 24h).
Step 4	Meter transmits the memorized metered values to the maintenance centre.

5.6 Power quality

5.6.1 General

Power Quality monitoring includes all methods to transfer power quality information from substations and other parts of the network to an application in the control centre or maintenance centre.

5.6.2 Constraints / assumptions / design considerations

The IED is configured to send the power quality information to the control centre or maintenance centre. Additionally the IED may store power quality information in local LOGs that can be retrieved from the control centre or maintenance centre.

Power quality information is used either for operational purpose and/or for offline analysis and grid code evaluation. Use cases might be extended in the future as a result of additional mappings to IEC 61850.

Currently the technical report IEC TR 61850-90-17[6], *Using IEC 61850 to transmit power quality data* is under development. The LOG of power quality information is mapped to a PQDIF file that can be retrieved from the device using file transfer services.

6 Under consideration.

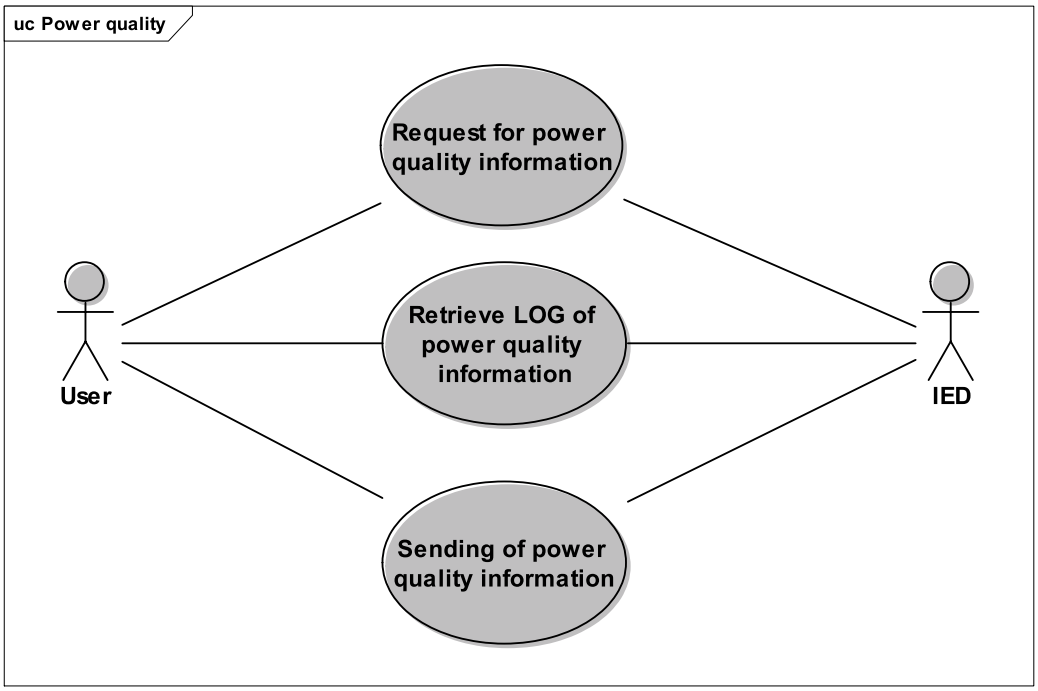
5.6.3 Actors

The power quality monitoring use case requires the following actors:

Name	Role description
IED	Has all necessary information to manage specifically the power quality (frequency, frequency variation, current, current unbalance, voltage, voltage unbalance, voltage variation, THD, etc. (non exhaustive list)).
User	As defined in 5.1.2.

5.6.4 Use cases diagram

Figure 7 shows a power quality use cases diagram.



IEC

Figure 7 – Power quality use cases diagram

5.6.5 Use cases description

Name	Service or information provided
Request for power quality information	After received request from control centre and/or maintenance centre, IED sends the right information to the user.
Retrieve LOG of power quality information	Historic power quality information that has been stored in the IED can be retrieved on request of the control centre.
Sending of power quality information	Power quality information measured/calculated in the IED will be transferred to the user spontaneously.

5.6.6 Sequence diagrams

5.6.6.1 Request for power quality information

Use case step	Description
Step 1	User sends a request to get information related to power quality management.
Step 2	IED transmits the information to the user.

5.6.6.2 Retrieve LOG of power quality information

Use case step	Description
Step 1	User sends a request to get information about historic power quality information stored in the IED.
Step 2	IED transmits the requested information to the user.

5.6.6.3 Sending of power quality information

Use case step	Description
Step 1	IED acquires power quality information.
Step 2	The power quality information is sent with time stamp, cause of transmission, etc. to the user.

5.7 Asset

5.7.1 General

Asset management, as shown in Figure 8, is a structured, integrated series of processes aligned with business goals and values and designed to minimize the life-cycle costs and maximize the life cycle benefits of power delivery asset ownership, while providing required performance levels and sustaining the system forward.

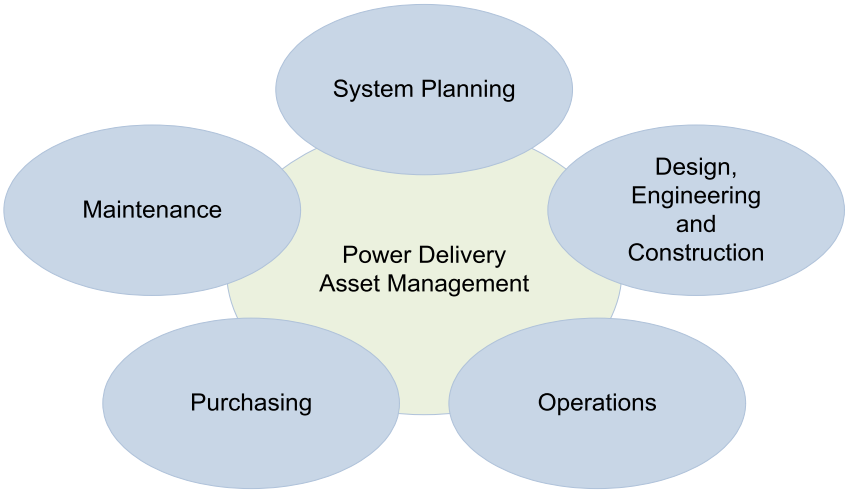


Figure 8 – Asset management touches a broad range of core electric utility processes

The asset manager requires information about the asset in an accurate and timely way to perform his task. Typical information collected is:

- Inventory of all assets
- Quantitative condition and performance measures
- Usage information

Asset information also includes data from IEC TR 61850-90-3[7] which defines logical nodes for condition monitoring.

7 To be published.

5.7.2 Constraints / assumptions / design considerations

The assets are equipped with an IEC 61850 interface and can provide the necessary data (e.g. condition monitoring data or nameplate information) to perform the task. Spontaneous alarms indicating asset manager actions are reported to the control centre, not directly to the asset management system. Any interaction required between the control centre and the asset management system to manage this information is outside the scope of this technical report.

5.7.3 Actors

The asset supervision use case requires the following actors:

Name	Role description
IED	Has all necessary information to manage asset, especially name plate (mandatory). But also, operation location, operation counter, etc. not mandatory but potentially available.
Maintenance centre	A place from where maintenance, management of asset, disturbance analysis and the metering are managed.

5.7.4 Use cases diagram

Figure 9 shows an asset supervision use cases diagram.

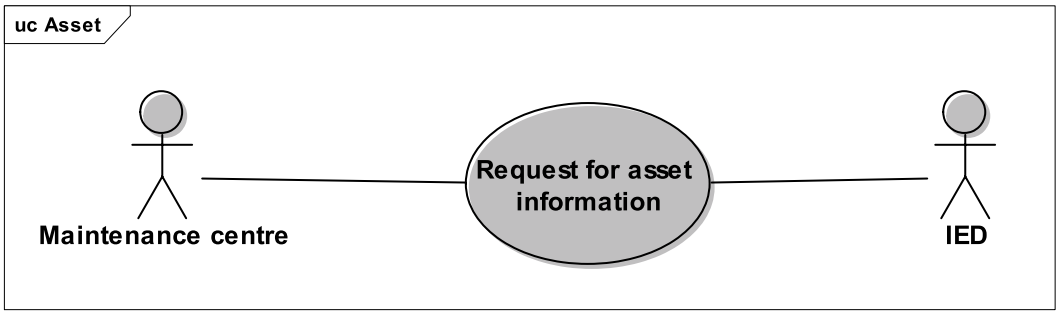


Figure 9 – Asset supervision use cases diagram

5.7.5 Use cases description

Name	Service or information provided
Request for asset information	After received request from maintenance centre, IED sends the requested information.

5.7.6 Sequence diagram

5.7.6.1 Request to receive information

Use case step	Description
Step 1	Maintenance centre sends a request to get information related to asset management
Step 2	IED transmits the information to the maintenance centre

5.8 Parameter configuration

5.8.1 General

Parameter configuration includes the management of configuration and operational parameters as well as IED configuration files from an engineering workplace in the maintenance centre.

IEDs may contain configuration and operational parameters. Configuration parameters are typically set off-line. Operational parameters may be set and changed on-line without disturbing the operation of the device.

The manufacturer specific IED configuration tool (ICT) generates and transfers IED-specific configuration files.

5.8.2 Constraints / assumptions / design considerations

Local management of configuration is not covered by this technical report. Exchange of legacy IED configuration files is done by direct access to the IED and out of scope of this technical report. Only the remote file transfer between the maintenance centre and the IED in this substation is covered by this technical report. Beneath the upload of configuration files to the IED, it might allow the change of single setting parameters.

Any change of parameters that affects the operation in the control centre will be notified to the control centre.

5.8.3 Actors

The remote parameter and configuration changes use case requires the following actors:

Name	Role Description
Maintenance centre	A place from where maintenance, management of asset, disturbance analysis and the metering are managed.
IED	Device containing parameters and/or configuration files.

5.8.4 Use cases diagram

Figure 10 shows a parameter configuration use cases diagram.

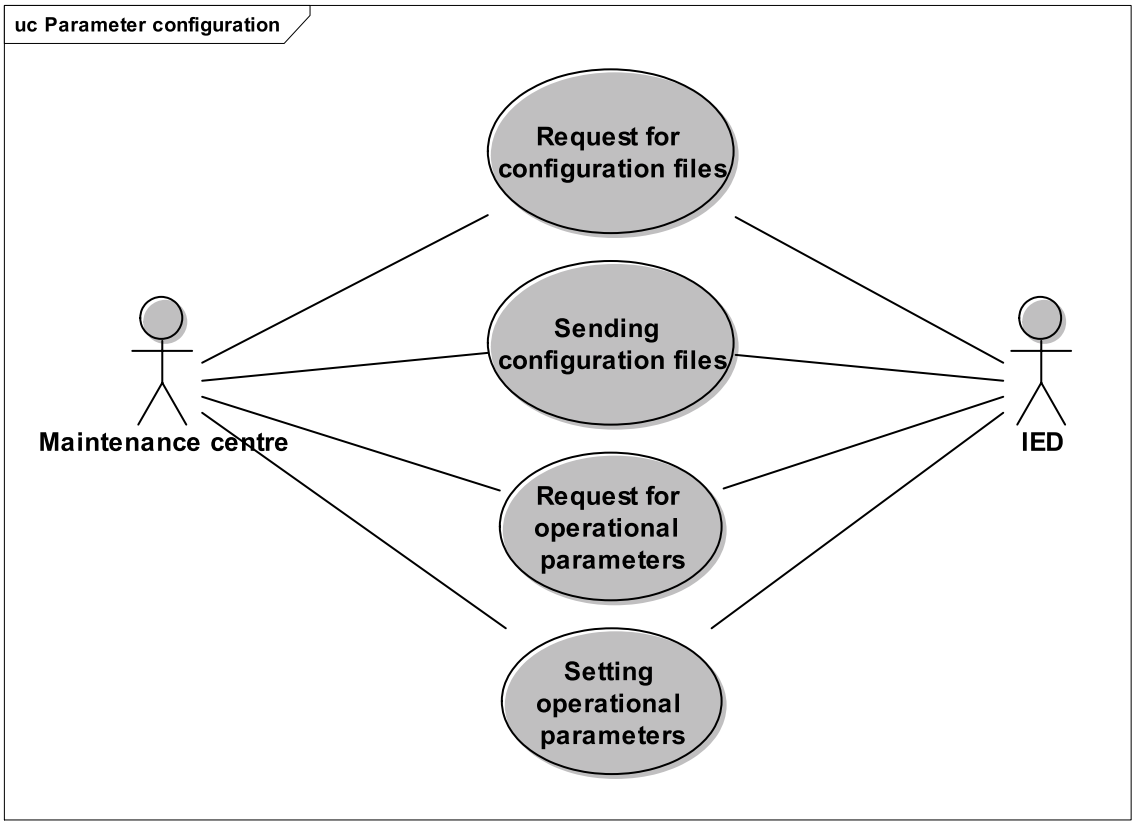


Figure 10 – Parameter configuration use cases diagram

5.8.5 Use cases description

Name	Service or information provided
Request for configuration files	After receiving request from maintenance centre, IED sends configuration files.
Sending configuration files	Maintenance centre sends configuration files to IED.
Request for operational parameters	After received request from maintenance centre, IED sends current operational parameters.
Setting operational parameters	Maintenance centre sends operational parameters to IED then IED validates new parameters. IED sends an acknowledgement after having successfully activated new parameters.

5.8.6 Sequence diagrams

5.8.6.1 Request for configuration files

Use case step	Description
Step 1	Maintenance centre requests configuration files from IED.
Step 2	IED transmits the requested configuration file to the maintenance centre.

5.8.6.2 Sending configuration files

Use case step	Description
Step 1	Maintenance centre transmits a configuration file to the IED.
Step 2	IED records the configuration file and sends an acknowledgement to the maintenance centre.

5.8.6.3 Request for operational parameters

Use case step	Description
Step 1	Maintenance centre requests current operational parameters from a particular IED.
Step 2	IED transmits the requested parameters to the maintenance centre.

5.8.6.4 Setting operational parameters

Use case step	Description
Step 1	Maintenance centre sends operational parameters to IED.
Step 2	IED transmits an acknowledgment to the maintenance centre.
Step 3	Maintenance centre sends a validation to IED for new parameters.
Step 4	IED activates new parameters.
Step 5	IED sends a message to maintenance centre to indicate that new parameters are activated.

5.9 Communication requirements for SS to CC communication

NOTE Subclause 5.9 collects the requirements according to part IEC 61850-5:2013 but focuses on substation to control centre communication.

5.9.1 General issues

5.9.1.1 Introduction

The substation to control centre communication refers to functions in control centre applications which demand information from the substation or perform control functions in the substation. Supporting functions are e.g. the transfer of disturbance records and the changing of settings.

5.9.1.2 Logical allocation of functions and interfaces

The functions of a substation automation system may be allocated logically on three different levels (station, bay/unit, or process). These levels are shown by the logical interpretation of Figure 11 together with the logical interfaces 1 to 11.

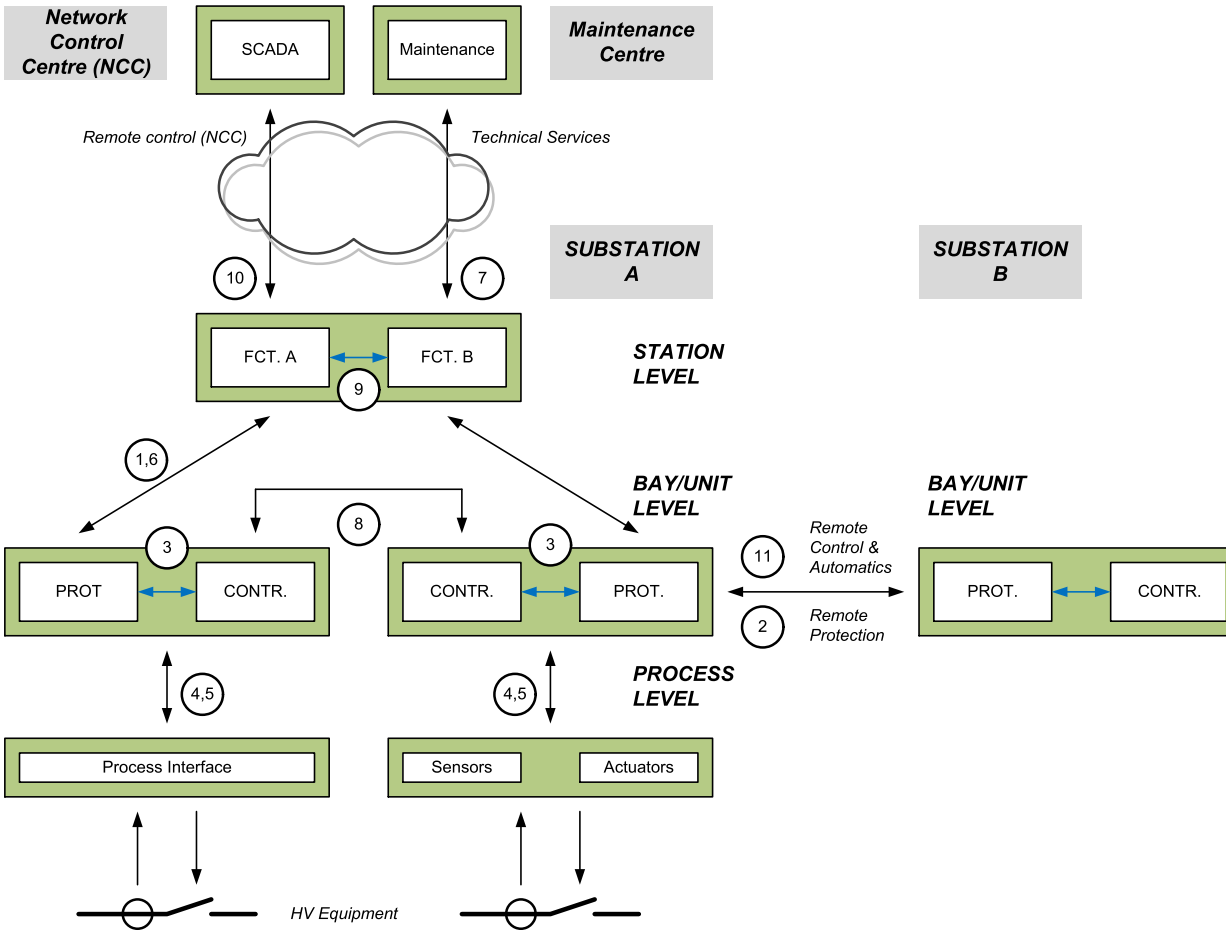


Figure 11 – Levels and logical interfaces in substation automation systems

The interfaces 1, 3 to 6, and 8 to 9 are connecting functions of the substation automation system inside the substation. Interface 10 represents as telecontrol interface the communication of the substation automation system to the remote control centre(s). Interface 7 represents as telemonitoring interface the communication to remote engineering, monitoring and maintenance places. Interface 2 represents as teleprotection interface the protection related function between substations, interface 11 represents the same for control related functions. The scope of this technical report is limited to the interfaces 10 and 7.

5.9.1.3 Requirements for the SS to CC communication interface

The communication between the substation and the network control centre is introduced in Figure 11 referring to interface 10. The basic requirements are the same as inside the substation for the connection between bay and station level. Binary values (status information, events, alarms, commands, etc. for remote control) and analogue values (calculated values e.g. for the energy flow) have to be exchanged depending on the functions applied. Differences are the longer communication distance and the transparent use of an external communication system with higher or lower bandwidth, which may increase the transmission delay.

5.9.1.4 Response behaviour requirements

Since interoperability is claimed for proper running of functions, the reaction of the application in the receiving node has to be considered.

- The basic behaviour of the functions in any degraded case, i.e. erroneous message has to fit into the overall requirement of the distributed function to be performed.

- The dedicated response on quality attributes i.e. in any degraded case like on erroneous messages, lost data by communication interrupts, resource limitations, out of range data, etc. belongs to the function itself and, therefore, is outside the scope of the technical report. But this behaviour should be described in the function or IED manual elsewhere. This is important if the overall task cannot be closed successfully, e.g. if the remote node does not respond in time or does not react in a proper way.
- The external communication system has to fit into the overall requirements of the distributed function to be performed.

The reaction and the behaviour of the functions itself are function related local issues and, therefore, outside the scope of this technical report.

5.9.2 Functions based on substation- to-control-centre communication

IEC 61850-5:2013 contains a non-exhaustive list of logical nodes that may be used for substation to control centre communication. Additionally all logical nodes defined in other standards using the IEC 61850 object model may also be used on this interface.

5.9.3 Message performance requirements

5.9.3.1 General

The basic definition of transfer time is given in 11.1.1.4 of IEC 61850-5:2013. For the purpose of the SS-CC communication this definition is extended to reflect the additional delays caused by the introduction of the Proxy/Gateway.

5.9.3.2 Transfer times for substation – control centre connections

If the connection between substation and control centre is a direct link, the time t_b for distances within power systems is negligible since the signal speed is – depending on the transmission mode and the impedance of the line for the signals of this mode – in between 2/3 and the full speed of light i.e. about between 200 million and 300 million meters per second. If there are switches, routers and other active communication devices in the communication path their processing times contribute reasonable to the network transfer time t_b. In Figure 12 dedicated times contributing to t_b are shown.

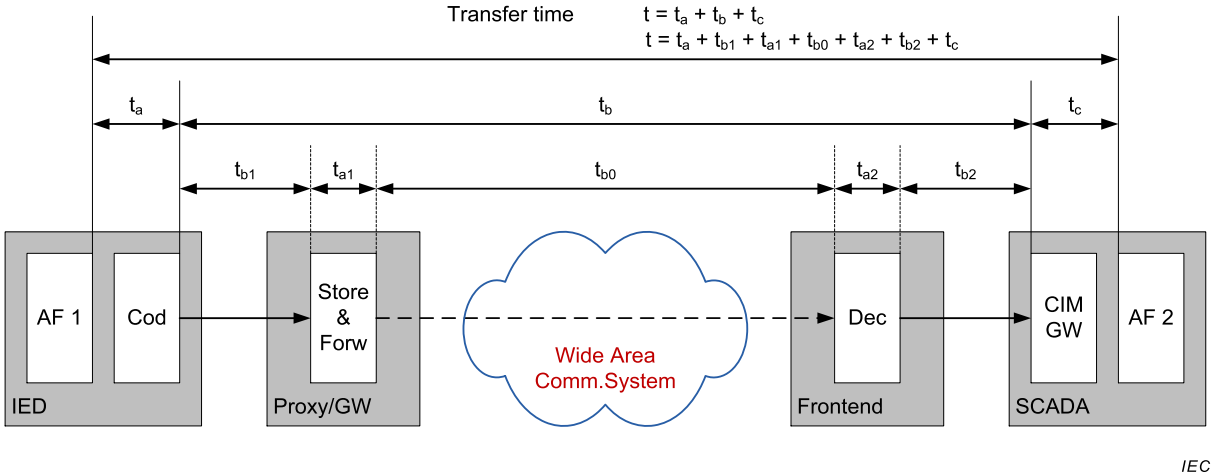


Figure 12 – Definition of transfer time t

All transfer time requirements are given by the needs of the application functions and, therefore, have to be kept under normal conditions without disturbance. How these requirements are kept is an implementation issue. The measures against disturbances are outside the scope of this technical report.

Disturbances may need a logical reconnection of the communication link, repetition of messages or other means increasing the transfer time. This behaviour is a matter of the services defined in IEC 61850-7-2:2010 and of the implementation within the IEDs. Any possible delay has to be defined and considered for the transfer time. Which normal and delayed transfer times are acceptable is depending on the project specification for functions.

5.9.4 Introduction and use of message performance classes

5.9.4.1 General

Message types and performance classes have been specified in 11.2 of IEC 61850-5:2013.

- Type 1 (Fast messages)
- Type 1A (Trip)
- Type 2 (Medium speed messages)
- Type 3 (Low speed messages)
- Type 4 (Raw data messages)
- Type 5 (File transfer functions)
- Type 6 (Time synchronisation messages)

Messages of Type 1, 1A and 4 are out-of-scope of the SS-CC interface. For the substation to control centre communication not all communication links have to support the same performance classes. For example downloading a new configuration file to an IED and switching a circuit breaker have different requirements, independent of each other. These links may be implemented in dedicated interfaces, or in a common WAN. The common WAN has to fulfil all requirements of the communication links embedded in the WAN.

The typical communication performance requirements are indicated below, but may be overwritten by dedicated function requirements or customer specifications.

5.9.4.2 Implementation issues

On a direct connection between two IEDs all messages travel with the same speed (refer to t_b in Figure 12). Different priorities and performance classes are not feasible. All active elements in the communication link like switches (if applicable) but also the sender and receiver at both ends of the link do some coding and decoding consuming time (refer to t_a and t_c in Figure 12) maybe different for the different message types. Different stacks and queues with different priorities may be needed to realize different performance classes. These implementation issues have to be considered in this technical report and in selecting active elements.

5.9.4.3 Typical transfer time requirements for control and monitoring data

The transfer time requirements for functions may be different depending on the voltage level and role of the substation, i.e. on distribution and transmission level. These algorithmic requirements are important for the users but outside the scope of this technical report.

For the substation to control centre communication the transfer times are not small compared to the function performance time and normally the same for transmission and distribution substations. The transfer time has to be small enough that it does not influence the operation time of the function. Typical functions in the control centre are SCADA, load dispatching and power flow calculations. Analogue data for control and monitoring are mainly the actual voltages and currents. Since the control centre usually does not perform protection functions, they are transferred as RMS values.

Table 5 – Typical Transfer time requirements for control and monitoring data

Typical transfer time [ms]	Application examples: Transfer of
>1000	Files, events, log contents, phasor data for state estimation
1000	Events, alarms, status changes, measurands
1000	Operator commands, automatic interactions

The required transfer times given in Table 5 can be mapped to the transfer time classes given in Table 1 of IEC 61850-5:2013.

The applications using the SS-CC communication do not impose special requirements on the variation of the transfer time (Jitter). If the transfer delay of a command exceeds a configurable limit the command will be rejected by the Proxy/Gateway server.

5.9.5 Requirements for data and communication quality

5.9.5.1 General

The definition of data integrity and the data integrity classes have been given in 11.3.2 of IEC 61850-5:2013. These definitions apply also to the SS-CC communication interface.

The residual error probability for commands and all other messages may not be higher than those defined in 11.3.2 of IEC 61850-5:2013.

5.9.5.2 Cyber security

Power automation applications belong to the critical infrastructure and cyber attacks could cause blackouts or grid disruption. IEC TR 61850-90-12 provides guidelines to achieve cyber security in wide area networks.

One aspect of cyber security – the end-to-end-security – is handled in the IEC 62351 series.

5.9.6 Reliability

IEC 60870-4:1990 addresses the reliability requirements of telecontrol systems. IEC TR 61850-90-12 describes in more details the factors influencing the reliability of a telecontrol system.

Based on the assumption that a control centre sends a command to the substation every 5 minutes for 10 years this results in about 1,05 million commands and only one of these may have an undetected error, which causes an unwanted behaviour. This results in:

$$P_{\mathrm{UC}} = \frac{Tolerable\ faulty\ commands}{Total\ number\ of\ commands} = \frac{1}{1050000} \sim 10^{-6}$$

The probability of unwanted telecontrol commands P_{UC} may not exceed 10^{-6}.

5.9.7 Availability

5.9.7.1 General

Availability is the probability that a system is operational at a certain point in time. The requested availability level needs to be considered already by the system design and cannot be generally defined, but depends on the requirements of the utility.

IEC 61850-5:2013 and IEC TR 61850-90-12 treat the availability aspects in more detail.

Scheduling according to IEC TR 61850-90-10[8] may be used to increase the availability during communication disruptions.

5.9.8 Requirements concerning the communication system

5.9.8.1 General

Failures of the communication system may have several effects:

- Inability to control part or whole of the substation. This situation can be tolerated for a certain time (e.g. a few seconds depending on the operator requirements) since controlled switching operations are infrequent.
- Inability to distinguish the substation state from a fault situation.

When the communication system is used directly to operate safety relevant elements, the availability of the communication system is security-(under function) relevant. In this case one should design that these components are completely redundant. Regarding the definition of operability of a communication system, two levels of requirements may be distinguished:

- A strong operational definition which states that the communication system is operational only when any node can communicate with any other node.
- A weak operational definition which states that the communication system is in a degraded but still operational mode when only one node is not operational and this node is not backed up by a redundant one. This assumes that within the substation or the power system independent functional areas may be defined which means that e.g. the failure of a function in one area has no impact on a function in the other.

Given the complexity of substation or power utility automation any per-function analysis may be too complex. For the substation to control centre communication the two areas to be considered may be the direct access and the indirect access. In such a case, the weak definition may be applied for the direct access. If parts of the functionality of the process bus and station bus are merged on the same communication system the stronger definition applies.

5.10 Modelling requirements for SS to CC communication

The server side of the Proxy/Gateway application has to support the needs of the control centre SCADA system. Existing control centre gateways based on telecontrol protocols such as IEC 60870-5-104 typically reduce the amount of information available in the substation and present it to the control centre in a way, which is independent of the data model and protocols of the IEDs in the substation. This approach allows the exchange of devices in the substation without affecting the control centre interface configuration.

The data model of the Proxy/Gateway may represent the whole information of the IED data models in the substations, as well as subsets, aggregations, or pre-processed information from the IED data models or any other information from local processes or local inputs and outputs.

The following enumeration lists possible transformations from the IED data model to the Proxy/Gateway data model. More detailed descriptions and examples are given in 7.1.3.5 and its subclauses.

- Translate data from legacy protocols such as IEC 60870-5-103, IEC 60870-5-104, IEEE 1815 (DNP3), IEC 61158-6 (Modbus), etc. into IEC 61850 data model

8 Under consideration.

- Add data local to the RTU hosting the Proxy/Gateway to the Proxy/Gateway server model
- Renaming of logical devices coming from IED level into logical device of the Proxy/Gateway server
- Rearranging/Renaming of logical nodes coming from IED level into logical device of the Proxy/Gateway server
- Merge of two or more information objects coming from two or more different logical nodes at IED level into one logical node of the Proxy/Gateway server
- Split of information objects coming from one logical node at IED level into two or more logical nodes of the Proxy/Gateway server where each logical node contains a subset of the information objects of the original logical node
- Transform a generic information object (e.g. GGIO, GAPC, etc.) at IED level into a semantically defined information object of the Proxy/Gateway server
- Convert a specific information object (e.g. MMTN) at IED level into another semantically defined information object (e.g. MMXU) of the Proxy/Gateway server
- Adapt the scale, information encoding and dead band configuration between the IED data object and the data object in the Proxy/Gateway server
- Logical (e.g. and, or, if/else, grouping of indications, etc.) and arithmetic (e.g. multiplication, division, addition, subtraction, etc.) transformations between one or more data objects at IED level and one or more data objects of the Proxy/Gateway server

6 Configuration aspects

6.1 Requirements

The following requirements apply to the engineering process

- Replacing an IED with a functionally equivalent IED in the substation may require a change to the configuration in the Proxy/Gateway but may not require a change of the configuration of the application client in the control/maintenance centre if the client is given an IID file of the Proxy/Gateway. If the IED provides a flexible engineering of the logical node allocation, the adaption of the new IED to the LN structure of the replaced IED can also be done in the new IED itself
- The Proxy/Gateway configuration will follow the requirements and processes laid out in IEC 61850-4:2011
- Enable consistent testing (application-to-application)
- External systems may require additional configuration or processes in addition to those described in IEC 61850-4:2011. This data should be provided by the engineering process
- Proxy/Gateway may offer hooks to CIM instances depending on harmonisation outcome
- Engineering data should be secured to ensure data consistency, e.g. by use of IEC 62351-11[9]. Moreover engineering also comprises the security related parameterization for the operational phase. This includes e.g. role based access and key management.

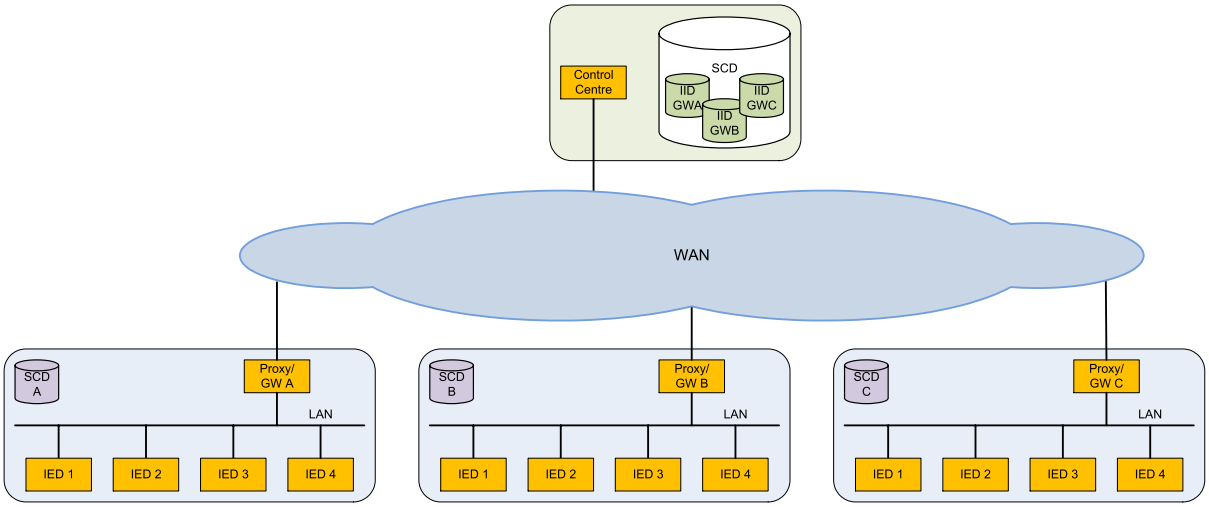
[9] To be published.

6.2 Extension of the engineering process with SCL

6.2.1 General

The engineering process follows the rules of IEC 61850-6:2009. As the SS to CC communication requires two levels of communication, it is recommended that the engineering process is done separately for the substation LAN and the SS to CC WAN.

One or more system configuration tools (SCT) may be used, one for each substation subnet and one for the SS to CC communication (WAN) as shown in Figure 13. The configuration of the Proxy/Gateway is done with an ICT (IED configuration tool). The ICT is used to create the mapping between the objects of the substation IEDs and the Proxy/Gateway server model. The ICT will generate an IID file of the Proxy/Gateway server.



IEC

Figure 13 – Scope of separated engineering workflow

6.2.2 Engineering workflow

Figure 14 shows the engineering workflow of the SS-CC communication.

At start of system engineering a SSD file may be entered; its <substation> section reflecting the targeted substation functional scope.

The IED capability (ICD) files are used by the substation LAN system configuration tool (SCT) as IED template description to instantiate project specific IEDs as needed.

Alternatively the substation LAN SCT can also import the description of an IED specifically preconfigured with name (and optionally addresses) for a concrete function in the process by importing an Instantiated IED Description (IID) file.

The Proxy/Gateway server and the Proxy/Gateway client are handled as separate IEDs. Only the Proxy/Gateway client is connected to the substation LAN.

The substation LAN SCT is used to define GOOSE and/or report control blocks as well as their data sets including the data that the Proxy/Gateway client IED will forward to the control centre.

The SCD file generated by the substation LAN SCT is then imported by the ICT for the Proxy/Gateway server configuration. In the ICT for the Proxy/Gateway server, the restructuring and renaming of logical nodes may be done. How the restructuring and renaming

is done is a local issue of the ICT and outside the scope of this technical report. However, as the data semantics inclusive the connection to the power system should be preserved during the engineering, there are recommendations for the Proxy/Gateway engineering.

Recommended rules for creation of Proxy/Gateway IID file:

- All LDs of lower level (source) IEDs, whose data has to be forwarded, are mapped as proxy LDs. Optional data objects not needed may be removed.
- The proxy LDs instances are named according to the source IED, e.g. proxy LD.inst:= Source IED.name + Source LD. The IED name in the proxy LPHD.PhyNam data object is set accordingly.

NOTE When creating the proxy LD names the LD name length restrictions have to be taken into account.

- All substation sections from the source SED / SCD files to which data source LNs are mapped are taken over, and the link to the source IED logical node is replaced by a link to the Proxy/Gateway LD logical node.

The output of the ICT is an IID file of the Proxy/Gateway server instance. The IID file may include a <substation> section describing the whole substation and the mapping of the Proxy/Gateway logical nodes.

The IID file of the Proxy/Gateway server together with the IID files of other Proxy/Gateway servers from other substations are used as inputs to the SS to CC WAN SCT. The configuration process of the SS to CC WAN is identical to the configuration process of the substation LAN. Any changes performed in the SS to CC WAN SCT are exported as SCD file.

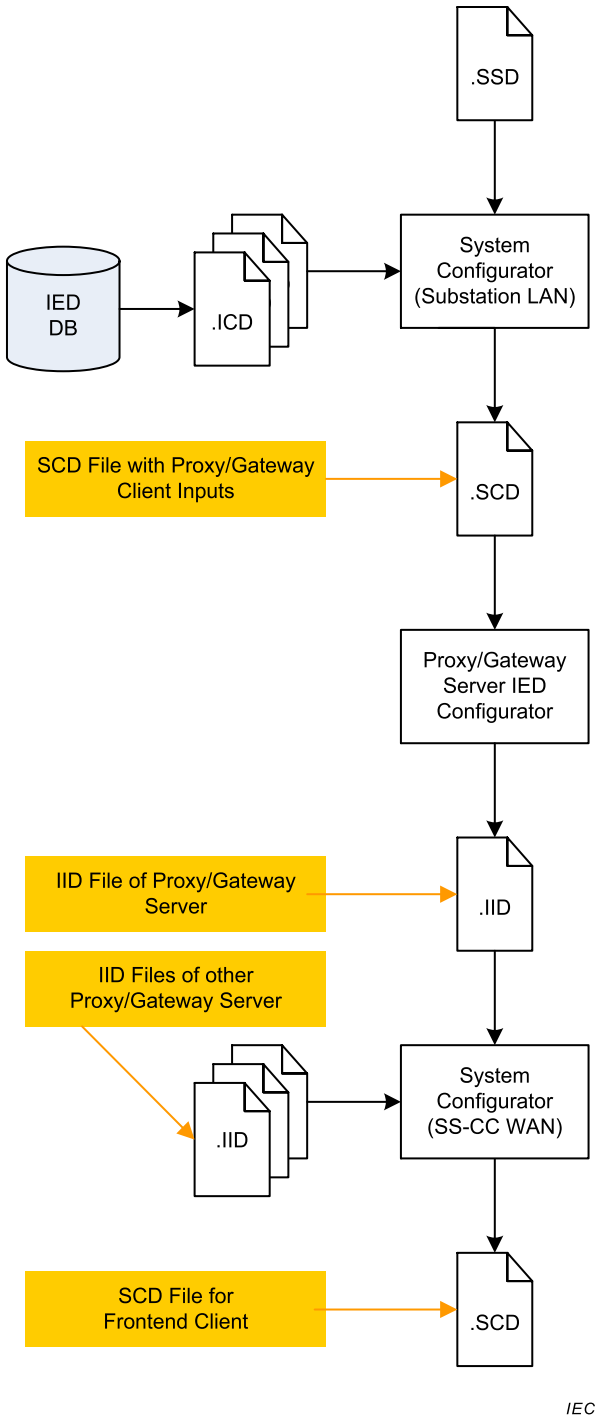
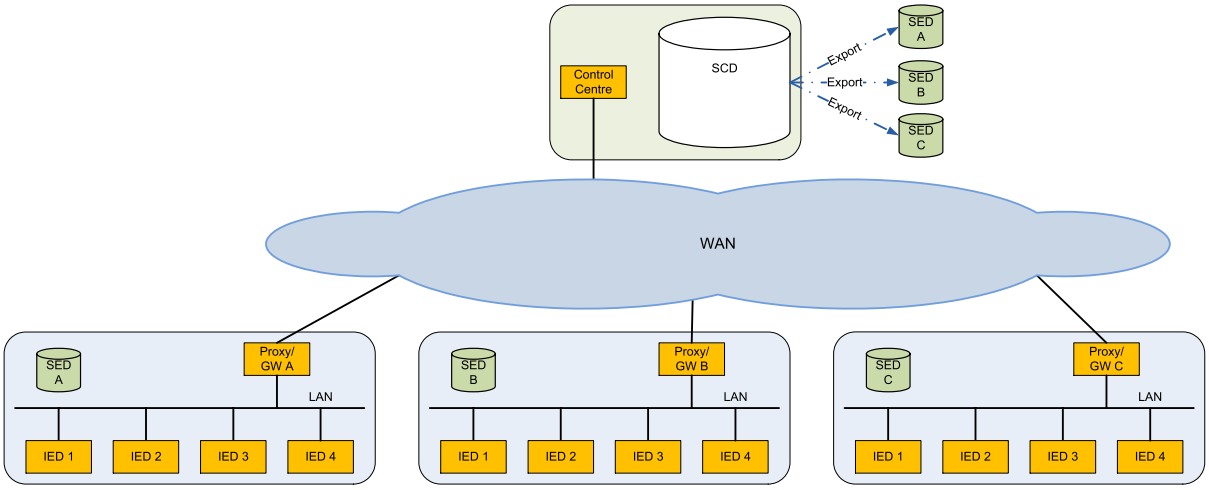


Figure 14 – Engineering workflow

6.2.3 Integrated engineering workflow – LANs with WAN

The purpose of this case is to create a single “project” (referring to IEC 61850-6:2009, 5.5) merging more than one substation together in one SCD file including their functional relationship as well as their relationship to the control centre as shown in Figure 15.



IEC

Figure 15 – Scope of integrated workflow

The process may follow the above schema, but in a simpler way, because there is no need to exchange/duplicate information between different files. Information is present only once.

It is not recommended to use this workflow, because it has several implications on the naming of the IEDs and their logical devices to create unique functional names. Additionally this approach is restricted to configurations with a limited number of IEDs (typically < 200).

Operating a maintenance centre in parallel to the control centre requires a second access point in the Proxy/Gateway or a second Proxy/Gateway.

6.3 Extension of the SCL schema from IEC 61850-6:2009

6.3.1 General

All extensions to the XML schema defined in IEC 61850-6:2009 belong to the XML name space:

xmlns:eTr-IEC61850-90-2="http://www.iec.ch/61850-90-2/2015/SCL"

This XML namespace is considered as "transitional" since the models are expected to be included in next editions of IEC 61850 international standards. Potential extensions/modifications may happen if/when the models are moved to the international standard status.

The whole schema can be found in Annex B.

6.3.2 Modelling of redundancy

6.3.2.1 General

The redundancy architecture of the SS-CC interface is described in detail in 7.1.2.5 of this technical report and relies on redundant servers and clients. Modelling of redundancy in SCL is not yet available in IEC 61850-6:2009. Thus the required additions are defined here.

The redundancy architecture chosen in this document requires that the redundant IEDs (clients and servers) are fully identical. Fully identical includes identical vendor, type, and software version. Especially the object model of the redundant server access points have to be identical down to the data type templates.

6.3.2.2 eTr-IEC61850-90-2:RedundancyModes

The system engineering tools require some additional knowledge about the redundancy capabilities of an IED to be able to form a group of redundant devices. The IED capabilities to support the redundancy schemes introduced in 7.1.2.5 of this technical report are expressed in the new SCL element eTr-IEC61850-90-2:RedundancyModes.

The attributes of the element reflect the capability of the IED to support the modes noRedundancy, accessPointRedundancy, deviceRedundancy and multipleRedundancy as described in 7.1.2.5.

Figure 16 shows the diagram of the eTr-IEC61850:RedundancyModes schema extension.

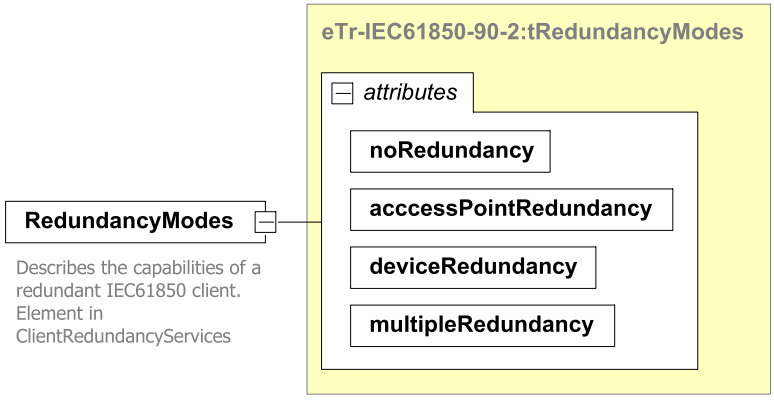


Figure 16 – Diagram of eTr-IEC61850-90-2:RedundancyModes

Excerpt from the XML schema:

```
<xs:complexType name="tRedundancyModes">
  <xs:attribute name="noRedundancy" type="xs:boolean" use="optional" default="true"/>
  <xs:attribute name="acccessPointRedundancy" type="xs:boolean" use="optional"
      default="false"/>
  <xs:attribute name="deviceRedundancy" type="xs:boolean" use="optional"
      default="false"/>
  <xs:attribute name="multipleRedundancy" type="xs:boolean" use="optional"
      default="false"/>
</xs:complexType>

<xs:element name="RedundancyModes" type="eTr-IEC61850-90-2:tRedundancyModes"/>
```

The attributes of the eTr-IEC61850-90-2:RedundancyModes element are defined in Table 6.

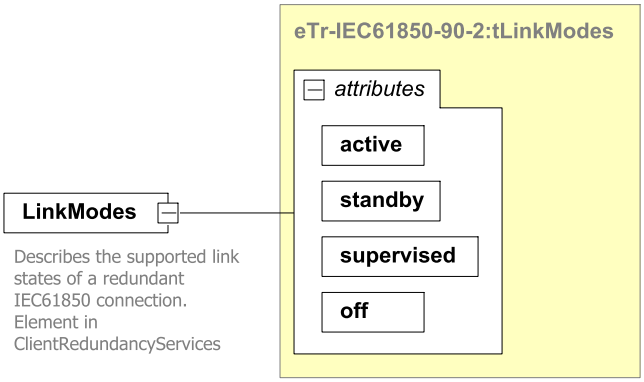
Table 6 – Attributes of the eTr-IEC61850-90-2:RedundancyModes element

Attribute name	Description
noRedundancy	When true the IED does not support redundancy
accessPointRedundancy	When true the IED supports redundant access points within the same IED
deviceRedundancy	When true the IED supports device redundancy
multipleRedundancy	When true the IED supports the device redundancy with redundant access points

6.3.2.3 eTr-IEC61850-90-2:LinkModes

The redundant links between the control centre and the Proxy/Gateway within the substation may be operated in different ways. The attributes of the element eTr-IEC61850-90-2: LinkModes reflect the capabilities of the IED to support the link operation modes defined in 7.1.2.4.4.

Figure 17 shows the diagram of the eTr-IEC61850:LinkModes schema extension.



IEC

Figure 17 – Diagram of eTr-IEC61850-90-2:LinkModes

Excerpt from the XML schema:

```
<xs:complexType name="tLinkModes">
  <xs:attribute name="active" type="xs:boolean" use="optional" default="false"/>
  <xs:attribute name="standby" type="xs:boolean" use="optional" default="false"/>
  <xs:attribute name="supervised" type="xs:boolean" use="optional" default="false"/>
  <xs:attribute name="off" type="xs:boolean" use="optional" default="false"/>
</xs:complexType>

<xs:element name="LinkModes" type="eTr-IEC61850-90-2:tLinkModes"/>
```

The attributes of the eTr-IEC61850-90-2:LinkModes element are defined in Table 7.

Table 7 – Attributes of the eTr-IEC61850-90-2:LinkModes element

Attribute name	Description
active	When true the link can be operated as main link for data exchange
standby	When true the link can be operated as backup link with active data transmission
supervised	When true the link can be operated as backup link without active data transmission
off	When true the link can be disabled when not active

6.3.2.4 eTr-IEC61850-90-2:ClientRedundancyServices

As it is not possible to extend the existing scl:Services element defined in IEC 61850-6:2009 with an element from another namespace the element eTr-IEC61850-90-2: ClientRedundancyServices is introduced to hold the eTr-IEC61850-90-2:RedundancyModes and eTr-IEC61850-90-2:LinkModes elements.

Figure 18 shows the diagram of the eTr-IEC61850:ClientRedundancyServices schema extension.

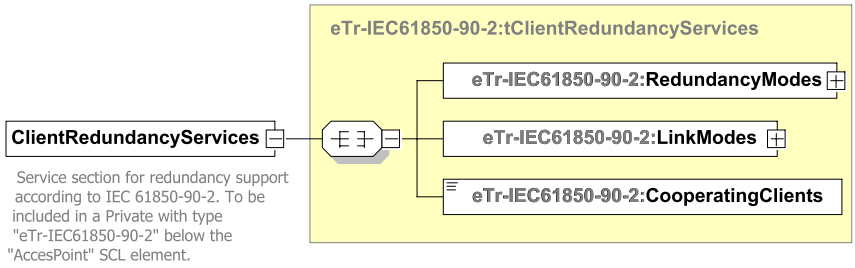


Figure 18 – Diagram of eTr-IEC61850-90-2:ClientRedundancyServices

Excerpt from the XML schema:

```
<xs:complexType name="tClientRedundancyServices">
  <xs:all>
    <xs:element name="RedundancyModes" type="eTr-IEC61850-90-2:tRedundancyModes"
minOccurs="0"/>
    <xs:element name="LinkModes" type="eTr-IEC61850-90-2:tLinkModes" minOccurs="0"/>
    <xs:element name="CooperatingClients" type="xs:boolean" default="false"
minOccurs="0"/>
  </xs:all>
</xs:complexType>

<xs:element name="ClientRedundancyServices"
    type="eTr-IEC61850-90-2:tClientRedundancyServices"/>
```

The eTr-IEC61850-90-2:ClientRedundancyServices element is put in a Private of type eTr-IEC61850-90-2 below the scl:AccessPoint element. The attributes of the eTr-IEC61850-90-2:ClientRedundancyServices element are defined Table 8.

Table 8 – Elements of the eTr-IEC61850-90-2:ClientRedundancyServices element

Attribute name	Description
RedundancyModes	The supported redundancy modes of the client access point
LinkModes	The supported link modes of the client access point
CooperatingClients	The client access point supports sharing server RCBs with one or more other clients

NOTE When this technical report will be integrated into a new edition of IEC 61850-6 it is intended to add the elements eTr-IEC61850-90-2:ClientRedundancyModes, eTr-IEC61850-90-2:LinkModes and eTr-IEC61850-90-2:CooperatingClients to the definition of scl:ClientServices and then the element eTr-IEC61850-90-2:ClientRedundancyServices will become obsolete.

6.3.2.5 eTr-IEC61850-90-2:LDeviceOverride

To allow redundant server definitions in different IEDs the eTr-IEC61850-90-2:RedundantServerTo element is introduced in 6.3.2.6. This allows the definition of the server to be missing below the access point. Nonetheless it might be necessary to provide a number of instance values for the redundant servers that differ from the referenced server. Such different instance values may be:

- Nameplate information, related to the physical device
- Associations to redundant clients
- Etc.

The element eTr-IEC61850-90-2:LDeviceOverride allows specifying only those instance values that are different from the referenced server, without repeating the whole data model.

Figure 19 shows the diagram of the eTr-IEC61850-90-2:LDeviceOverride schema extension.

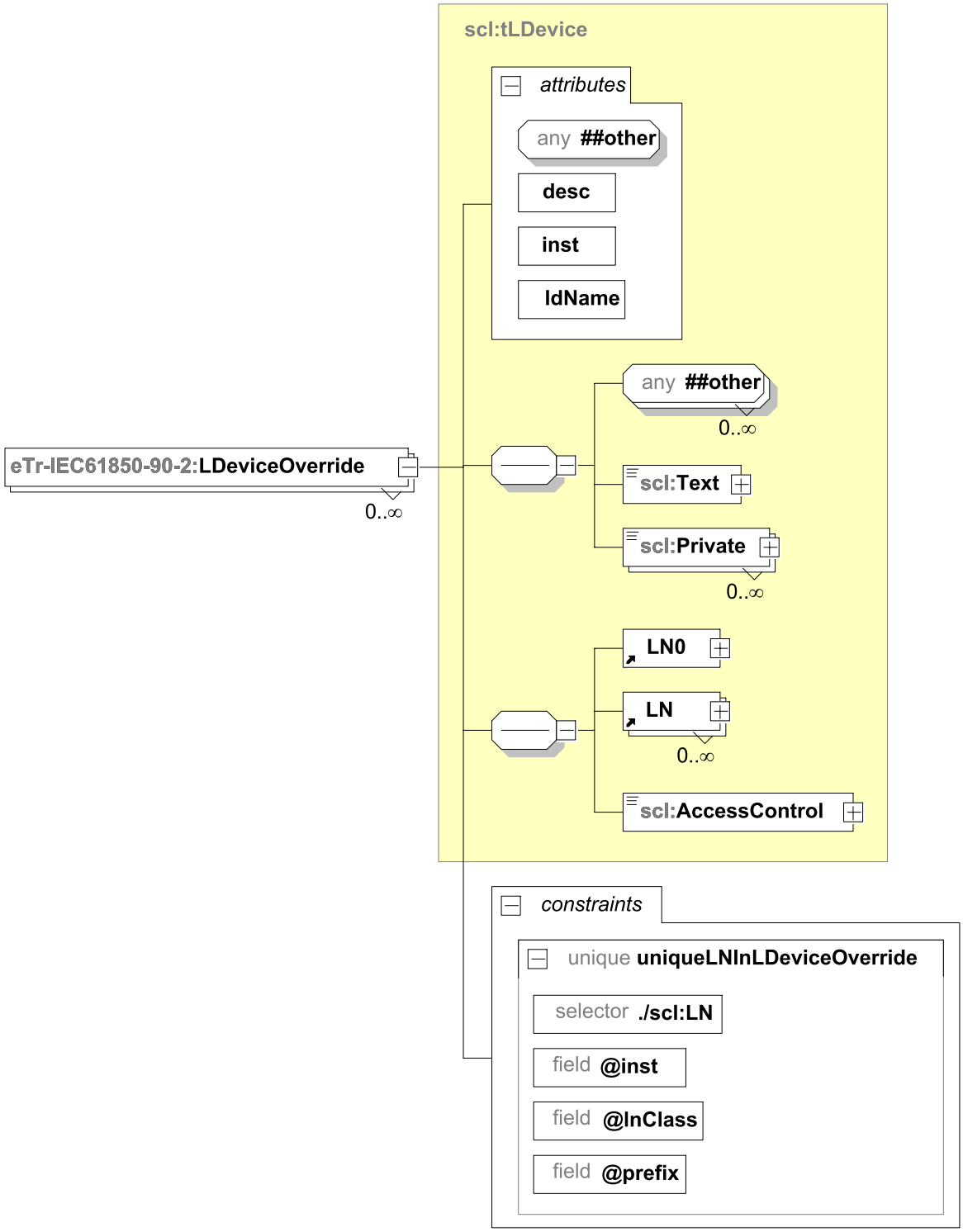


Figure 19 – Diagram of eTr-IEC61850-90-2:LDeviceOverride

Excerpt from the XML schema:

```
<xs:element name="LDeviceOverride" type="scl:tLDevice" minOccurs="0"
maxOccurs="unbounded">
  <xs:unique name="uniqueLNInLDeviceOverride">
    <xs:selector xpath="./scl:LN"/>
    <xs:field xpath="@inst"/>
    <xs:field xpath="@lnClass"/>
    <xs:field xpath="@prefix"/>
  </xs:unique>
</xs:element>
```

The eTr-IEC61850-90-2:LDeviceOverride is an element in the complex type eTr-IEC61850-90-2:tRedundantServerTo which is defined in 6.3.2.6. The element is of the type scl:tLDevice, which is defined in IEC 61850-6:2009.

6.3.2.6 eTr-IEC61850-90-2:RedundantServerTo

SCL already provides a means to express functionally equivalent servers within one IED using the scl:ServerAt element. The definition of the scl:ServerAt element cannot be extended with a new element from another namespace, thus an additional SCL element is required to express the redundancy of servers.

The element eTr-IEC61850-90-2:RedundantServerTo is introduced to express such server redundancy relations. To avoid redundant definitions in the SCL the eTr-IEC61850-90-2:RedundantServerTo element may not be used in one of the access points forming a group of redundant servers. eTr-IEC61850-90-2:RedundantServerTo is a reciprocal function and therefore can be missing in one of the redundant server access points. It allows the object model of the server to be missing.

This element has attributes iedName and apName referencing the IED to which the access point is redundant. The referenced IED may be the same as the IED giving the reference to allow redundant client access points within one IED.

Figure 20 shows the diagram of the eTr-IEC61850-90-2:RedundantServerTo schema extension.

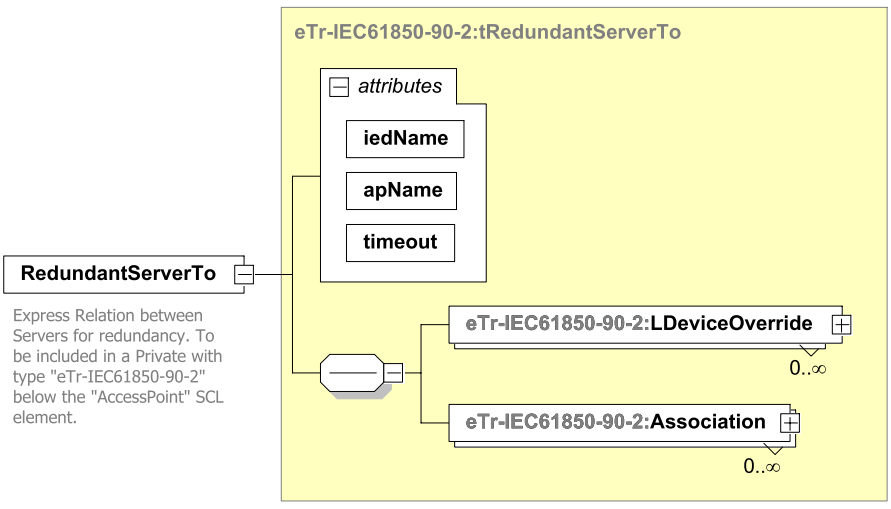


Figure 20 – Diagram of eTr-IEC61850-90-2:RedundantServerTo

Excerpt from the XML schema:

```
<xs:complexType name="tRedundantServerTo">
  <xs:sequence>
    <xs:element name="LDeviceOverride" type="scl:tLDevice" minOccurs="0"
        maxOccurs="unbounded">
      <xs:unique name="uniqueLNInLDeviceOverride">
        <xs:selector xpath="./scl:LN"/>
        <xs:field xpath="@inst"/>
        <xs:field xpath="@lnClass"/>
        <xs:field xpath="@prefix"/>
      </xs:unique>
    </xs:element>
    <xs:element name="Association" type="scl:tAssociation" minOccurs="0"
        maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="iedName" type="scl:tIEDName" use="required"/>
  <xs:attribute name="apName" type="scl:tAccessPointName" use="required"/>
  <xs:attribute name="timeout" type="xs:unsignedInt" use="optional" default="30"/>
</xs:complexType>

<xs:element name="RedundantServerTo" type="eTr-IEC61850-90-2:tRedundantServerTo">
```

The eTr-IEC61850-90-2:RedundantServerTo element is put in a Private of type eTr-IEC61850-90-2 below the scl:AccessPoint element. The definition of the Server object model may be added, but it is not required. When the definition of the server object model is missing the LN definitions of the redundant access point are used. The attributes of the eTr-IEC61850-90-2:RedundantServerTo element are defined in Table 9.

Table 9 – Attributes of the eTr-IEC61850-90-2:RedundantServerTo element

Attribute name	Description
iedName	IED name of the server that holds the redundant access point
apName	Name of the server access point used for redundancy in the redundant IED

In the communication section the addresses for all redundant access points are defined as normal.

NOTE When this technical report is integrated into a new edition of IEC 61850-6 it is intended to add the attribute iedName of eTr-IEC61850-90-2:RedundantServerTo to the definition of scl:ServerAt and then the eTr-IEC61850-90-2:RedundantServerTo element will become obsolete.

6.3.2.7 eTr-IEC61850-90-2:RedundantClientTo

To express the redundancy relation of client access points an additional SCL element is required. Because clients typically do not implement server functionality, the eTr-IEC61850-90-2:RedundantServerTo element cannot be used.

Therefore the element eTr-IEC61850-90-2:RedundantClientTo is introduced to express client redundancies. To avoid redundant definitions in the SCL the eTr-IEC61850-90-2: RedundantClientTo element may not be used in one of the access points forming a group of redundant clients. eTr-IEC61850-90-2:RedundantClientTo is a reciprocal function and therefore can be missing in one of the redundant client access points.

This element has attributes iedName and apName referencing the IED to which the access point is redundant. The referenced IED may be the same as the IED giving the reference to allow redundant client access points within one IED.

Figure 21 shows the diagram of the eTr-IEC61850-90-2:RedundantClientTo schema extension.

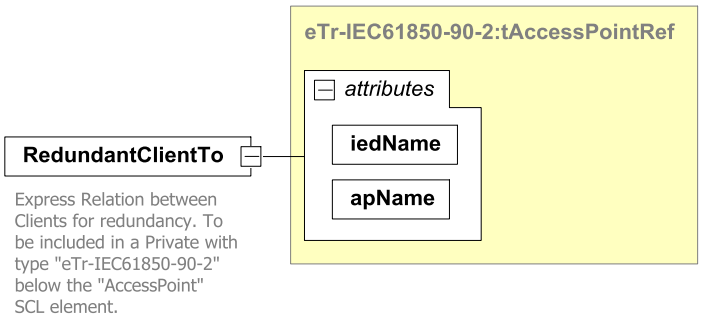


Figure 21 – Diagram of eTr-IEC61850-90-2:RedundantClientTo

Excerpt from the XML schema:

```
<xs:complexType name="tAccessPointRef">
  <xs:attribute name="iedName" type="scl:tIEDName" use="required"/>
  <xs:attribute name="apName" type="scl:tAccessPointName" use="required"/>
</xs:complexType>

<xs:element name="RedundantClientTo" type="eTr-IEC61850-90-2:tAccessPointRef"/>
```

The eTr-IEC61850-90-2: RedundantClientTo element is put in a Private of type eTr-IEC61850-90-2 below the scl:AccessPoint element. The definition of the client Logical Nodes may be added, but it is not required. When the definition of the client LNs is missing the LN definitions of the redundant client are used. The attributes of the eTr-IEC61850-90-2:RedundantClientTo element are defined in Table 10.

Table 10 – Attributes of the eTr-IEC61850-90-2:RedundantClientTo element

Attribute name	Description
iedName	IED name of the client that holds the redundant access point
apName	Name of the client access point used for redundancy in the redundant IED

In the communication section the addresses for all redundant access points are defined as normal.

6.3.2.8 eTr-IEC61850-90-2:StandbyLinkMode

To express the operation mode of a backup communication link an additional SCL element is required. Therefore the element eTr-IEC61850-90-2:StandbyLinkMode is introduced.

Only those values are allowed for eTr-IEC61850-90-2:StandbyLinkMode that are supported by the access point. The capabilities of the access point are expressed in eTr-IEC61850-90-2:LinkModes element.

Figure 22 shows the diagram of the eTr-IEC61850-90-2:StandbyLinkMode schema extension.

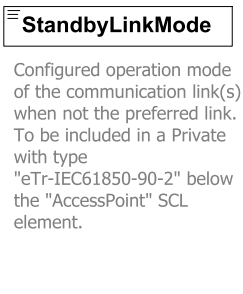


Figure 22 – Diagram of eTr-IEC61850-90-2:StandbyLinkMode

Excerpt from the XML schema:

```
<xs:simpleType name="tLinkModeEnum">
  <xs:restriction base="xs:Name">
    <xs:enumeration value="Standby"/>
    <xs:enumeration value="Supervised"/>
    <xs:enumeration value="Off"/>
  </xs:restriction>
</xs:simpleType>

<xs:element name="StandbyLinkMode" type="eTr-IEC61850-90-2:tLinkModeEnum"/>
```

The eTr-IEC61850-90-2: StandbyLinkMode element is put in a Private of type eTr-IEC61850-90-2 below the scl:AccessPoint element. The allowed values of the eTr-IEC61850-90-2:tLinkModeEnum are defined in Table 11.

Table 11 – Values of the eTr-IEC61850-90-2:tLinkModeEnum

Attribute name	Description
Standby	Backup link with active data transmission
Supervised	Backup link without active data transmission, but link active supervision
Off	Backup link disabled

6.3.3 Modelling of data references between SCL files

6.3.3.1 General

To support automatic and manual testing it is essential to know where the original source of a data object is located. As the control centre SCD file may contain data objects from many different substations, it is essential to know in which substation SCD file the source of the information is defined. To support this, two new SCL elements are introduced. The element eTR-IEC61850-90-2:ExternalSCL can hold a storage location and version information of a SCL file. The element eTr-IEC61850-90-2:ProxyOf (defined in 6.3.3.3) gives a reference to a logical node, data object or data attribute in another IED. The IED may be contained in the same, or in an external SCL File.

6.3.3.2 eTr-IEC61850-90-2:ExternalSCL

The element eTr-IEC61850-90-2:ExternalSCL is used to hold the storage location of an external SCL file. The attribute name is used as a key for a reference in the element eTr-IEC61850-90-2:ProxyOf defined in 6.3.3.3 of this technical report.

Figure 23 shows the diagram of the eTr-IEC61850-90-2:ExternalSCL schema extension.

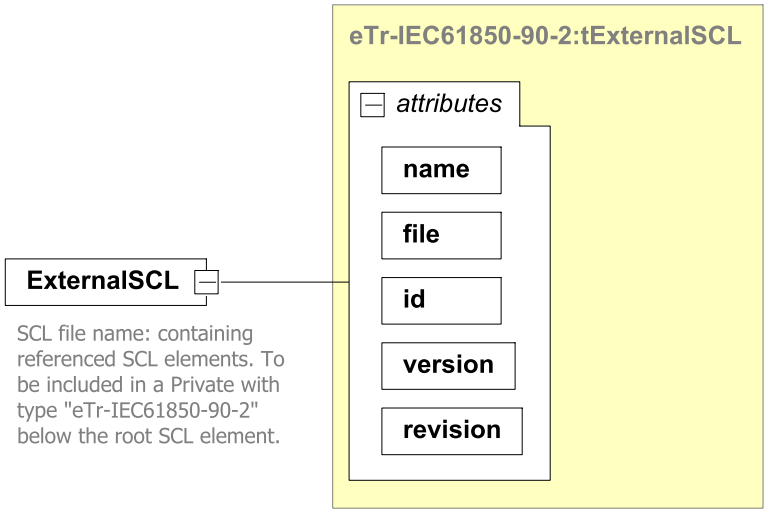


Figure 23 – Diagram of eTr-IEC61850-90-2:ExternalSCL

Excerpt from the XML schema:

```
<xs:complexType name="tExternalSCL">
  <xs:attribute name="name" type="xs:normalizedString" use="required"/>
  <xs:attribute name="file" type="xs:anyURI" use="required"/>
  <xs:attribute name="id" type="xs:normalizedString" use="optional"/>
  <xs:attribute name="version" type="xs:normalizedString" use="optional"/>
  <xs:attribute name="revision" type="xs:normalizedString" use="optional"/>
</xs:complexType>

<xs:element name="ExternalSCL" type="eTr-IEC61850-90-2:tExternalSCL"/>
```

The eTr-IEC61850-90-2:ExternalSCL is put in a Private of type eTr-IEC61850-90-2 below the root SCL element. The attributes of the eTr-IEC61850-90-2:ExternalSCL element are defined in Table 12.

Table 12 – Attributes of the eTr-IEC61850-90-2:ExternalSCL element

Attribute name	Description
name	The name of the ExternalSCL block
file	URI of the referenced SCL file
id	Value of the id attribute in the Header element of the referenced SCL file
version	Value of the version attribute in the Header element of the referenced SCL file
revision	Value of the revision attribute in the Header element of the referenced SCL file

6.3.3.3 eTr-IEC61850-90-2:ProxyOf

To support automatic and manual testing, each logical node that is a proxy of another logical node in the same or another IED contains an XML-element eTr-IEC61850-90-2:ProxyOf, to express the relation to the original logical node. This reference may be within one SCL file but may also refer to the logical node of an IED defined in another SCL file. The attribute externalScl when it exists, contains the value of the name attribute of an eTr-IEC61850-90-2:externalSCL element defined in 6.3.3.2 of this technical report.

Figure 24 shows the diagram of the eTr-IEC61850-90-2:ProxyOf schema extension.

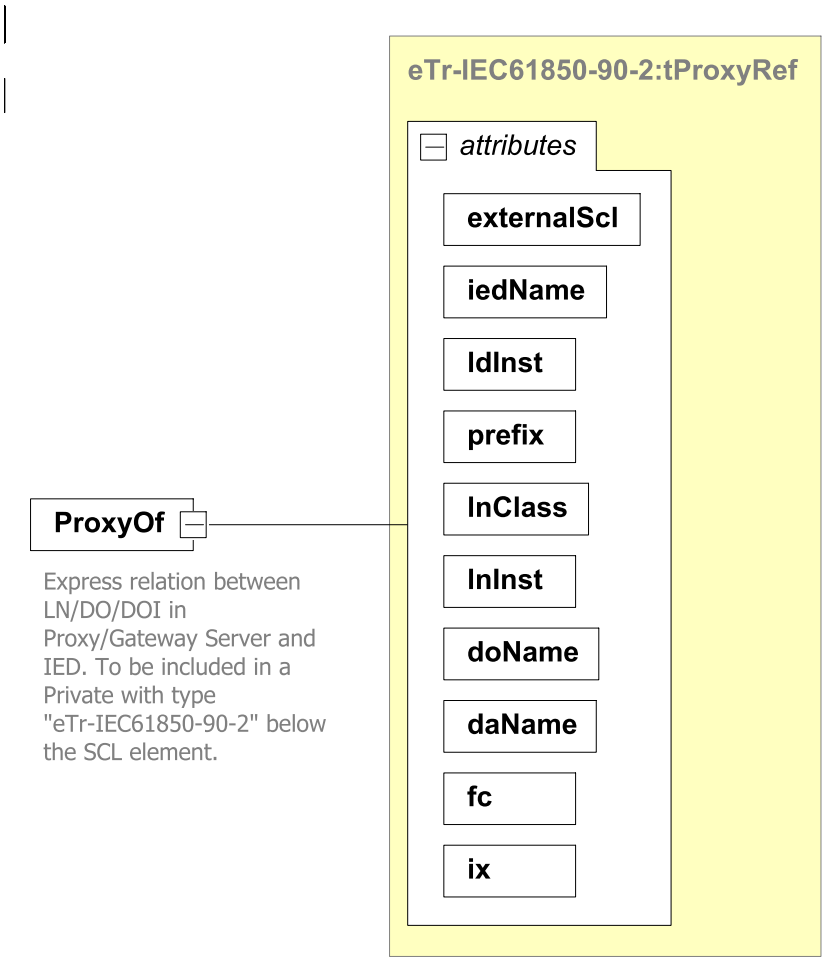


Figure 24 – Diagram of eTr-IEC61850-90-2:ProxyOf

Excerpt from the XML schema:

```
<xs:complexType name="tProxyRef">
  <xs:attribute name="externalScl" use="optional">
    <xs:simpleType>
      <xs:restriction base="xs:normalizedString">
        <xs:minLength value="1"/>
      </xs:restriction>
    </xs:simpleType>
  </xs:attribute>
  <xs:attribute name="iedName" type="scl:tIEDName" use="required"/>
  <xs:attribute name="ldInst" type="scl:tLDInst" use="required"/>
  <xs:attribute name="prefix" type="scl:tPrefix" use="optional" default=""/>
  <xs:attribute name="lnClass" type="scl:tLNClassEnum" use="required"/>
  <xs:attribute name="lnInst" type="scl:tLNInst" use="optional"/>
  <xs:attribute name="doName" type="scl:tFullDOName" use="optional"/>
  <xs:attribute name="daName" type="scl:tFullAttributeName" use="optional"/>
  <xs:attribute name="fc" type="scl:tFCEnum" use="optional"/>
  <xs:attribute name="ix" type="xs:unsignedInt" use="optional"/>
</xs:complexType>

<xs:element name="ProxyOf" type="eTr-IEC61850-90-2:tProxyRef"/>
```

The attributes of the eTr-IEC61850-90-2:ProxyOf element are defined in Table 13.

Table 13 – Attributes of the eTr-IEC61850-90-2:ProxyOf element

Attribute name	Description
externalSCL	Identifies the SCL file in which the SCL configuration of the IED is stored
iedName	The IED where the data object resides
ldInst	The LD where the data object resides
prefix	Prefix identifying together with lnInst and lnClass where the data object resides
lnClass	LN class of the LN where the data object resides
lnInst	Instance number of the LN where the data object resides
doName	A name identifying the data object (within the LN). For elements or parts of structured data object types, all name parts are contained, separated by dots (.), down to (but without) the level where the fc is defined. If an SDO array element is selected, the appropriate name part contains at its end before a possible dot the array element number in the form (ArrayElementNumber)
daName	The attribute name – if missing, all attributes with functional characteristic given by fc are selected. For elements or parts of structured data types, all name parts are contained, separated by dots (.), starting at the level where the fc is defined. If an attribute's array element is selected, the appropriate attribute name part contains at its end before any separating dot the array element number in the form (ArrayElementNumber)
fc	All attributes of this functional constraint are selected. Possible constraint values see IEC 61850-7-2:2010
ix	An index to select an array element in case that one of the data elements is an array. The ix value shall be identical to the ArrayElementNumber value in the doName or daName part

6.3.4 Functional naming

Redundant servers, especially with same logical device model, will lead to multiple LNode allocations of the same LN class to the same element in the substation / process structure, thus having the same functional name. The constraints of the SCL schema do not allow more than one reference to a LN class from the same element in the substation / process structure to guarantee unique functional names. Thus the allocation of LN classes to the substation / process structure is done only for the IED, within a group of redundant IEDs, which does not contain the eTr-IEC61850-90-2:RedundantServerTo element. The engineering tools have to support the resolution of the functional names for the redundant IEDs of the group.

6.3.5 Examples

Examples of redundant client and server configurations are given in Annex C and Annex D. The sample SCD files are valid, but may be incomplete. They are there solely for educational purpose and to support the understanding of the usage of the new SCL elements.

Additionally the sample SCL files make use of the use cases of 7.1.3.5.

6.4 Security aspects

The implemented security mechanisms depend on the requirements of the target system. If secure exchange of configuration data is requested, the SCL data can be secured according to IEC 62351-11[10]. The relevant parts of IEC 62351 may be used to secure the configuration data exchange between the configuration and the runtime system.

[10] To be published.

7 Basic Communication Structure – Principles and models

7.1 Communication and Modelling aspects

7.1.1 General

The run time models of IEC 61850 are used directly for the communication to the control centre applications. The existing models of IEC 61850 can be used for communication with the control centre applications without adding new logical nodes. Harmonisation of these models with CIM models are not within the scope of this report. Consistency with the harmonisation project between CIM and IEC 61850 will be ensured. A device that needs some further discussions with regard to the modelling aspects is the Proxy/Gateway introduced in 7.1.2.1.2.

7.1.2 Communication aspects

7.1.2.1 Basic communication architecture

7.1.2.1.1 General

The basic concept for communication between the maintenance or control centre and the substation is shown in Figure 25. It consists of the following elements:

- Applications running at the maintenance or control centre location
- Access control (access control contains one or more security access points)
- The wide area communication network
- Proxy/Gateway
- IEDs

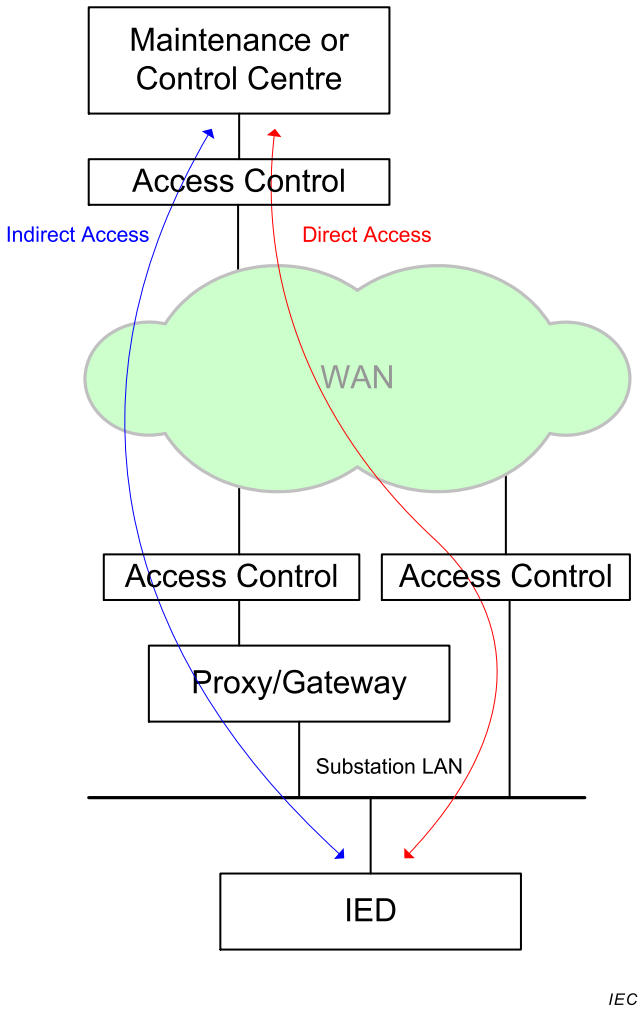


Figure 25 – Communication concept

NOTE This simplified concept diagram does not illustrate all elements required for physical implementation, security aspects, etc.

The SCADA in the control centre and other applications can access the IED through the Proxy/Gateway. Other applications, e.g. in the maintenance centre, like IED configuration tools may bypass the Proxy/Gateway and access the IED directly via a security access point. These two communication mechanisms are considered in this technical report.

Network and security configurations for both access methods can be found in IEC TR 62351-10:2012, 6.4.3.

7.1.2.1.2 Proxy/Gateway

Applications with indirect access preferably access the IEC 61850 information from a substation through a Proxy/Gateway. Reasons for this include:

- Filtering and transformation of information
- Address mapping (e.g. translation from a product oriented addressing scheme to a functional addressing scheme)
- Reduction of the number of associations to be established and supervised
- Physical decoupling of networks
- Reduction of communication overhead in IEDs and applications
- Restriction of access methods between Proxy/Gateway and applications

7.1.2.1.3 IEDs

The IEDs are the sources for the information in the substation location.

7.1.2.1.4 WAN – Wide area communication network

The communication network interconnects the IED or Proxy/Gateway typically located at the substation and the applications typically located at the control centre or maintenance centre. For the purposes of this document it is assumed that the access to the wide area network is controlled. Access control can be done by firewalls and the use of role based access according to IEC TS 62351-8:2011 and key management according to IEC 62351-9[11]. Refer also to 5.9.5.2. More information on the use of IEC 61850 with wide area networks can be found in IEC TR 61850-90-12.

7.1.2.1.5 Application with indirect access

These applications have indirect access to the IED data via the Proxy/Gateway, e.g. SCADA.

7.1.2.1.6 Application with direct access

These applications have direct access to the IED data bypassing the Proxy/Gateway and accessing the substation network directly via a security access point, e.g. for disturbance recording collection. Direct access can be achieved using tunnelling.

7.1.2.2 Services: what services apply?

Modelling an IEC 61850 server application requires the usage of a basic set of ACSI classes. Some services are common for all use cases and therefore are listed here and not repeated in each use case. Those services include:

- GenServerClass model
- Application association model
  - TWO-PARTY-APPLICATION-ASSOCIATION (TPAA) class model
- GenLogicalDeviceClass model
- GenLogicalNodeClass model
- Generic data object class model
- Generic common data class model
- DATA-SET class model
- Modelling of control block classes
- Time and time-synchronization model

Naming conventions are the same as given in IEC 61850-7-2:2010, 22.

Table 14 shows the typical services and access types for the different use cases. Nevertheless the final design of the communication system depends on the requirements of the customer. Especially this table does not imply that the usage of a Proxy/Gateway for the telecontrol use case is mandatory.

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11 Under consideration.

Table 14 – Use case vs. IEC 61850 – Service table

Area	Use case	Access type	IEC 61850-7-2 service involved
Telecontrol	Acquisition of status	Indirect	REPORT-CONTROL-BLOCK class model • Unbuffered reporting • Buffered reporting
	Acquisition of measurement	Indirect	REPORT-CONTROL-BLOCK class model • Unbuffered reporting
	Acquisition of alarms	Indirect	REPORT-CONTROL-BLOCK class model • Unbuffered reporting • Buffered reporting
	Remote control	Indirect	CONTROL class model • Control with normal security • Control with enhanced security • Time activated operate
	Sending setpoint	Indirect	SETTING-GROUP-CONTROL-BLOCK class model • SGCB class services
	General interrogation	Indirect	REPORT-CONTROL-BLOCK class model • GI – general-interrogation
	Control authority management	Indirect	Handled as an application as per IEC 61850-7-4:2010, Annex B
	Telemonitoring blocking	Indirect	Not available in IEC 61850-7-2:2010, described in 7.1.3.6.9. Handled as an application.
Disturbance	Getting list of disturbance or fault records	Direct	File transfer model • File services – GetServerDirectory(FILE)
	Getting disturbance or fault records corresponding to a given period of time	Direct	File transfer model • File services – GetServerDirectory(FILE) – GetFileAttributeValues – GetFile
	Getting disturbance or fault records for one given device	Direct	File transfer model • File services – GetServerDirectory(FILE) – GetFileAttributeValues – GetFile
	Sending disturbance or fault records	Direct Direct / Indirect	File transfer model • File services – SetFile REPORT-CONTROL-BLOCK class model • Unbuffered reporting • Buffered reporting
	Getting configuration recording parameters	Direct	SETTING-GROUP-CONTROL-BLOCK class model • SGCB services – GetEditSGValue

Area	Use case	Access type	IEC 61850-7-2 service involved
	Setting configuration recording parameters	Direct	SETTING-GROUP-CONTROL-BLOCK class model • SGCB services – SelectEditSG – GetEditSGValue – SetEditSGValue – ConfirmEditSGValues – SelectActiveSG
Counting	Acquisition of integrated totals	Indirect	REPORT-CONTROL-BLOCK class model • Unbuffered reporting • Buffered reporting
	Acquisition of incremental information	Indirect	REPORT-CONTROL-BLOCK class model • Unbuffered reporting • Buffered reporting
	Request counting information	Indirect	GenDataObjectClass services • GetDataValues
Power quality	Request for power quality information	Indirect	GenDataObjectClass services • GetDataValues
	Retrieve LOG of power quality information	Direct Direct	File transfer model • File services – GetFileAttributeValues – GetFile LOG-CONTROL-BLOCK class model • LOG services – QueryLogByTime – QueryLogAfter
	Sending of power quality information	Direct / Indirect Direct Direct	REPORT-CONTROL-BLOCK class model • Unbuffered reporting • Buffered reporting File transfer model • File services – GetFileAttributeValues – GetFile LOG-CONTROL-BLOCK class model • LOG services – QueryLogByTime – QueryLogAfter
Asset	Request for asset information	Direct / Indirect	GenDataObjectClass services • GetDataValues
Parameter configuration	Request for configuration files	Direct / Indirect	File transfer model • File services – GetFileAttributeValues – GetFile
	Sending configuration files	Direct / Indirect	File transfer model • File services – SetFile

Area	Use case	Access type	IEC 61850-7-2 service involved
	Request for operational parameters	Direct / Indirect	SETTING-GROUP-CONTROL-BLOCK class model • SGCB services – SelectEditSG – GetEditSGValue – SetEditSGValue ConfirmEditSGValues
	Setting operational parameters	Direct / Indirect	SETTING-GROUP-CONTROL-BLOCK class model • SGCB services – SelectEditSG – GetEditSGValue – SetEditSGValue – ConfirmEditSGValues – SelectActiveSG

7.1.2.3 Communication architectures for direct access

The use of routable network protocols allows direct access to IEDs within substations from a maintenance or control centre. The data exchange between the control centre LAN and the substation LAN takes place over a public or private wide area network (WAN). Routers separate the broadcast domains and forward routable data to the destination address. IEC 61850-8-1:2011 defines the communication mapping used for direct access.

Access to the networks should be controlled by security mechanisms as defined in the IEC 62351 series. Network engineering guidelines as per IEC TR 61850-90-12 should be followed.

For IEC 61850 the relevant kinds of traffic would be TCP/IP (for client/server communication) and multicast messages on Ethernet layer 2 (GOOSE and SV). No use cases for GOOSE and SV have been identified within the scope of this technical report. Multicast and Broadcast messages from within the substation are not forwarded to the control centre. Substation to control centre communication only has to carry layer 3 traffic.

Figure 26 shows the concept of direct access from the maintenance or control centre to IEDs within the substation.

IEC TR 61850-90-12 provides guidelines for redundant communication setups using WANs.

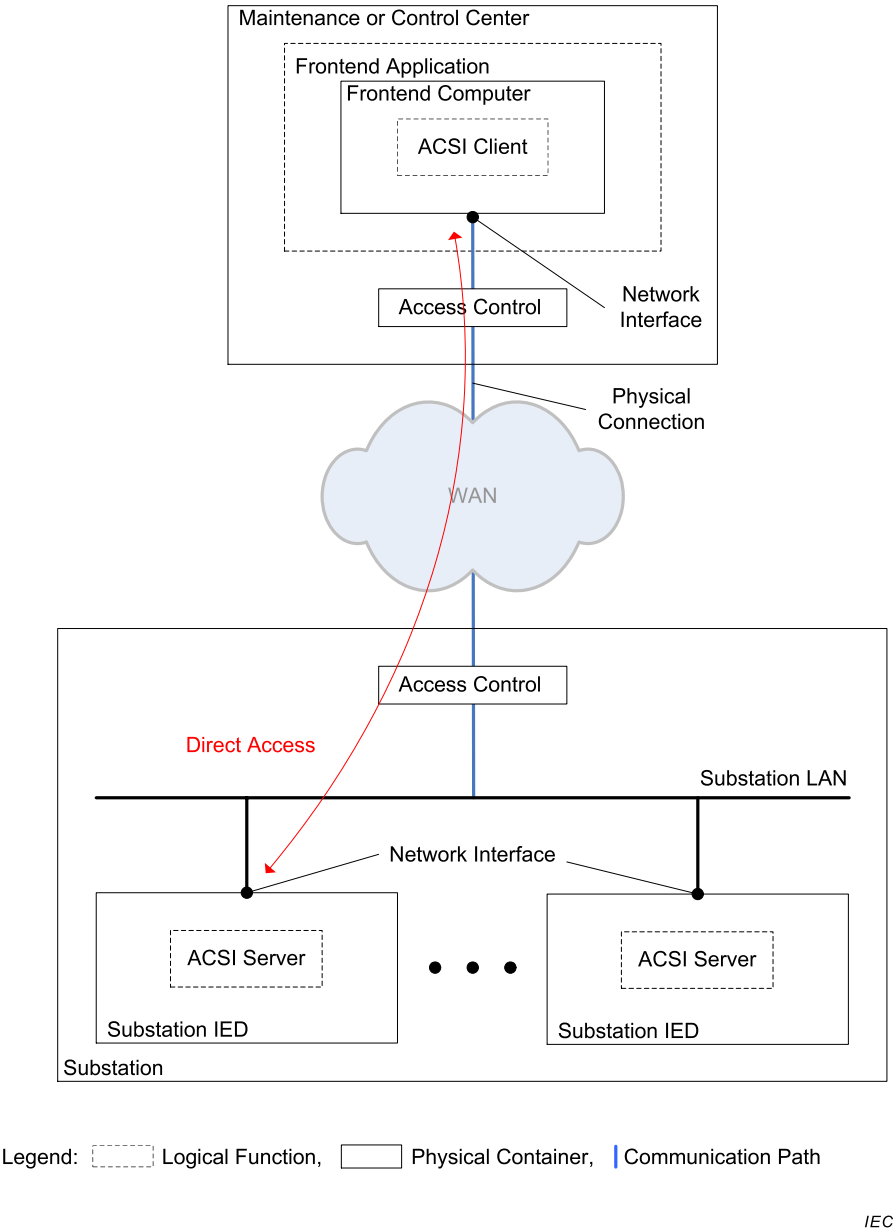


Figure 26 – SS to CC communication via direct access

7.1.2.4 Communication architectures for indirect access

7.1.2.4.1 General

Indirect access is used for, but not limited to, SCADA applications. In order to achieve the availability of substation to control centre communication that is required for a particular application, redundancy concepts may be applied.

The principle of functional redundancy is a proven method. Functional redundancy means the additional use of functionally identical or comparable resources, which are not required during normal operation. In the present application these resources can be hardware components, logical functions, communication paths, or data storage.

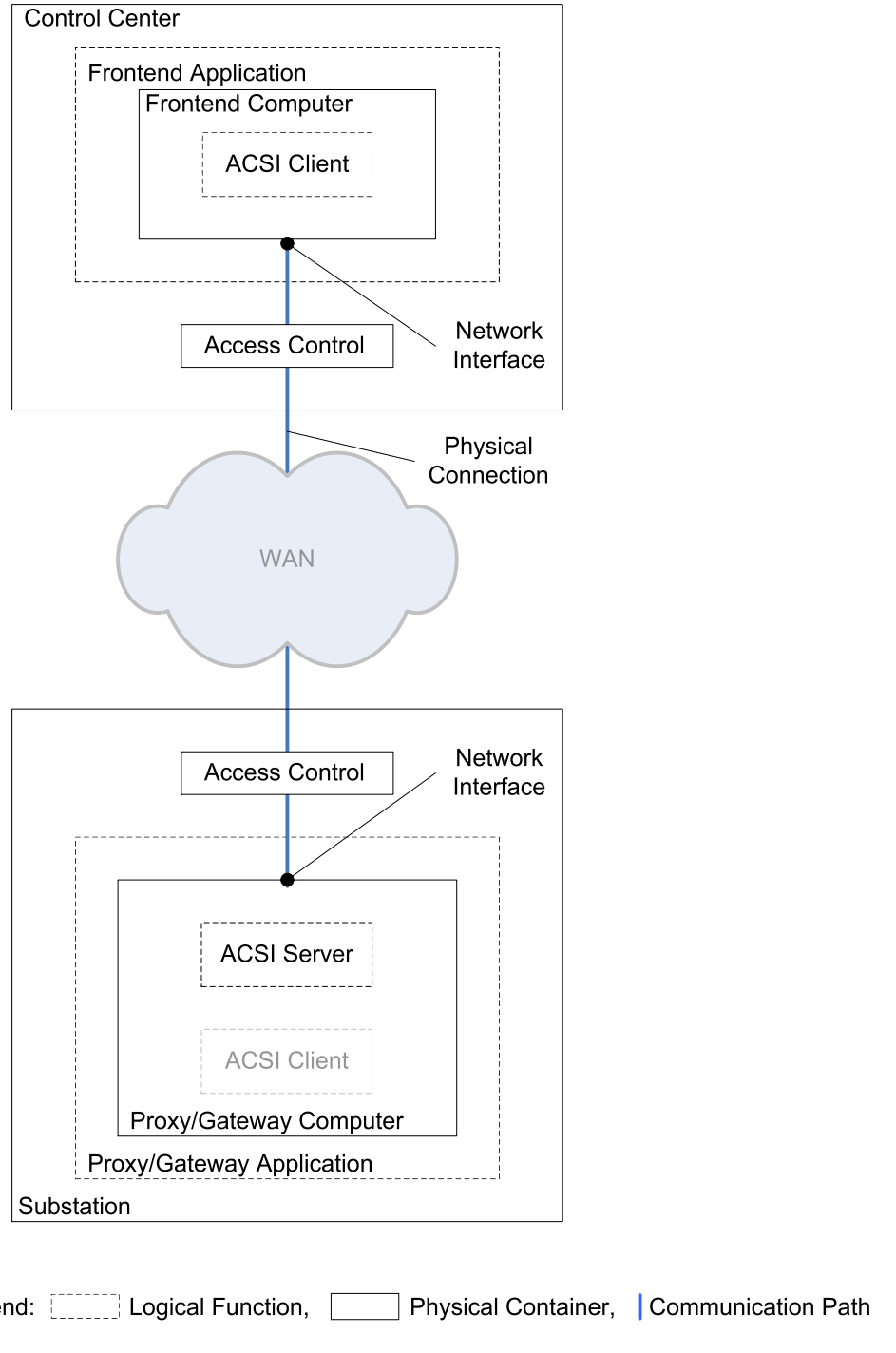


Figure 27 – Basic configuration for indirect access

The basic configuration consists of:

- A Proxy/Gateway computer including an ACSI client and ACSI server function and at least one network interface. Typically ACSI client and ACSI server are using different network interfaces.
- A frontend computer including an ACSI client and at least one network interface.
- A frontend application that handles the functional redundancy of the frontend.

Proxy/Gateway and frontend computer are logically connected via a physical WAN connection by means of routers. Redundant SCADA applications, databases, IEDs or other elements not shown in Figure 27 are not in the scope of this technical report.

An ACSI client or server according to this technical report is typically one instance of a software process, implementing an IEC 61850 client or server according to IEC 61850-8-1:2011. Each client or server has its own process data image and resources such as control blocks and event buffers. To benefit from the redundancy it is recommended to use separate network interface cards for each client or server and keep the communication networks separated, to avoid a single point of failure.

A physical connection should support the associations as specified in IEC 61850-7-2:2010. Mapping to specific profiles is selected in accordance with the requirements of the application functions.

The redundancy scheme may be applied to the basic system configuration, which is given in Figure 27. The redundancy scheme has been chosen to fulfil the following redundancy rules:

- Proxy/Gateway applications (substation) and front end applications (control centre) can handle multiple (N) logical associations.
- The N logical associations represent one redundancy group.
- A logical association can have four states: active, standby, supervised and off.
- Only one logical association is in active state, all other logical associations of a redundancy group are in standby state, supervised state or off.
- The Proxy/Gateway application is sending time-stamped user data in parallel on all logical associations in active or standby mode of a redundancy group.
- The frontend application defines which logical association of a redundancy group is in active state.

NOTE The client determines incoming user data via different logical connections to be identical on data reference, data type, content and time stamp basis (time stamp according to IEC 61850-7-2:2010, 6.1.2.9. The client may use a time window for discrimination of identical user data.

It is not necessary that the user data sent via different logical associations of a redundancy group has to be generated out of a common process data image.

7.1.2.4.2 Selection of the specific communication service mapping (SCSM)

The SS-CC communication makes use of the mapping to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3 as specified in IEC 61850-8-1:2011. Additional T-Profiles may be used for WAN communication. See also IEC TR 61850-90-12.

7.1.2.4.3 Association model

The two party application association class model according to IEC 61850-7-2:2010 is used. The application of dedicated protection mechanisms, i.e. to ensure source authentication, message integrity and confidentiality is recommended. Authentication for IEC 61850 is defined in IEC TS 62351-4:2007. Refer to 5.9.5.2 also.

7.1.2.4.4 Association states

The status of an association between the frontend application and the Proxy/Gateway application is controlled by the frontend application. An association can have the states according to Table 15. The table defines also which actions are possible in that state.

Table 15 – Link states

State	Reporting	Control	Setting group control	Logging	File transfer	Link supervision
Off	No	No	No	No	No	No
Supervised	No	No	No	No	No	Yes
Standby	Yes	No	No	No	No	Yes
Active	Yes	Yes	Yes	Yes	Yes	Yes

Generally the frontend application is responsible to follow the rules defined in Table 15.

State Off

No communication between the frontend client and the Proxy/Gateway.

State Supervised

Frontend client has at least established a TCP/IP connection with the Proxy/Gateway and monitors the status of the link. No data exchange on application level.

State Standby

Frontend client has established an MMS association with the Proxy/Gateway and enabled the reporting. Client may not issue any control action on this link.

State Active

Frontend client has established an MMS association with the Proxy/Gateway and enabled the reporting. This link is fully functional. Control actions may be performed.

7.1.2.4.5 Usage of buffered and unbuffered reporting

The usage of buffered / unbuffered reporting depends on the required redundancy configuration and the operation mode of the non active link(s), as shown in Table 16. The type of reporting selected for a redundancy type does not imply that the client has enabled the reporting. Table 15 shows whether reports are sent in a given link state.

Table 16 – Usage of buffered / unbuffered reporting for the redundancy schemes

Redundancy type	Operating mode of link	Reporting type Alarms/events		Reporting type measurands	
		Unbuffered	Buffered	Unbuffered	Buffered
No redundancy	Off	n/a	n/a	n/a	n/a
	Supervised	n/a	n/a	n/a	n/a
	Standby	n/a	n/a	n/a	n/a
	Active	No	Yes	Yes	Yes
AccessPoint redundancy	Off	No	Yes	Yes	Yes
	Supervised	No	Yes	Yes	Yes
	Standby	Yes	Yes	Yes	Yes
	Active	Yes	Yes	Yes	Yes
Device redundancy	Off	No	Yes	Yes	Yes
	Supervised	No	Yes	Yes	Yes

Redundancy type	Operating mode of link	Reporting type Alarms/events		Reporting type measurands	
		Unbuffered	Buffered	Unbuffered	Buffered
	Standby	Yes	Yes	Yes	Yes
	Active	Yes	Yes	Yes	Yes
Multiple redundancy	Off	No	Yes	Yes	Yes
	Supervised	No	Yes	Yes	Yes
	Standby	Yes	Yes	Yes	Yes
	Active	Yes	Yes	Yes	Yes

7.1.2.4.6 Selection guide for redundancy configurations

The supported redundancy schemes allow a variety of configurations. Table 17 will give a guideline which configuration is preferably used depending on the requirements.

Table 17 – Requirements versus redundancy scheme

Requirement	No redundancy	Access point redundancy	Device redundancy frontend	Device redundancy frontend and proxy	Multiple redundancy
Data exchange between Proxy/Gateway and frontend	yes	yes	yes	yes	Yes
Handle single failure in communication network	no	yes	yes	yes	Yes
Handle a single failure in control centre / SCADA applications	no	no	yes	yes	Yes
Handle a single failure in the Proxy/Gateway application	no	no	no	yes	yes

7.1.2.5 Redundancy configurations

7.1.2.5.1 General

In the following redundancy configurations (Figure 28 to Figure 32) the active link is shown in green colour. Standby links are shown in blue colour.

7.1.2.5.2 No redundancy

The configuration in Figure 28 implements the basic functionality of a SS-CC communication. It is a simple client / server scheme without redundancy.

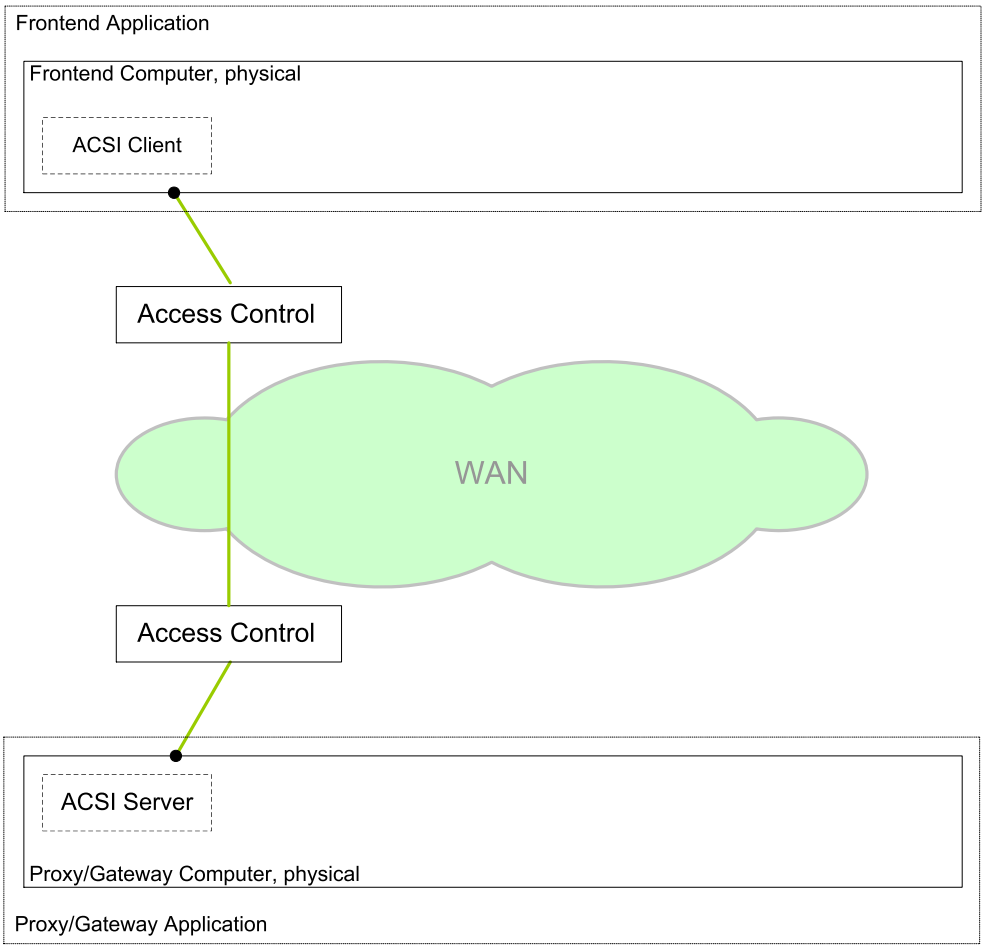


Figure 28 – Configuration without redundancy

Buffered reporting may be used to avoid loss of data in case of short communication interruptions. Resources for buffering data on the Proxy/Gateway computer are limited; therefore a long lasting interruption of the communication may result in loss of data.

7.1.2.5.3 AccessPoint redundancy

The configuration in Figure 29 provides a network redundancy. Two independent ACSI clients establish an independent association to a Proxy/Gateway server. The client redundancy logic takes care that the data of only one communication link is forwarded to SCADA and other control centre applications. The telecommunication provider has to ensure that each link has a separate path through the WAN to avoid a single point of failure. The second link is either supervised or standby and the received data are temporarily stored in a standby buffer (refer to 7.1.2.5.10).

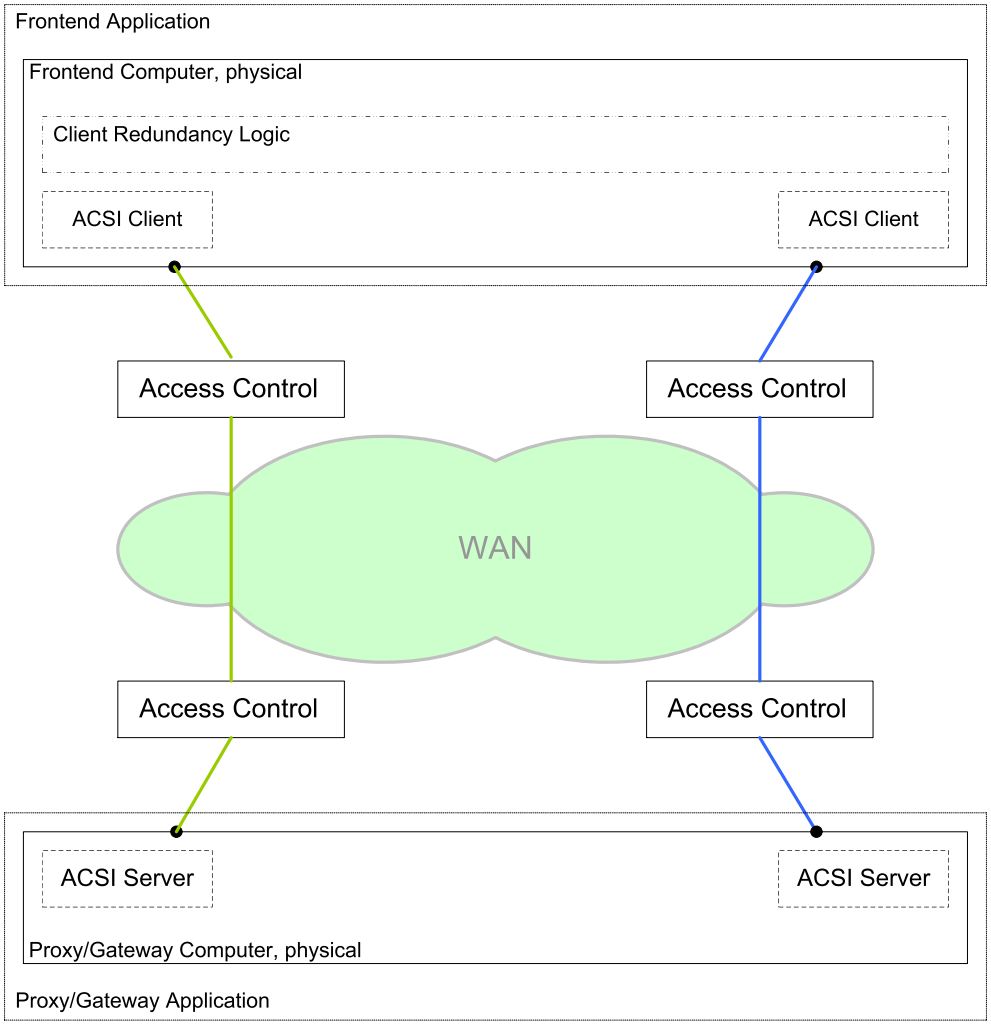


Figure 29 – AccessPoint redundancy

Buffered reporting may be used in supervised mode. In this case the buffer time in the Proxy/Gateway shall be greater than the time to detect the loss of the association on the active link plus the time to establish the association on the standby link.

NOTE It is assumed that in case of standby mode only the data of the active link is processed by the SCADA.

As a variation of the redundancy configuration shown in Figure 29, it is also possible to have only one ACSI Server in the Proxy/Gateway computer. This ACSI server is then connected to two access points. In this variation both ACSI client associations can use different RCB instances, or the same (B)RCB instance at the one ACSI server. In the second case only the link modes ‘supervised’ and ‘off’ are possible. From server perspective the two clients appear as the same IED with different IHMI logical node instances.

7.1.2.5.4 Device redundancy of frontend computers

The configuration in Figure 30 provides a network redundancy plus a redundant frontend computer in the control centre. The telecommunication provider has to ensure that each link has a separate path through the WAN to avoid a single point of failure. Two independent ACSI clients running on two independent frontend computers establish an independent association to a single Proxy/Gateway server with multiple access points in the substation. The second link is either supervised or standby and the received data are temporarily stored in a standby buffer (refer to 7.1.2.5.10).

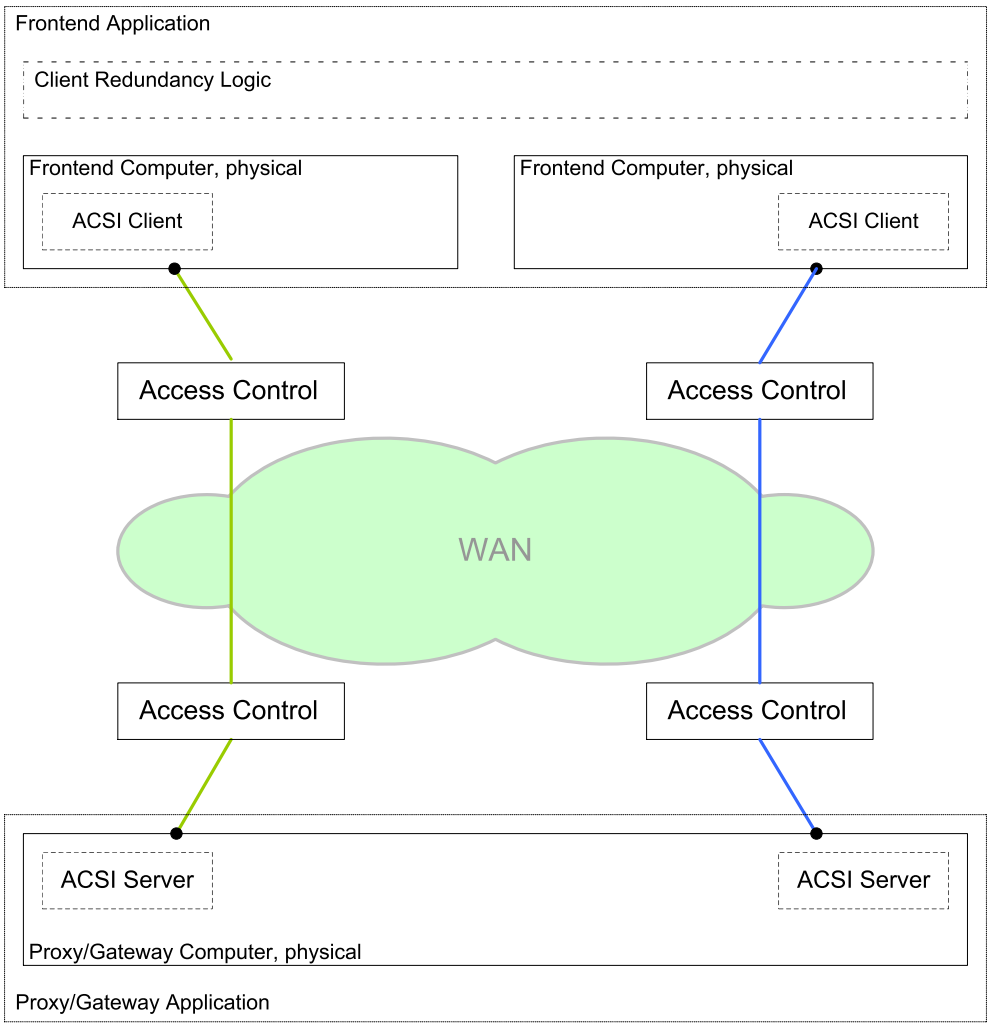


Figure 30 – Device redundancy of frontend computers

Buffered reporting may be used in supervised mode. In this case the buffer time in the Proxy/Gateway shall be greater than the time to detect the loss of the association on the active link plus the time to establish the association on the standby link.

NOTE It is assumed that in case of standby mode only the data of the active link is processed by the SCADA.

As a variation of the redundancy configuration shown in Figure 30, it is also possible to have only one ACSI Server in the Proxy/Gateway computer. This ACSI server is then connected to two access points. In this variation both ACSI client associations can use different RCB instances, or the same (B)RCB instance at the one ACSI server. In the second case only the link modes ‘supervised’ and ‘off’ are possible. From server perspective the two clients appear as two different but cooperating IEDs sharing the same RCBs.

7.1.2.5.5 Device redundancy of Proxy/Gateway and frontend computers

The configuration in Figure 31 provides a network redundancy plus redundant frontend and Proxy/Gateway computers. The telecommunication provider has to ensure that each link has a separate path through the WAN to avoid a single point of failure. Each ACSI client on the frontend computers establishes an independent association to an independent Proxy/Gateway server in the substation. The second link is either supervised or standby and the received data are temporarily stored in a standby buffer (refer to 7.1.2.5.10).

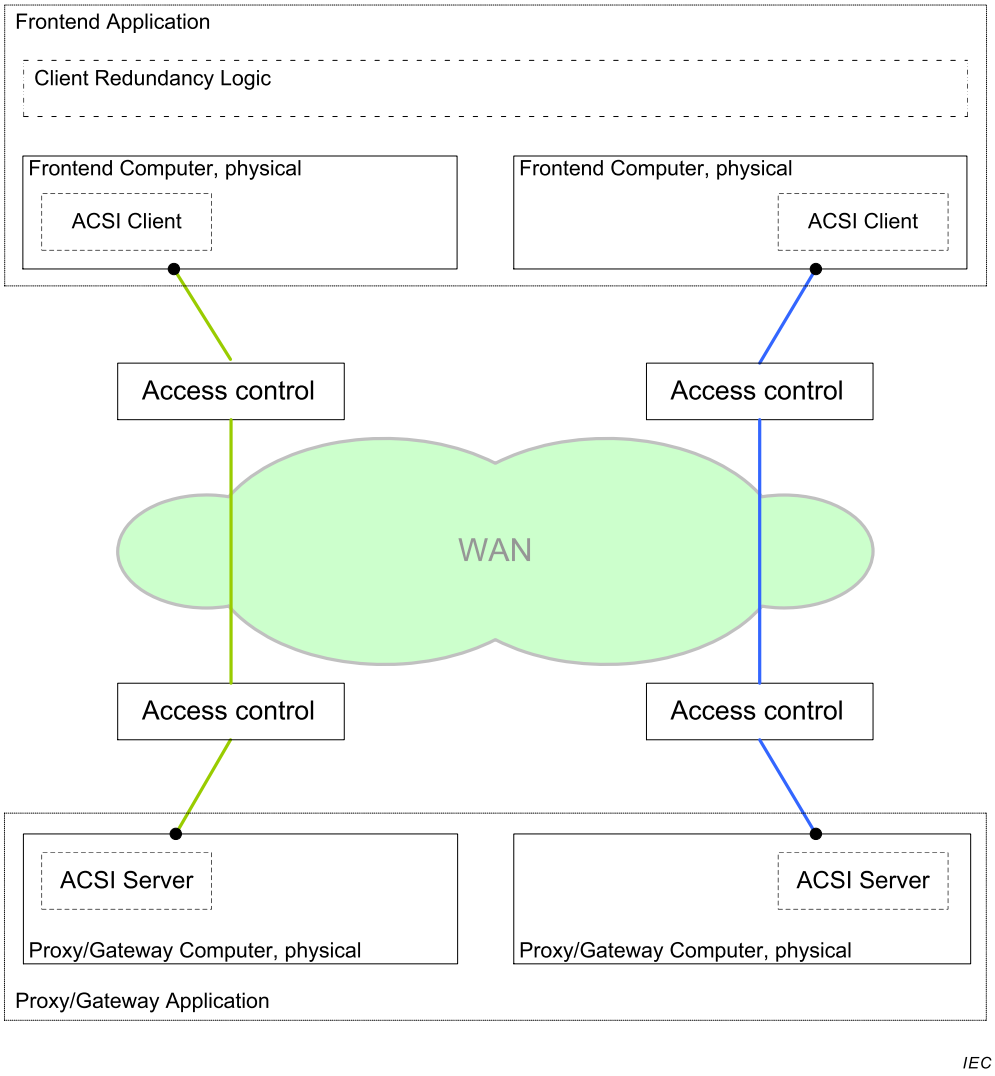


Figure 31 – Device redundancy of Proxy/Gateway and frontend computers

Buffered reporting may be used in supervised mode. In this case the buffer time in the Proxy/Gateway shall be greater than the time to detect the loss of the association on the active link plus the time to establish the association on the standby link.

NOTE It is assumed that in case of standby mode only the data of the active link is processed by the SCADA.

7.1.2.5.6 Multiple redundancies

The configuration in Figure 32 provides an enhanced redundancy scheme with four independent associations belonging to one redundancy group. The telecommunication provider has to ensure that each link has a separate path through the WAN to avoid a single point of failure. Each ACSI client on the frontend computers establishes an independent association to an independent Proxy/Gateway server in the substation. The other links are either supervised or standby and the received data are temporarily stored in a standby buffer for each link (refer to 7.1.2.5.10).

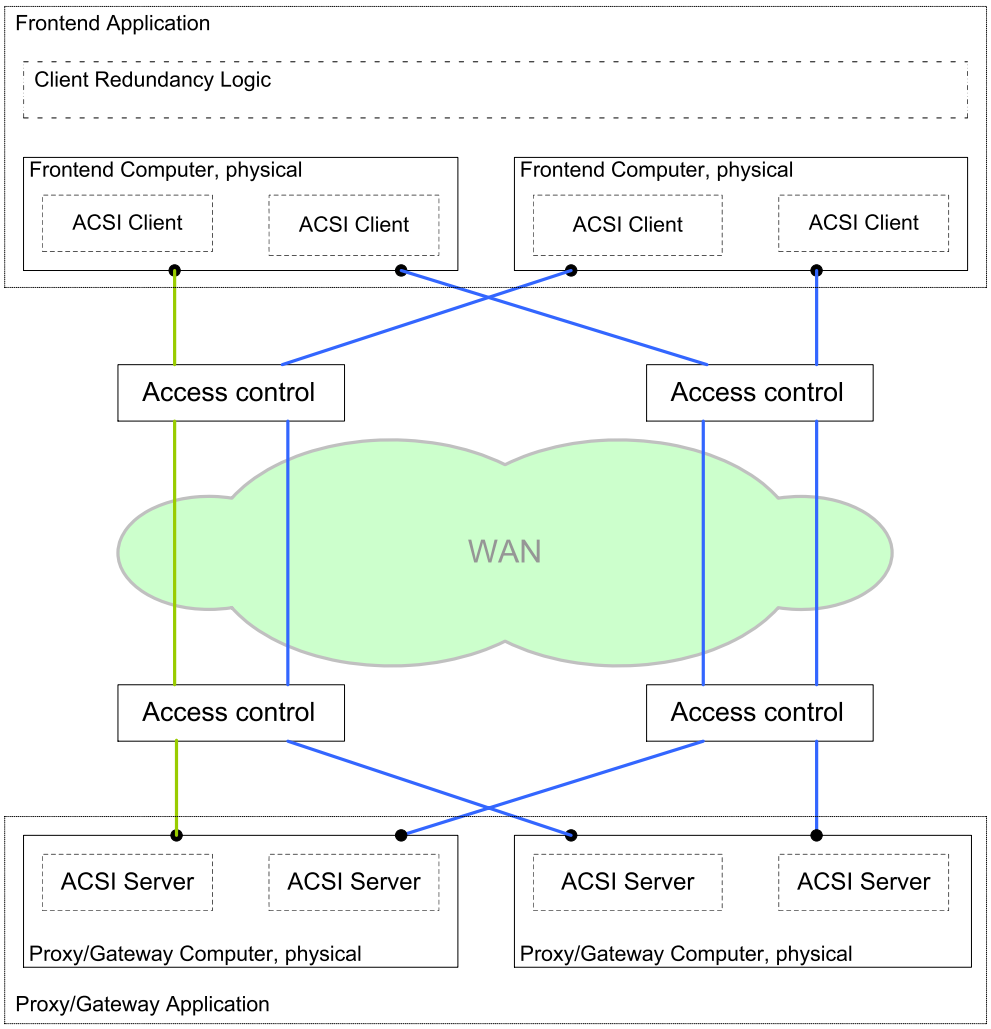


Figure 32 – Multiple redundancies

Buffered reporting may be used in supervised mode. In this case the buffer time in the Proxy/Gateway shall be greater than the time to detect the loss of the association on the active link plus the time to establish the association on the standby link.

NOTE It is assumed that in case of standby mode only the data of the active link is processed by the SCADA.

As a variation of the redundancy configuration shown in Figure 32, it is also possible to have only one ACSI Server per Proxy/Gateway computer. This ACSI server is then connected to two access points. In this variation both ACSI client associations from the same frontend IED can use different RCB instances, or the same (B)RCB instances at the one ACSI server. In the second case only the link modes ‘supervised’ and ‘off’ are possible. From server perspective the two clients appear as the same IED with different IHMI logical node instances, connected via the same or different server access points.

7.1.2.5.7 Transport reliability

Whilst a communication path between sender and receiver exists, the reliability and order of the data is provided by the use of the TCP transport layer. TCP allows detecting the loss of data and will automatically retransmit data that are not acknowledged by the receiving side.

To support the detection of missing reports on application level the ACSI client in the front end computer may set the following OptFlds of the report:

- sequence number (to include SqNum in the report)
- report-time-stamp (to include TimeOfEntry in the report)
- buffer-overflow (to include BufOvfl in the report)
- entryID (to include EntryID in the report)

The ACSI server in the Proxy/Gateway computer has to support these OptFlds.

Redundancy and buffered reporting may be used to increase the transport reliability in case of interruptions of the active link.

7.1.2.5.8 Link supervision

Link supervision is essential for a reliable detection of a link loss. As defined in IEC 61850-8-1:2011 the TCP_KEEPALIVE according to RFC 1122 is used.

The recommended minimum-maximum value of the allowable time range is equal to the minimum transfer time of the used performance classes according to Table 5.

7.1.2.5.9 Client redundancy logic

The task of the client redundancy logic is to manage the switchover between the available links in redundant systems. When the link supervision signals a connection loss to the client redundancy logic the active link will go to the standby or supervised mode. The next available link will change from standby or supervised to the active mode. The client redundancy logic will not switch to supervised links when the links supervision indicates a communication error. In case the non-active links are not supervised, the client redundancy logic will switch to the next link. Eventually it may happen that the now active link cannot connect to the Proxy/Gateway server either. In this case the redundancy logic will switch to the next link, or when all available links have been probed, back to the initial link. Whether the redundancy logic continues to probe the other links at the same or a lower rate or remains on the initial link is a matter of configuration.

The order in which the links are tested is an implementation issue.

One link may be defined as a preferred link. After system start up the redundancy logic will first use the preferred link to establish a connection with the Proxy/Gateway server in the substation. When another link is set to preferred, the redundancy logic will initiate a switch over to the preferred link.

Additionally the client redundancy logic implements the buffer handling according to 7.1.2.5.10.

NOTE Whether a non-active link is in state standby mode or supervised mode depends on the configuration of the usage of link supervision for the redundant links.

7.1.2.5.10 Buffer Handling

Communication buffers are required to support the redundancy schemes. Without additional buffering seamless switchover between the links is not possible. The principle communication architecture including the buffers is shown in Figure 33.

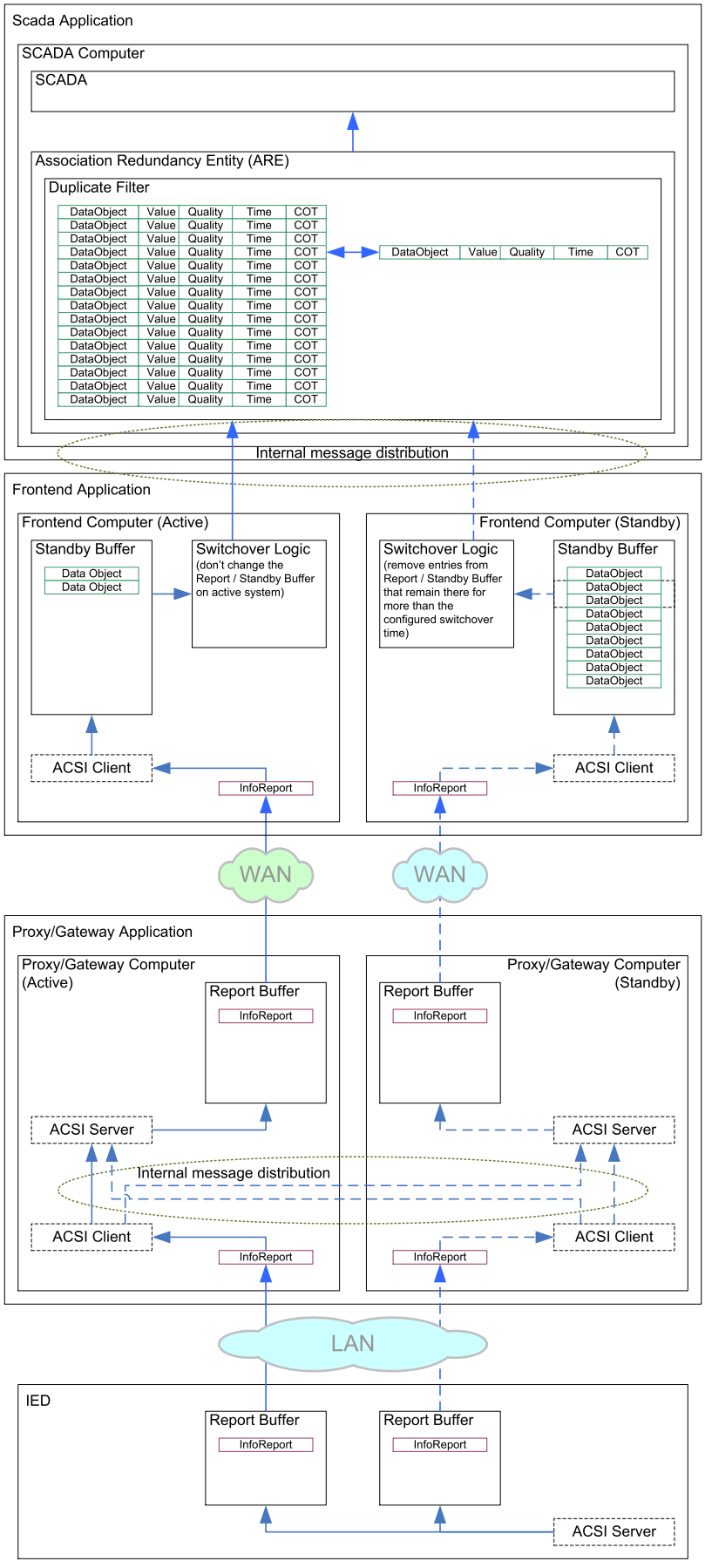
Data received by the Proxy/Gateway client from the IED is forwarded to all Proxy/Gateway servers, depending on the redundancy configuration within the substation. How this is done is a local issue of the Proxy/Gateway implementation.

When unbuffered reporting is used for the control centre connection there are no buffers on the Proxy/Gateway side. When no redundancy is implemented, or the redundant links are operated in supervised mode, this may result in loss of data during the switchover from the formerly active link to the now active link. Buffered reporting may be used to overcome this situation. The report buffers have to be big enough to buffer all data changes that appear during the switchover. The required size depends on the update rate of the reported data, the number of data to report and the switchover time and therefore cannot be determined in advance.

When the redundant links are operated in standby mode the data will be transferred in parallel on all communication links. On the one hand this allows the switch over between these links without loss of data; on the other hand it may be required to implement a method to handle data that has been received on multiple links.

The data received on the standby links are stored in a link specific standby buffer. Data will be deleted from the standby buffer after a configurable time when no switchover happens. The deletion time has to be greater than the time to detect a communication error on the active link plus the time required to switch over to the redundant link. To avoid race conditions in the potential duplicate filter the standby link does not forward the received data to the SCADA application.

When a link switchover has taken place, all entries in the standby buffer are forwarded to the control centre applications (SCADA, etc.) before new incoming data of the now active link are forwarded. As IEC 61850 uses time-stamped data, the duplicate filter can detect and remove duplicate data based on the timestamp. The duplicate filter keeps track of all MMS addresses and their last received timestamp. When a data object value is sent to the duplicate filter, the filter checks whether the data object belonging to it has been seen before. If not, the data object is added to the repository, together with the timestamp and potentially other filter criteria and forwarded to the SCADA application(s). The duplicate filter checks the timestamps of the received data. Data objects with timestamps older than the entry in the repository will be discarded. When the timestamp is newer the repository will be updated with the new timestamp and the data object value(s) with timestamp and quality will be forwarded to the SCADA application(s). The detailed handling of the standby buffer and detection of duplicate data is a local, implementation specific topic and therefore out of the scope of this technical report.



IEC

Figure 33 – Usage of buffers and duplicate filter

7.1.3 Proxy/Gateway model

7.1.3.1 General

IEC 61850-7-1:2011, 8.2.3, describes the use of proxies and gateways. Subclause 7.1.3.2 extends the modelling rules of IEC 61850-7-1:2011. Whether a Proxy/Gateway implementation supports the full set of model transformations or only a subset is a local issue and depends on the capabilities of the Proxy/Gateway.

7.1.3.2 Modelling rules

The basic requirements of the Proxy/Gateway are as follows:

- The Proxy/Gateway client and server side are treated as separate IEDs. In case of physical redundancy of an IED, each device has its own SCL description. The communication interface of the IED is described by appropriate SCL objects in -icd, -iid, -cid, -sed and -scd files according IEC 61850-6:2009.
- All data from the IEDs that are used by the control centre are included on the Proxy/Gateway data model.
- A logical node that appears in the data model of the Proxy/Gateway
  - includes all mandatory data of the respective logical node of the IED.
  - includes those optional data of the respective logical node of the IED, which are used by the control centre.
  - sets the validity of data objects to invalid and the detailQual to failure in case the data is not received from the respective IED. All other data attributes of those data objects contain a value but cannot be used for further processing.
  - sets the validity of data objects to questionable and the detailQual to oldData in case the data was not updated during a specific time interval (e.g. due to “fail silent” errors) See also IEC 61850-7-3:2010, 6.2.8 for more details on the relation between quality identifiers.
- In principle the control process is transparent through the Proxy/Gateway, but includes appropriate error handling as described in 7.2.2.
- A Proxy/Gateway implements at least one logical device that relates to the Proxy/Gateway itself.
- It has to be ensured that all necessary data is available for the correct operation of the intended functionality (Mod/Beh).
- To model the relation between the Proxy/Gateway and the original physical device the common LN class definition from IEC 61850-7-4:2010 is extended by one data object. Table 18 shows only the new (additional) data object. This new data object is in the namespace “(Tr)IEC 61850-90-2:2015A”. This namespace is transitional according to IEC 61850-7-1:2011, 13.3.2.

Table 18 – Extension of the common LN class

Common LN class				
Data object name	Common data class	Explanation	T	M/O/C
Data objects				
Mandatory and conditional logical node information (shall be inherited by ALL LN but LPHD)				
Data objects				
Mir	SPS	If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.		C6
Condition C6: if and only if the LN, containing the data object Mir, mirrors a LN from another LD that does not reflect this physical device (in which case its stVal must be true).				

7.1.3.3 Naming

7.1.3.3.1 General

There is a need to uniquely identify an object within the CC application. Currently, IEC 61850-7-2:2010 defines references of objects as follow:

Logical node reference: <LDName>/<LNName>

Data object reference: <LDName>/<LNName>.<DOName>

IEC 61850-6:2009, 8.5.3, gives more details on signal identification.

7.1.3.3.2 Product-related naming

Using product related naming the LDName is build by the concatenation of the IED name and the IED relative LD instance identification.

In consequence the IED name of the Proxy/Gateway has to be unique within the control centre SCD file. Addressing information from the control centre then typically results in a product specific name.

The product related names for the current measurements in Figure 34 in the Proxy/Gateway would be:

- IED99IED2MEAS/MMXU1.A
- IED99IED4MEAS/MMXU2.A

Exchanging the substation IED with an IED with another IED name or a different LN structure would directly impact the address of the Proxy/Gateway server, as the IED name and LD name are part of the data object address of the Proxy Gateway server.

7.1.3.3.3 Function-related naming

The address structure of the SS-CC interface should be independent of the product related naming within the substation, to allow device exchange and/or reconfiguration without affecting the control centre interface.

This goal can be achieved by the use of function related naming. Function related naming uses the substation topology to create LD names in the Proxy/Gateway server according to the substation topology.

The function related names for the current measurements in Figure 34 in the Proxy/Gateway server would be:

- AA1E1Q1T1MMXU.A
- AA1E1Q2T1MMXU.A

The uniqueness of the reference is given by the uniqueness of the substation name.

For the substation – control centre interface the usage of function related naming is preferred, based on IEC 81346-1:2009 and IEC 81346-2:2009 as recommended by IEC 61850-6:2009.

The whole example SCL file of the substation can be found in Annex C.

For redundant systems the functional reference from the substation section to the IED logical node is done only for that IED that does not have the eTr-IEC61850-90-2:RedundantServerTo element. By this the uniqueness of the LN class reference can be achieved.

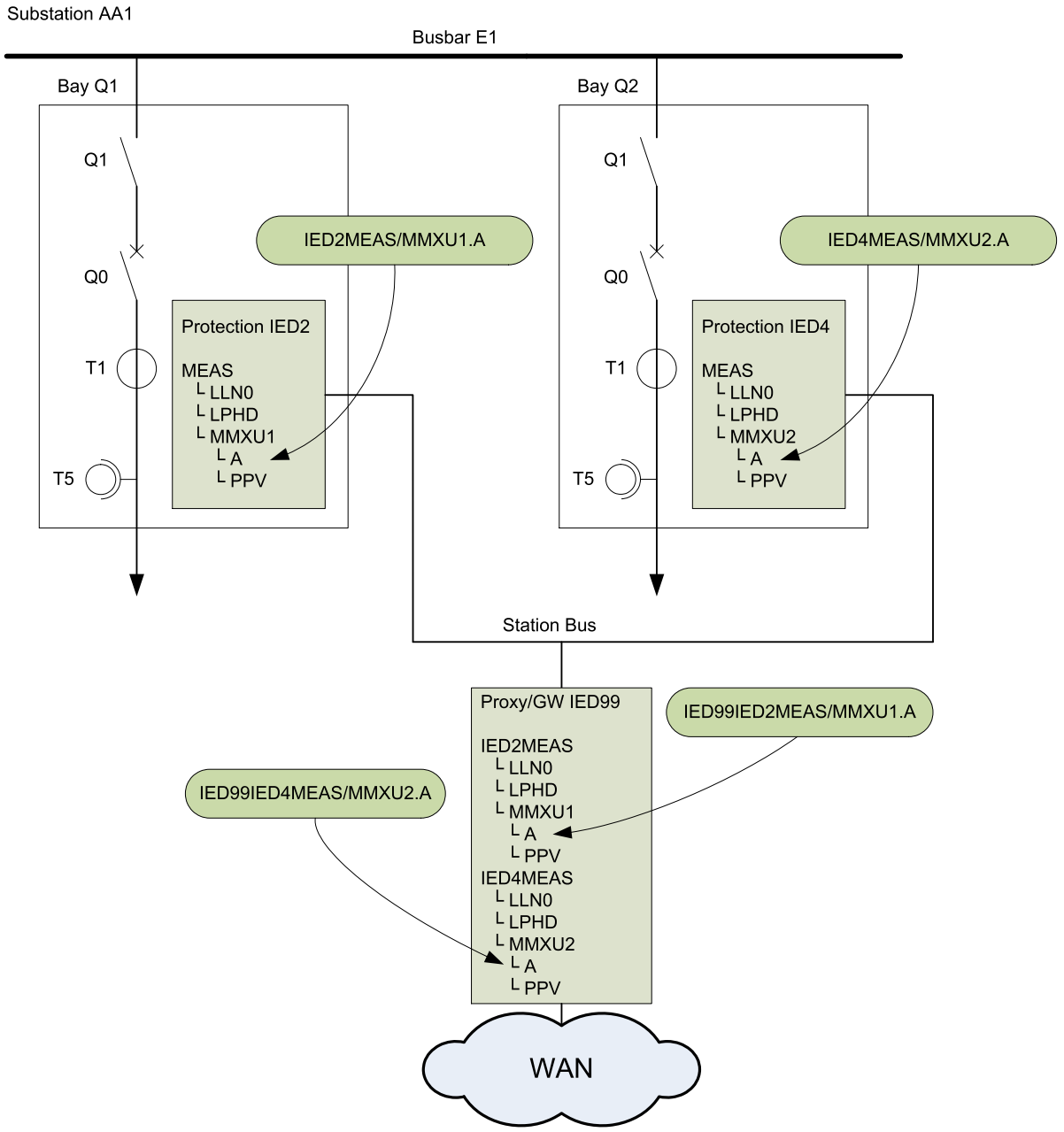


Figure 34 – Product related naming Proxy/Gateway

7.1.3.4 Expressing functional links between the Proxy/Gateway server model and the IED data model

To support end to end testing through the Proxy/Gateway functional links between the data objects in the Proxy/Gateway server and the original source of information in a substation IED can be expressed, using the SCL extensions defined in 6.3.3.

In the example of Figure 34 the LN instance “1” of LN class “MMXU”, of the IED named “IED2”, attached to the bay “Q1”, of voltage level “E1” of the substation “AA1” is mapped to the LN instance “1” of LN class “MMXU” of the Proxy/Gateway named “IED99” in the LD “IED2MEAS”. As described in 6.3.3.3 links can be created on each level of the data model using the element eTr-IEC61850-90-2:ProxyOf.

In the example of Figure 34 the reference from the measurement LN of the Proxy/Gateway IED99 would be:

```
<LN lnClass="MMXU" lnType="MMXU" inst="1">
   <Private type="eTr-IEC61850-90-2">
      <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED2" ldInst="MEAS"
         lnClass="MMXU" lnInst="1"/>
   </Private>
</LN>
```

7.1.3.5 Use cases

7.1.3.5.1 General

In subclause 5.10 requirements for the modelling of a Proxy/Gateway server are given. In the following subclauses those requirements are treated in more detail and the corresponding Proxy/Gateway server object model is shown. In the use case examples only those LNs and DOs are shown that are directly involved, all other are not shown to increase the readability.

The sample SCL files containing most of the use cases can be found in Annex C and Annex D.

7.1.3.5.2 Use Case – Preserve the logical devices coming from IED level as logical device of the Proxy/Gateway server

The Proxy/Gateway server repeats the object model of the original IED without modifying the structure of the information within the Proxy/Gateway. In other word, either the original logical device is available or is not available within the Proxy/Gateway IED, but in case it is available, the original logical nodes are member of the same logical devices within the Proxy/Gateway IED. Figure 35 illustrates such a Proxy/Gateway IED. The IED5 of bay Q2 contains the logical device COUNT, which is repeated in the Proxy/Gateway IED99. The name of the LD was changed from COUNT to IED5COUNT to ensure the uniqueness of the LD names in the Proxy/Gateway server. To show that the Proxy/Gateway LD IED5COUNT is not the original source of the data, this LD set the data LPHD.Proxy.stVal to TRUE. The logical device LD0 of the Proxy/Gateway IED however contains logical nodes related to the Proxy/Gateway IED functionality itself; therefore its LPHD.Proxy.stVal has a value of FALSE.

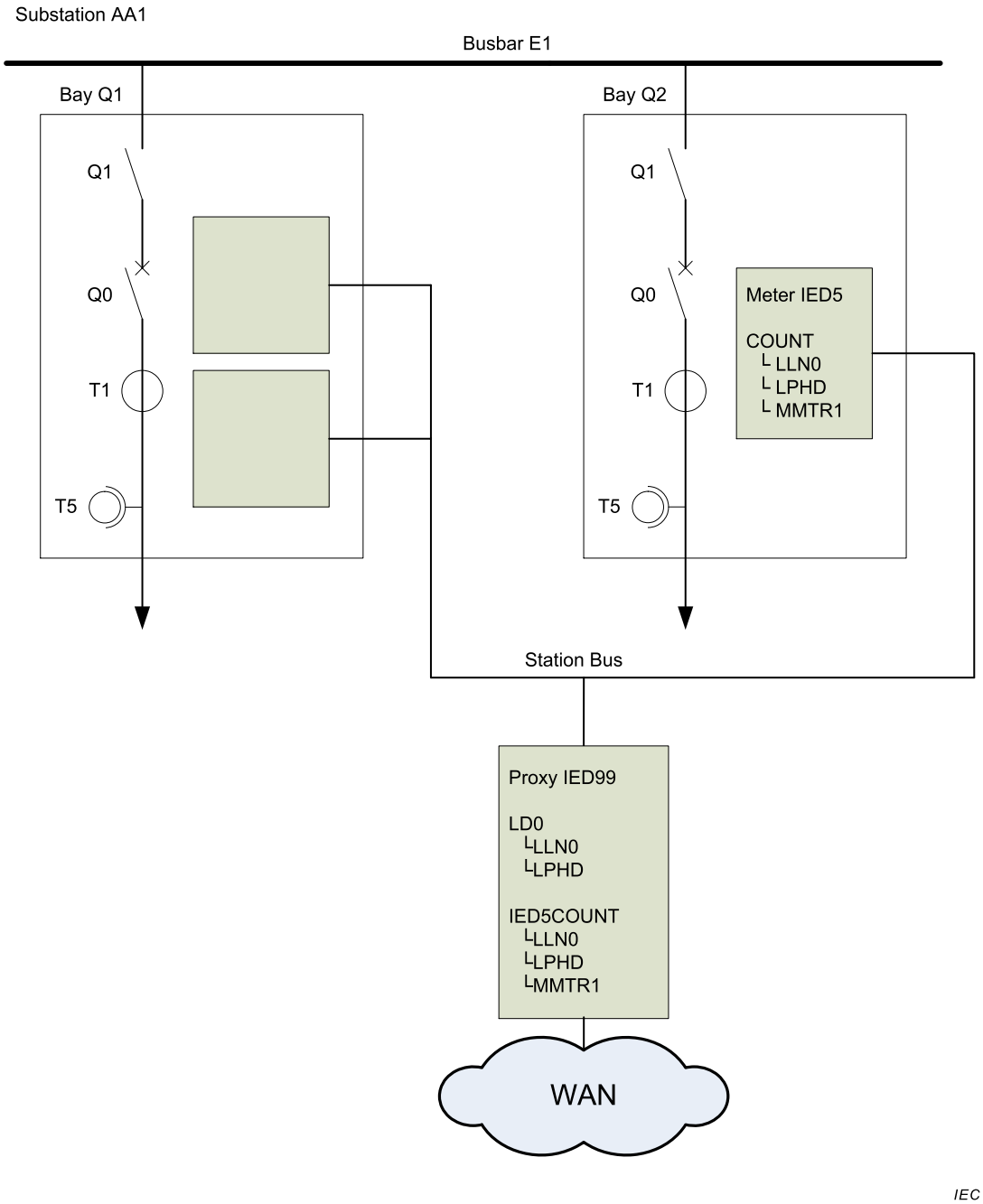


Figure 35 – Modelling a Proxy/Gateway IED – Preserving the logical devices

7.1.3.5.3 Renaming of logical devices coming from IED level into logical device of the Proxy/Gateway server

The logical device structure of the Proxy/Gateway is independent of the object model in the original IED. The new Proxy/Gateway server may support functional naming to provide an interface to the control centre which is independent of the product related naming within the substation. For this use cases the logical devices of the IEDs are completely copied to the Proxy/Gateway server, but the LD name is changed to the topological path where the function is located. Figure 36 illustrates such a Proxy/Gateway IED. To show that the Proxy/Gateway LD AA1E1Q2 is not the original source of the data, this LD set the data LPHD.Proxy.stVal to TRUE. The logical device LD0 of the Proxy/Gateway IED however contains logical nodes related to the Proxy/Gateway IED functionality itself; therefore its LPHD.Proxy.stVal has a value of FALSE.

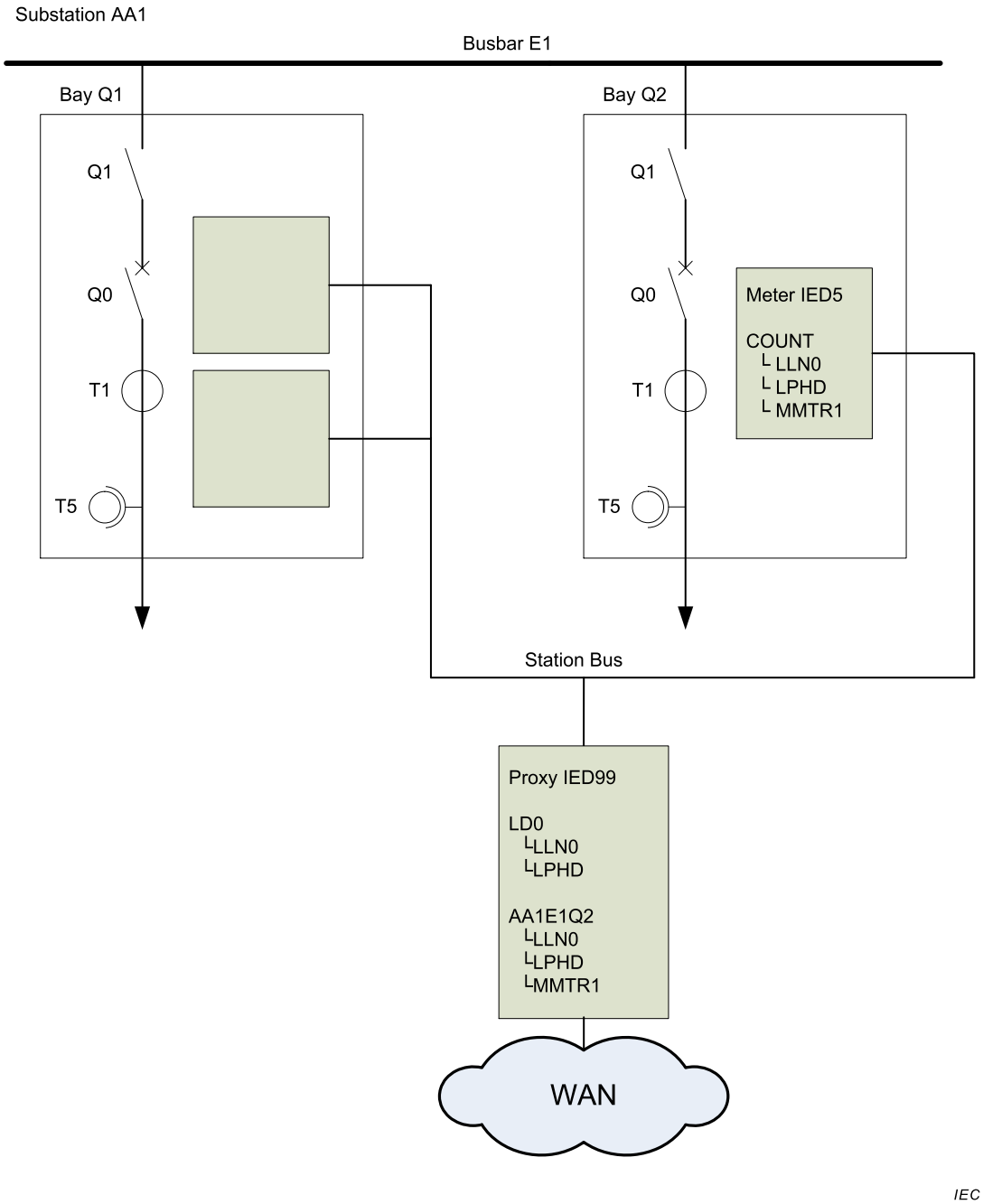


Figure 36 – Modelling a Proxy/Gateway IED – Renaming of logical devices

7.1.3.5.4 Use case – Rearranging/Renaming of logical nodes coming from IED level into logical device of the Proxy/Gateway server

As stated before it may make sense to hide IED implementation details from the control centre. The substation topology is used to create Logical Devices and the lowest functional level of the hierarchy is assigned as a LN prefix. In the example in Figure 37 the logical node Q0CSWI1 of IED1 has been renamed to QACSWI1. Additionally the instance number of the LN PTOC1 of IED2 has been changed to 2. Both LNs became part of the new LD AA1E1Q1. To show that the Proxy/Gateway logical devices AA1E1Q1is not the original source of the data this LD sets the data LPHD.Proxy.stVal to FALSE. The logical device LD0 of the Proxy/Gateway IED contains logical nodes related to the Proxy/Gateway IED functionality itself; thus its LPHD.Proxy.stVal has a value of FALSE.

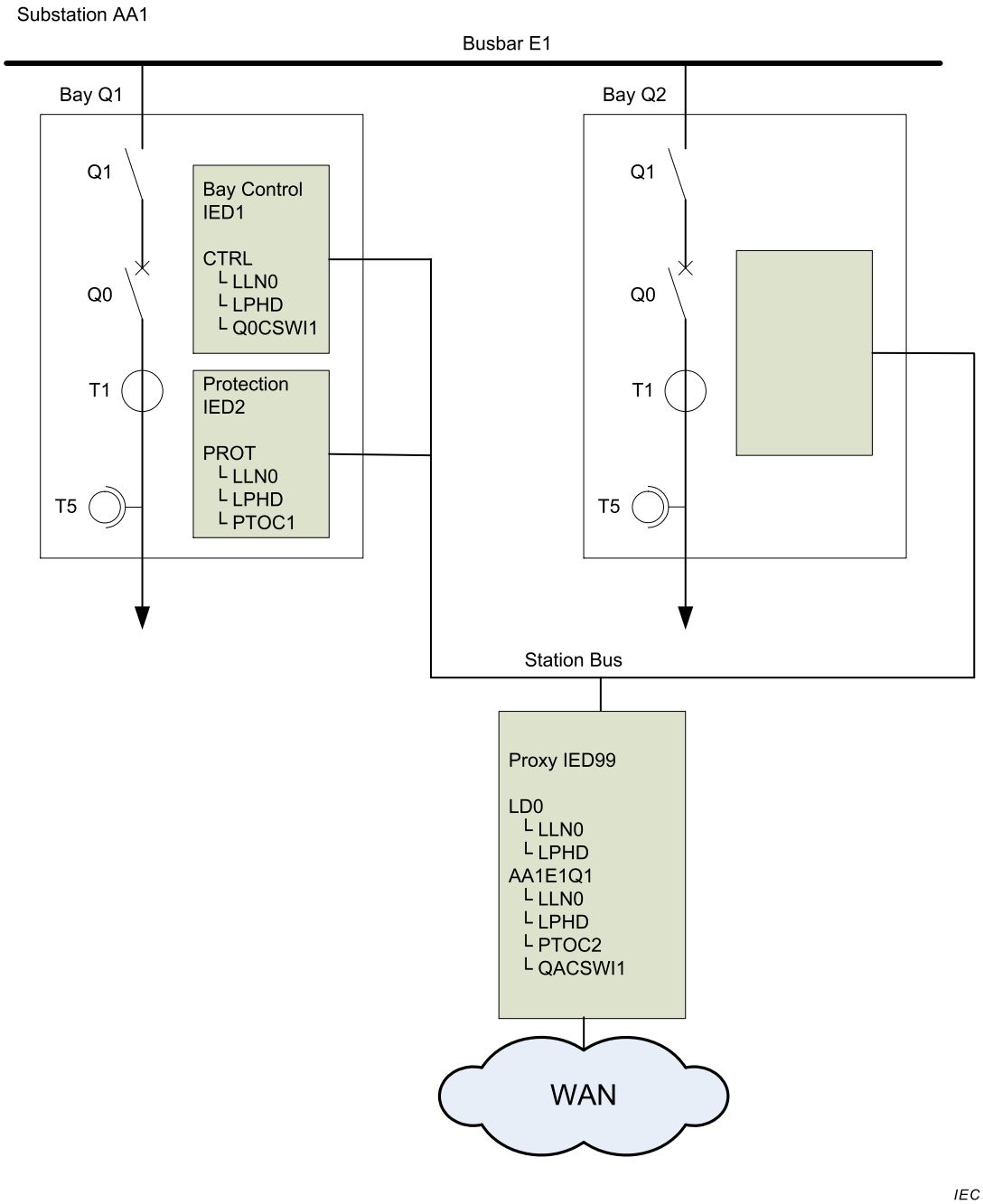


Figure 37 – Modelling a Proxy/Gateway IED – Rearranging logical nodes

When logical nodes from different IEDs are merged together into one logical device of the Proxy/Gateway server the values of Mod and Beh require special treatment. The value of Mod and Beh of the logical device in the Proxy/Gateway server is created locally and does not reflect the value of Mod and Beh of the logical devices in the source IEDs. The value of Mod of the logical nodes below the new logical device is the same as in the source IEDs. The value of the logical node Beh depends on the value of the logical device Mod in the Proxy/Gateway server. For more details on the handling of Mod and Beh see 7.1.3.6.4.

7.1.3.5.5 Use case – Merge of two or more information objects coming from two or more different logical nodes at IED level into one logical node of the Proxy/Gateway server

To achieve an IED and vendor independent object model for the control centre communication logical instances from one or more IEDs could be merged together. The new logical node

contains data objects from all source logical nodes. For sure this makes sense only for a limited number of logical nodes. As an example the logical nodes MMXU1 and MMXU2 of IED4 in Figure 38 are merged together to a new logical node MMXU1 in the LD AA1E1Q2 of the Proxy/Gateway IED99. The LN MMXU1 of the Proxy/Gateway is no longer an exact copy of the MMXU logical nodes in IED4, thus the LPHD.Proxy.stVal of the LD AA1E1Q2 is set to FALSE. The logical device LD0 of the Proxy/Gateway IED however contains logical nodes related to the Proxy/Gateway IED functionality itself; therefore its LPHD.Proxy.stVal has a value of FALSE.

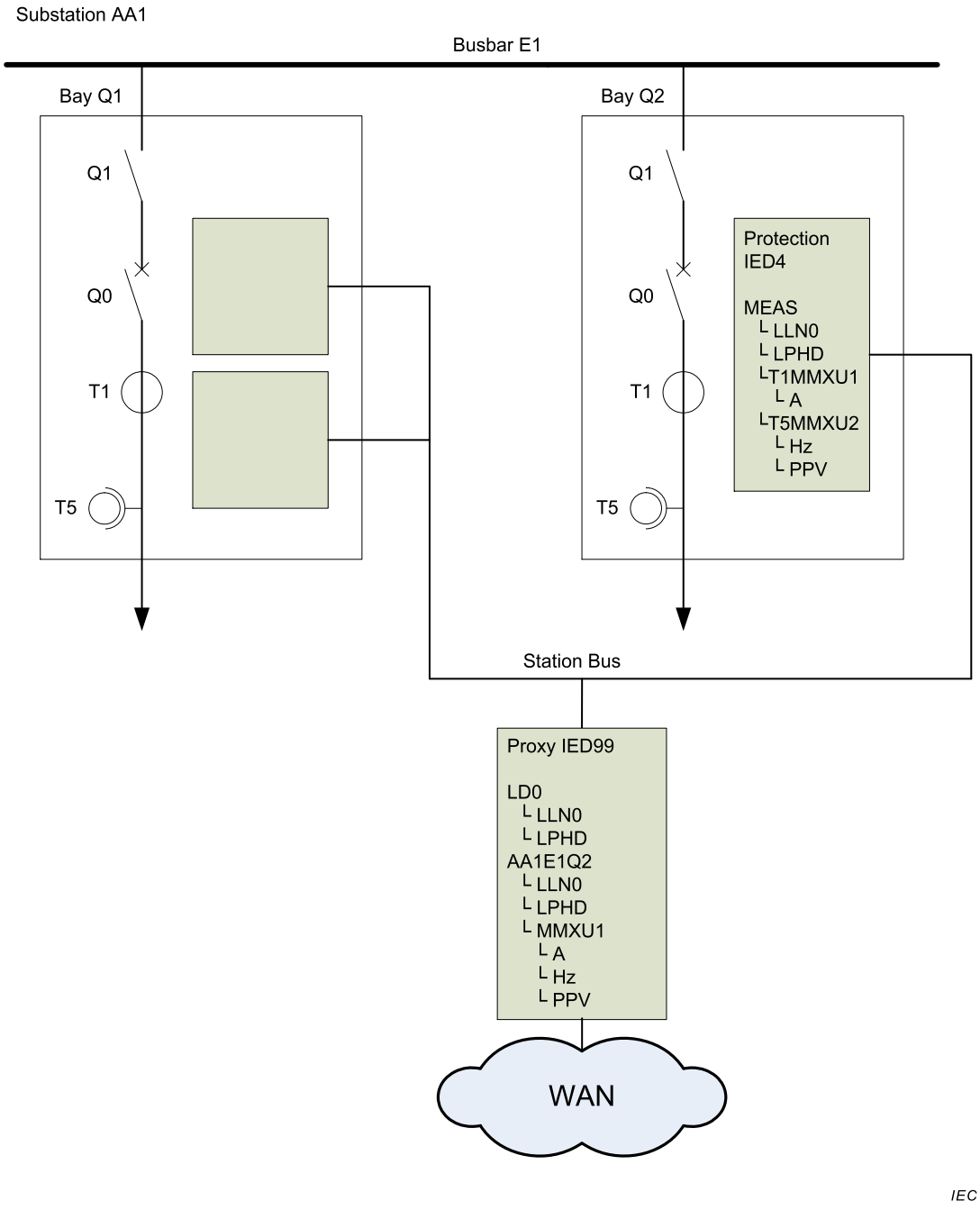


Figure 38 – Modelling a Proxy/Gateway IED – Merging of logical nodes

7.1.3.5.6 Use case – Split of information objects coming from one logical node at IED level into two or more logical nodes of the Proxy/Gateway server where each logical node contains a subset of the information objects of the original logical node

To achieve an IED and vendor independent object model for the control centre communication one logical node instance of an IED could be split up into several logical nodes, each containing only a subset of the data objects of the source logical. For sure this makes sense only for a limited number of logical nodes. As an example the logical node MMXU1 of IED2 in Figure 39 is split up into the new logical nodes MMXU1 and MMXU2 in the Proxy/Gateway IED99. The logical nodes MMXU1 and MMXU2 of the Proxy/Gateway are no longer an exact copy of the MMXU1 logical node in IED2, thus the LPHD.Proxy.stVal of the LD AA1E1Q1 is set to FALSE. The logical device LD0 of the Proxy/Gateway IED contains logical nodes related to the Proxy/Gateway IED functionality itself; therefore its LPHD.Proxy.stVal has a value of FALSE.

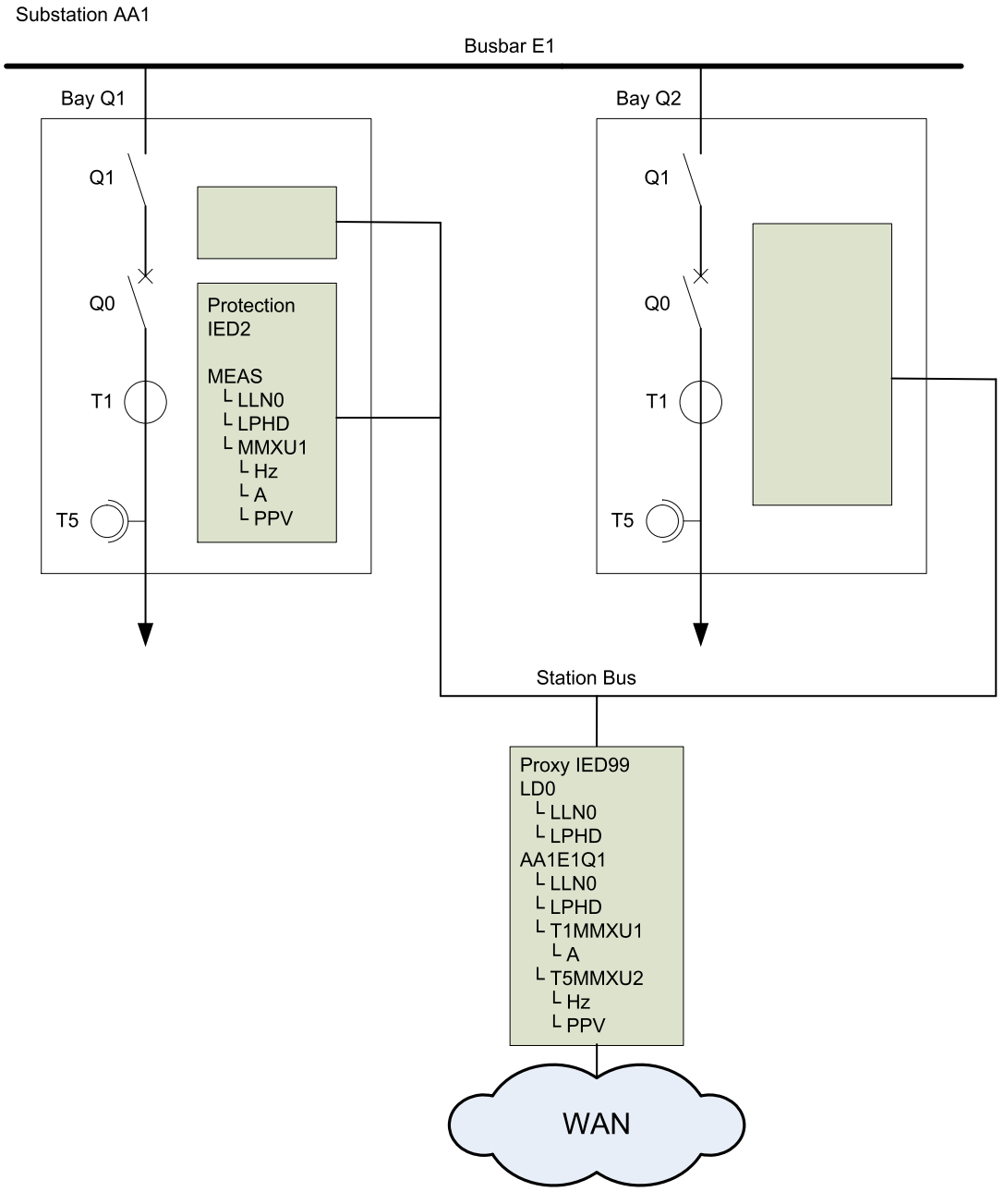


Figure 39 – Modelling a Proxy/Gateway IED – Splitting of logical nodes

7.1.3.5.7 Use case – Transform a generic information object (e.g. GGIO, GAPC...) at IED level into a semantically defined information object of the Proxy/Gateway server

Sometimes simple IO devices with a fixed object model (typically using GGIO logical nodes) are used to get access to some auxiliary data in the substation. For use in the control centre these data should be transformed to semantically defined data.

In the example in Figure 40 the data objects Ind1 and Ind2 of the logical node GGIO1 in IED6 are transformed into the data objects FADet and SwArcDet of the logical node SARC1 in the LD AA1E1Q2 of the Proxy/Gateway IED99. This logical node is local to the Proxy/Gateway, thus the LPHD.Proxy.stVal of the LD AA1E1Q2 containing this LN is set to FALSE. The logical device LD0 of the Proxy/Gateway IED contains logical nodes related to the Proxy/Gateway IED functionality itself; therefore its LPHD.Proxy.stVal has a value of FALSE.

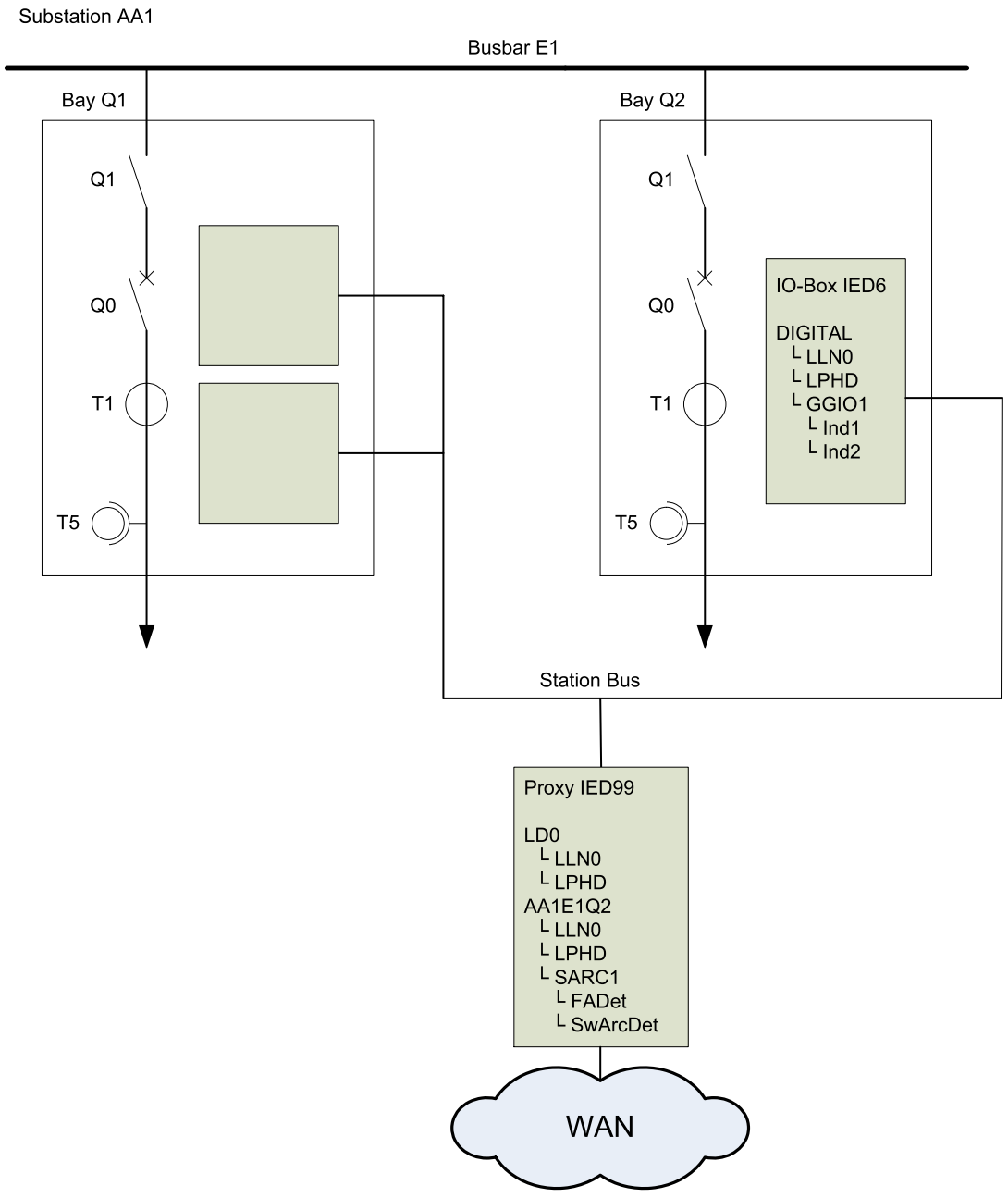


Figure 40 – Modelling a Proxy/Gateway IED – Transform to semantically defined LN

7.1.3.5.8 Transform a specific information object (e.g. MMTN) at IED level into another semantically defined information object of the Proxy/Gateway server

Sometimes it is necessary to create semantically defined data out of other semantically defined data, e.g. the control centre expects the net apparent energy TotVAh as measured value, but from the IED it is only available as counts of a metered value. This requires the data objects to be transformed from one logical node to another and changing the common data class. Typically these new data objects will not exist in the target logical node and have to be added with a private namespace. In the example in Figure 41 the data objects TotVAh, TotWh and TotVArh of the logical node MMTR1 in IED5 are transformed into the private data objects TotVAhMV, TotWhMV and TotVArhMV of the logical node MMXN1 in the Proxy/Gateway IED99. This logical node is local to the Proxy/Gateway, thus the LPHD.Proxy.stVal of the LD AA1E1Q2 containing this LN is set to FALSE. The logical device LD0 of the Proxy/Gateway IED contains logical nodes related to the Proxy/Gateway IED functionality itself; therefore its LPHD.Proxy.stVal has a value of FALSE.

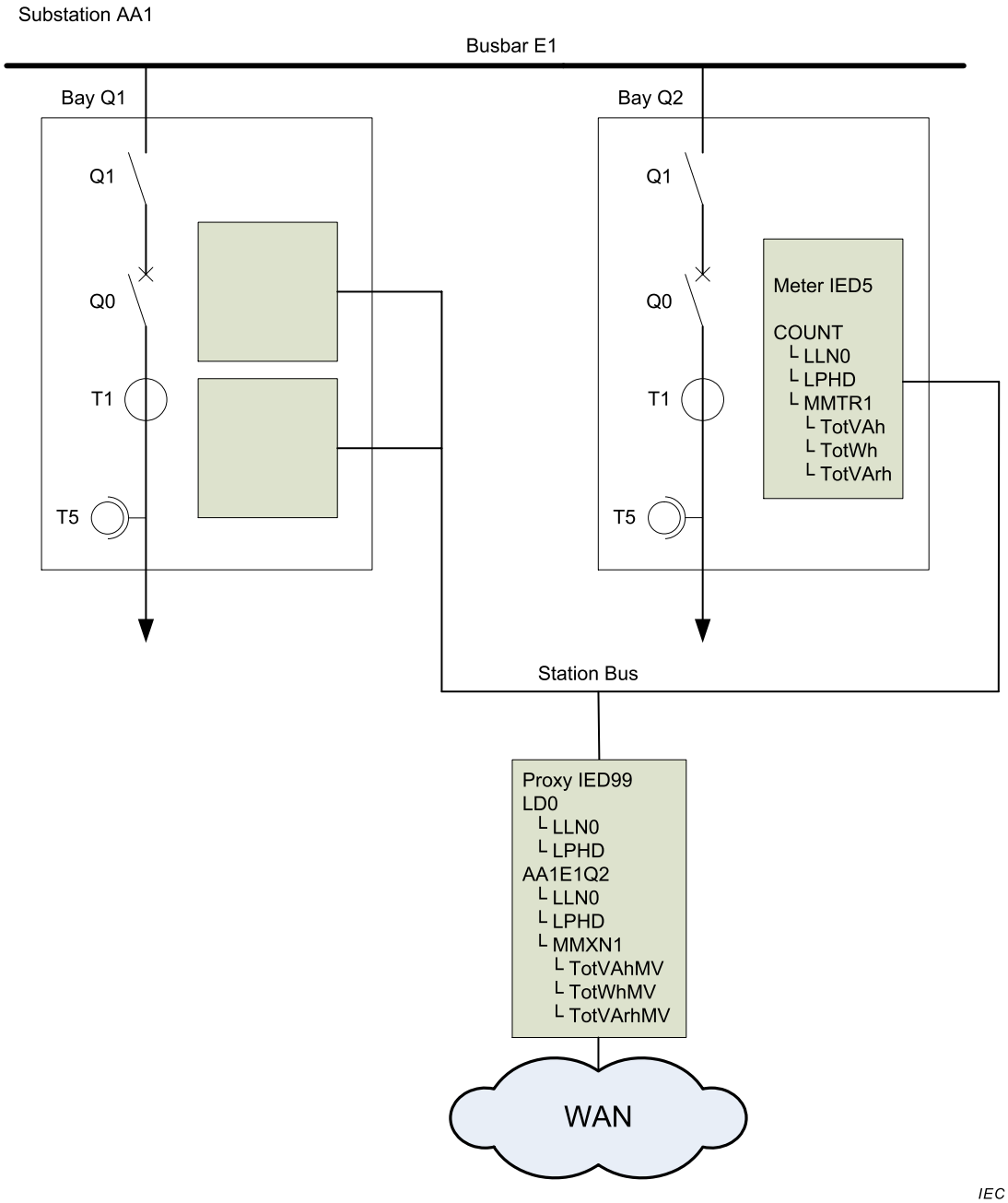


Figure 41 – Modelling a Proxy/Gateway IED – Convert semantically defined LNs

7.1.3.5.9 Create a subset of an array for the Proxy/Gateway server

Power Quality devices within the substation can measure harmonic and interharmonic values. This detailed information is required in the maintenance centre, but often not required in that detail in the control centre. To reduce the amount of transmitted values, e.g. the interharmonics could be sorted out, or the number of harmonics is reduced.

The logical device LD0 of the Proxy/Gateway IED contains logical nodes related to the Proxy/Gateway IED functionality itself; therefore its LPHD.Proxy.stVal has a value of FALSE.

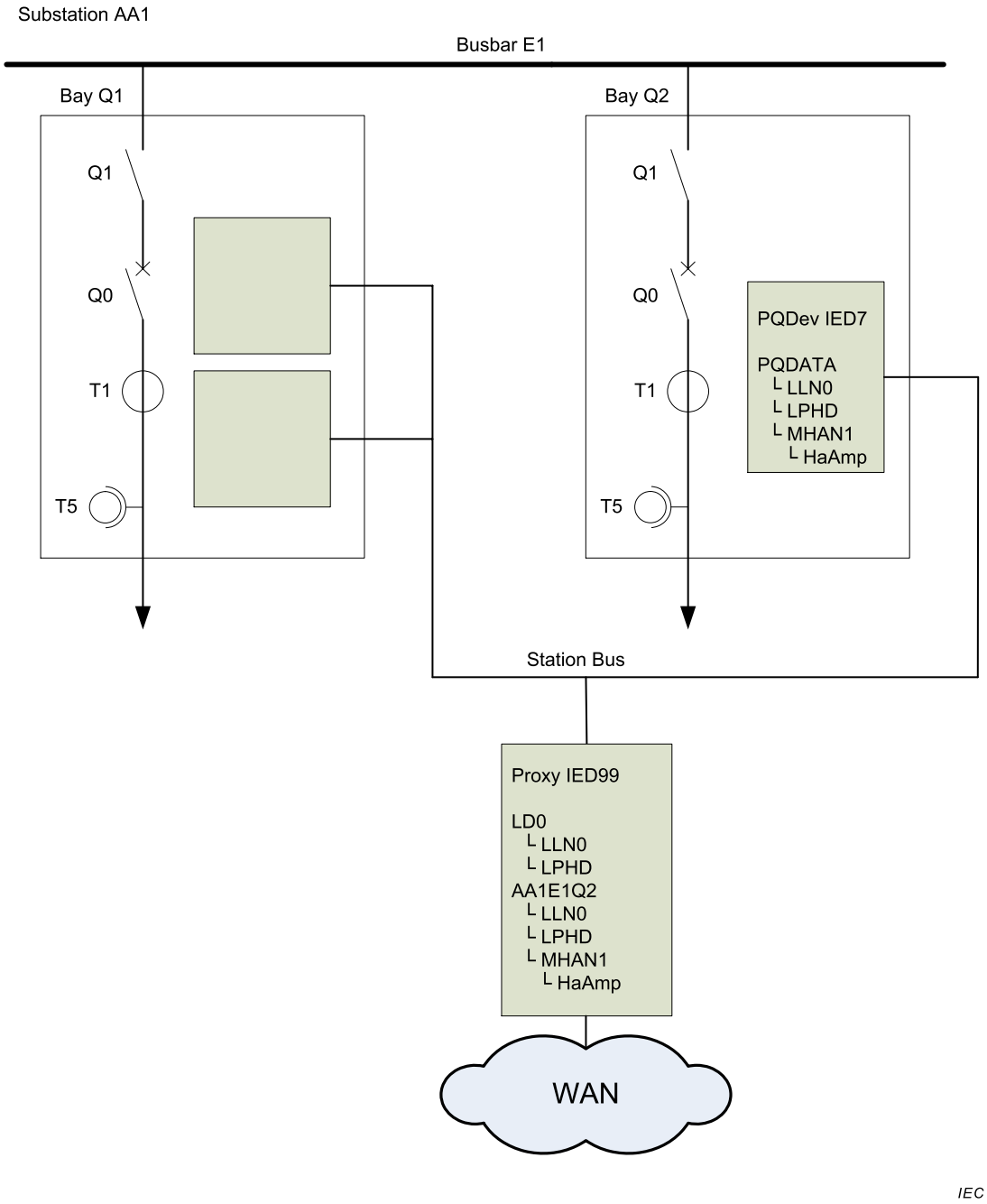


Figure 42 – Modelling a Proxy/Gateway IED – Create an array subset

To describe the relation of the array elements between the Proxy/Gateway server and the substation IED the SCL attribute eTR-IEC61850-90-2:ProxyOf can be used. The following excerpt from a Proxy/Gateway server IID file shows the usage of the eTR-IEC61850-90-2:ProxyOf attribute to map array elements.

```
<LN lnClass="MHAN" lnType="MHAN" inst="1">
   <DOI name="HaAmp">
      <DAI name="har" ix="0">
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED7" ldInst="PQDATA"
lnClass="MHAN" lnInst="1" prefix="" doName="HaAmp" daName="har" ix="0"/>
         </Private>
      </DAI>
      <DAI name="har" ix="1">
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED7" ldInst="PQDATA"
lnClass="MHAN" lnInst="1" prefix="" doName="HaAmp" daName="har" ix="2"/>
         </Private>
      </DAI>
      <DAI name="har" ix="2">
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED7" ldInst="PQDATA"
lnClass="MHAN" lnInst="1" prefix="" doName="HaAmp" daName="har" ix="4"/>
         </Private>
      </DAI>
      <DAI name="har" ix="3">
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED7" ldInst="PQDATA"
lnClass="MHAN" lnInst="1" prefix="" doName="HaAmp" daName="har" ix="6"/>
         </Private>
      </DAI>
      <DAI name="har" ix="4">
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED7" ldInst="PQDATA"
lnClass="MHAN" lnInst="1" prefix="" doName="HaAmp" daName="har" ix="8"/>
         </Private>
      </DAI>
      <DAI name="har" ix="5">
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED7" ldInst="PQDATA"
lnClass="MHAN" lnInst="1" prefix="" doName="HaAmp" daName="har" ix="10"/>
         </Private>
      </DAI>
   </DOI>
</LN>
```

7.1.3.5.10 Use case – Translate data from legacy protocols such as IEC 60870-5-103, IEC 60870-5-104, IEEE 1815 (DNP3), IEC 61158-6 (Modbus) etc. into IEC 61850 data model

In many substations existing IEDs supporting only legacy protocols have to be added to the control centre interface. The IEC 61850 series defines mappings for several legacy protocols. Additionally the converted data have to be transferred into semantically defined IEC61850 objects. The gateway function for legacy protocols may reside on the Proxy/Gateway IED, or on another IED in the substation. In the Proxy/Gateway configuration tool the resulting logical nodes and data objects can be treated as any other data object or logical node.

When the gateway function for legacy protocols resides in the Proxy/Gateway IED itself and the converted data are not externally exposed, the mapping to semantically defined IEC 61850 data objects may be done in the Proxy/Gateway configuration tool.

7.1.3.5.11 Use case – Add data local to the RTU hosting the Proxy/Gateway to the Proxy/Gateway server model

The Proxy/Gateway IED may have local inputs and outputs or other local status information related to the Proxy/Gateway IED itself. When these data have to be accessed through the substation LAN they can be added to the Proxy/Gateway client IED, creating a second access point with a server. In the Proxy/Gateway configuration tool the resulting logical nodes and data objects can be treated as any other data object or logical node.

When the Proxy/Gateway local objects are not externally exposed to the substation LAN, the mapping to semantically defined IEC 61850 data objects may be done in the Proxy/Gateway configuration tool and only visible in the Proxy/Gateway server side IID file.

7.1.3.5.12 Use case – Adapt the scale, information encoding and dead band configuration between the IED data object and the data object in the Proxy/Gateway server

The adaption of scale factors for measured values and the configuration of dead band values is typically a local issue of the Proxy/Gateway IED. Whether the Proxy/Gateway allows rescaling and dead band filtering is an implementation issue and out of scope of this report.

When rescaling and dead band filtering is supported the IID file of the Proxy/Gateway contains the actual values.

7.1.3.5.13 Use case – Logical (e.g.: and, or, if/else, grouping of indications, etc.) and arithmetic (e.g.: multiplication, division, addition, subtraction, etc.) transformations between one or more data objects at IED level and one or more data objects of the Proxy/Gateway server

The ability to use logic functions in the Proxy/Gateway IED is an implementation issue. When it is supported the resulting new semantically defined data objects are treated like other data that are local to the RTU hosting the Proxy/Gateway server.

At the time this report has been written a task force started to elaborate a formal description for logic transformations within an IED. The logic then becomes part of the server IID file. When the technical report is available the content may be applied also to the substation control centre interface. The work of the task force will result in IEC TR 61850-90-11[12].

7.1.3.6 Functionality of a Proxy/Gateway

7.1.3.6.1 General

Substation automation functionalities, which are typically performed by station controllers or dedicated IED (grouping of information, reprocessing and type conversions, logical functions, automation functions, etc.), are outside the scope of the Proxy/Gateway functionality itself. Nevertheless they may be part of the IED containing the Proxy/Gateway.

7.1.3.6.2 Transparent access

Transparent access is a way to exchange information between a maintenance or control centre, via a Proxy/Gateway, and an IED without involving a local process data image of the Proxy/Gateway server.

Most communication services supported by the Proxy/Gateway server can operate on a local process data image of the server. The correct and timely update of the local process data image is an implementation issue of the Proxy/Gateway. It has to ensure the consistency of the local process data image with the data stored in the substation IEDs.

Other services (typically those that influence the behaviour or configuration of the substation IED itself) may not involve a Proxy/Gateway process data image. The request from the frontend client has to be forwarded to the substation IED. The response to the frontend client has to be created by the substation IED. The role of the Proxy/Gateway during a transparent access is to forward the request / response between the frontend client and the substation IED. The Proxy/Gateway can perform address translation when necessary, but may not change the content of the data exchanged.

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12 Under consideration.

Figure 43 illustrates the differences between the access methods.

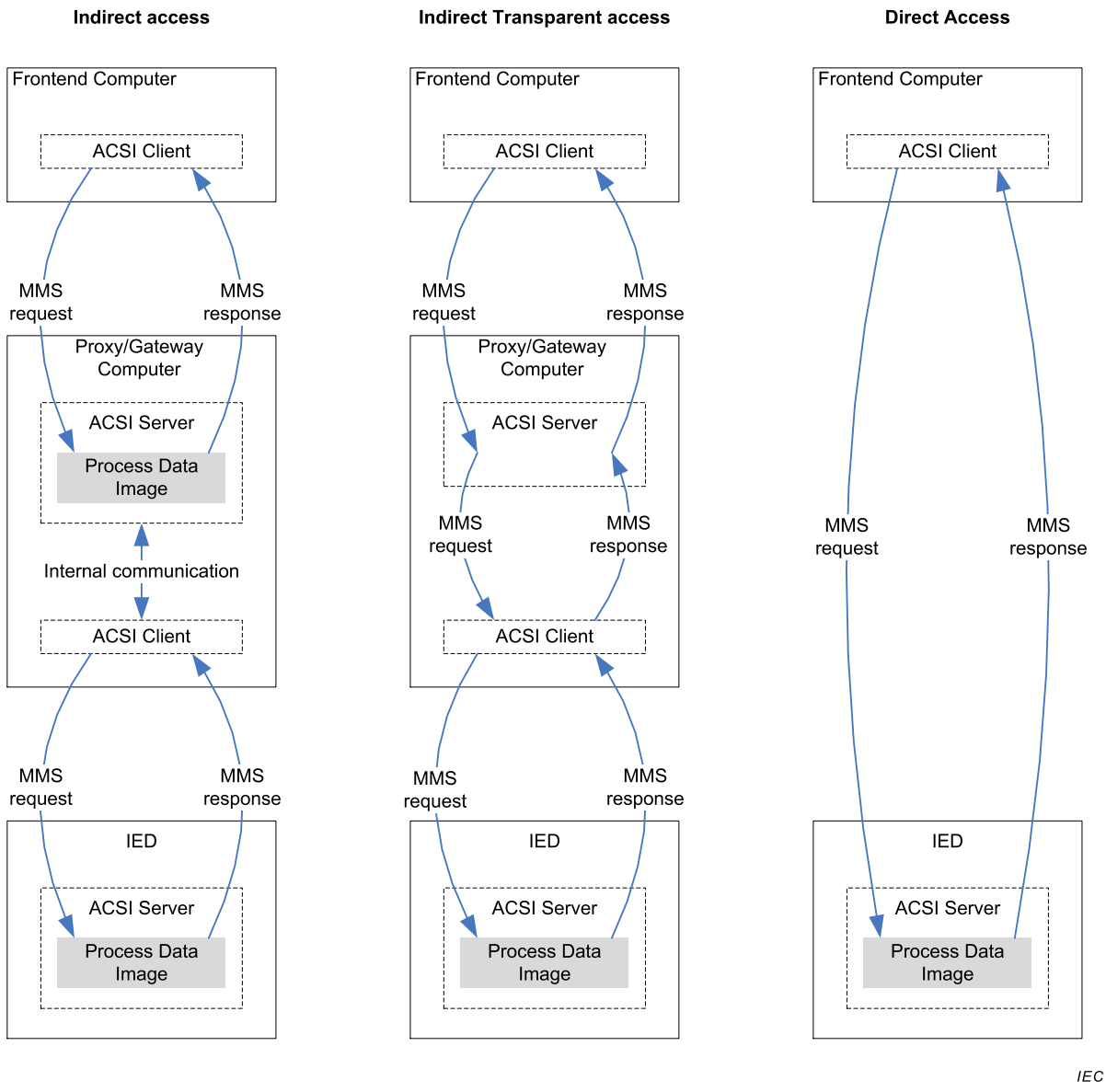


Figure 43 – Comparison of indirect, indirect transparent and direct access

The Proxy/Gateway server can be transparent only for those services on data objects with a one to one relation between the object in the Proxy/Gateway server and the object in the substation IED. Renaming and restructuring of data as well as translation between function oriented naming and product related naming is possible.

The Proxy/Gateway server shall state in its PIXIT document which services are performed on a local process data image and which services are performed with transparent access to the IED.

One application in the maintenance or control centre may not use transparent access and reporting at the same time, because the delivery of data in the correct (timely) order cannot be guaranteed by the Proxy/Gateway.

7.1.3.6.3 Handling of communication interruptions between the Proxy/Gateway client and a substation IED

7.1.3.6.3.1 General

The communication between a substation IED and the Proxy/Gateway client can be disturbed for various reasons. This will also influence the communication between the Proxy/Gateway server and the frontend client. The following clauses define the behaviour of the Proxy/Gateway server.

7.1.3.6.3.2 Status and Measurands

If the Proxy/Gateway maintains a local process data image, the quality of status information and measurands will follow the rules given in IEC 61850-7-3:2010, 6.2.7 and 6.2.8. A GetDataValues request will return the last value received from the IED with the updated status information. A SetDataValues request will result in a ServiceError.

If the Proxy/Gateway server supports transparent access for a GetDataValues request, the Proxy/Gateway server will issue a ServiceError for a disconnected device in response to a GetDataValues request.

7.1.3.6.3.3 Control

When a substation IED is disconnected from the Proxy/Gateway server, the Proxy/Gateway server will respond with a ServiceError to all attempts to control one of the values. See also 7.2.2 for more details of the control models in the Proxy/Gateway.

7.1.3.6.3.4 Setting Group Control

As described in 7.2.3 the Proxy/Gateway is transparent for all services of the setting-group-control-block class. Thus the Proxy/Gateway server will issue a ServiceError for all setting-group-control-block services related to a disconnected substation IED.

7.1.3.6.3.5 Report Control

Reporting, buffered and unbuffered, requires a local process data image. When the communication between the substation IED and the Proxy/Gateway client is disturbed, the quality of the related data in the local process data image will be changed (see 7.1.3.6.3.2). If the trigger option TrgOpt = qchg (quality-change) is set, reports with the updated values will be send to the frontend client.

The reporting function itself is not influenced by the communication interruption between the substation IED and the Proxy/Gateway client, because the reports for the frontend client are created in the Proxy/Gateway server.

7.1.3.6.3.6 Substitution

If Proxy/Gateway server maintains a local process data image for the data to be substituted, the substitution happens only locally. The service will operate as normal.

If the Proxy/Gateway is transparent for the substitution service, the substitution would happen in the substation IED. When the substation IED is disconnected the Proxy/Gateway server will issue a ServiceError in response to the substitution request.

7.1.3.6.3.7 File Transfer

If the Proxy/Gateway has a local copy of the files, the file transfer services are not influenced by the communication interruption to the substation IED.

If the Proxy/Gateway is transparent for the file transfer services, the Proxy/Gateway server will issue a ServiceError in response to all file transfer service requests for a disconnected device.

7.1.3.6.4 Handling of Mod and Beh

IEC 61850 supports the possibility of changing the mode of logical devices or logical nodes by using the data object Mod that is found in every logical node including in LLN0. Changing any Mod in the Proxy/Gateway follows the basic rules for operations in the control direction. However the capability of controlling the Mod data object is the responsibility of the function owner, i.e. logical node owner. The Proxy/Gateway property does not change the ctlModel attribute of a given Mod. Either the Mod is controllable in the IED device and therefore is also controllable in the Proxy/Gateway, or it is not controllable (ctlModel = status-only), and will not be neither in the Proxy/Gateway.

The LLN0 that belongs to the Proxy/Gateway where the modelling of the logical device follows the rule of 7.1.3.5.3, does not have a controllable Mod since its change cannot be inherited in the LN Beh belonging to the logical device: the associated logical nodes do not really belong to that logical device. The Mod of the logical device in this case is always “On”.

The data object Beh of the logical nodes of the IEDs are available in the Proxy/Gateway object model, and their value will follow the value delivered by the IED.

The data object Health of the logical nodes of the IEDs is available in the Proxy/Gateway object model, and their value will follow the value delivered by the IED.

The data object Health of LLN0 of the logical devices whose modelling follows the rule of 7.1.3.5.3, represents, as IEC 61850-7-4:2010 defines it, the worst “health” of the logical nodes that are part of the logical device associated with LLN0.

7.1.3.6.5 Handling of configuration parameters

The Proxy/Gateway may support changes of measurement value configurations according IEC 61850-7-2:2010, such as e.g. scaling or dead band parameters.

Whether the configuration parameters are applied locally or are forwarded to the IED depends on the implementation of the Proxy/Gateway. The PIXIT contains the information how configuration parameters are handled.

7.1.3.6.6 Handling of substitution

If supported by the Proxy/Gateway implementation substitution from control centre will take place in the Proxy/Gateway. Substitution in the IED is possible from the substation level.

If the value is substituted in the IED the quality will go through the Proxy/Gateway to signal the control centre the value is substituted.

7.1.3.6.7 Handling of settings

Settings are preferably changed by direct access from the maintenance centre. In some cases it may be useful to change some settings of an IED in the substation from the control centre. In these cases the Proxy/Gateway is transparent (see 7.1.3.6.2 for details of transparent access) for settings (functional constraint SP) taken over in the Proxy/Gateway server model from an IED. Transparent in this respect means that the settings are not stored in an object model local to the Proxy/Gateway, but are forwarded to the IED holding the settings. Also the response to the maintenance or control centre is not created locally, but the response from the IED is returned to the maintenance or control centre.

Additional setpoints from local reprocessing may be local to the Proxy/Gateway.

7.1.3.6.8 Handling of telemonitoring blocking

7.1.3.6.8.1 General

Telemonitoring blocking is a common functionality used in the communication with the control centre. When a telemonitoring blocking is set, the data of a certain device, bay or logical node is no longer updated to the control centre.

As the requirements from the control centre may vary for different utilities there is not only one way to achieve the desired behaviour.

7.1.3.6.8.2 Telemonitoring blocking for individual values

Each data object has an optional data attribute blkEna. When blkEna is set to TRUE, the operator-blocked quality flag is set, and the process value is no longer updated. To block more than one data object the control centre client has to write the blkEna for each data object that shall be blocked. Setting blkEna to TRUE in a Proxy/Gateway data object will block only the update to the control centre. It is not forwarded to the source data object in the IED. The information update within the substation is not affected.

7.1.3.6.8.3 Telemonitoring blocking for a report

Telemonitoring blocking can also be achieved by a local implementation in the control centre front end. The telemonitoring blocking is achieved by disabling a report from the IED to the control centre. The report can be disabled by request of an operator or an automatic function within the control centre. In consequence the Proxy/Gateway server stops forwarding changed data, included in this specific report to the control centre. The disadvantage of this solution is, that either at engineering time, the reports are created with a high granularity, which results in many reports, or when the granularity is low (many data included in one report) the control centre might miss relevant information updates.

7.1.3.6.8.4 Telemonitoring blocking by creating a filter in the control centre front end

Telemonitoring blocking can also be achieved by a local implementation in the control centre front end. In this case the information update between the control centre and the substation Proxy/Gateway is not affected. On request of an operator or an automatic function the control centre client stops forwarding the received value changes to the SCADA function. The disadvantage of this solution is that oscillating information might require more bandwidth on the communication line between the control centre and the substation.

7.1.3.6.9 Handling of telecontrol blocking

7.1.3.6.9.1 Blocking incoming commands

The data object CmdBlk is used to block incoming commands at LN level. When the blocking is activated, the command will not be accepted and an appropriate negative response is sent to the client who initiated the command. Setting CmdBlk to TRUE in a Proxy/Gateway logical node will block only the command from the control centre. It is not forwarded to the source logical node in the IED. The control within the substation from a substation HMI is not affected.

Blocking of commands can also be achieved setting LocSta at bay level to “TRUE”. This requires that the Proxy/Gateway forwards the originator to the IED as received from the control centre. Setting the ITCI.LocSta of the Proxy/Gateway server in the Proxy/Gateway to “TRUE” will block all commands from the control centre.

7.1.3.6.9.2 Blocking output to the process

The data object Mod is used to put a logical node in different modes. The mode TEST-Blocked is interpreted as the mode which explicitly disables any physical outputs having an effect on the process.

The handling of the Mod and Beh objects follows the rules defined in 7.1.3.6.4.

7.1.4 Service tracking

Tracking of services is local to the Proxy/Gateway for all services that are handled in the Proxy/Gateway and transparent for all services that are handled in the IED.

7.2 Modelling and control block classes

7.2.1 General

IEC 61850-7-2:2010 defines control blocks for settings, reporting, logging, GSE and SV. Only settings, reporting and logging are used for telecontrol application.

Subclause 7.2.2 will describe how these services are used in the Proxy/Gateway server.

7.2.2 CONTROL class model for Proxy/Gateway

7.2.2.1 Introduction

IEC 61850-7-2:2010, Clause 20 defines four different behaviours of a control object, each described by a state machine.

The state machine of the control model of a Proxy/Gateway differs from the state machine of the IED, because it is expected to be transparent on the one hand, but also has to handle those situations where there is no response from the IED. For the IED the control model definitions of IEC 61850-7-2:2010 apply.

The concept of the Proxy/Gateway control model is depicted in Figure 44.

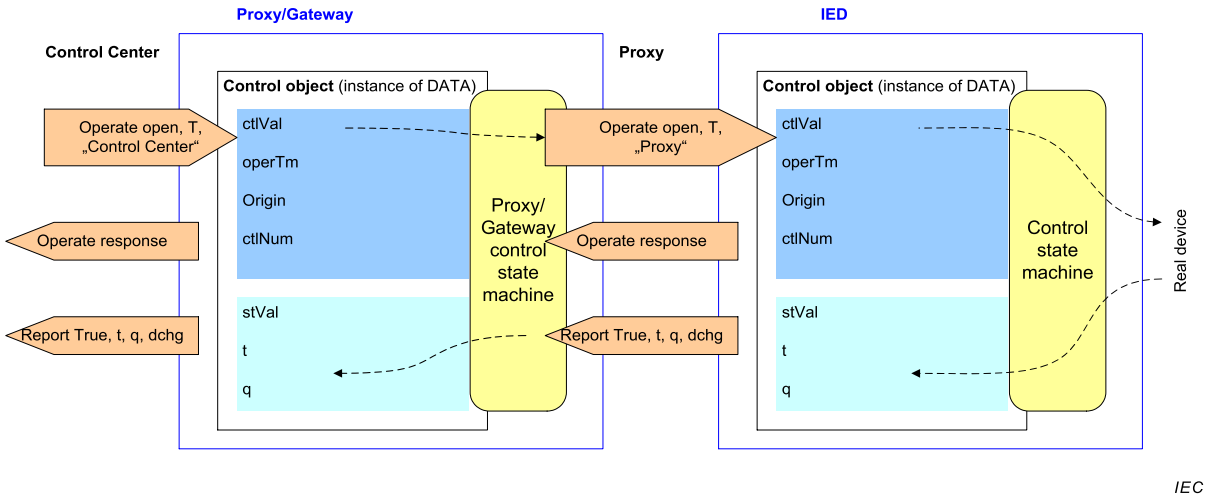


Figure 44 – Principle of the Proxy/Gateway control model

The control centre issues the Operate service that is immediately forwarded to the Proxy/Gateway client which issues the Operate service to the IED. The Operate service is immediately confirmed by the Operate response. The new state change is reported by an independent Report indicating the final result of the control operation.

The services Select, SelectWithValue, Cancel, Operate, TimeActivatedOperate, TimeActivatedOperateTermination, and CommandTermination are related. The behaviour of these services is as defined in the state machines contained in this clause.

The Proxy/Gateway uses the same control model as the respective data in the IED.

The behaviour for the different control models is described in the following subclauses with state diagrams. These state diagrams however show only those conditions which lead to new states. Table 19 contains the handling of control model related service requests, which do not change the state and are negatively responded by the Proxy/Gateway. Table 19 only takes care of defining the behaviour of the control model when application errors occur. When a command is forwarded to the IED a state change will take place and the response to the control centre is as received from the IED.

The state machines show only the behaviour of the control itself. The related data in monitoring direction are not shown. The values of those data will be as in the source IED when the data is available in the Proxy/Gateway. Otherwise the validity of the data will be set to invalid and the detail quality set to failure. When the data is only temporarily not available, e.g. due to loss of communication with the IED, the validity is set to questionable and the detail quality is OldData.

Table 19 – Negative responses to service requests

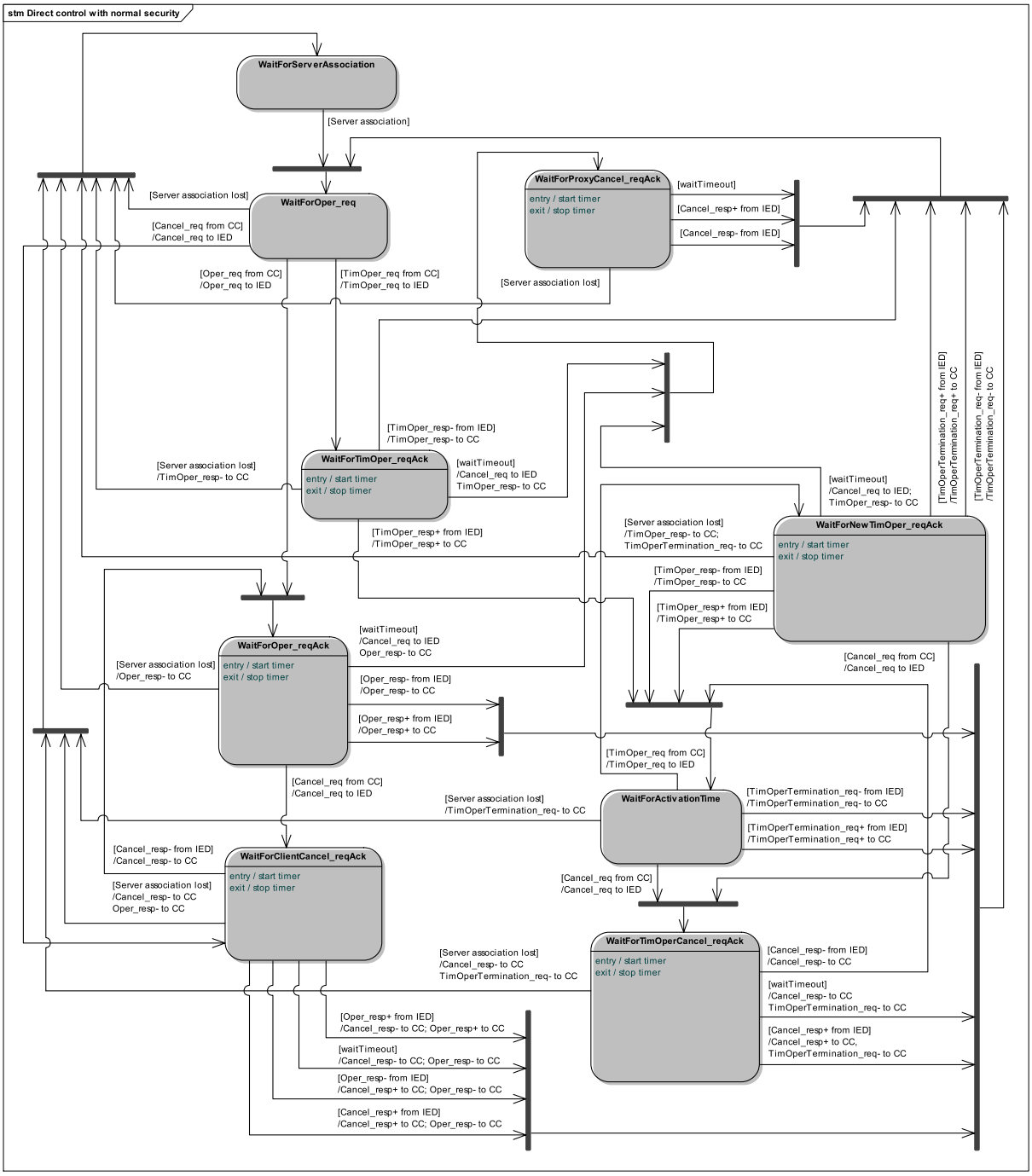
State	Service request	Action	AddCause	Comments
WaitForServerAssociation	Sel_req	Sel_resp-	Abortion-by-communication-loss	The service cannot be performed, because the client of the Proxy/Gateway lost the connection with the IED
	SelVal_req	SelVal_resp-	Abortion-by-communication-loss	
	Cancel_req	Cancel_resp-	Abortion-by-communication-loss	
	Oper_req	Oper_resp-	Abortion-by-communication-loss	
	TimOper_req	TimOper_resp-	Abortion-by-communication-loss	
WaitForSel_req	Oper_req	Oper_resp-	Object-not-selected	For SBO control with normal security
	TimOper_req	TimOper_resp-	Object-not-selected	
WaitForSelVal_req	Oper_req	Oper_resp-	Object-not-selected	For SBO control with enhanced security
	TimOper_req	TimOper_resp-	Object-not-selected	
WaitForSel_reqAck	Sel_req	Sel_resp-	Command-already-in-execution	For SBO control with normal security
	Oper_req	Oper_resp-	Command-already-in-execution	
	TimOper_req	TimOper_resp-	Command-already-in-execution	
WaitForSelVal_reqAck	SelVal_req	SelVal_resp-	Command-already-in-execution	For SBO control with enhanced security
	Oper_req	Oper_resp-	Command-already-in-execution	
	TimOper_req	TimOper_resp-	Command-already-in-execution	
WaitForOper_req	Sel_req	Sel_resp-	Object-already-selected	For SBO control with normal security
	SelVal_req	SelVal_resp-	Object-already-selected	For SBO control with enhanced security
WaitForOper_reqAck	Sel_req	Sel_resp-	Object-already-selected	For SBO control with normal security
	SelVal_req	SelVal_resp-	Object-already-selected	For SBO control with enhanced security
	Oper_req	Oper_req-	Command-already-in-execution	
	TimOper_req	TimOper_resp-	Command-already-in-execution	
WaitForClientCancel_reqAck	Sel_req	Sel_resp-	Command-already-in-execution	For SBO control with normal security
	SelVal_req	SelVal_resp-	Command-already-in-execution	For SBO control with enhanced security
	Cancel_req	Cancel_resp-	Command-already-in-execution	
	Oper_req	Oper_resp-	Command-already-in-execution	

State	Service request	Action	AddCause	Comments
	TimOper_req	TimOper_resp-	Command-already-in-execution	
WaitForProxyCancel_reqAck	Sel_req	Sel_resp-	Command-already-in-execution	For SBO control with normal security
	SelVal_req	SelVal_resp-	Command-already-in-execution	For SBO control with enhanced security
	Cancel_req	Cancel_resp-	Command-already-in-execution	
	Oper_req	Oper_resp-	Command-already-in-execution	
	TimOper_req	TimOper_resp-	Command-already-in-execution	
WaitForTimOperCancel_reqAck	Sel_req	Sel_resp-	Command-already-in-execution	For SBO control with normal security
	SelVal_req	SelVal_resp-	Command-already-in-execution	For SBO control with enhanced security
	Cancel_req	Cancel_resp-	Command-already-in-execution	
	Oper_req	Oper_resp-	Command-already-in-execution	
	TimOper_req	TimOper_resp-	Command-already-in-execution	
WaitForTimOper_reqAck	Sel_req	Sel_resp-	Object-already-selected	For SBO control with normal security
	SelVal_req	SelVal_resp-	Object-already-selected	For SBO control with enhanced security
	Oper_req	Oper_resp-	Command-already-in-execution	
	TimOper_req	TimOper_resp-	Command-already-in-execution	
WaitForNewTimOper_reqAck	Sel_req	Sel_resp-	Object-already-selected	For SBO control with normal security
	SelVal_req	SelVal_resp-	Object-already-selected	For SBO control with enhanced security
	Oper_req	Oper_resp-	Command-already-in-execution	
	TimOper_req	TimOper_resp-	Command-already-in-execution	
WaitForActivationTime	Sel_req	Sel_resp-	Object-already-selected	For SBO control with normal security
	SelVal_req	SelVal_resp-	Object-already-selected	For SBO control with enhanced security
	Oper_req	Oper_resp-	Command-already-in-execution	
WaitForCmdTerm	Sel_req	Sel_resp-	Object-already-selected	For SBO control with normal security

State	Service request	Action	AddCause	Comments
	SelVal_req	SelVal_resp-	Object-already-selected	For SBO control with enhanced security
	Cancel_req	Cancel_resp-	Command-already-in-execution	
	Oper_req	Oper_resp-	Command-already-in-execution	
	TimOper_req	TimOper_resp-	Command-already-in-execution	
All States	Control related request, not belonging to control model	xxx-resp-	Unknown	For example a Sel_req for ctlModel = direct - with-enhanced-security
	Cancel_req	Cancel_resp-	Inconsistent-parameters	Discrepancy between service parameters of Sel_req, SelVal_req or Oper_req and Cancel_req
	Cancel_req	Cancel_resp-	Locked-by-other-client	The second service is not performed by the client which performed the positively acknowledged Oper_req
	Oper_req	Oper_resp-	Inconsistent-parameters	Discrepancy between service parameters of Oper_req and Sel_req / SelVal_req
	Oper_req	Oper_resp-	Locked-by-other-client	The second service is not performed by the client which performed the positively acknowledged Sel_req or SelVal_req
	TimOper_req	TimOper_resp-	Inconsistent-parameters	Discrepancy between service parameters of TimOper_req and Sel_req / SelVal_req
	TimOper_req	TimOper_resp-	Locked-by-other-client	The second service is not performed by the client which performed the positively acknowledged Sel_req or SelVal_req

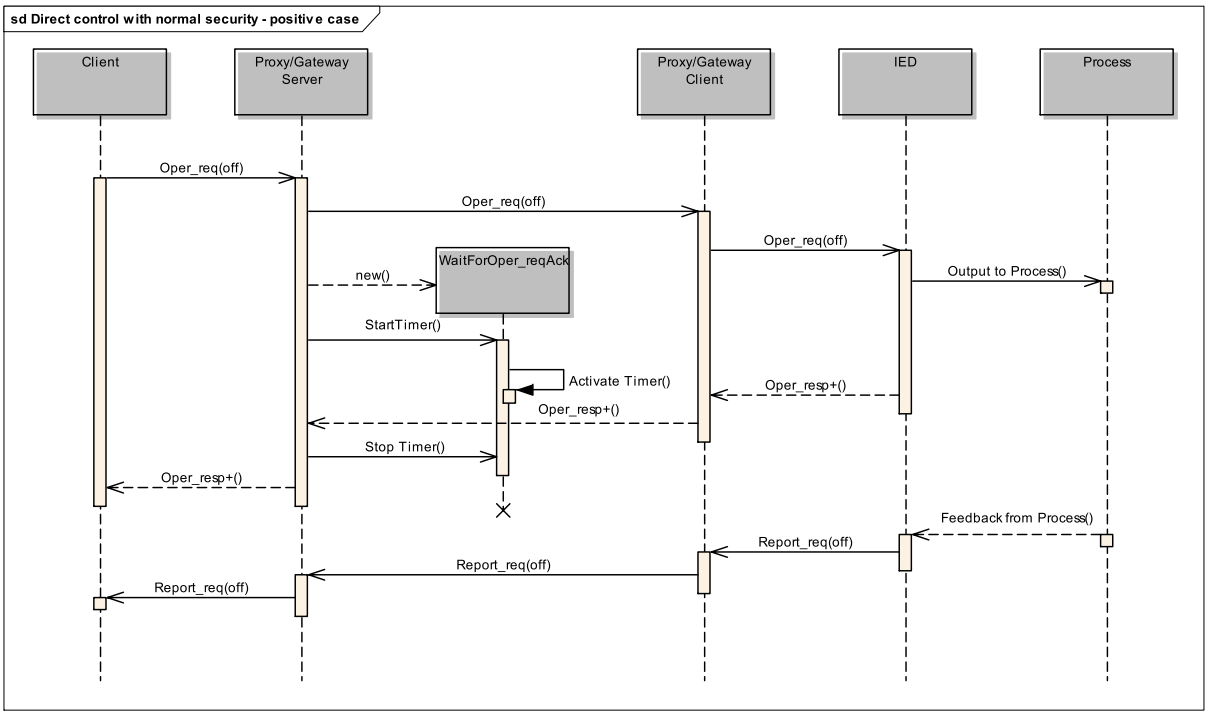
7.2.2.2 Direct control with normal security

This model makes use of the services Operate, TimeActivatedOperate and Cancel. The state machine Figure 45 and the sequence diagrams Figure 46 and Figure 47 define the operation.



IEC

Figure 45 – State machine of direct control with normal security



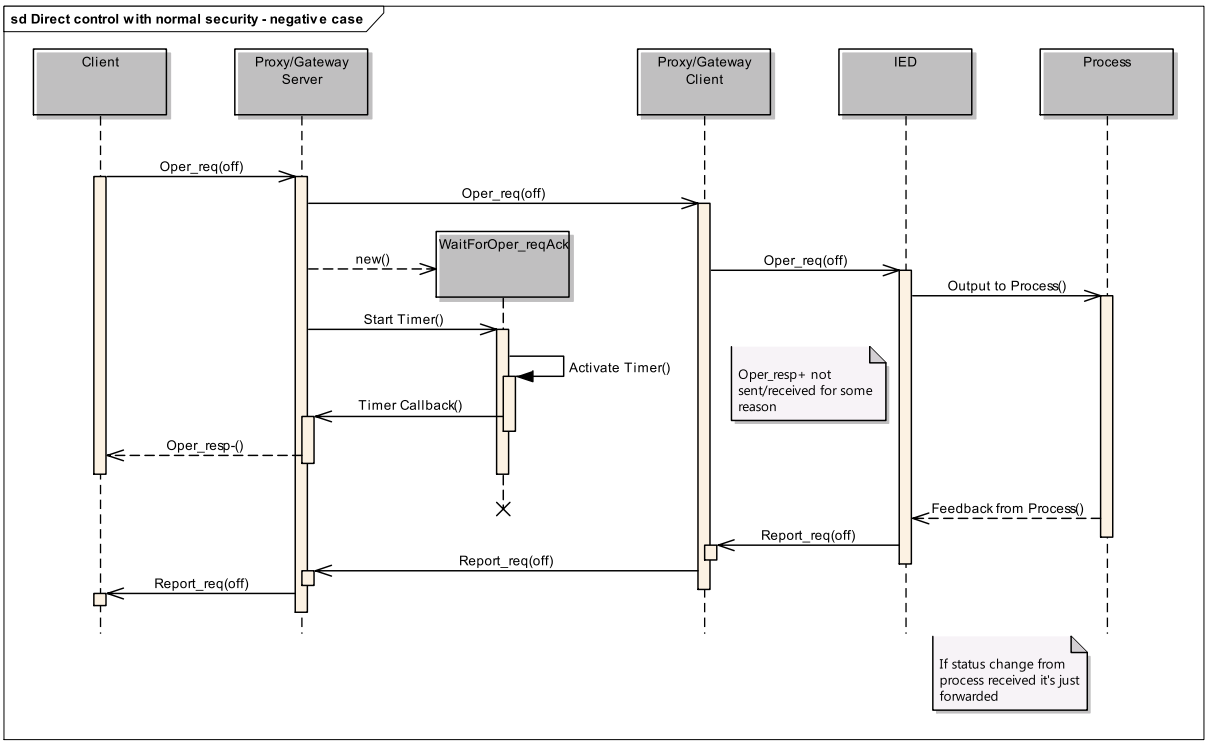
IEC

Figure 46 – Direct control with normal security – positive case

The procedure is as follows:

On receipt of the Oper_req, the Proxy/Gateway server forwards the request to the Proxy/Gateway client. The communication between the Proxy/Gateway server and the Proxy/Gateway client is an internal communication of the Proxy/Gateway and not part of this technical report. The Proxy/Gateway client will issue the Oper_req to the IED and start a timer to monitor the reception of the command response from the IED. The IED will perform the tests according to IEC 61850-7-2:2010. The Proxy/Gateway server waits for the result of the tests in the state WaitForOper_reqAck. On receipt of the positive operate response Oper_resp+ the Proxy/Gateway server forwards the response to the client and stops the timer.

The new status of the control object in the IED may optionally be reported by the Report service. The respective value changes will be stored in the process data image of the Proxy/Gateway server. The Proxy/Gateway server then will report it by the Report service to the Client.



IEC

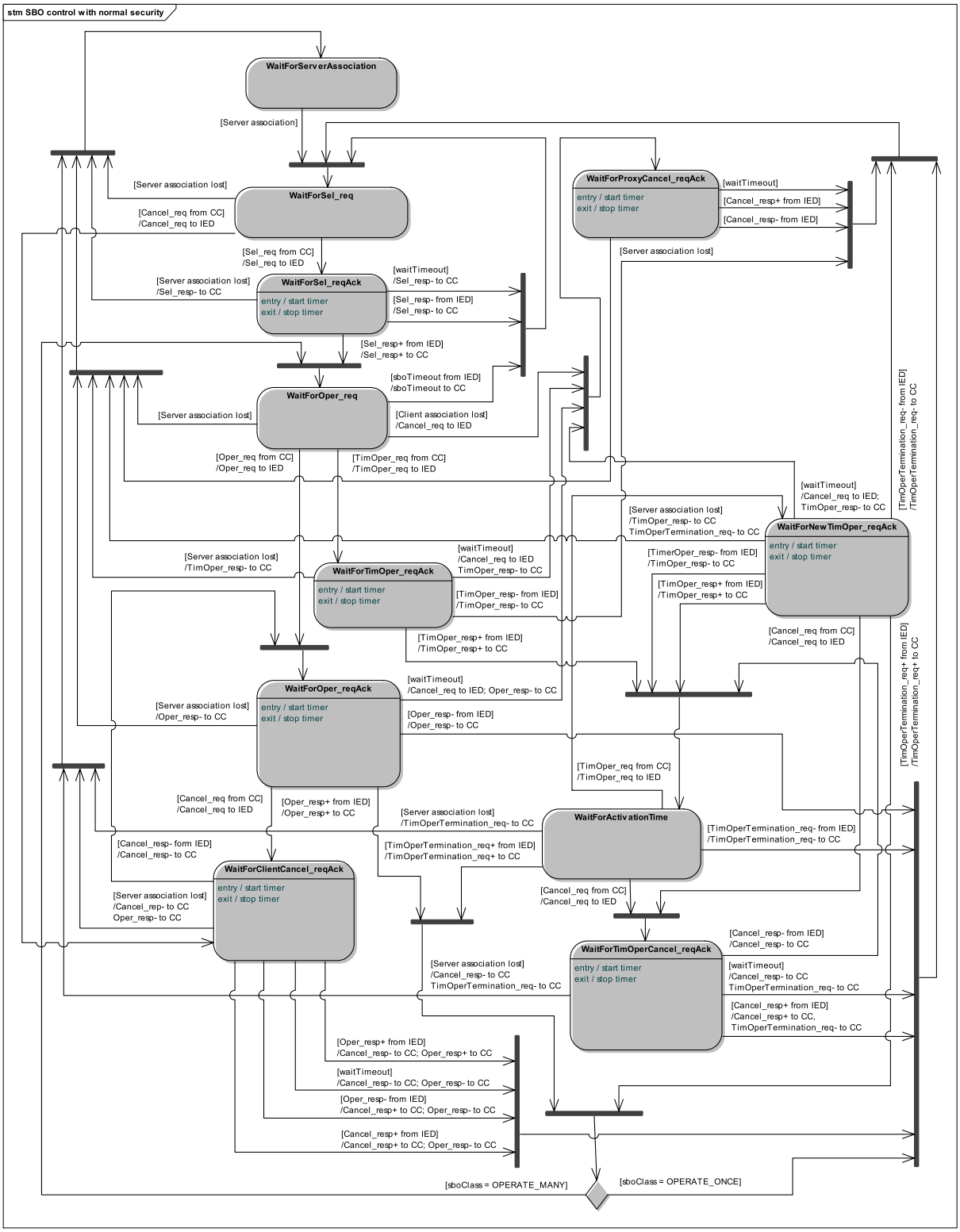
Figure 47 – Direct control with normal security – negative case

If the control object in the IED does not respond before the waitTimeout expires, the Proxy/Gateway server issues an Oper_resp- to the client.

If a state change of the control object in the IED is reported after the Proxy/Gateway server sent out the Oper_resp- the state change is reported to the frontend client as a spontaneous change.

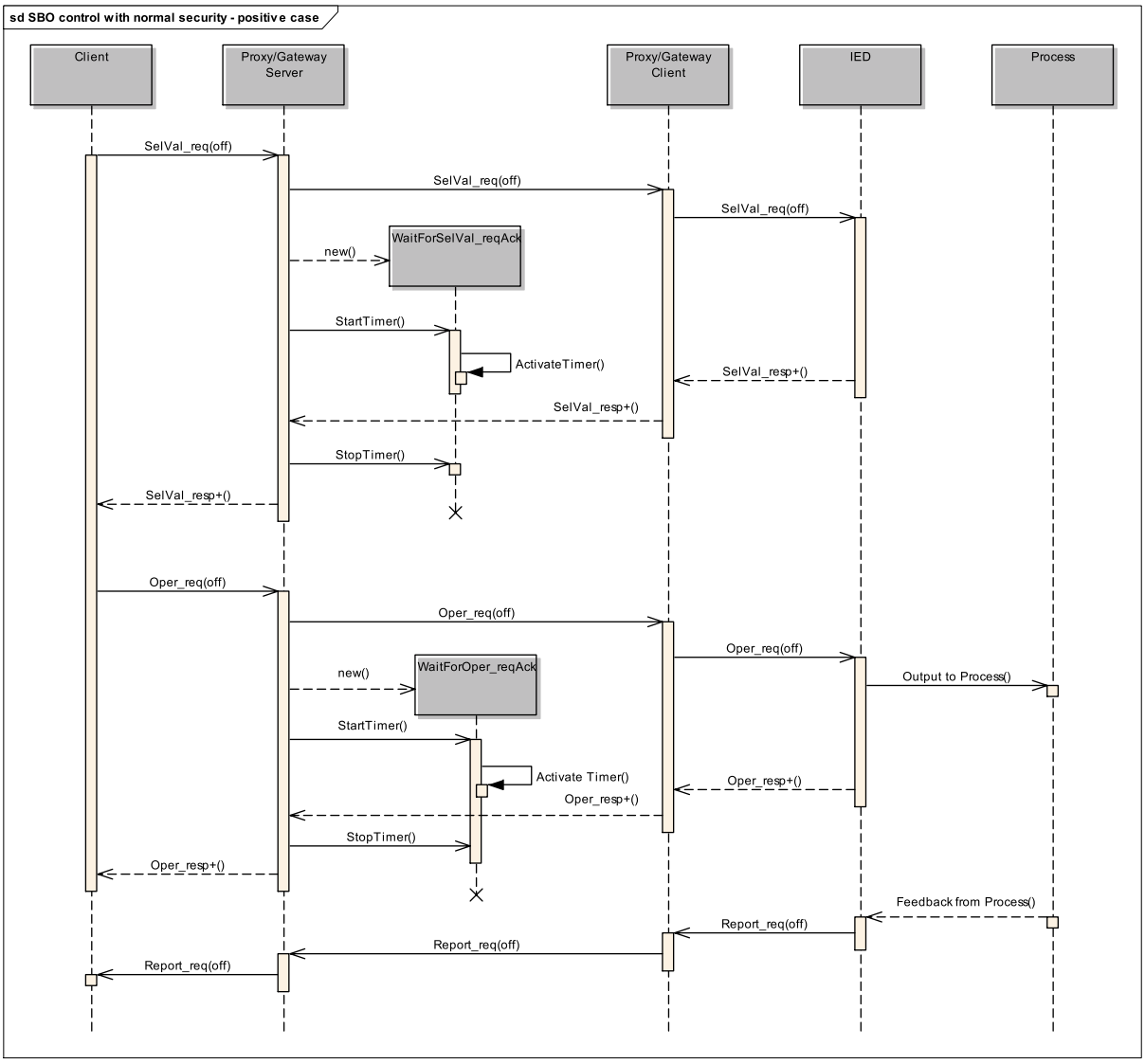
7.2.2.3 SBO Control with normal security

This model makes use of the services SelectWithValue, Operate, TimeActivatedOperate and Cancel. The state machine in Figure 48 and the sequence diagrams in Figure 49 and Figure 50 define the operation.



IEC

Figure 48 – State machine of SBO control with normal security



IEC

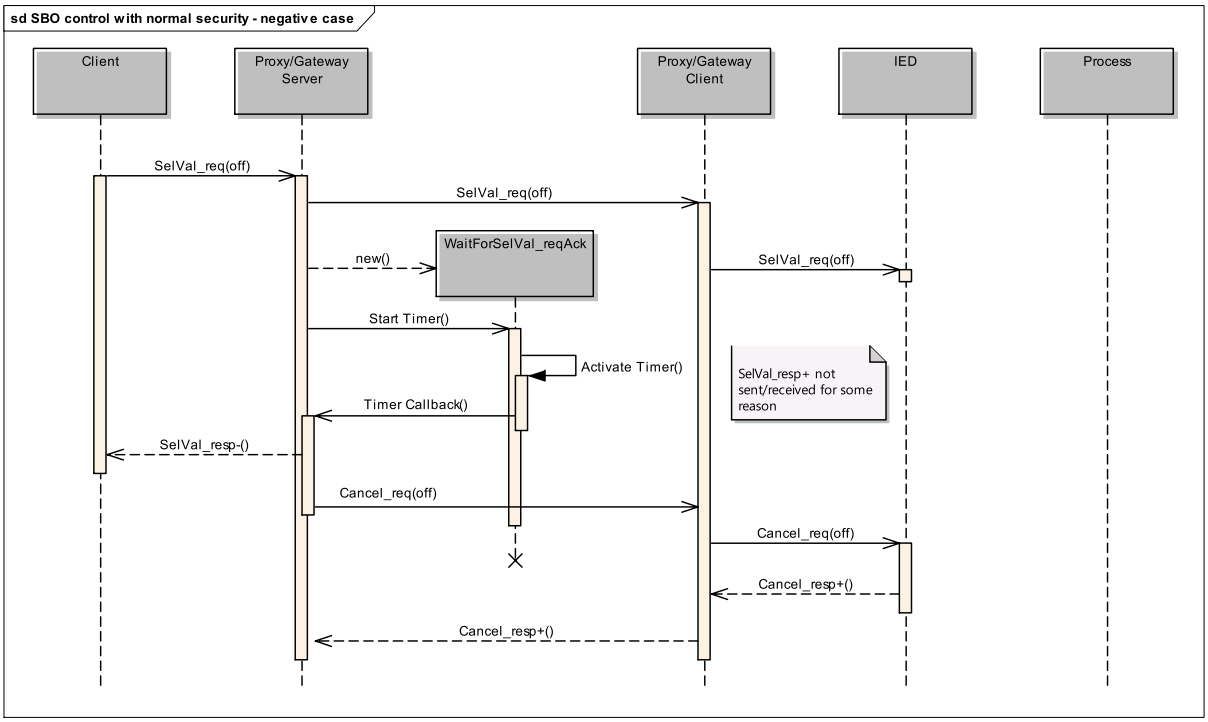
Figure 49 – SBO control with normal security – positive case

The procedure is as follows:

On receipt of the SelVal_req, the Proxy/Gateway server forwards the request to the Proxy/Gateway client. No tests are performed in the Proxy/Gateway server. The communication between the Proxy/Gateway server and the Proxy/Gateway client is an internal communication of the Proxy/Gateway and not part of this technical report. The Proxy/Gateway client will issue the SelVal_req to the IED and start a timer to monitor the reception of the select response from the IED. The IED will perform the tests according to IEC 61850-7-2:2010. The Proxy/Gateway server waits for the result of the tests in the state WaitForSelVal_reqAck. On receipt of the positive select confirmation SelVal_resp+ the Proxy/Gateway server forwards the response to the client and stops the timer.

On receipt of the Oper_req, the Proxy/Gateway server forwards the request to the Proxy/Gateway client. No tests are performed in the Proxy/Gateway server. The Proxy/Gateway client will issue the Oper_req to the IED and start a timer to monitor the reception of the command response from the IED. The IED will perform the tests according to IEC 61850-7-2:2010. The Proxy/Gateway server waits for the result of the tests in the state WaitForOper_reqAck. On receipt of the positive operate response Oper_resp+ the Proxy/Gateway server forwards the response to the client and stops the timer.

The new status of the control object in the IED may optionally be reported by the Report service. The respective value changes will be stored in the process data image of the Proxy/Gateway server. The Proxy/Gateway server then will report it by the Report service to the Client.



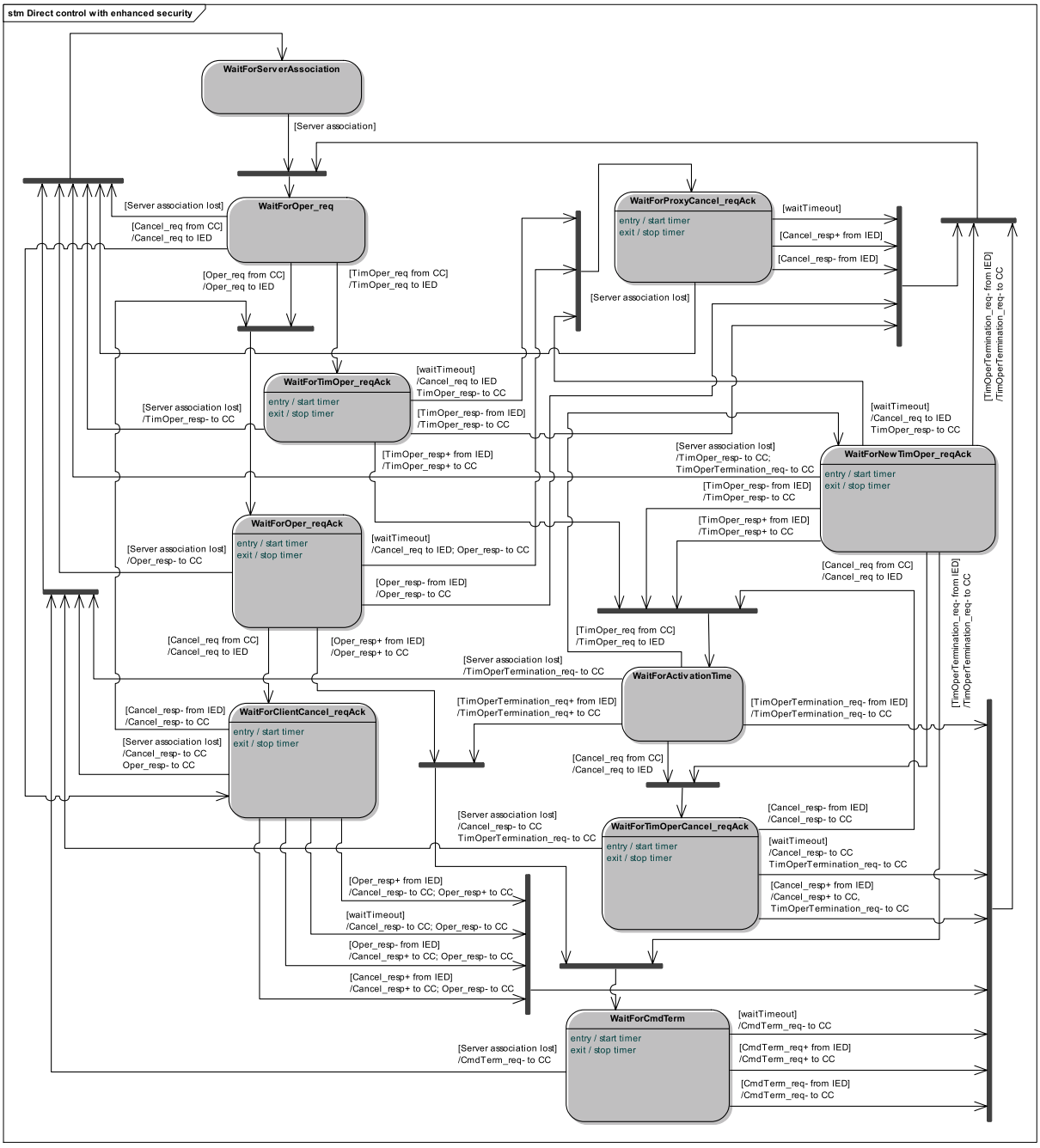
IEC

Figure 50 – SBO control with normal security – negative case

If the control object in the IED does not respond before the waitTimeout expires, the Proxy/Gateway server issues an Oper_resp- to the client. In parallel the Proxy/Gateway client issues a Cancel_req to the IED. Depending on the state of the IED association the Cancel_req may be successful or not. Anyhow the client is not informed about the result of the Cancel_req.

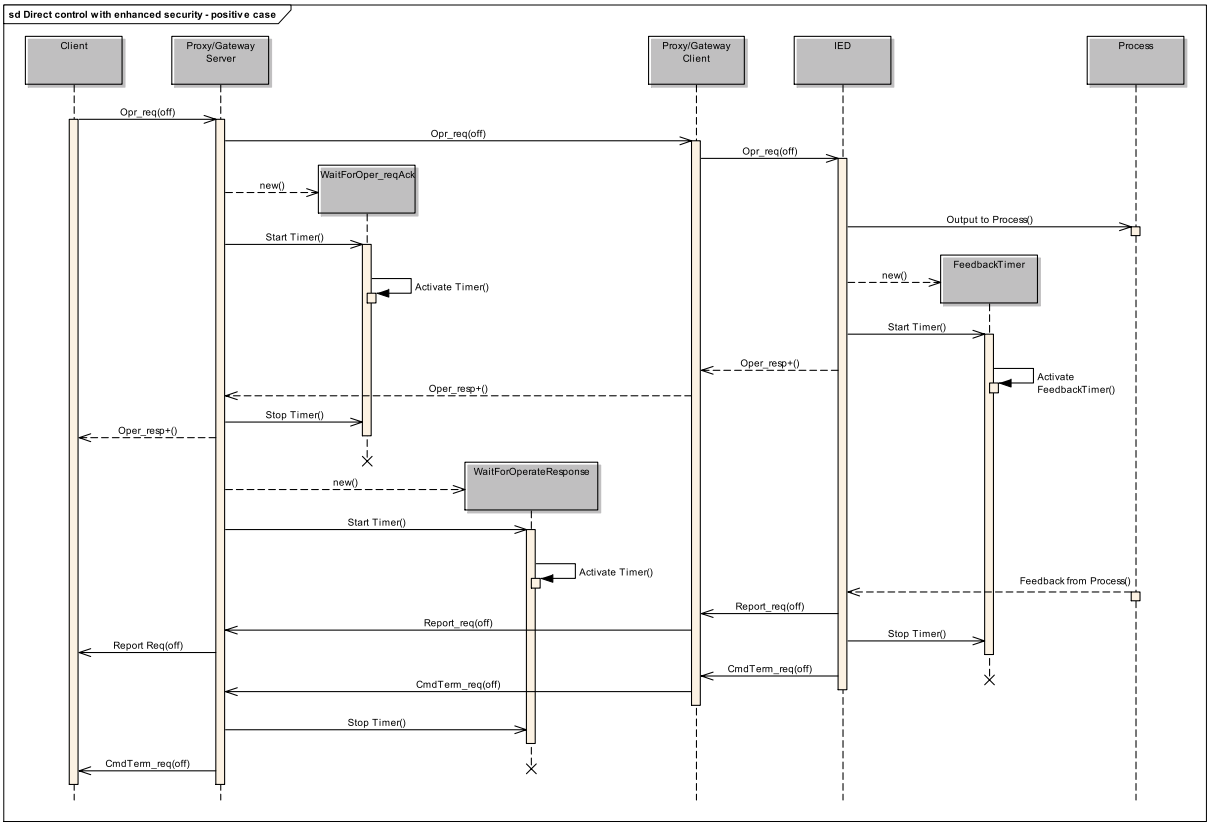
7.2.2.4 Direct control with enhanced security

This model makes use of the services Operate, TimeActivatedOperate and Cancel. The state machine in Figure 51 and the sequence diagrams in Figure 52 and Figure 53 define the operation.



IEC

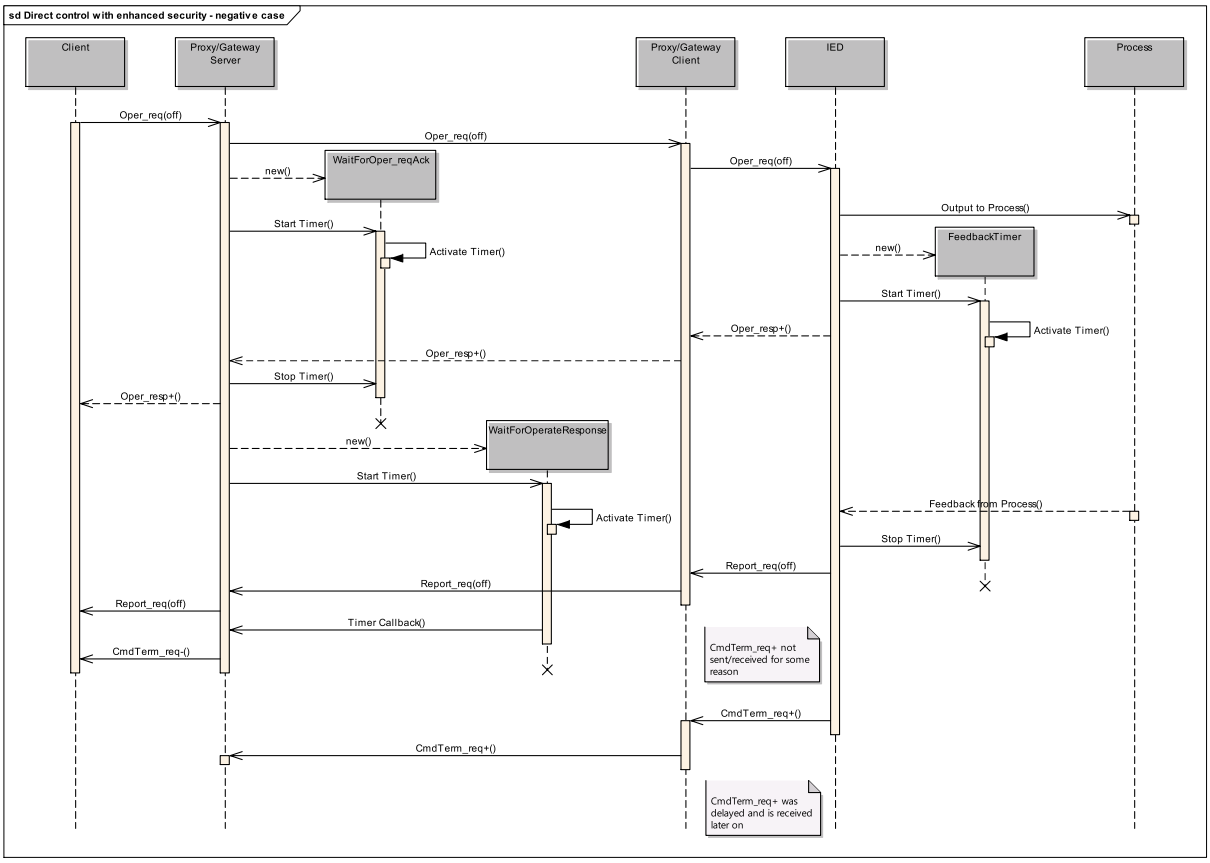
Figure 51 – State machine of direct control with enhanced security



IEC

Figure 52 – Direct control with enhanced security – positive case

The state machine behaves as for direct control with normal security, see 7.2.2.2. Additionally the reception of the Command Termination CmdTerm_req is monitored. Figure 52 shows the normal behaviour of the Proxy/Gateway.



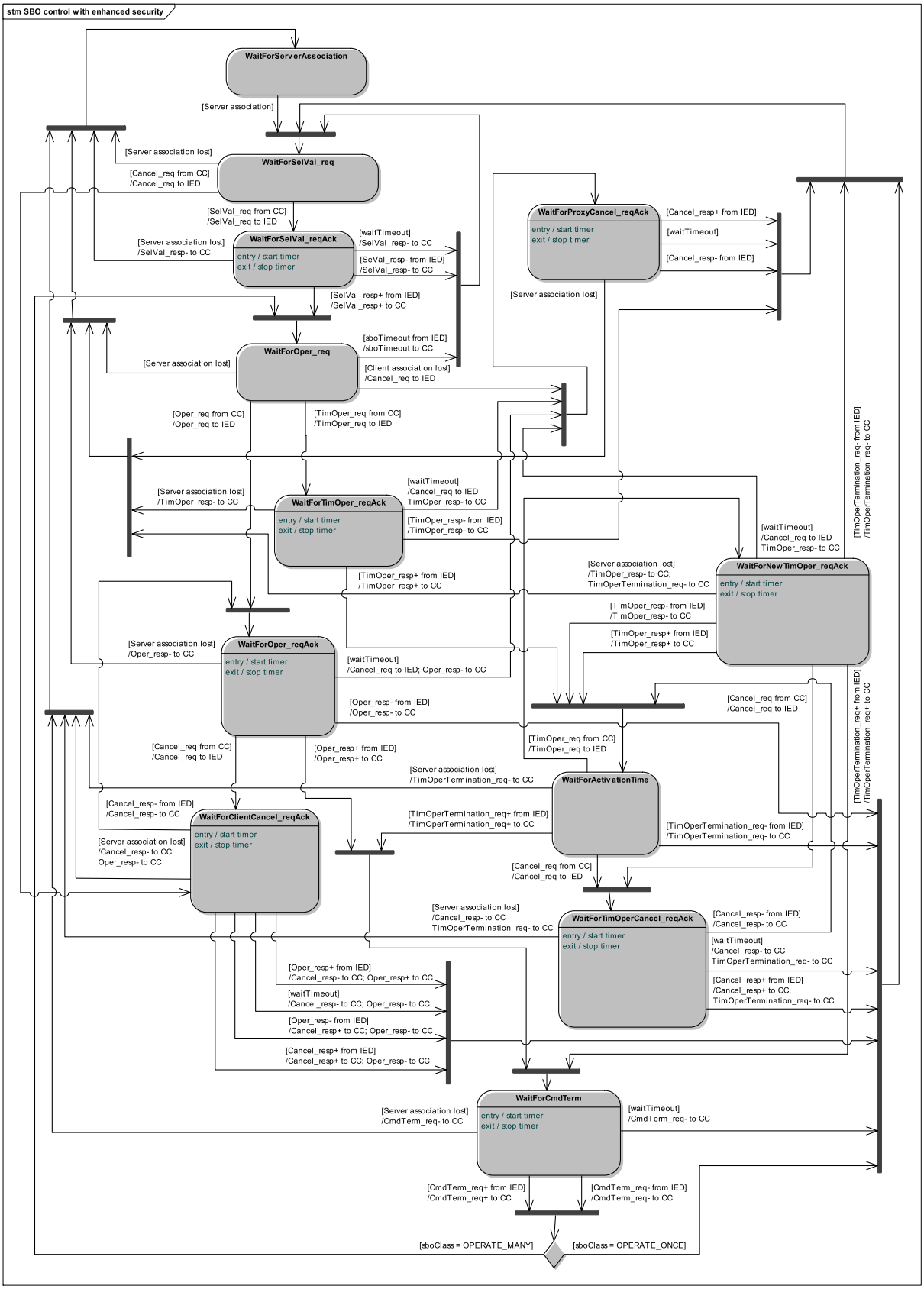
IEC

Figure 53 – Direct control with enhanced security – negative case

If the control object does not send the CmdTerm_Req before the WaitTimeout expires, the Proxy/Gateway server issues the CmdTerm_req to the client.

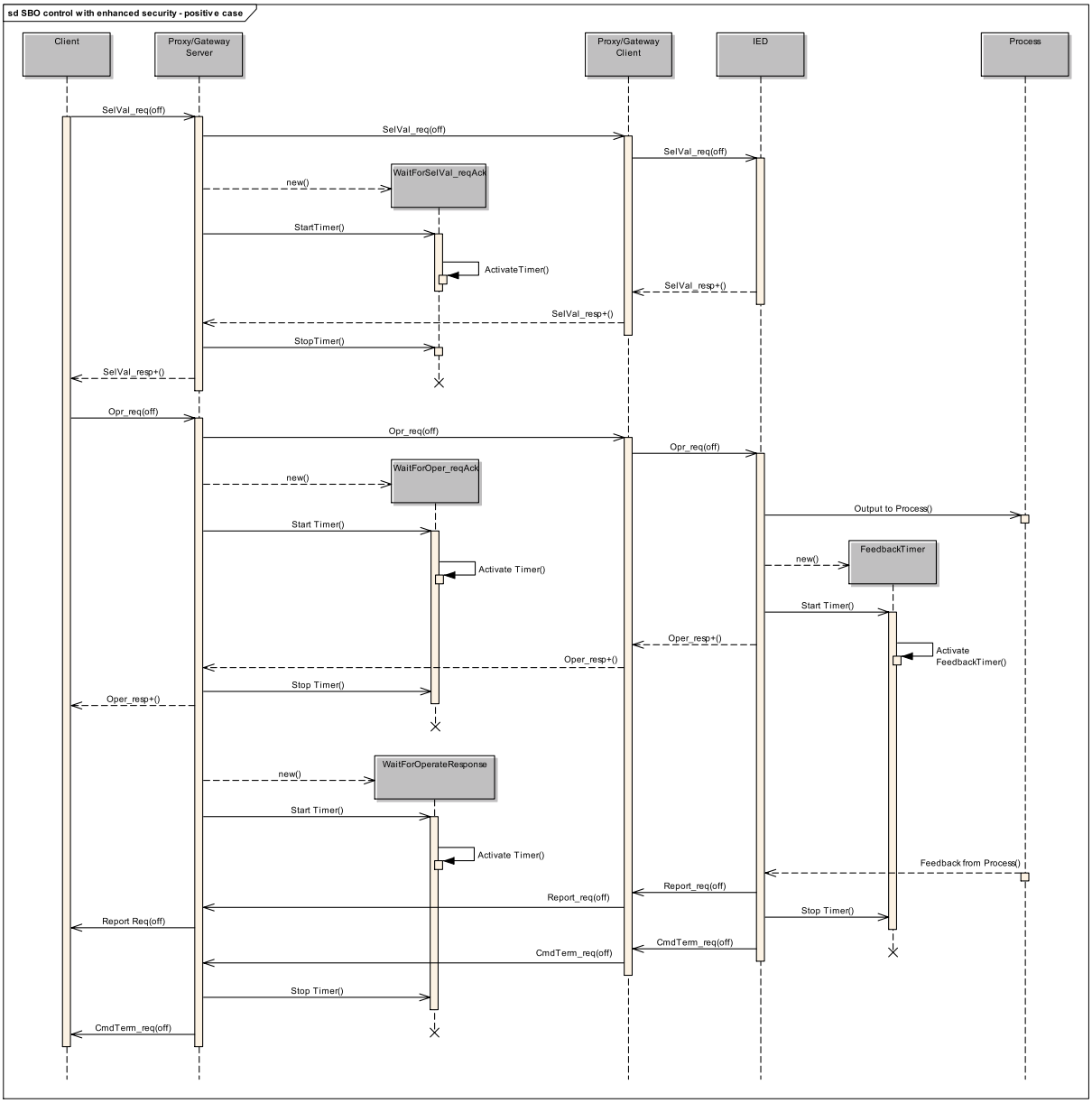
7.2.2.5 SBO control with enhanced security

This model makes use of the services SelectWithValue, Operate, TimeActivatedOperate and Cancel. The state machine in Figure 54 and the sequence diagrams in Figure 55 and Figure 56 define the operation.



IEC

Figure 54 – State machine of SBO control with enhanced security



IEC

Figure 55 – SBO control with enhanced security – positive case

The procedure is as follows:

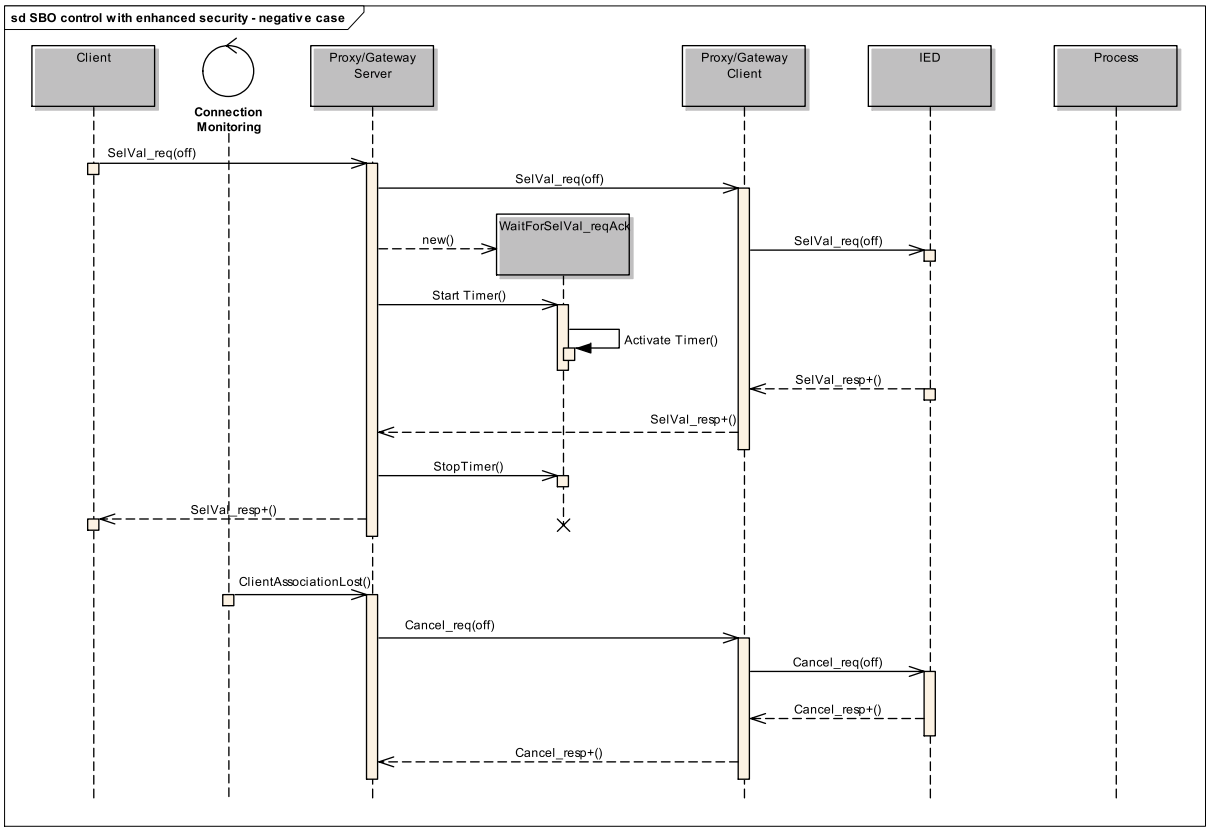
On receipt of the SelVal_req, the Proxy/Gateway server forwards the request to the Proxy/Gateway client. No tests are performed in the Proxy/Gateway server. The communication between the Proxy/Gateway server and the Proxy/Gateway client is an internal communication of the Proxy/Gateway and not part of this technical report. The Proxy/Gateway client will issue the SelVal_req to the IED and start a timer to monitor the reception of the select response from the IED. The IED will perform the tests according to IEC 61850-7-2:2010. The Proxy/Gateway server waits for the result of the tests in the state WaitForSelVal_reqAck. On receipt of the positive select confirmation SelVal_resp+ the Proxy/Gateway server forwards the response to the client and stops the timer.

On receipt of the Oper_req, the Proxy/Gateway server forwards the request to the Proxy/Gateway client. No tests are performed in the Proxy/Gateway server. The Proxy/Gateway client will issue the Oper_req to the IED and start a timer to monitor the reception of the command response from the IED. The IED will perform the tests according to IEC 61850-7-2:2010. The Proxy/Gateway server waits for the result of the tests in the state

WaitForOper_reqAck. On receipt of the positive operate response Oper_resp+ the Proxy/Gateway server forwards the response to the client and stops the timer.

To wait for the resulting CmdTerm_req a new timer is started in the state WaitForOperateResponse. The timer will be stop when the CmdTerm_Req was received by the Proxy/Gateway server. Afterwards the CmdTerm_req is send to the client.

The new status of the control object in the IED is reported by the Report service. The respective value changes will be stored in the process data image of the Proxy/Gateway server. The Proxy/Gateway server then will report it by the Report service to the Client.



IEC

Figure 56 – SBO control with enhanced security – negative case

In the negative case in Figure 56 the association to the client is lost, after the SelVal_req has been received and positively acknowledged by the IED. If the Proxy/Gateway would not send a command termination after the connection to the client was lost, the IED would remain in armed state until the arm time expires. To avoid this, the Proxy/Gateway issues a Cancel_req. This allows other control centres or another redundant Proxy/Gateway client within the substation to control the IED without waiting for the timeout.

7.2.3 SETTING-GROUP-CONTROL-BLOCK class model for Proxy/Gateway

Setting groups span a logical device, and therefore the SGCB, if it exists at all, is located in LLN0. A logical node zero may have one Setting-Group-Control-Block.

The use of Setting-Group-Control-Blocks in the Proxy/Gateway server is only allowed when the structure of the logical devices in the IED is taken over unchanged into the object model of the Proxy/Gateway server, which implies that renaming or restructuring of logical nodes and data may not be done. To reduce the size of the Proxy/Gateway object model it is allowed to use only a subset of the settings in the IED in the Proxy/Gateway.

The Proxy/Gateway server is transparent for all services of the SGCB class. All service requests are forwarded to the Proxy/Gateway client to be executed on the requested device and all responses from the device are sent unchanged to the frontend, see also 7.1.3.6.7.

The use of function oriented naming together with Setting-Group-Control-Blocks in the Proxy/Gateway server is not allowed, because it would require assigning the LLN0 to a bay in the substation section of the Proxy/Gateway server IID file. As it is not allowed to assign the same logical node type more than once to a hierarchy level, it would not be possible to have more than one setting group per bay.

7.2.4 REPORT-CONTROL-BLOCK class model for Proxy/Gateway

The Proxy/Gateway is not transparent for reports received from IEDs connected to the Proxy/Gateway client. Instead the reports to the frontend client will be defined in the Proxy/Gateway server. The reporting model of IEC 61850-7-2:2010 and the MMS mapping according to IEC 61850-8-1:2011 is used.

The report settings for the client side and the server side of the Proxy/Gateway could be different, depending on the configuration. The Proxy/Gateway will use the report settings as configured for the client and the server side. Report settings changed by the frontend client will not automatically be used for the reporting between the Proxy/Gateway and the IEDs within the substation. Having reports recreated for the frontend client with possibly different settings, this may result in a different cause of transmission for a given data object.

If buffered reporting is used between the Proxy/Gateway and the frontend client, the reports are preconfigured for permanent usage (See IEC 61850-6:2009, 9.3.8). The access to the report is limited to configured clients.

7.2.5 LOG-CONTROL-BLOCK class model for Proxy/Gateway

The Proxy/Gateway is not transparent for LOG services. If logging is used the LOGs are locally stored in the Proxy/Gateway server. Access to the logs in the IEDs requires a client with direct access in the control or maintenance centre.

7.2.6 File transfer

File transfer is typically done by direct access to the IED which is the original source of the file, e.g. a disturbance record.

If file transfer services are supported by the Proxy/Gateway, a copy of the IED files is stored in a local repository of the Proxy/Gateway server. The access to these files is direct. To allow the unambiguous identification of the files, the Proxy/Gateway provides an IED specific COMTRADE directory. The COMTRADE directory is part of an IED specific logical device. The name of the logical device equates to the IED name as shown in Table 20. The file name remains unchanged.

Table 20 – Mapping of Comtrade folder names in the Proxy/Gateway

Storage Location	IED	Proxy/Gateway
Root	COMTRADE	IEDName/COMTRADE
Logical Device	LDName/COMTRADE	LDName/COMTRADE

The DeleteFile service will delete the file only from repository of the Proxy/Gateway. The AdFile service will add the file only locally to the repository of the Proxy/Gateway server.

7.2.7 Applying cyber security to the Proxy/Gateway

A future version of IEC 62351-4 (later than 62351-4:2007) will define profiles for end-to-end-security providing different levels of message integrity. They will allow using role based access between the maintenance or control centre and the substation IED with a Proxy/Gateway in between.

The profile shown in Figure 57 provides integrity protection for the ClearToken and carries authentication values from the originator in all MMS messages. Note that this profile does not provide message integrity and may thus be used to allow intermediate nodes to make certain changes in the MMS message, while keeping the authenticator information untouched. This profile suits well to the needs of a Proxy/Gateway doing address translation between the frontend client and the substation IED. The authenticator is calculated from both, sender and receiver, over the ClearToken only. Using indirect access the role based access control can be implemented in the Proxy/Gateway server or the substation IED.

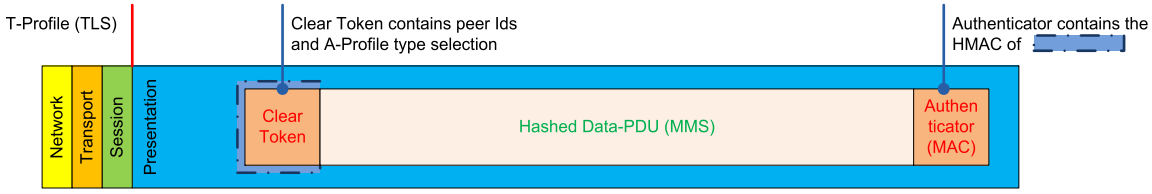


Figure 57 – Integrity protection for the Clear Token

The profile shown in Figure 58 provides integrity protection for ClearToken and the MMS message container and carries an authentication value from the originator in all messages. The authentication is calculated from both, sender and receiver, over the ClearToken and the Hashed Data-PDU containing the MMS message. Using indirect access the role based access control has to be implemented in the Proxy/Gateway. Confidentiality is not supported with this profile.

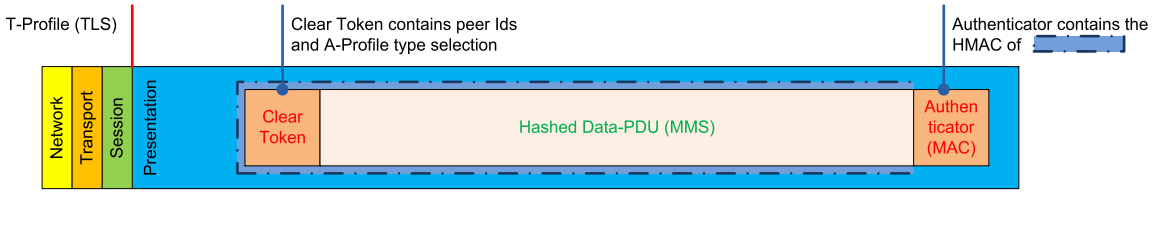


Figure 58 – Integrity protection for the Clear Token and the MMS message

The profile shown in Figure 59 provides integrity protection for ClearToken and the MMS message and carries an authentication value from the originator in all messages. Additionally it provides encryption for the MMS message container. Using indirect access the role based access control has to be implemented in the Proxy/Gateway.

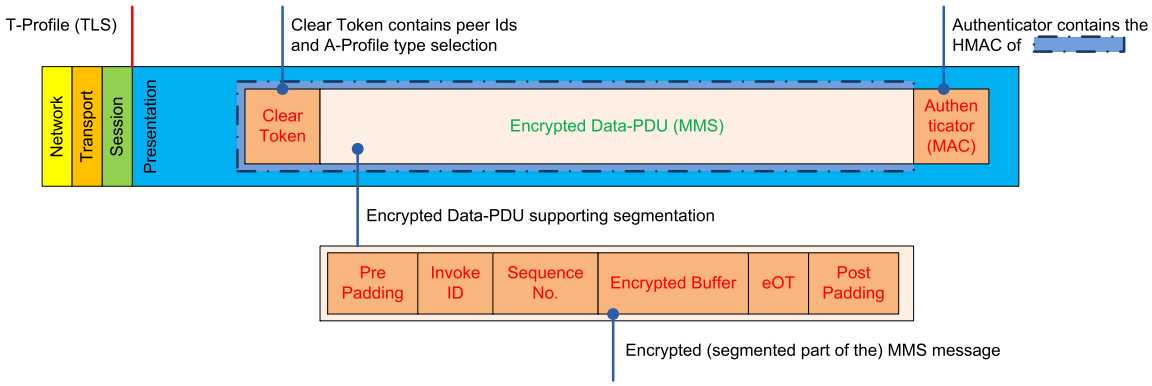


Figure 59 – Integrity protection and encryption for the MMS message

8 SCSM aspects – MMS and ISO/IEC 8802-3

8.1 General

The substation control centre communication is mapped to the SCSM IEC 61850-8-1:2011. Additional Transport-Profiles may be used for WAN communication. The Wide Area Network Engineering Guideline IEC TR 61850-90-12 may assist the user to select the WAN technology that suits his requirements.

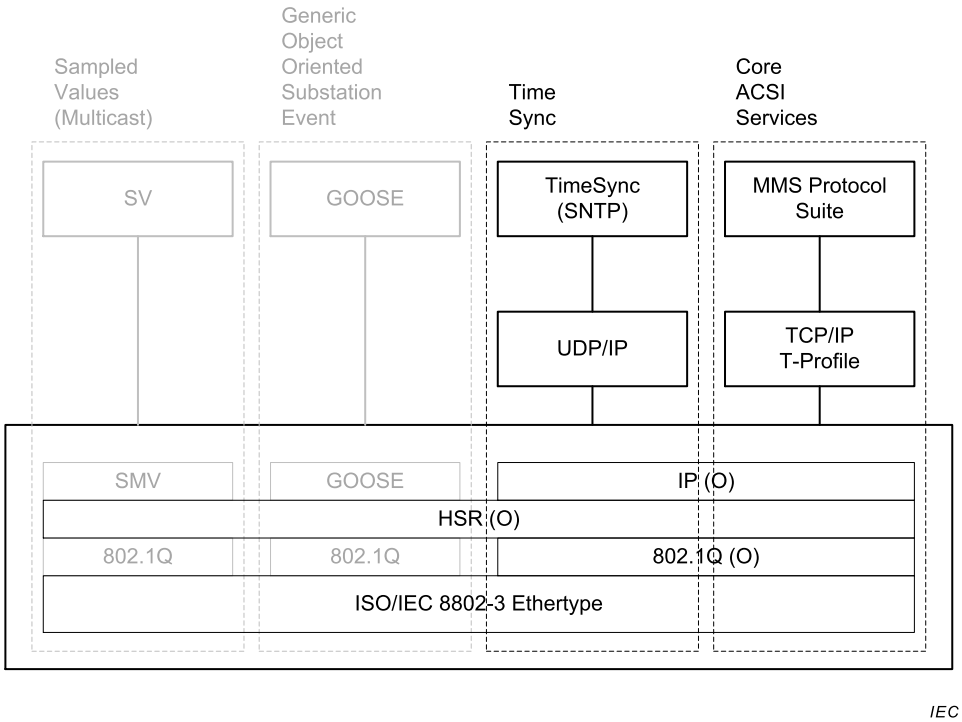


Figure 60 – MMS Objects and services used

The MMS services used for the SS-CC communication is a subset of the services defined in IEC 61850-7-2:2010 as shown in Figure 60.

8.2 TCP/IP T-Profiles

Table 4 of IEC 61850-8-1:2011 defines the T-Profiles to be used within the security perimeters of the substation. Additional T-Profiles selected from IEC TR 61850-90-12 may be

used between the security access points of the control or maintenance centre and the substation.

8.3 OSI T-Profile

The OSI T-Profile of IEC 61850-8-1:2011 is not permitted for the SS-CC communication.

9 SCSM aspects – Sampled values over ISO/IEC 8802-3 (IEC 61850-9-2)

None of the identified use cases for telecontrol and technical services requires the use of sampled values on the interfaces to the control or maintenance centre. The only exceptions from this are described in the phasor data use case, but these are handled in IEC TR 61850-90-5:2012. Therefore no mapping is defined here.

Annex A
(informative)

Protocol Implementation Conformance Statement

A.1 General

The following ACSI conformance statements are used to provide an overview and details about <device ID and name>, with firmware <version>:

- ACSI basic conformance statement,
- ACSI models conformance statement,
- ACSI service conformance statement

The statements specify the communication features mapped to IEC 61850-8-1 and IEC 61850-9-2 as well as the special functions defined in IEC TR 61850-90-2.

A.2 ACSI basic conformance statement

The basic conformance statement is defined in Table A.1.

Table A.1 – Basic conformance statement

		Client/ Subscriber	Server/ Publisher	Value/ Comments
Client-Server roles				
B11	**Server** side (of TWO-PARTY-APPLICATION-ASSOCIATION)	—	Y/N	
B12	**Client** side of (TWO-PARTY-APPLICATION-ASSOCIATION)	Y/N	—	
SCSMs supported				
B21	**SCSM**: IEC 61850-8-1 used	Y/N	Y/N	
B22	**SCSM**: IEC 61850-9-1 used			Deprecated Ed2
B23	**SCSM**: IEC 61850-9-2 used			
B24	**SCSM**: other			
Generic substation event model (GSE)				
B31	**Publisher** side	—	Y/N	
B32	**Subscriber** side	Y/N	—	
Transmission of sampled value model (SVC)				
B41	**Publisher** side	—	Y/N	
B42	**Subscriber** side	Y/N	—	

– = not applicable
Y = supported
N or empty = not supported

A.3 ACSI models conformance statement

The ACSI models conformance statement is defined in Table A.2.

Table A.2 – ACSI models conformance statement

		Client/ Subscriber	Server/ Publisher	Value/ Comments
If **Server** side (B11) and/or **Client** side (B12) supported				
M1	**Logical device**	Y/N	Y/N	
M2	**Logical node**	Y/N	Y/N	
M3	**Data**	Y/N	Y/N	
M4	**Data set**	Y/N	Y/N	
M5	**Substitution**	Y/N	Y/N	
M6	**Setting group control**	Y/N	Y/N	
	Reporting			
M7	**Buffered report control**	Y/N	Y/N	
M7-1	sequence-number	Y/N	Y/N	
M7-2	report-time-stamp	Y/N	Y/N	
M7-3	reason-for-inclusion	Y/N	Y/N	
M7-4	data-set-name	Y/N	Y/N	
M7-5	data-reference	Y/N	Y/N	
M7-6	buffer-overflow	Y/N	Y/N	
M7-7	entryID	Y/N	Y/N	
M7-8	BufTm	Y/N	Y/N	
M7-9	IntgPd	Y/N	Y/N	
M7-10	GI	Y/N	Y/N	
M7-11	conf-revision	Y/N	Y/N	
M8	**Unbuffered report control**	Y/N	Y/N	
M8-1	sequence-number	Y/N	Y/N	
M8-2	report-time-stamp	Y/N	Y/N	
M8-3	reason-for-inclusion	Y/N	Y/N	
M8-4	data-set-name	Y/N	Y/N	
M8-5	data-reference	Y/N	Y/N	
M8-6	BufTm	Y/N	Y/N	
M8-7	IntgPd	Y/N	Y/N	
M8-8	GI	Y/N	Y/N	
M8-9	conf-revision	Y/N	Y/N	
	Logging	Y/N	Y/N	
M9	**Log control**	Y/N	Y/N	
M9-1	IntgPd	Y/N	Y/N	
M10	**Log**	Y/N	Y/N	
M11	**Control**	Y/N	Y/N	
M17	**File Transfer**	Y/N	Y/N	
M18	**Application association**	Y/N	Y/N	
M19	**GOOSE Control Block**	Y/N	Y/N	

		Client/ Subscriber	Server/ Publisher	Value/ Comments
M20	**Sampled Value Control Block**	Y/N	Y/N	
If **GSE** (B31/32) is supported				
M12	**GOOSE**	Y/N	Y/N	
M13	**GSSE**			Deprecated Ed2
If **SVC** (B41/42) is supported				
M14	Multicast SVC	Y/N	Y/N	
M15	Unicast SVC	Y/N	Y/N	
For all IEDs				
M16	**Time**	Y	Y/N	Time source with required accuracy shall be available. Only Time Master are SNTP (Mode 4 response) time server. All other Client / Server devices require SNTP (Mode 3 request) clients
Y = service is supported N or empty = service is not supported				

A.4 ACSI service conformance statement

The ACSI service conformance statement is defined in Table A.3 (depending on the statements in Table A.1 and in Table A.2).

Table A.3 – ACSI service conformance statement

	Ed.	Services	AA: TP/MC	Client (C)	Server (S)	Transparent access	Comments
	Server						
S1	1,2	GetServerDirectory (LOGICAL-DEVICE)	TP	Y/N	Y/N	N	
	Application association						
S2	1,2	Associate		Y/N	Y/N	N	
S3	1,2	Abort		Y/N	Y/N	N	
S4	1,2	Release		Y/N	Y/N	N	
	Logical device						
S5	1,2	GetLogicalDeviceDirectory	TP	Y/N	Y/N	N	
	Logical node						
S6	1,2	GetLogicalNodeDirectory	TP	Y/N	Y/N	N	
S7	1,2	GetAllDataValues	TP	Y/N	Y/N	Y/N	

	Ed.	Services	AA: TP/MC	Client (C)	Server (S)	Transparent access	Comments
	Data						
S8	1,2	GetDataValues	TP	Y/N	Y/N	Y/N	
S9	1,2	SetDataValues	TP	Y/N	Y/N	Y/N	
S10	1,2	GetDataDirectory	TP	Y/N	Y/N	N	
S11	1,2	GetDataDefinition	TP	Y/N	Y/N	N	

	Data set						
S12	1,2	GetDataSetValues	TP	Y/N	Y/N	Y/N	
S13	1,2	SetDataSetValues	TP	Y/N	Y/N	Y/N	
S14	1,2	CreateDataSet	TP	Y/N	Y/N	N	
S15	1,2	DeleteDataSet	TP	Y/N	Y/N	N	
S16	1,2	GetDataSetDirectory	TP	Y/N	Y/N	N	

	Substitution						
S17	1	SetDataValues	TP	Y/N	Y/N	Y/N	

	Setting group control						
S18	1,2	SelectActiveSG	TP	Y/N	Y/N	Y/N	
S19	1,2	SelectEditSG	TP	Y/N	Y/N	Y/N	
S20	1,2	SetSGValues	TP	Y/N	Y/N	Y/N	
S21	1,2	ConfirmEditSGValues	TP	Y/N	Y/N	Y/N	
S22	1,2	GetSGValues	TP	Y/N	Y/N	Y/N	
S23	1,2	GetSGCBValues	TP	Y/N	Y/N	Y/N	

	Reporting						
	Buffered report control block (BRCB)						
S24	1,2	Report	TP	Y/N	Y/N	N	
S24-1	1,2	data-change (dchg)		Y/N	Y/N	N	
S24-2	1,2	quality-change (qchg)		Y/N	Y/N	N	
S24-3	1,2	data-update (dupd)		Y/N	Y/N	N	
S25	1,2	GetBRCBValues	TP	Y/N	Y/N	N	
S26	1,2	SetBRCBValues	TP	Y/N	Y/N	N	
	Unbuffered report control block (URCB)						
S27	1,2	Report	TP	Y/N	Y/N	N	
S27-1	1,2	data-change (dchg)		Y/N	Y/N	N	
S27-2	1,2	quality-change (qchg)		Y/N	Y/N	N	
S27-3	1,2	data-update (dupd)		Y/N	Y/N	N	
S28	1,2	GetURCBValues	TP	Y/N	Y/N	N	
S29	1,2	SetURCBValues	TP	Y/N	Y/N	N	

	Logging						
	Log control block						
S30	1,2	GetLCBValues	TP	Y/N	Y/N	N	
S31	1,2	SetLCBValues	TP	Y/N	Y/N	N	
	Log						
S32	1,2	QueryLogByTime	TP	Y/N	Y/N	N	
S33	1,2	QueryLogAfter	TP	Y/N	Y/N	N	
S34	1,2	GetLogStatusValues	TP	Y/N	Y/N	N	

	Ed.	Services	AA: TP/MC	Client (C)	Server (S)	Transparent access	Comments
	Generic substation event model (GSE)						
	GOOSE						
S35	1,2	SendGOOSEMessage	MC	Y/N	Y/N	n/a	
	GOOSE-CONTROL-BLOCK						
S36	1,2	GetGoReference	TP	Y/N	Y/N	n/a	
S37	1,2	GetGOOSEElementNumber	TP	Y/N	Y/N	n/a	
S38	1,2	GetGoCBValues	TP	Y/N	Y/N	n/a	
S39	1,2	SetGoCBValues	TP	Y/N	Y/N	n/a	
	GSSE						
S40	1	SendGSSEMessage	MC				Deprecated in Edition 2
	GSSE-CONTROL-BLOCK						
S41	1	GetReference	TP				Deprecated in Edition 2
S42	1	GetGSSEElementNumber	TP				Deprecated in Edition 2
S43	1	GetGsCBValues	TP				Deprecated in Edition 2
S44	1	SetGsCBValues	TP				Deprecated in Edition 2

	Transmission of sampled value model (SVC)						
	Multicast SV						
S45	1,2	SendMSVMessage	MC	Y/N	Y/N	n/a	
	Multicast Sampled Value Control Block						
S46	1,2	GetMSVCBValues	TP	Y/N	Y/N	n/a	
S47	1,2	SetMSVCBValues	TP	Y/N	Y/N	n/a	
	Unicast SV						
S48	1,2	SendUSVMessage	TP	Y/N	Y/N	n/a	
	Unicast Sampled Value Control Block						
S49	1,2	GetUSVCBValues	TP	Y/N	Y/N	n/a	
S50	1,2	SetUSVCBValues	TP	Y/N	Y/N	n/a	
S49	1,2	GetUSVCBValues	TP	Y/N	Y/N	n/a	
S50	1,2	SetUSVCBValues	TP	Y/N	Y/N	n/a	

	Control						
S51	1,2	Select	TP	Y/N	Y/N	Y	
S52	1,2	SelectWithValue	TP	Y/N	Y/N	Y	
S53	1,2	Cancel	TP	Y/N	Y/N	Y	
S54	1,2	Operate	TP	Y/N	Y/N	Y	
S55	1,2	CommandTermination	TP	Y/N	Y/N	Y	
S56	1,2	TimeActivatedOperate	TP	Y/N	Y/N	Y	

	File transfer						
S57	1,2	GetFile	TP	Y/N	Y/N	N	
S58	1,2	SetFile	TP	Y/N	Y/N	N	
S59	1,2	DeleteFile	TP	Y/N	Y/N	N	
S60	1,2	GetFileAttributeValues	TP	Y/N	Y/N	N	
S61	1,2	GetServerDirectory (FILE-SYSTEM)	TP	Y/N	Y/N	N	

	Time						
T1	1,2	Time resolution of internal clock		xx	xx	n/a	Nearest negative power of 2^{-n} in seconds (number 0 .. 24)

	Ed.	Services	AA: TP/MC	Client (C)	Server (S)	Transparent access	Comments
T2	1,2	Time accuracy of internal clock		Tx	Tx	n/a	TL (ms) (low accuracy), T3 < 7) (only Ed2) T0 (ms) (<= 10 ms), 7 <= T3 < 9 T1 (µs) (<= 1 ms), 10 <= T3 < 13 T2 (µs) (<= 100 µS), 13 <= T3 < 15 T3 (µs) (<= 25 µS), 15 <= T3 < 18 T4 (µs) (<= 25 µS), 15 <= T3 < 18 T5 (µs) (<= 1 µS), T3 >= 20
T3	1,2	Supported TimeStamp resolution	-	xx	xx	n/a	Nearest value of 2^{-n} in seconds (number 0 .. 24)

A.5 Redundancy support statement

The support of redundancy mechanisms defined in IEC TR 61850-90-2 is defined in Table A.4.

Table A.4 – Redundancy mechanism support statement

		Client (C)	Server (S)	Value/ Comments
Redundancy Capabilities supported				
R1	No Redundancy	Y/N	Y/N	
R2	Access Point Redundancy	Y/N	Y/N	
R3	Device Redundancy	Y/N	Y/N	
R4	Multiple Redundancy	Y/N	Y/N	
R5	Cooperating Clients	Y/N	Y/N	
Link Modes supported				
R6	Active	Y/N	Y/N	
R7	Standby	Y/N	Y/N	
R8	Supervised	Y/N	Y/N	
R9	Off	Y/N	Y/N	
Duplicate Filter supported				
R6	Duplicate Filter	Y/N	n/a	

A.6 Transformation function support statement

The support of transformation functions defined in IEC TR 61850-90-2 is defined in Table A.5.

Table A.5 – Proxy/Gateway transformation function support statement

		Proxy/ Gateway	Value/ Comments
Transformation functions supported			
L1	Preserve logical devices from IED level	Y/N	
L2	Rename logical devices from IED level	Y/N	
L3	Rearrange/Rename logical nodes from IED level	Y/N	
L4	Merge data objects from IED level	Y/N	
L5	Split data objects from IED level	Y/N	
L6	Transform generic data to semantically defined data	Y/N	
L7	Transform semantically defined data to other semantically defined data	Y/N	
L8	Create a subset of an data array from IED level	Y/N	
L9	Translate data from legacy protocols	Y/N	
L10	Support of local Proxy/Gateway data	Y/N	

A.7 Proxy/Gateway model support statement

The support of Proxy/Gateway models defined in IEC TR 61850-90-2 is defined in Table A.6.

Table A.6 – Proxy/Gateway model support statement

		Client (C)	Server (S)	Value/ Comments
Naming conventions supported				
P1	Function related naming	Y/N	Y/N	
P2	Product related naming	Y/N	Y/N	
Access methods supported				
P3	Direct access	n/a	Y/N	
P4	Transparent access	n/a	Y/N	
Substitution methods supported				
P5	Substitution in Proxy/Gateway server	n/a	Y/N	
P6	Substitution in IED via transparent access	n/a	Y/N	
Telemonitoring blocking methods supported				
P7	Blocking of individual values	Y/N	Y/N	
P8	Blocking of reports	Y/N	Y/N	
P9	Filter in frontend client side	Y/N	n/a	
Telecontrol blocking methods supported				
P10	CmdBlk in Proxy/Gateway	Y/N	Y/N	
P11	LocSta at bay level	Y/N	Y/N	
P12	LocSta of ITCI for telecontrol interface	Y/N	Y/N	

		Client (C)	Server (S)	Value/ Comments
Setting group control supported				
P13	Local setting groups	n/a	Y/N	
P14	Transparent access for IED setting groups	n/a	Y/N	

File transfer methods supported				
P15	Transparent access to IED	Y/N	Y/N	
P16	Local file repository	Y/N	Y/N	

A.8 Instruction and comments on using this template

NOTE This is NOT part of the PICS file.

A.8.1 Comments

The template has the following differences compared to IEC 61850-7-2 Edition 2:

- inserted changes suggested for IEC TR 61850-90-2
- Added column for service trans
- all services are optional
- It's not required to include the MMS conformance statement from IEC 61850-8-1 Annex A

A.8.2 Instructions

- format of the document may be changed into your company format
- enter the applicable IED name and firmware version
- update the Y/N values
- for a server-only devices remove the Y/N values in the client columns
- for a client-only devices remove the Y/N values in the server columns
- for each device with multiple access points with different capabilities, alter the column header to indicate the access point name(s). Add additional columns for each access point with unique capabilities
- remove the instructions, comments and revision history

A.8.3 Revision history

Revision	Date	Remarks
1.0	2015-11-11	First version

Annex B
(informative)

SCL syntax: XML schema definition

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:scl="http://www.iec.ch/61850/2003/SCL" xmlns:eTr-IEC61850-90-
2="http://www.iec.ch/61850-90-2/2015/SCL" xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
targetNamespace="http://www.iec.ch/61850-90-2/2015/SCL" elementFormDefault="qualified"
attributeFormDefault="unqualified" version="2015A1">
   <xs:annotation>
      <xs:documentation xml:lang="en">SSCC schema version "2015" revision "A" release "1",
for IEC 61850-90-2 Ed. 1.0. Draft 2015-02-27. The schema imports the SCL schema "2007"
revision "B" release 1,  for IEC 61850-6 Ed. 2.1. Draft 2014-07-18.

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for any personal injury, property or other damages of any nature whatsoever, whether special,
indirect, consequential or compensatory, directly or indirectly resulting from this software
and the document upon which its methods are based, use of, or reliance upon.
      </xs:documentation>
   </xs:annotation>
   <xs:import namespace="http://www.iec.ch/61850/2003/SCL" schemaLocation="SCL.xsd"/>
   <xs:complexType name="tExternalSCL">
      <xs:annotation>
         <xs:documentation xml:lang="en">SCL file name containing the definition of a
referenced SCL element.</xs:documentation>
      </xs:annotation>
      <xs:attribute name="name" use="required">
         <xs:simpleType>
            <xs:restriction base="xs:normalizedString">
               <xs:minLength value="1"/>
            </xs:restriction>
         </xs:simpleType>
      </xs:attribute>
      <xs:attribute name="file" use="required">
         <xs:simpleType>
            <xs:restriction base="xs:anyURI">
               <xs:minLength value="1"/>
            </xs:restriction>
         </xs:simpleType>
      </xs:attribute>
      <xs:attribute name="id" use="optional">
         <xs:simpleType>
            <xs:restriction base="xs:normalizedString">
               <xs:minLength value="1"/>
            </xs:restriction>
         </xs:simpleType>
      </xs:attribute>
      <xs:attribute name="version" use="optional">
         <xs:simpleType>
            <xs:restriction base="xs:normalizedString">
               <xs:minLength value="1"/>
            </xs:restriction>
         </xs:simpleType>
      </xs:attribute>
      <xs:attribute name="revision" use="optional">
         <xs:simpleType>
            <xs:restriction base="xs:normalizedString">
               <xs:minLength value="1"/>
            </xs:restriction>
         </xs:simpleType>
      </xs:attribute>
   </xs:complexType>
   <xs:complexType name="tRedundancyModes">
      <xs:annotation>
```

```
         <xs:documentation xml:lang="en">Describes the capabilities of a redundant IEC61850
client</xs:documentation>
      </xs:annotation>
      <xs:attribute name="noRedundancy" type="xs:boolean" use="optional" default="true"/>
      <xs:attribute name="acccessPointRedundancy" type="xs:boolean" use="optional"
default="false"/>
      <xs:attribute name="deviceRedundancy" type="xs:boolean" use="optional" default="false"/>
      <xs:attribute name="multipleRedundancy" type="xs:boolean" use="optional"
default="false"/>
   </xs:complexType>
   <xs:complexType name="tLinkModes">
      <xs:annotation>
         <xs:documentation xml:lang="en">Describes the supported link states of a redundant
IEC61850 connection</xs:documentation>
      </xs:annotation>
      <xs:attribute name="active" type="xs:boolean" use="optional" default="false"/>
      <xs:attribute name="standby" type="xs:boolean" use="optional" default="false"/>
      <xs:attribute name="supervised" type="xs:boolean" use="optional" default="false"/>
      <xs:attribute name="off" type="xs:boolean" use="optional" default="true"/>
   </xs:complexType>
   <xs:complexType name="tClientRedundancyServices">
      <xs:annotation>
         <xs:documentation xml:lang="en">Service section for redundancy support according to
IEC 61850-90-2</xs:documentation>
      </xs:annotation>
      <xs:all>
         <xs:element name="RedundancyModes" type="eTr-IEC61850-90-2:tRedundancyModes"
minOccurs="0"/>
         <xs:element name="LinkModes" type="eTr-IEC61850-90-2:tLinkModes" minOccurs="0"/>
         <xs:element name="CooperatingClients" type="xs:boolean" default="false"
minOccurs="0"/>
      </xs:all>
   </xs:complexType>
   <xs:complexType name="tProxyRef">
      <xs:annotation>
         <xs:documentation xml:lang="en">Express relation between LN/DO/DOI in Proxy/Gateway
Server and IED.</xs:documentation>
      </xs:annotation>
      <xs:attribute name="externalScl" use="optional">
         <xs:simpleType>
            <xs:restriction base="xs:normalizedString">
               <xs:minLength value="1"/>
            </xs:restriction>
         </xs:simpleType>
      </xs:attribute>
      <xs:attribute name="iedName" type="scl:tIEDName" use="required"/>
      <xs:attribute name="ldInst" type="scl:tLDInst" use="required"/>
      <xs:attribute name="prefix" type="scl:tPrefix" use="optional" default=""/>
      <xs:attribute name="lnClass" type="scl:tLNClassEnum" use="required"/>
      <xs:attribute name="lnInst" type="scl:tLNInst" use="optional"/>
      <xs:attribute name="doName" type="scl:tFullDOName" use="optional"/>
      <xs:attribute name="daName" type="scl:tFullAttributeName" use="optional"/>
      <xs:attribute name="fc" type="scl:tFCEnum" use="optional"/>
      <xs:attribute name="ix" type="xs:unsignedInt" use="optional"/>
   </xs:complexType>
   <xs:complexType name="tRedundantServerTo">
      <xs:annotation>
         <xs:documentation>Describes the reference to a server access point in another IED and
allows to override instance values</xs:documentation>
      </xs:annotation>
      <xs:sequence>
         <xs:element name="LDeviceOverride" type="scl:tLDevice" minOccurs="0"
maxOccurs="unbounded">
            <xs:unique name="uniqueLNInLDeviceOverride">
               <xs:selector xpath="./scl:LN"/>
               <xs:field xpath="@inst"/>
               <xs:field xpath="@lnClass"/>
               <xs:field xpath="@prefix"/>
```

```
            </xs:unique>
         </xs:element>
         <xs:element name="Association" type="scl:tAssociation" minOccurs="0"
maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attribute name="iedName" type="scl:tIEDName" use="required"/>
      <xs:attribute name="apName" type="scl:tAccessPointName" use="required"/>
      <xs:attribute name="timeout" type="xs:unsignedInt" use="optional" default="30"/>
   </xs:complexType>
   <xs:complexType name="tAccessPointRef">
      <xs:annotation>
         <xs:documentation>Describes the reference to an access point in another
IED</xs:documentation>
      </xs:annotation>
      <xs:attribute name="iedName" type="scl:tIEDName" use="required"/>
      <xs:attribute name="apName" type="scl:tAccessPointName" use="required"/>
   </xs:complexType>
   <xs:simpleType name="tLinkModeEnum">
      <xs:annotation>
         <xs:documentation>Enumeration for the possibel operation modes of a non active
communication link</xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:Name">
         <xs:enumeration value="Standby"/>
         <xs:enumeration value="Supervised"/>
         <xs:enumeration value="Off"/>
      </xs:restriction>
   </xs:simpleType>
   <xs:element name="ExternalSCL" type="eTr-IEC61850-90-2:tExternalSCL">
      <xs:annotation>
         <xs:documentation xml:lang="en">SCL file name: containing referenced SCL elements. To
be included in a Private with type "eTr-IEC61850-90-2" below the root SCL
element.</xs:documentation>
      </xs:annotation>
   </xs:element>
   <xs:element name="RedundancyModes" type="eTr-IEC61850-90-2:tRedundancyModes">
      <xs:annotation>
         <xs:documentation xml:lang="en">Describes the capabilities of a redundant IEC61850
client. Element in ClientRedundancyServices</xs:documentation>
      </xs:annotation>
   </xs:element>
   <xs:element name="LinkModes" type="eTr-IEC61850-90-2:tLinkModes">
      <xs:annotation>
         <xs:documentation xml:lang="en">Describes the supported link states of a redundant
IEC61850 connection. Element in ClientRedundancyServices</xs:documentation>
      </xs:annotation>
   </xs:element>
   <xs:element name="ClientRedundancyServices" type="eTr-IEC61850-90-
2:tClientRedundancyServices">
      <xs:annotation>
         <xs:documentation xml:lang="en">Service section for redundancy support according to
IEC 61850-90-2. To be included in a Private with type "eTr-IEC61850-90-2" below the
"AccesPoint" SCL element.</xs:documentation>
      </xs:annotation>
   </xs:element>
   <xs:element name="ProxyOf" type="eTr-IEC61850-90-2:tProxyRef">
      <xs:annotation>
         <xs:documentation xml:lang="en">Express relation between LN/DO/DOI in Proxy/Gateway
Server and IED. To be included in a Private with type "eTr-IEC61850-90-2" below the SCL
element.</xs:documentation>
      </xs:annotation>
   </xs:element>
   <xs:element name="RedundantServerTo" type="eTr-IEC61850-90-2:tRedundantServerTo">
      <xs:annotation>
         <xs:documentation xml:lang="en">Express Relation between Servers for redundancy. To
be included in a Private with type "eTr-IEC61850-90-2" below the "AccessPoint" SCL
element.</xs:documentation>
      </xs:annotation>
```

```
   </xs:element>
   <xs:element name="RedundantClientTo" type="eTr-IEC61850-90-2:tAccessPointRef">
      <xs:annotation>
         <xs:documentation xml:lang="en">Express Relation between Clients for redundancy. To
be included in a Private with type "eTr-IEC61850-90-2" below the "AccessPoint" SCL
element.</xs:documentation>
      </xs:annotation>
   </xs:element>
   <xs:element name="StandbyLinkMode" type="eTr-IEC61850-90-2:tLinkModeEnum">
      <xs:annotation>
         <xs:documentation xml:lang="en">Configured operation mode of the communication
link(s) when not the preferred link. To be included in a Private with type "eTr-IEC61850-90-2"
below the "AccessPoint" SCL element.</xs:documentation>
      </xs:annotation>
   </xs:element>
</xs:schema>
```

Annex C
(informative)

Substation SCD example

```
<?xml version="1.0" encoding="utf-8"?>
<SCL version="2007" revision="B" release="1" xmlns="http://www.iec.ch/61850/2003/SCL"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:eTr-IEC61850-90-
2="http://www.iec.ch/61850-90-2/2015/SCL" xsi:schemaLocation="http://www.iec.ch/61850-90-
2/2015/SCL C:\Users\nb241630\Desktop\90-2\Schema\SSCC.xsd">
   <Private type="eTr-IEC61850-90-2">
      <eTr-IEC61850-90-2:ExternalSCL name="Proxy/Gateway" file="Proxy-Gateway.scd" id="90-2
ProxyGatewayServer Sample SCL" version="1" revision="A"/>
   </Private>
   <Header id="Substation Sample SCL" version="1" revision="A" nameStructure="IEDName"/>
   <Substation name="AA1">
      <VoltageLevel name="E1">
         <Bay name="Q1">
            <ConductingEquipment type="CBR" name="Q0">
               <LNode lnClass="CSWI" iedName="IED1" ldInst="CTRL" lnInst="1" prefix="Q0"/>
               <LNode lnClass="XCBR" iedName="IED1" ldInst="CTRL" lnInst="1" prefix="Q0"/>
               <LNode lnClass="CILO" iedName="IED1" ldInst="CTRL" lnInst="1" prefix="Q0"/>
            </ConductingEquipment>
            <ConductingEquipment type="DIS" name="Q1">
            </ConductingEquipment>
            <ConductingEquipment type="VTR" name="T5">
            </ConductingEquipment>
            <ConductingEquipment type="CTR" name="T1">
            </ConductingEquipment>
         </Bay>
         <Bay name="Q2">
            <ConductingEquipment type="CBR" name="Q0">
               <LNode lnClass="CSWI" iedName="IED3" ldInst="CTRL" lnInst="1" prefix=""/>
               <LNode lnClass="XCBR" iedName="IED3" ldInst="CTRL" lnInst="1" prefix=""/>
               <LNode lnClass="CILO" iedName="IED3" ldInst="CTRL" lnInst="1" prefix=""/>
            </ConductingEquipment>
            <ConductingEquipment type="DIS" name="Q1"/>
            <ConductingEquipment type="VTR" name="T5"/>
            <ConductingEquipment type="CTR" name="T1"/>
         </Bay>
      </VoltageLevel>
   </Substation>
   <Communication>
      <SubNetwork name="SubNet1" type="8-MMS">
         <ConnectedAP iedName="IED1" apName="AP1">
            <Address>
               <P type="IP">10.0.0.1</P>
               <P type="IP-GATEWAY">10.0.1.1</P>
               <P type="OSI-TSEL">0001</P>
               <P type="OSI-PSEL">00000001</P>
               <P type="OSI-SSEL">0001</P>
               <P type="OSI-AP-Title">1,3,9999,23</P>
               <P type="OSI-AE-Qualifier">23</P>
            </Address>
         </ConnectedAP>
         <ConnectedAP iedName="IED2" apName="AP1">
            <Address>
               <P type="IP">10.0.0.2</P>
               <P type="IP-GATEWAY">10.0.1.1</P>
               <P type="OSI-TSEL">0001</P>
               <P type="OSI-PSEL">00000001</P>
               <P type="OSI-SSEL">0001</P>
               <P type="OSI-AP-Title">1,3,9999,23</P>
               <P type="OSI-AE-Qualifier">23</P>
            </Address>
         </ConnectedAP>
```

```
            <ConnectedAP iedName="IED3" apName="AP1">
               <Address>
                  <P type="IP">10.0.0.3</P>
                  <P type="IP-GATEWAY">10.0.1.1</P>
                  <P type="OSI-TSEL">0001</P>
                  <P type="OSI-PSEL">00000001</P>
                  <P type="OSI-SSEL">0001</P>
                  <P type="OSI-AP-Title">1,3,9999,23</P>
                  <P type="OSI-AE-Qualifier">23</P>
               </Address>
            </ConnectedAP>
            <ConnectedAP iedName="IED4" apName="AP1">
               <Address>
                  <P type="IP">10.0.0.4</P>
                  <P type="IP-GATEWAY">10.0.1.1</P>
                  <P type="OSI-TSEL">0001</P>
                  <P type="OSI-PSEL">00000001</P>
                  <P type="OSI-SSEL">0001</P>
                  <P type="OSI-AP-Title">1,3,9999,23</P>
                  <P type="OSI-AE-Qualifier">23</P>
               </Address>
            </ConnectedAP>
            <ConnectedAP iedName="IED5" apName="AP1">
               <Address>
                  <P type="IP">10.0.0.5</P>
                  <P type="IP-GATEWAY">10.0.1.1</P>
                  <P type="OSI-TSEL">0001</P>
                  <P type="OSI-PSEL">00000001</P>
                  <P type="OSI-SSEL">0001</P>
                  <P type="OSI-AP-Title">1,3,9999,23</P>
                  <P type="OSI-AE-Qualifier">23</P>
               </Address>
            </ConnectedAP>
            <ConnectedAP iedName="IED6" apName="AP1">
               <Address>
                  <P type="IP">10.0.0.6</P>
                  <P type="IP-GATEWAY">10.0.1.1</P>
                  <P type="OSI-TSEL">0001</P>
                  <P type="OSI-PSEL">00000001</P>
                  <P type="OSI-SSEL">0001</P>
                  <P type="OSI-AP-Title">1,3,9999,23</P>
                  <P type="OSI-AE-Qualifier">23</P>
               </Address>
            </ConnectedAP>
            <ConnectedAP iedName="IED99_1" apName="AP1">
               <Address>
                  <P type="IP">10.0.0.99</P>
                  <P type="IP-GATEWAY">10.0.1.1</P>
               </Address>
            </ConnectedAP>
            <ConnectedAP iedName="IED99_2" apName="AP1">
               <Address>
                  <P type="IP">10.0.0.100</P>
                  <P type="IP-GATEWAY">10.0.1.1</P>
               </Address>
            </ConnectedAP>
         </SubNetwork>
      </Communication>
      <IED desc="Bay Controller E1Q1" name="IED1" type="Bay Controller" manufacturer="IEC"
configVersion="1">
         <Services>
            <DynAssociation/>
            <GetDirectory/>
            <GetDataObjectDefinition/>
            <DataObjectDirectory/>
            <GetDataSetValue/>
            <SetDataSetValue/>
            <DataSetDirectory/>
```

```
         <ConfDataSet max="32" maxAttributes="32" modify="false"/>
         <ReadWrite/>
         <ConfReportControl max="32" bufMode="both" bufConf="true"/>
         <GetCBValues/>
         <ReportSettings cbName="Conf" datSet="Conf" rptID="Conf" optFields="Dyn"
bufTime="Conf" trgOps="Conf" intgPd="Conf"/>
         <GSESettings cbName="Conf" datSet="Conf" appID="Conf"/>
         <GOOSE max="16"/>
         <GSSE max="0"/>
         <ConfLNs fixLnInst="true"/>
      </Services>
      <AccessPoint name="AP1">
         <Server>
            <Authentication/>
            <LDevice inst="CTRL">
               <LN0 lnClass="LLN0" lnType="LLN0" inst="">
                  <DataSet name="Dataset1">
                     <FCDA ldInst="CTRL" lnClass="LPHD" lnInst="1" doName="PhyHealth"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="CSWI" lnInst="1" doName="Beh"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="CSWI" lnInst="1" doName="Health"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="CSWI" lnInst="1" doName="Pos"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="CILO" lnInst="1" doName="Beh"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="CILO" lnInst="1" doName="Health"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="CILO" lnInst="1" doName="EnaOpn"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="CILO" lnInst="1" doName="EnaCls"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="XCBR" lnInst="1" doName="Beh"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="XCBR" lnInst="1" doName="Health"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="XCBR" lnInst="1" doName="Loc"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="XCBR" lnInst="1" doName="OpCnt"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="XCBR" lnInst="1" doName="Pos"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="XCBR" lnInst="1" doName="BlkOpn"
fc="ST"/>
                     <FCDA ldInst="CTRL" prefix="Q0" lnClass="XCBR" lnInst="1" doName="BlkCls"
fc="ST"/>
                  </DataSet>
                  <ReportControl name="BRCB" datSet="Dataset1" confRev="1" buffered="true"
bufTime="100">
                     <TrgOps dchg="true" qchg="true" dupd="true" period="true"/>
                     <OptFields bufOvfl="true" configRef="true" entryID="true"
reasonCode="true" seqNum="true" timeStamp="true"/>
                     <RptEnabled max="2">
                        <ClientLN iedName="IED99_1" apRef="AP1" lnInst="1" lnClass="ITCI"
ldInst="LD0"/>
                        <ClientLN iedName="IED99_2" apRef="AP1" lnInst="1" lnClass="ITCI"
ldInst="LD0"/>
                     </RptEnabled>
                  </ReportControl>
                  <DOI name="NamPlt">
                     <DAI name="vendor">
                        <Val>IEC</Val>
                     </DAI>
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         <DAI name="d">
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    <DataObjectDirectory/>
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    <DataSetDirectory/>
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    <GetCBValues/>
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bufTime="Conf" trgOps="Conf" intgPd="Conf"/>
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    <GOOSE max="16"/>
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    <ConfLNs fixLnInst="true"/>
  </Services>
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doName="PhyHealth" fc="ST"/>
            <FCDA ldInst="PROT" prefix="" lnClass="PTOC" lnInst="1" doName="Beh"
fc="ST"/>
            <FCDA ldInst="PROT" prefix="" lnClass="PTOC" lnInst="1" doName="Health"
fc="ST"/>
```

```
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fc="ST"/>
                    <FCDA ldInst="PROT" prefix="" lnClass="PTOC" lnInst="1" doName="Op"
fc="ST"/>
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                    <OptFields bufOvfl="true" configRef="true" entryID="true"
reasonCode="true" seqNum="true" timeStamp="true"/>
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ldInst="LD0"/>
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ldInst="LD0"/>
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                    <DAI name="model">
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                    <DAI name="owner">
                        <Val>Utility</Val>
                    </DAI>
                    <DAI name="ePSName">
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                    </DAI>
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doName="PhyHealth" fc="ST"/>
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fc="MX"/>
                     <FCDA ldInst="MEAS" prefix="" lnClass="MMXU" lnInst="1" doName="Health"
fc="MX"/>
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fc="MX"/>
                     <FCDA ldInst="MEAS" prefix="" lnClass="MMXU" lnInst="1" doName="A"
fc="MX"/>
                     <FCDA ldInst="MEAS" prefix="" lnClass="MMXU" lnInst="1" doName="PPV"
fc="MX"/>
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reasonCode="true" seqNum="true" timeStamp="true"/>
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ldInst="LD0"/>
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                        </DAI>
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            <GetDataObjectDefinition/>
            <DataObjectDirectory/>
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            <SetDataSetValue/>
            <DataSetDirectory/>
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fc="ST"/>
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fc="ST"/>
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fc="ST"/>
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fc="ST"/>
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fc="ST"/>
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fc="ST"/>
                        <FCDA ldInst="CTRL" prefix="Q0" lnClass="XCBR" lnInst="1" doName="Beh"
fc="ST"/>
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fc="ST"/>
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ldInst="LD0"/>
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                    </DAI>
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                    </DAI>
                    <DAI name="configRev">
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                    <DAI name="owner">
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                    </DAI>
                    <DAI name="ePSName">
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         <GOOSE max="16"/>
         <GSSE max="0"/>
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      </Services>
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doName="PhyHealth" fc="ST"/>
                     <FCDA ldInst="PROT" prefix="" lnClass="PTOC" lnInst="1" doName="Beh"
fc="ST"/>
                     <FCDA ldInst="PROT" prefix="" lnClass="PTOC" lnInst="1" doName="Health"
fc="ST"/>
                     <FCDA ldInst="PROT" prefix="" lnClass="PTOC" lnInst="1" doName="Str"
fc="ST"/>
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ldInst="LD0"/>
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doName="PhyHealth" fc="ST"/>
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fc="MX"/>
                        <FCDA ldInst="MEAS" prefix="" lnClass="MMXU" lnInst="1" doName="Health"
fc="MX"/>
                        <FCDA ldInst="MEAS" prefix="" lnClass="MMXU" lnInst="1" doName="A"
fc="MX"/>
                        <FCDA ldInst="MEAS" prefix="" lnClass="MMXU" lnInst="2" doName="Beh"
fc="MX"/>
                        <FCDA ldInst="MEAS" prefix="" lnClass="MMXU" lnInst="2" doName="Health"
fc="MX"/>
                        <FCDA ldInst="MEAS" prefix="" lnClass="MMXU" lnInst="2" doName="Hz"
fc="MX"/>
                        <FCDA ldInst="MEAS" prefix="" lnClass="MMXU" lnInst="2" doName="PPV"
fc="MX"/>
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ldInst="LD0"/>
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               <LN lnClass="MMXU" lnType="MMXU_Voltage" inst="2" prefix=""/>
            </LDevice>
         </Server>
      </AccessPoint>
   </IED>
   <IED desc="Meter E1Q2" name="IED5" type="Meter" manufacturer="IEC" configVersion="1">
      <Services>
         <DynAssociation/>
         <GetDirectory/>
         <GetDataObjectDefinition/>
         <DataObjectDirectory/>
         <GetDataSetValue/>
         <SetDataSetValue/>
         <DataSetDirectory/>
         <ConfDataSet max="32" maxAttributes="32" modify="false"/>
         <ReadWrite/>
         <ConfReportControl max="32" bufMode="both" bufConf="true"/>
         <GetCBValues/>
         <ReportSettings cbName="Conf" datSet="Conf" rptID="Conf" optFields="Dyn"
bufTime="Conf" trgOps="Conf" intgPd="Conf"/>
         <GSESettings cbName="Conf" datSet="Conf" appID="Conf"/>
         <GOOSE max="16"/>
         <GSSE max="0"/>
         <ConfLNs fixLnInst="true"/>
      </Services>
      <AccessPoint name="AP1">
         <Server>
            <Authentication/>
            <LDevice inst="COUNT">
               <LN0 lnClass="LLN0" lnType="LLN0" inst="">
                  <DataSet name="Dataset1">
                     <FCDA ldInst="COUNT" prefix="" lnClass="LPHD" lnInst="1"
doName="PhyHealth" fc="ST"/>
```

```
                    <FCDA ldInst="COUNT" prefix="" lnClass="MMTR" lnInst="1" doName="TotVAh"
fc="ST"/>
                    <FCDA ldInst="COUNT" prefix="" lnClass="MMTR" lnInst="1" doName="TotWh"
fc="ST"/>
                    <FCDA ldInst="COUNT" prefix="" lnClass="MMTR" lnInst="1" doName="TotVArh"
fc="ST"/>
                 </DataSet>
                 <ReportControl name="URCB" datSet="Dataset1" confRev="1" buffered="false"
bufTime="100">
                    <TrgOps dchg="true" qchg="true" dupd="true" period="true"/>
                    <OptFields bufOvfl="false" configRef="true" entryID="false"
reasonCode="true" seqNum="true" timeStamp="true"/>
                    <RptEnabled max="2">
                       <ClientLN iedName="IED99_1" apRef="AP1" lnInst="1" lnClass="ITCI"
ldInst="LD0"/>
                       <ClientLN iedName="IED99_2" apRef="AP1" lnInst="1" lnClass="ITCI"
ldInst="LD0"/>
                    </RptEnabled>
                 </ReportControl>
                 <DOI name="NamPlt">
                    <DAI name="vendor">
                       <Val>IEC</Val>
                    </DAI>
                    <DAI name="swRev">
                       <Val>1.0.0</Val>
                    </DAI>
                    <DAI name="d">
                       <Val>Meter</Val>
                    </DAI>
                    <DAI name="configRev">
                       <Val>1.0.0</Val>
                    </DAI>
                 </DOI>
                 <DOI name="Mod">
                    <DAI name="ctlModel">
                       <Val>direct-with-normal-security</Val>
                    </DAI>
                 </DOI>
              </LN0>
              <LN lnClass="LPHD" lnType="LPHD" inst="1" prefix="">
                 <DOI name="PhyNam">
                    <DAI name="vendor">
                       <Val>IEC</Val>
                    </DAI>
                    <DAI name="hwRev">
                       <Val>1.0.0</Val>
                    </DAI>
                    <DAI name="swRev">
                       <Val>1.0.0</Val>
                    </DAI>
                    <DAI name="serNum">
                       <Val>00000005</Val>
                    </DAI>
                    <DAI name="model">
                       <Val>IEC Meter</Val>
                    </DAI>
                    <DAI name="location">
                       <Val>Substation</Val>
                    </DAI>
                    <DAI name="owner">
                       <Val>Utility</Val>
                    </DAI>
                    <DAI name="ePSName">
                       <Val>Bay</Val>
                    </DAI>
                 </DOI>
              </LN>
              <LN lnClass="MMTR" lnType="MMTR" inst="1"/>
```

```
            </LDevice>
         </Server>
      </AccessPoint>
   </IED>
   <IED desc="I/O Box E1Q2" name="IED6" type="I/O Box" manufacturer="IEC" configVersion="1">
      <Services>
         <DynAssociation/>
         <GetDirectory/>
         <GetDataObjectDefinition/>
         <DataObjectDirectory/>
         <GetDataSetValue/>
         <SetDataSetValue/>
         <DataSetDirectory/>
         <ConfDataSet max="32" maxAttributes="32" modify="false"/>
         <ReadWrite/>
         <ConfReportControl max="32" bufMode="both" bufConf="true"/>
         <GetCBValues/>
         <ReportSettings cbName="Conf" datSet="Conf" rptID="Conf" optFields="Dyn"
bufTime="Conf" trgOps="Conf" intgPd="Conf"/>
         <GSESettings cbName="Conf" datSet="Conf" appID="Conf"/>
         <GOOSE max="16"/>
         <GSSE max="0"/>
         <ConfLNs fixLnInst="true"/>
      </Services>
      <AccessPoint name="AP1">
         <Server>
            <Authentication/>
            <LDevice inst="DIGITAL">
               <LN0 lnClass="LLN0" lnType="LLN0" inst="">
                  <DataSet name="Dataset1">
                     <FCDA ldInst="DIGITAL" prefix="" lnClass="LPHD" lnInst="1"
doName="PhyHealth" fc="ST"/>
                     <FCDA ldInst="DIGITAL" prefix="" lnClass="GGIO" lnInst="1" doName="Beh"
fc="ST"/>
                     <FCDA ldInst="DIGITAL" prefix="" lnClass="GGIO" lnInst="1"
doName="Health" fc="ST"/>
                     <FCDA ldInst="DIGITAL" prefix="" lnClass="GGIO" lnInst="1" doName="Ind01"
fc="ST"/>
                     <FCDA ldInst="DIGITAL" prefix="" lnClass="GGIO" lnInst="1" doName="Ind02"
fc="ST"/>
                  </DataSet>
                  <ReportControl name="BRCB" datSet="Dataset1" confRev="1" buffered="true"
bufTime="100">
                     <TrgOps dchg="true" qchg="true" dupd="true" period="true"/>
                     <OptFields bufOvfl="true" configRef="true" entryID="true"
reasonCode="true" seqNum="true" timeStamp="true"/>
                     <RptEnabled max="2">
                        <ClientLN iedName="IED99_1" apRef="AP1" lnInst="1" lnClass="ITCI"
ldInst="LD0"/>
                        <ClientLN iedName="IED99_2" apRef="AP1" lnInst="1" lnClass="ITCI"
ldInst="LD0"/>
                     </RptEnabled>
                  </ReportControl>
                  <DOI name="NamPlt">
                     <DAI name="vendor">
                        <Val>IEC</Val>
                     </DAI>
                     <DAI name="swRev">
                        <Val>1.0.0</Val>
                     </DAI>
                     <DAI name="d">
                        <Val>I/O Box</Val>
                     </DAI>
                     <DAI name="configRev">
                        <Val>1.0.0</Val>
                     </DAI>
                  </DOI>
                  <DOI name="Mod">
```

```
                  <DAI name="ctlModel">
                     <Val>direct-with-normal-security</Val>
                  </DAI>
               </DOI>
            </LN0>
            <LN lnClass="LPHD" lnType="LPHD" inst="1" prefix="">
               <DOI name="PhyNam">
                  <DAI name="vendor">
                     <Val>IEC</Val>
                  </DAI>
                  <DAI name="hwRev">
                     <Val>1.0.0</Val>
                  </DAI>
                  <DAI name="swRev">
                     <Val>1.0.0</Val>
                  </DAI>
                  <DAI name="serNum">
                     <Val>00000006</Val>
                  </DAI>
                  <DAI name="model">
                     <Val>IEC I/O Box</Val>
                  </DAI>
                  <DAI name="location">
                     <Val>Substation</Val>
                  </DAI>
                  <DAI name="owner">
                     <Val>Utility</Val>
                  </DAI>
                  <DAI name="ePSName">
                     <Val>Bay</Val>
                  </DAI>
               </DOI>
            </LN>
            <LN lnClass="GGIO" lnType="GGIO" inst="1" prefix="">
               <DOI name="NamPlt">
                  <DAI name="vendor">
                     <Val>IEC</Val>
                  </DAI>
                  <DAI name="swRev">
                     <Val>1.0.0</Val>
                  </DAI>
                  <DAI name="d">
                     <Val>I/O Box</Val>
                  </DAI>
               </DOI>
            </LN>
         </LDevice>
      </Server>
   </AccessPoint>
</IED>
<IED desc="Proxy/GW Client" name="IED99_1" type="Proxy/Gateway" manufacturer="IEC"
configVersion="1">
   <Services nameLength="64">
      <ClientServices bufReport="true" unbufReport="true" maxAttributes="50000"
maxReports="200" supportsLdName="true">
         <TimeSyncProt/>
      </ClientServices>
   </Services>
   <AccessPoint name="AP1">
      <Private type="eTr-IEC61850-90-2">
         <eTr-IEC61850-90-2:ClientRedundancyServices>
            <eTr-IEC61850-90-2:RedundancyModes noRedundancy="false"
acccessPointRedundancy="false" deviceRedundancy="true" multipleRedundancy="false"/>
            <eTr-IEC61850-90-2:LinkModes off="true" standby="true" supervised="true"
active="true"/>
            <eTr-IEC61850-90-2:CooperatingClients>false</eTr-IEC61850-90-
2:CooperatingClients>
         </eTr-IEC61850-90-2:ClientRedundancyServices>
```

```
         </Private>
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:StandbyLinkMode>Standby</eTr-IEC61850-90-2:StandbyLinkMode>
         </Private>
         <LN lnClass="ITCI" inst="1" lnType="ITCI">
            <DOI name="NamPlt">
               <DAI name="vendor">
                  <Val>IEC</Val>
               </DAI>
               <DAI name="swRev">
                  <Val>1.0.0</Val>
               </DAI>
               <DAI name="d">
                  <Val>Telecontrol interface</Val>
               </DAI>
               <DAI name="configRev">
                  <Val>1.0.0</Val>
               </DAI>
            </DOI>
         </LN>
      </AccessPoint>
   </IED>
   <IED desc="Proxy/GW Client" name="IED99_2" type="Proxy/Gateway" manufacturer="IEC"
configVersion="1">
      <Services nameLength="64">
         <ClientServices bufReport="true" unbufReport="true" maxAttributes="50000"
maxReports="200" supportsLdName="true">
            <TimeSyncProt/>
         </ClientServices>
      </Services>
      <AccessPoint name="AP1">
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:ClientRedundancyServices>
               <eTr-IEC61850-90-2:RedundancyModes noRedundancy="false"
acccessPointRedundancy="false" deviceRedundancy="true" multipleRedundancy="false"/>
               <eTr-IEC61850-90-2:LinkModes active="true" standby="true" supervised="true"
off="true"/>
               <eTr-IEC61850-90-2:CooperatingClients>false</eTr-IEC61850-90-
2:CooperatingClients>
            </eTr-IEC61850-90-2:ClientRedundancyServices>
            <eTr-IEC61850-90-2:RedundantClientTo iedName="IED99_1" apName="AP1"/>
         </Private>
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:StandbyLinkMode>Standby</eTr-IEC61850-90-2:StandbyLinkMode>
         </Private>
         <LN lnClass="ITCI" inst="1" lnType="ITCI">
            <DOI name="NamPlt">
               <DAI name="vendor">
                  <Val>IEC</Val>
               </DAI>
               <DAI name="swRev">
                  <Val>1.0.0</Val>
               </DAI>
               <DAI name="d">
                  <Val>Telecontrol interface</Val>
               </DAI>
               <DAI name="configRev">
                  <Val>1.0.0</Val>
               </DAI>
            </DOI>
         </LN>
      </AccessPoint>
   </IED>
   <DataTypeTemplates>
      <LNodeType id="CILO" desc="Circuit switch interlocking" lnClass="CILO">
         <DO desc="Name Plate" name="NamPlt" type="LPL"/>
         <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
         <DO desc="Health" name="Health" type="ENSHealth"/>
```

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    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Enable open" name="EnaOpn" type="SPS"/>
    <DO desc="Enable close" name="EnaCls" type="SPS"/>
    <DO desc="Indicates if this LN is a proxy" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="CSWI" desc="Circuit breaker controller" lnClass="CSWI">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Switch, general" name="Pos" type="DPC"/>
    <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="GGIO" desc="Process I/O" lnClass="GGIO">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO name="Ind01" type="SPS"/>
    <DO name="Ind02" type="SPS"/>
    <DO name="Ind03" type="SPS"/>
    <DO name="Ind04" type="SPS"/>
    <DO name="Ind05" type="SPS"/>
    <DO name="Ind06" type="SPS"/>
    <DO name="Ind07" type="SPS"/>
    <DO name="Ind08" type="SPS"/>
    <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="ITCI" desc="Telecontrol Interface" lnClass="ITCI">
    <DO desc="Name Plate" name="NamPlt" type="LPL_client"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="KVLV" desc="Valve Control" lnClass="KVLV">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Closed end position reached" name="ClsPos" type="SPS"/>
    <DO desc="Open end position reached" name="OpnPos" type="SPS"/>
    <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="LLN0" desc="Logical node zero" lnClass="LLN0">
    <DO desc="Name Plate" name="NamPlt" type="LPL_4_LLN0"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Local control behaviour" name="Loc" type="SPS"/>
    <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="LPHD" desc="Physical device information" lnClass="LPHD">
    <DO desc="Physical device name plate" name="PhyNam" type="DPL"/>
    <DO desc="Physical device health" name="PhyHealth" type="ENSHealth"/>
    <DO desc="Indicates if this LN is a proxy" name="Proxy" type="SPS"/>
  </LNodeType>
  <LNodeType id="MMTR" desc="Metering 3 Phase" lnClass="MMTR">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Net apparent energy" name="TotVAh" type="BCR"/>
    <DO desc="Net real energy" name="TotWh" type="BCR"/>
    <DO desc="Net reactive energy" name="TotVArh" type="BCR"/>
    <DO desc="Real energy supply" name="SupWh" type="BCR"/>
    <DO desc="Reactive energy supply" name="SupVArh" type="BCR"/>
    <DO desc="Real energy demand" name="DmdWh" type="BCR"/>
```

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    <DO desc="Reactive energy demand" name="DmdVArh" type="BCR"/>
    <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="MMXN" desc="Measurement not phase related" lnClass="MMXN">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Net apparent energy" name="TotVAhMV" type="CMV_With_dataNs"/>
    <DO desc="Net real energy" name="TotWhMV" type="CMV_With_dataNs"/>
    <DO desc="Net reactive energy" name="TotVArhMV" type="CMV_With_dataNs"/>
    <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="MMXU" desc="Measurement" lnClass="MMXU">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Total active power (total P)" name="TotW" type="MV"/>
    <DO desc="Total reactive power (total Q)" name="TotVAr" type="MV"/>
    <DO desc="Total apparent power (total S)" name="TotVA" type="MV"/>
    <DO desc="Total power factor (total PF)" name="TotPF" type="MV"/>
    <DO desc="Frequency" name="Hz" type="MV"/>
    <DO desc="Phase to phase voltages (VL1, VL2, ...)" name="PPV" type="DEL"/>
    <DO desc="Phase to ground voltages (VL1ER, ...)" name="PhV" type="WYE"/>
    <DO desc="Phase currents (IL1, IL2, IL3)" name="A" type="WYE"/>
    <DO desc="Phase active power (P)" name="W" type="WYEabc"/>
    <DO desc="Phase reactive power (Q)" name="VAr" type="WYEabc"/>
    <DO desc="Phase apparent power (S)" name="VA" type="WYEabc"/>
    <DO desc="Phase power factor" name="PF" type="WYEabc"/>
    <DO desc="Phase impedance" name="Z" type="WYEabc"/>
    <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="MMXU_Current" desc="Measurement" lnClass="MMXU">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Phase currents (IL1, IL2, IL3)" name="A" type="WYE"/>
    <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="MMXU_Voltage" desc="Measurement" lnClass="MMXU">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Frequency" name="Hz" type="MV"/>
    <DO desc="Phase to phase voltages (VL1, VL2, ...)" name="PPV" type="DEL"/>
    <DO desc="Phase to ground voltages (VL1ER, ...)" name="PhV" type="WYE"/>
    <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="PTOC" desc="Time overcurrent" lnClass="PTOC">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO name="Str" type="ACD"/>
    <DO name="Op" type="ACT"/>
    <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="XCBR" desc="Circuit breaker " lnClass="XCBR">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Local control behaviour" name="Loc" type="SPS"/>
    <DO desc="Operation counter" name="OpCnt" type="INS"/>
    <DO desc="Switch position" name="Pos" type="DPC"/>
```

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      <DO desc="Block opening" name="BlkOpn" type="SPC"/>
      <DO desc="Block closing" name="BlkCls" type="SPC"/>
      <DO desc="LN represents a LN in another IED" name="Proxy" type="SPS_with_dataNs"/>
    </LNodeType>
    <DOType id="ACD" cdc="ACD">
      <DA name="general" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="dirGeneral" bType="Enum" type="dir" fc="ST" dchg="true"/>
      <DA name="phsA" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="dirPhsA" bType="Enum" type="dir" fc="ST" dchg="true"/>
      <DA name="phsB" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="dirPhsB" bType="Enum" type="dir" fc="ST" dchg="true"/>
      <DA name="phsC" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="dirPhsC" bType="Enum" type="dir" fc="ST" dchg="true"/>
      <DA name="q" bType="Quality" fc="ST" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="ST"/>
    </DOType>
    <DOType id="ACT" cdc="ACT" desc="Protection activation information">
      <DA name="general" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="q" bType="Quality" fc="ST" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="ST"/>
      <DA name="origin" bType="Struct" type="Originator" fc="ST"/>
      <DA name="operTm" bType="Timestamp" type="" fc="CF" dchg="true"/>
    </DOType>
    <DOType id="BCR" cdc="BCR" desc="Binary counter reading">
      <DA name="actVal" bType="INT64" fc="ST"/>
      <DA name="frVal" bType="INT64" fc="ST" dupd="true"/>
      <DA name="frTm" bType="Timestamp" fc="ST"/>
      <DA name="q" bType="Quality" fc="ST" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="ST"/>
      <DA name="units" bType="Struct" type="Unit" fc="CF" dchg="true"/>
      <DA name="pulsQty" bType="FLOAT32" fc="CF" dchg="true"/>
      <DA name="frEna" bType="BOOLEAN" fc="CF" dchg="true"/>
      <DA name="strTm" bType="Timestamp" fc="CF" dchg="true"/>
      <DA name="frPd" bType="INT32" fc="CF" dchg="true"/>
      <DA name="frRs" bType="BOOLEAN" fc="CF" dchg="true"/>
    </DOType>
    <DOType id="CMV" cdc="CMV" desc="Complex measured value">
      <DA name="instCVal" bType="Struct" type="Vector" fc="MX"/>
      <DA name="cVal" bType="Struct" type="Vector" fc="MX" dchg="true"/>
      <DA name="range" bType="Enum" type="range" fc="MX"/>
      <DA name="q" bType="Quality" fc="MX" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="MX"/>
      <DA name="units" bType="Struct" type="Unit" fc="CF" dchg="true"/>
      <DA name="db" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="dbAng" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="zeroDb" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="rangeC" bType="Struct" type="RangeConfig" fc="CF" dchg="true"/>
    </DOType>
    <DOType id="CMV_With_dataNs" cdc="CMV" desc="Complex measured value">
      <DA name="instCVal" bType="Struct" type="Vector" fc="MX"/>
      <DA name="cVal" bType="Struct" type="Vector" fc="MX" dchg="true"/>
      <DA name="range" bType="Enum" type="range" fc="MX"/>
      <DA name="q" bType="Quality" fc="MX" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="MX"/>
      <DA name="units" bType="Struct" type="Unit" fc="CF" dchg="true"/>
      <DA name="db" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="dbAng" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="zeroDb" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="rangeC" bType="Struct" type="RangeConfig" fc="CF" dchg="true"/>
      <DA name="dataNs" bType="VisString255" valKind="RO" fc="EX">
        <Val>IEC Private Extension</Val>
      </DA>
    </DOType>
    <DOType id="DEL" cdc="DEL" desc="Phase to phase related measured values of a three phase
system">
      <SDO name="phsAB" type="CMV"/>
      <SDO name="phsBC" type="CMV"/>
      <SDO name="phsCA" type="CMV"/>
```

```
</DOType>
<DOType id="DPC" cdc="DPC" desc="Controllable double point">
   <DA name="origin" bType="Struct" type="Originator" fc="ST"/>
   <DA name="stVal" bType="Dbpos" fc="ST" dchg="true"/>
   <DA name="q" bType="Quality" fc="ST" qchg="true"/>
   <DA name="t" bType="Timestamp" fc="ST"/>
   <DA name="stSeld" bType="BOOLEAN" fc="ST" dchg="true"/>
   <DA name="pulseConfig" bType="Struct" type="PulseConfig" fc="CF" dchg="true"/>
   <DA name="ctlModel" bType="Enum" type="ctlModel" fc="CF" dchg="true"/>
   <DA name="sboTimeout" bType="INT32U" fc="CF" dchg="true"/>
   <DA name="sboClass" bType="Enum" type="sboClass" fc="CF" dchg="true"/>
   <DA name="operTimeout" bType="INT32U" fc="CF" dchg="true"/>
</DOType>
<DOType id="DPL" cdc="DPL" desc="Device name plate">
   <DA name="vendor" bType="VisString255" fc="DC"/>
   <DA name="hwRev" bType="VisString255" fc="DC"/>
   <DA name="swRev" bType="VisString255" fc="DC"/>
   <DA name="serNum" bType="VisString255" fc="DC"/>
   <DA name="model" bType="VisString255" fc="DC"/>
   <DA name="location" bType="VisString255" fc="DC"/>
   <DA name="owner" bType="VisString255" fc="DC"/>
   <DA name="ePSName" bType="VisString255" fc="DC"/>
</DOType>
<DOType id="ENCModStatusOnly" cdc="ENC">
   <DA name="stVal" bType="Enum" type="Mod" fc="ST"/>
   <DA name="q" bType="Quality" fc="ST"/>
   <DA name="t" bType="Timestamp" fc="ST"/>
   <DA name="ctlModel" bType="Enum" type="ctlModel" fc="CF">
      <Val>status-only</Val>
   </DA>
   <DA name="d" bType="VisString255" fc="DC"/>
</DOType>
<DOType id="ENSBeh" cdc="ENS" desc="Behaviour">
   <DA name="stVal" bType="Enum" type="Beh" fc="ST" dchg="true"/>
   <DA name="q" bType="Quality" fc="ST" qchg="true"/>
   <DA name="t" bType="Timestamp" fc="ST"/>
   <DA name="d" bType="VisString255" fc="DC"/>
</DOType>
<DOType id="ENSHealth" cdc="ENS">
   <DA name="stVal" bType="Enum" type="Health" fc="ST"/>
   <DA name="q" bType="Quality" fc="ST"/>
   <DA name="t" bType="Timestamp" fc="ST"/>
   <DA name="d" bType="VisString255" fc="DC"/>
</DOType>
<DOType id="ENSSwTyp" cdc="ENS" desc="Switch Type">
   <DA name="stVal" bType="Enum" type="SwTyp" fc="ST" dchg="true"/>
   <DA name="q" bType="Quality" fc="ST" qchg="true"/>
   <DA name="t" bType="Timestamp" fc="ST"/>
   <DA name="d" bType="VisString255" fc="DC"/>
</DOType>
<DOType id="INC" cdc="INC" desc="Controllable integer status">
   <DA name="origin" bType="Struct" type="Originator" fc="ST"/>
   <DA name="stVal" bType="INT32" fc="ST" dchg="true"/>
   <DA name="q" bType="Quality" fc="ST" qchg="true"/>
   <DA name="t" bType="Timestamp" fc="ST"/>
   <DA name="stSeld" bType="BOOLEAN" fc="ST" dchg="true"/>
   <DA name="ctlModel" bType="Enum" type="ctlModel" fc="CF" dchg="true"/>
   <DA name="sboTimeout" bType="INT32U" fc="CF" dchg="true"/>
   <DA name="sboClass" bType="Enum" type="sboClass" fc="CF" dchg="true"/>
   <DA name="minVal" bType="INT32" fc="CF" dchg="true"/>
   <DA name="maxVal" bType="INT32" fc="CF" dchg="true"/>
   <DA name="stepSize" bType="INT32U" fc="CF" dchg="true"/>
   <DA name="operTimeout" bType="INT32U" fc="CF" dchg="true"/>
</DOType>
<DOType id="INS" cdc="INS" desc="Integer status">
   <DA name="stVal" bType="INT32" fc="ST" dchg="true"/>
   <DA name="q" bType="Quality" fc="ST" qchg="true"/>
   <DA name="t" bType="Timestamp" fc="ST"/>
```

```
</DOType>
<DOType id="LPL" cdc="LPL" desc="Logical node name plate">
   <DA name="vendor" bType="VisString255" fc="DC"/>
   <DA name="swRev" bType="VisString255" fc="DC"/>
   <DA name="d" bType="VisString255" fc="DC"/>
   <DA name="configRev" bType="VisString255" fc="DC"/>
</DOType>
<DOType id="LPL_4_LLN0" cdc="LPL" desc="Logical node name plate">
   <DA name="vendor" bType="VisString255" fc="DC"/>
   <DA name="swRev" bType="VisString255" fc="DC"/>
   <DA name="ldNs" bType="VisString255" fc="DC">
      <Val>IEC 61850-7-4:2007</Val>
   </DA>
   <DA name="d" bType="VisString255" fc="DC"/>
   <DA name="configRev" bType="VisString255" fc="DC"/>
</DOType>
<DOType id="LPL_client" cdc="LPL" desc="Logical node name plate">
   <DA name="vendor" bType="VisString255" fc="DC"/>
   <DA name="swRev" bType="VisString255" fc="DC"/>
   <DA name="lnNs" bType="VisString255" fc="DC">
      <Val>IEC 61850-7-4:2007</Val>
   </DA>
   <DA name="d" bType="VisString255" fc="DC"/>
   <DA name="configRev" bType="VisString255" fc="DC"/>
</DOType>
<DOType id="MV" cdc="MV" desc="Measured value">
   <DA name="instMag" bType="Struct" type="AnalogueValue" fc="MX"/>
   <DA name="mag" bType="Struct" type="AnalogueValue" fc="MX" dchg="true" dupd="true"/>
   <DA name="range" bType="Enum" type="range" fc="MX" dchg="true"/>
   <DA name="q" bType="Quality" fc="MX" qchg="true"/>
   <DA name="t" bType="Timestamp" fc="MX"/>
   <DA name="units" bType="Struct" type="Unit" fc="CF" dchg="true"/>
   <DA name="db" bType="INT32U" fc="CF" dchg="true"/>
   <DA name="zeroDb" bType="INT32U" fc="CF" dchg="true"/>
   <DA name="rangeC" bType="Struct" type="RangeConfig" fc="CF" dchg="true"/>
</DOType>
<DOType id="SEQ" cdc="SEQ" desc="Sequence">
   <DA name="seqT" bType="Enum" type="seqT" fc="MX"/>
   <SDO name="c1" type="CMV"/>
   <SDO name="c2" type="CMV"/>
   <SDO name="c3" type="CMV"/>
</DOType>
<DOType id="SPC" cdc="SPC" desc="Controllable single point">
   <DA name="origin" bType="Struct" type="Originator" fc="ST"/>
   <DA name="stVal" bType="BOOLEAN" fc="ST" dchg="true"/>
   <DA name="q" bType="Quality" fc="ST" qchg="true"/>
   <DA name="t" bType="Timestamp" fc="ST"/>
   <DA name="stSeld" bType="BOOLEAN" fc="ST" dchg="true"/>
   <DA name="pulseConfig" bType="Struct" type="PulseConfig" fc="CF" dchg="true"/>
   <DA name="ctlModel" bType="Enum" type="ctlModel" fc="CF" dchg="true"/>
   <DA name="sboTimeout" bType="INT32U" fc="CF" dchg="true"/>
   <DA name="sboClass" bType="Enum" type="sboClass" fc="CF" dchg="true"/>
   <DA name="operTimeout" bType="INT32U" fc="CF" dchg="true"/>
</DOType>
<DOType id="SPS" cdc="SPS" desc="Single point status">
   <DA name="stVal" bType="BOOLEAN" fc="ST"/>
   <DA name="q" bType="Quality" fc="ST"/>
   <DA name="t" bType="Timestamp" fc="ST"/>
</DOType>
<DOType id="SPS_with_dataNs" cdc="SPS" desc="Single point status">
   <DA name="stVal" bType="BOOLEAN" fc="ST"/>
   <DA name="q" bType="Quality" fc="ST"/>
   <DA name="t" bType="Timestamp" fc="ST"/>
   <DA name="dataNs" bType="VisString255" fc="EX">
      <Val>(TR)IEC61850-90-2:2015</Val>
   </DA>
</DOType>
```

```
      <DOType id="WYE" cdc="WYE" desc="Phase to ground related measured values of a three
phase system">
         <SDO name="phsA" type="CMV"/>
         <SDO name="phsB" type="CMV"/>
         <SDO name="phsC" type="CMV"/>
         <SDO name="neut" type="CMV"/>
         <SDO name="res" type="CMV"/>
      </DOType>
      <DOType id="WYEabc" cdc="WYE" desc="Phase to ground related measured values of a three
phase system">
         <SDO name="phsA" type="CMV"/>
         <SDO name="phsB" type="CMV"/>
         <SDO name="phsC" type="CMV"/>
      </DOType>
      <DAType id="AnalogueValue" desc="Analogue value">
         <BDA desc="Floating point representation of the measured value" name="f"
bType="FLOAT32"/>
      </DAType>
      <DAType id="Originator" desc="Originator">
         <BDA name="orCat" bType="Enum" type="orCategory"/>
         <BDA name="orIdent" bType="Octet64"/>
      </DAType>
      <DAType id="PulseConfig" desc="Pulse configuration">
         <BDA name="cmdQual" bType="Enum" type="cmdQual"/>
         <BDA name="onDur" bType="INT32U"/>
         <BDA name="offDur" bType="INT32U"/>
         <BDA name="numPls" bType="INT32U"/>
      </DAType>
      <DAType id="RangeConfig" desc="Configuration parameters as used in the context with the
range attribute">
         <BDA name="hhLim" bType="Struct" type="AnalogueValue"/>
         <BDA name="hLim" bType="Struct" type="AnalogueValue"/>
         <BDA name="lLim" bType="Struct" type="AnalogueValue"/>
         <BDA name="llLim" bType="Struct" type="AnalogueValue"/>
         <BDA desc="Minimum process measurement for which values of i or f are considered
within process limits" name="min" bType="Struct" type="AnalogueValue"/>
         <BDA desc="Maximum process measurement for which values of i or f are considered
within process limits" name="max" bType="Struct" type="AnalogueValue"/>
      </DAType>
      <DAType id="Unit" desc="Units of the attribute(s) representing the value of the data">
         <BDA desc="Defines an SI Unit" name="SIUnit" bType="Enum" type="SIUnit"/>
         <BDA desc="Multiplier value" name="multiplier" bType="Enum" type="Multiplier"/>
      </DAType>
      <DAType id="Vector" desc="Deadbanded complex value">
         <BDA desc="Magnitude of the complex value." name="mag" bType="Struct"
type="AnalogueValue"/>
         <BDA desc="Angle of the complex value." name="ang" bType="Struct"
type="AnalogueValue"/>
      </DAType>
      <EnumType id="Beh">
         <EnumVal ord="1">on</EnumVal>
         <EnumVal ord="2">blocked</EnumVal>
         <EnumVal ord="3">test</EnumVal>
         <EnumVal ord="4">test/blocked</EnumVal>
         <EnumVal ord="5">off</EnumVal>
      </EnumType>
      <EnumType id="cmdQual">
         <EnumVal ord="0">pulse</EnumVal>
         <EnumVal ord="1">persistent</EnumVal>
      </EnumType>
      <EnumType id="ctlModel">
         <EnumVal ord="0">status-only</EnumVal>
         <EnumVal ord="1">direct-with-normal-security</EnumVal>
         <EnumVal ord="2">sbo-with-normal-security</EnumVal>
         <EnumVal ord="3">direct-with-enhanced-security</EnumVal>
         <EnumVal ord="4">sbo-with-enhanced-security</EnumVal>
      </EnumType>
      <EnumType id="dir">
```

```
    <EnumVal ord="0">unknown</EnumVal>
    <EnumVal ord="1">forward</EnumVal>
    <EnumVal ord="2">backward</EnumVal>
    <EnumVal ord="3">both</EnumVal>
</EnumType>
<EnumType id="Health">
    <EnumVal ord="1">Ok</EnumVal>
    <EnumVal ord="2">Warning</EnumVal>
    <EnumVal ord="3">Alarm</EnumVal>
</EnumType>
<EnumType id="orCategory">
    <EnumVal ord="0">not-supported</EnumVal>
    <EnumVal ord="1">bay-control</EnumVal>
    <EnumVal ord="2">station-control</EnumVal>
    <EnumVal ord="3">remote-control</EnumVal>
    <EnumVal ord="4">automatic-bay</EnumVal>
    <EnumVal ord="5">automatic-station</EnumVal>
    <EnumVal ord="6">automatic-remote</EnumVal>
    <EnumVal ord="7">maintenance</EnumVal>
    <EnumVal ord="8">process</EnumVal>
</EnumType>
<EnumType id="range">
    <EnumVal ord="0">normal</EnumVal>
    <EnumVal ord="1">high</EnumVal>
    <EnumVal ord="2">low</EnumVal>
    <EnumVal ord="3">high-high</EnumVal>
    <EnumVal ord="4">low-low</EnumVal>
</EnumType>
<EnumType id="sboClass">
    <EnumVal ord="0">operate-once</EnumVal>
    <EnumVal ord="1">operate-many</EnumVal>
</EnumType>
<EnumType id="seqT">
    <EnumVal ord="0">pos-neg-zero</EnumVal>
    <EnumVal ord="1">dir-quad-zero</EnumVal>
</EnumType>
<EnumType id="SIUnit">
    <EnumVal ord="1"/>
    <EnumVal ord="2">m</EnumVal>
    <EnumVal ord="3">kg</EnumVal>
    <EnumVal ord="4">s</EnumVal>
    <EnumVal ord="5">A</EnumVal>
    <EnumVal ord="6">K</EnumVal>
    <EnumVal ord="7">mol</EnumVal>
    <EnumVal ord="8">cd</EnumVal>
    <EnumVal ord="9">deg</EnumVal>
    <EnumVal ord="10">rad</EnumVal>
    <EnumVal ord="11">sr</EnumVal>
    <EnumVal ord="21">Gy</EnumVal>
    <EnumVal ord="22">Bq</EnumVal>
    <EnumVal ord="23">°C</EnumVal>
    <EnumVal ord="24">Sv</EnumVal>
    <EnumVal ord="25">F</EnumVal>
    <EnumVal ord="26">C</EnumVal>
    <EnumVal ord="27">S</EnumVal>
    <EnumVal ord="28">H</EnumVal>
    <EnumVal ord="29">V</EnumVal>
    <EnumVal ord="30">ohm</EnumVal>
    <EnumVal ord="31">J</EnumVal>
    <EnumVal ord="32">N</EnumVal>
    <EnumVal ord="33">Hz</EnumVal>
    <EnumVal ord="34">lx</EnumVal>
    <EnumVal ord="35">Lm</EnumVal>
    <EnumVal ord="36">Wb</EnumVal>
    <EnumVal ord="37">T</EnumVal>
    <EnumVal ord="38">W</EnumVal>
    <EnumVal ord="39">Pa</EnumVal>
    <EnumVal ord="41">m²</EnumVal>
```

```
      <EnumVal ord="42">m³</EnumVal>
      <EnumVal ord="43">m/s</EnumVal>
      <EnumVal ord="44">m/s²</EnumVal>
      <EnumVal ord="45">m³/s</EnumVal>
      <EnumVal ord="46">m/m³</EnumVal>
      <EnumVal ord="47">M</EnumVal>
      <EnumVal ord="48">kg/m³</EnumVal>
      <EnumVal ord="49">m²/s</EnumVal>
      <EnumVal ord="50">W/m K</EnumVal>
      <EnumVal ord="51">J/K</EnumVal>
      <EnumVal ord="52">ppm</EnumVal>
      <EnumVal ord="53">1/s</EnumVal>
      <EnumVal ord="54">rad/s</EnumVal>
      <EnumVal ord="55">W/m²</EnumVal>
      <EnumVal ord="56">J/m²</EnumVal>
      <EnumVal ord="57">S/m</EnumVal>
      <EnumVal ord="58">K/s</EnumVal>
      <EnumVal ord="59">Pa/s</EnumVal>
      <EnumVal ord="60">J/kg K</EnumVal>
      <EnumVal ord="61">VA</EnumVal>
      <EnumVal ord="62">Watts</EnumVal>
      <EnumVal ord="63">VAr</EnumVal>
      <EnumVal ord="64">phi</EnumVal>
      <EnumVal ord="65">cos(phi)</EnumVal>
      <EnumVal ord="66">Vs</EnumVal>
      <EnumVal ord="67">V²</EnumVal>
      <EnumVal ord="68">As</EnumVal>
      <EnumVal ord="69">A²</EnumVal>
      <EnumVal ord="70">A²t</EnumVal>
      <EnumVal ord="71">VAh</EnumVal>
      <EnumVal ord="72">Wh</EnumVal>
      <EnumVal ord="73">VArh</EnumVal>
      <EnumVal ord="74">V/Hz</EnumVal>
      <EnumVal ord="75">Hz/s</EnumVal>
      <EnumVal ord="76">char</EnumVal>
      <EnumVal ord="77">char/s</EnumVal>
      <EnumVal ord="78">kgm²</EnumVal>
      <EnumVal ord="79">dB</EnumVal>
      <EnumVal ord="80">J/Wh</EnumVal>
      <EnumVal ord="81">W/s</EnumVal>
      <EnumVal ord="82">l/s</EnumVal>
      <EnumVal ord="83">dBm</EnumVal>
      <EnumVal ord="84">h</EnumVal>
      <EnumVal ord="85">min</EnumVal>
   </EnumType>
   <EnumType id="Multiplier">
      <EnumVal ord="-24">y</EnumVal>
      <EnumVal ord="-21">z</EnumVal>
      <EnumVal ord="-18">a</EnumVal>
      <EnumVal ord="-15">f</EnumVal>
      <EnumVal ord="-12">p</EnumVal>
      <EnumVal ord="-9">n</EnumVal>
      <EnumVal ord="-6">µ</EnumVal>
      <EnumVal ord="-3">m</EnumVal>
      <EnumVal ord="-2">c</EnumVal>
      <EnumVal ord="-1">d</EnumVal>
      <EnumVal ord="0"/>
      <EnumVal ord="1">da</EnumVal>
      <EnumVal ord="2">h</EnumVal>
      <EnumVal ord="3">k</EnumVal>
      <EnumVal ord="6">M</EnumVal>
      <EnumVal ord="9">G</EnumVal>
      <EnumVal ord="12">T</EnumVal>
      <EnumVal ord="15">P</EnumVal>
      <EnumVal ord="18">E</EnumVal>
      <EnumVal ord="21">Z</EnumVal>
      <EnumVal ord="24">Y</EnumVal>
   </EnumType>
```

```
      <EnumType id="SwTyp">
         <EnumVal ord="1">Load Break</EnumVal>
         <EnumVal ord="2">Disconnector</EnumVal>
         <EnumVal ord="3">Earthing Switch</EnumVal>
         <EnumVal ord="4">High Speed Earthing Switch</EnumVal>
      </EnumType>
   </DataTypeTemplates>
</SCL>
```

Annex D
(informative)

Control Centre SCD example

```
<?xml version="1.0" encoding="UTF-8"?>
<SCL version="2007" revision="B" release="1" xmlns="http://www.iec.ch/61850/2003/SCL"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:eTr-IEC61850-90-
2="http://www.iec.ch/61850-90-2/2015/SCL" xsi:schemaLocation="http://www.iec.ch/61850-90-
2/2015/SCL C:\Users\nb241630\Desktop\90-2\Schema\SSCC.xsd">
   <Private type="eTr-IEC61850-90-2">
      <eTr-IEC61850-90-2:ExternalSCL name="Substation" file="Substation.scd" id="Substation
Sample SCL" version="1" revision="A"/>
   </Private>
   <Header id="90-2 Sample SCL" version="1" revision="A" nameStructure="IEDName"/>
   <Substation name="AA1">
      <VoltageLevel name="E1">
         <Bay name="Q1">
            <ConductingEquipment type="CBR" name="Q0">
               <LNode lnClass="CSWI" iedName="IED99_1" ldInst="CTRL" lnInst="1"/>
               <LNode lnClass="XCBR" iedName="IED99_1" ldInst="CTRL" lnInst="1"/>
               <LNode lnClass="CILO" iedName="IED99_1" ldInst="CTRL" lnInst="1"/>
            </ConductingEquipment>
            <ConductingEquipment type="DIS" name="Q1"/>
            <ConductingEquipment type="VTR" name="T5"/>
            <ConductingEquipment type="CTR" name="T1"/>
         </Bay>
         <Bay name="Q2">
            <ConductingEquipment type="CBR" name="Q0">
               <LNode lnClass="CSWI" iedName="IED99_1" ldInst="CTRL" lnInst="1"/>
               <LNode lnClass="XCBR" iedName="IED99_1" ldInst="CTRL" lnInst="1"/>
               <LNode lnClass="CILO" iedName="IED99_1" ldInst="CTRL" lnInst="1"/>
            </ConductingEquipment>
            <ConductingEquipment type="DIS" name="Q1"/>
            <ConductingEquipment type="VTR" name="T5"/>
            <ConductingEquipment type="CTR" name="T1"/>
         </Bay>
      </VoltageLevel>
   </Substation>
   <Communication>
      <SubNetwork name="SubNet1" type="8-MMS">
         <ConnectedAP iedName="IED99_1" apName="AP1">
            <Address>
               <P type="IP">10.0.1.101</P>
               <P type="IP-GATEWAY">10.0.1.1</P>
               <P type="OSI-TSEL">0001</P>
               <P type="OSI-PSEL">00000001</P>
               <P type="OSI-SSEL">0001</P>
               <P type="OSI-AP-Title">1,3,9999,23</P>
               <P type="OSI-AE-Qualifier">23</P>
            </Address>
         </ConnectedAP>
         <ConnectedAP iedName="IED99_2" apName="AP1">
            <Address>
               <P type="IP">10.0.1.102</P>
               <P type="IP-GATEWAY">10.0.1.1</P>
               <P type="OSI-TSEL">0001</P>
               <P type="OSI-PSEL">00000001</P>
               <P type="OSI-SSEL">0001</P>
               <P type="OSI-AP-Title">1,3,9999,23</P>
               <P type="OSI-AE-Qualifier">23</P>
            </Address>
         </ConnectedAP>
         <ConnectedAP iedName="CC_FE1_1" apName="AP1">
            <Address>
               <P type="IP">10.0.1.201</P>
```

```
            <P type="IP-GATEWAY">10.0.1.1</P>
         </Address>
      </ConnectedAP>
      <ConnectedAP iedName="CC_FE1_2" apName="AP1">
         <Address>
            <P type="IP">10.0.1.202</P>
            <P type="IP-GATEWAY">10.0.1.1</P>
         </Address>
      </ConnectedAP>
   </SubNetwork>
</Communication>
<IED desc="Proxy/GW Server 1" name="IED99_1" type="Proxy/Gateway" manufacturer="IEC"
configVersion="1">
   <Services nameLength="64">
      <DynAssociation/>
      <GetDirectory/>
      <GetDataObjectDefinition/>
      <DataObjectDirectory/>
      <GetDataSetValue/>
      <SetDataSetValue/>
      <DataSetDirectory/>
      <ConfDataSet max="32" maxAttributes="32" modify="false"/>
      <ReadWrite/>
      <ConfReportControl max="32" bufMode="both" bufConf="true"/>
      <GetCBValues/>
      <ReportSettings cbName="Conf" datSet="Conf" rptID="Conf" optFields="Dyn"
bufTime="Conf" trgOps="Conf" intgPd="Conf"/>
      <GSESettings cbName="Conf" datSet="Conf" appID="Conf"/>
      <GOOSE max="16"/>
      <GSSE max="0"/>
      <ConfLNs fixLnInst="true"/>
   </Services>
   <AccessPoint name="AP1">
      <Server>
         <Authentication/>
         <LDevice inst="IED1CTRL">
            <LN0 lnClass="LLN0" lnType="LLN0" inst="">
               <Private type="eTr-IEC61850-90-2">
                  <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED1"
ldInst="CTRL" lnClass="LLN0"/>
               </Private>
               <DataSet name="Dataset1">
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fc="ST" prefix=""/>
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reasonCode="true" seqNum="true" timeStamp="true"/>
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ldInst="LD0"/>
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               </ReportControl>
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                  </DAI>
                  <DAI name="swRev">
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                  </DAI>
                  <DAI name="d">
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                  </DAI>
                  <DAI name="configRev">
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                  </DAI>
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ldInst="CTRL" lnClass="LPHD" lnInst="1"/>
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                   <DAI name="owner">
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                   </DAI>
                   <DAI name="ePSName">
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                </DOI>
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          </LDevice>
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ldInst="Prot" lnClass="LLN0"/>
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fc="ST" prefix=""/>
                </DataSet>
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bufTime="100">
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ldInst="LD0"/>
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                    </DAI>
                    <DAI name="d">
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                    </DAI>
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                    </DAI>
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                    <DAI name="owner">
                       <Val>Utility</Val>
                    </DAI>
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fc="ST" prefix=""/>
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ldInst="LD0"/>
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                    <DAI name="d">
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                    <DAI name="model">
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                       <Val>Utility</Val>
                    </DAI>
                    <DAI name="ePSName">
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                    </DAI>
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ldInst="CTRL" lnClass="LLN0"/>
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fc="ST" prefix=""/>
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bufTime="100">
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ldInst="LD0"/>
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                </ReportControl>
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ldInst="CTRL" lnClass="LPHD" lnInst="1"/>
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                    </DAI>
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                    </DAI>
                </DOI>
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ldInst="PROT" lnClass="LLN0"/>
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ldInst="LD0"/>
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                </ReportControl>
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                </DOI>
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ldInst="PROT" lnClass="LPHD" lnInst="1"/>
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                   </DAI>
                   <DAI name="model">
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                        </DAI>
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                        </DAI>
                        <DAI name="ePSName">
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                        </DAI>
                     </DOI>
                     <DOI name="Proxy">
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                        </DAI>
                     </DOI>
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ldInst="MEAS" lnClass="LLN0"/>
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fc="ST" prefix=""/>
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bufTime="100">
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reasonCode="true" seqNum="true" timeStamp="true"/>
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ldInst="LD0"/>
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                        </DAI>
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ldInst="MEAS" lnClass="LPHD" lnInst="1"/>
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                        <DAI name="hwRev">
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                    </DAI>
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                    </DAI>
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ldInst="COUNT" lnClass="LLN0"/>
                 </Private>
                 <DataSet name="Dataset1">
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fc="ST" prefix=""/>
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bufTime="100">
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reasonCode="true" seqNum="true" timeStamp="true"/>
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ldInst="LD0"/>
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                 </ReportControl>
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                    </DAI>
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                    </DAI>
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                    </DAI>
                 </DOI>
              </LN0>
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                   </DAI>
                   <DAI name="ePSName">
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                   </DAI>
                </DOI>
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ldInst="MMTR" lnClass="LPHD" lnInst="1" prefix=""/>
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          </LDevice>
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                   <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED6"
ldInst="DIGITAL" lnClass="LLN0"/>
                </Private>
                <DataSet name="Dataset1">
                   <FCDA ldInst="IED6DIGITAL" lnClass="LPHD" lnInst="1" doName="PhyHealth"
fc="ST" prefix=""/>
                </DataSet>
                <ReportControl name="BRCB" datSet="Dataset1" confRev="1" buffered="true"
bufTime="100">
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                   <OptFields bufOvfl="true" configRef="true" entryID="true"
reasonCode="true" seqNum="true" timeStamp="true"/>
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                      <ClientLN iedName="CC_FE1_1" apRef="AP1" lnInst="1" lnClass="ITCI"
ldInst="LD0"/>
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                </ReportControl>
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                   </DAI>
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                     </DAI>
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fc="ST" prefix=""/>
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doName="Health" fc="ST"/>
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fc="ST"/>
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fc="ST"/>
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doName="EnaOpn" fc="ST"/>
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doName="EnaCls" fc="ST"/>
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fc="ST"/>
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doName="OpCnt" fc="ST"/>
                    <FCDA ldInst="AA1E1Q1" prefix="Q0" lnClass="XCBR" lnInst="1"
doName="BlkOpn" fc="ST"/>
                    <FCDA ldInst="AA1E1Q1" prefix="Q0" lnClass="XCBR" lnInst="1"
doName="BlkCls" fc="ST"/>
                    <FCDA ldInst="AA1E1Q1" lnClass="PTOC" lnInst="1" doName="Str" fc="ST"
prefix=""/>
                    <FCDA ldInst="AA1E1Q1" lnClass="PTOC" lnInst="1" doName="Op" fc="ST"
prefix=""/>
                 </DataSet>
                 <DataSet name="Dataset2">
                    <FCDA ldInst="AA1E1Q1" lnClass="MMXU" lnInst="1" doName="Hz" fc="ST"
prefix=""/>
                    <FCDA ldInst="AA1E1Q1" lnClass="MMXU" lnInst="1" doName="A" fc="ST"
prefix=""/>
                    <FCDA ldInst="AA1E1Q1" lnClass="MMXU" lnInst="1" doName="PPV" fc="ST"
prefix=""/>
                 </DataSet>
                 <ReportControl name="BRCB" datSet="Dataset1" confRev="1" buffered="true"
bufTime="100">
                    <TrgOps dchg="true" qchg="true" dupd="true" period="true"/>
                    <OptFields bufOvfl="true" configRef="true" entryID="true"
reasonCode="true" seqNum="true" timeStamp="true"/>
                    <RptEnabled max="2">
                       <ClientLN iedName="CC_FE1_1" apRef="AP1" lnInst="1" lnClass="ITCI"
ldInst="LD0"/>
                    </RptEnabled>
                 </ReportControl>
                 <ReportControl name="URCB" datSet="Dataset2" confRev="1" buffered="false"
bufTime="100">
                    <TrgOps dchg="true" qchg="true" dupd="true" period="true"/>
                    <OptFields bufOvfl="false" configRef="true" entryID="false"
reasonCode="true" seqNum="true" timeStamp="true"/>
                    <RptEnabled max="2">
                       <ClientLN iedName="CC_FE1_1" apRef="AP1" lnInst="1" lnClass="ITCI"
ldInst="LD0"/>
                    </RptEnabled>
                 </ReportControl>
                 <DOI name="NamPlt">
                    <DAI name="vendor">
                       <Val>IEC</Val>
                    </DAI>
                    <DAI name="swRev">
                       <Val>1.0.0</Val>
                    </DAI>
                    <DAI name="d">
                       <Val>Proxy/Gateway</Val>
                    </DAI>
                    <DAI name="configRev">
                       <Val>1.0.0</Val>
                    </DAI>
                 </DOI>
                 <DOI name="Mod">
                    <DAI name="ctlModel">
                       <Val>direct-with-normal-security</Val>
                    </DAI>
                 </DOI>
              </LN0>
              <LN lnClass="LPHD" lnType="LPHD" inst="1">
                 <DOI name="PhyNam">
                    <DAI name="vendor">
                       <Val>IEC</Val>
                    </DAI>
                    <DAI name="hwRev">
                       <Val>1.0.0</Val>
```

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                    </DAI>
                    <DAI name="swRev">
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                    </DAI>
                    <DAI name="serNum">
                       <Val>00000101</Val>
                    </DAI>
                    <DAI name="model">
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                    </DAI>
                    <DAI name="location">
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                    </DAI>
                    <DAI name="owner">
                       <Val>Utility</Val>
                    </DAI>
                    <DAI name="ePSName">
                       <Val>Control Room</Val>
                    </DAI>
                 </DOI>
                 <DOI name="Proxy">
                    <DAI name="stVal">
                       <Val>false</Val>
                    </DAI>
                 </DOI>
              </LN>
              <LN lnClass="CSWI" lnType="CSWI" inst="1" prefix="Q0">
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                    <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED1"
ldInst="CTRL" lnClass="CSWI" lnInst="1"/>
                 </Private>
                 <DOI name="NamPlt">
                    <DAI name="vendor">
                       <Val>IEC</Val>
                    </DAI>
                    <DAI name="swRev">
                       <Val>1.0.0</Val>
                    </DAI>
                    <DAI name="d">
                       <Val>Bay Controller</Val>
                    </DAI>
                 </DOI>
                 <DOI name="Pos">
                    <DAI name="ctlModel">
                       <Val>sbo-with-enhanced-security</Val>
                    </DAI>
                 </DOI>
                 <DOI name="Mir">
                    <DAI name="stVal">
                       <Val>true</Val>
                    </DAI>
                 </DOI>
              </LN>
              <LN lnClass="CILO" lnType="CILO" inst="1" prefix="Q0">
                 <Private type="eTr-IEC61850-90-2">
                    <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED1"
ldInst="CTRL" lnClass="CILO" lnInst="1"/>
                 </Private>
                 <DOI name="NamPlt">
                    <DAI name="vendor">
                       <Val>IEC</Val>
                    </DAI>
                    <DAI name="swRev">
                       <Val>1.0.0</Val>
                    </DAI>
                    <DAI name="d">
                       <Val>Bay Controller</Val>
                    </DAI>
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                </DOI>
                <DOI name="Proxy">
                   <DAI name="stVal">
                      <Val>true</Val>
                   </DAI>
                </DOI>
             </LN>
             <LN lnClass="XCBR" lnType="XCBR" inst="1" prefix="Q0">
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                   <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED1"
ldInst="CTRL" lnClass="XCBR" lnInst="1"/>
                </Private>
                <DOI name="NamPlt">
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                   </DAI>
                   <DAI name="swRev">
                      <Val>1.0.0</Val>
                   </DAI>
                   <DAI name="d">
                      <Val>Bay Controller</Val>
                   </DAI>
                </DOI>
                <DOI name="Pos">
                   <DAI name="ctlModel">
                      <Val>sbo-with-enhanced-security</Val>
                   </DAI>
                </DOI>
                <DOI name="BlkOpn">
                   <DAI name="ctlModel">
                      <Val>direct-with-normal-security</Val>
                   </DAI>
                </DOI>
                <DOI name="BlkCls">
                   <DAI name="ctlModel">
                      <Val>direct-with-normal-security</Val>
                   </DAI>
                </DOI>
                <DOI name="Mir">
                   <DAI name="stVal">
                      <Val>true</Val>
                   </DAI>
                </DOI>
             </LN>
             <LN lnClass="MMXU" lnType="MMXU" inst="1">
                <DOI name="Beh">
                   <Private type="eTr-IEC61850-90-2">
                      <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED2"
ldInst="MEAS" lnClass="MMXU" lnInst="1" doName="Beh"/>
                   </Private>
                </DOI>
                <DOI name="Health">
                   <Private type="eTr-IEC61850-90-2">
                      <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED2"
ldInst="MEAS" lnClass="MMXU" lnInst="1" doName="Health"/>
                   </Private>
                </DOI>
                <DOI name="A">
                   <Private type="eTr-IEC61850-90-2">
                      <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED2"
ldInst="MEAS" lnClass="MMXU" lnInst="1" doName="A"/>
                   </Private>
                </DOI>
                <DOI name="Mir">
                   <DAI name="stVal">
                      <Val>false</Val>
                   </DAI>
                </DOI>
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            <LN lnClass="MMXU" lnType="MMXU" inst="2">
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                  <Private type="eTr-IEC61850-90-2">
                     <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED2"
ldInst="MEAS" lnClass="MMXU" lnInst="1" doName="Beh"/>
                  </Private>
               </DOI>
               <DOI name="Health">
                  <Private type="eTr-IEC61850-90-2">
                     <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED2"
ldInst="MEAS" lnClass="MMXU" lnInst="1" doName="Health"/>
                  </Private>
               </DOI>
               <DOI name="Hz">
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                     <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED2"
ldInst="MEAS" lnClass="MMXU" lnInst="1" doName="Hz"/>
                  </Private>
               </DOI>
               <DOI name="PPV">
                  <Private type="eTr-IEC61850-90-2">
                     <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED2"
ldInst="MEAS" lnClass="MMXU" lnInst="1" doName="PPV"/>
                  </Private>
               </DOI>
               <DOI name="Mir">
                  <DAI name="stVal">
                     <Val>false</Val>
                  </DAI>
               </DOI>
            </LN>
            <LN lnClass="PTOC" lnType="PTOC" inst="1">
               <Private type="eTr-IEC61850-90-2">
                  <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED2"
ldInst="PROT" lnClass="PTOC" lnInst="1"/>
               </Private>
               <DOI name="Mir">
                  <DAI name="stVal">
                     <Val>true</Val>
                  </DAI>
               </DOI>
            </LN>
         </LDevice>
         <LDevice inst="AA1E1Q2">
            <LN0 lnClass="LLN0" lnType="LLN0" inst="">
               <DataSet name="Dataset1">
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fc="ST" prefix=""/>
                  <FCDA ldInst="AA1E1Q2" prefix="Q0" lnClass="CSWI" lnInst="1"
doName="Health" fc="ST"/>
                  <FCDA ldInst="AA1E1Q2" prefix="Q0" lnClass="CSWI" lnInst="1" doName="Pos"
fc="ST"/>
                  <FCDA ldInst="AA1E1Q2" prefix="Q0" lnClass="CSWI" lnInst="1" doName="Pos"
fc="ST"/>
                  <FCDA ldInst="AA1E1Q2" prefix="Q0" lnClass="CILO" lnInst="1"
doName="EnaOpn" fc="ST"/>
                  <FCDA ldInst="AA1E1Q2" prefix="Q0" lnClass="CILO" lnInst="1"
doName="EnaCls" fc="ST"/>
                  <FCDA ldInst="AA1E1Q2" prefix="Q0" lnClass="XCBR" lnInst="1" doName="Loc"
fc="ST"/>
                  <FCDA ldInst="AA1E1Q2" prefix="Q0" lnClass="XCBR" lnInst="1"
doName="OpCnt" fc="ST"/>
                  <FCDA ldInst="AA1E1Q2" prefix="Q0" lnClass="XCBR" lnInst="1"
doName="BlkOpn" fc="ST"/>
                  <FCDA ldInst="AA1E1Q2" prefix="Q0" lnClass="XCBR" lnInst="1"
doName="BlkCls" fc="ST"/>
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                    <FCDA ldInst="AA1E1Q2" lnClass="PTOC" lnInst="1" doName="Str" fc="ST"
prefix=""/>
                    <FCDA ldInst="AA1E1Q2" lnClass="PTOC" lnInst="1" doName="Op" fc="ST"
prefix=""/>
                </DataSet>
                <DataSet name="Dataset2">
                    <FCDA ldInst="AA1E1Q2" lnClass="MMXU" lnInst="1" doName="Hz" fc="MX"
prefix=""/>
                    <FCDA ldInst="AA1E1Q2" lnClass="MMXU" lnInst="1" doName="A" fc="MX"
prefix=""/>
                    <FCDA ldInst="AA1E1Q2" lnClass="MMXU" lnInst="1" doName="PPV" fc="MX"
prefix=""/>
                    <FCDA ldInst="AA1E1Q2" lnClass="MMXN" lnInst="1" doName="TotVAh" fc="MX"
prefix=""/>
                    <FCDA ldInst="AA1E1Q2" lnClass="MMXN" lnInst="1" doName="TotWh" fc="MX"
prefix=""/>
                    <FCDA ldInst="AA1E1Q2" lnClass="MMXN" lnInst="1" doName="TotVArh" fc="MX"
prefix=""/>
                </DataSet>
                <ReportControl name="BRCB" datSet="Dataset1" confRev="1" buffered="true"
bufTime="100">
                    <TrgOps dchg="true" qchg="true" dupd="true" period="true"/>
                    <OptFields bufOvfl="true" configRef="true" entryID="true"
reasonCode="true" seqNum="true" timeStamp="true"/>
                    <RptEnabled max="2">
                        <ClientLN iedName="CC_FE1_1" apRef="AP1" lnInst="1" lnClass="ITCI"
ldInst="LD0"/>
                    </RptEnabled>
                </ReportControl>
                <ReportControl name="URCB" datSet="Dataset2" confRev="1" buffered="false"
bufTime="100">
                    <TrgOps dchg="true" qchg="true" dupd="true" period="true"/>
                    <OptFields bufOvfl="false" configRef="true" entryID="false"
reasonCode="true" seqNum="true" timeStamp="true"/>
                    <RptEnabled max="2">
                        <ClientLN iedName="CC_FE1_1" apRef="AP1" lnInst="1" lnClass="ITCI"
ldInst="LD0"/>
                    </RptEnabled>
                </ReportControl>
                <DOI name="NamPlt">
                    <DAI name="vendor">
                        <Val>IEC</Val>
                    </DAI>
                    <DAI name="swRev">
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                    </DAI>
                    <DAI name="d">
                        <Val>I/O Box</Val>
                    </DAI>
                    <DAI name="configRev">
                        <Val>1.0.0</Val>
                    </DAI>
                </DOI>
                <DOI name="Mod">
                    <DAI name="ctlModel">
                        <Val>direct-with-normal-security</Val>
                    </DAI>
                </DOI>
            </LN0>
            <LN lnClass="LPHD" lnType="LPHD" inst="1">
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                    <DAI name="vendor">
                        <Val>IEC</Val>
                    </DAI>
                    <DAI name="hwRev">
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                    </DAI>
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                     </DAI>
                     <DAI name="serNum">
                        <Val>00000101</Val>
                     </DAI>
                     <DAI name="model">
                        <Val>IEC Proxy/Gateway</Val>
                     </DAI>
                     <DAI name="location">
                        <Val>Substation</Val>
                     </DAI>
                     <DAI name="owner">
                        <Val>Utility</Val>
                     </DAI>
                     <DAI name="ePSName">
                        <Val>Control Room</Val>
                     </DAI>
                  </DOI>
                  <DOI name="Proxy">
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                        <Val>false</Val>
                     </DAI>
                  </DOI>
               </LN>
               <LN lnClass="CSWI" lnType="CSWI" inst="1" prefix="Q0">
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                     <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED3"
ldInst="CTRL" lnClass="CSWI" lnInst="1"/>
                  </Private>
                  <DOI name="NamPlt">
                     <DAI name="vendor">
                        <Val>IEC</Val>
                     </DAI>
                     <DAI name="swRev">
                        <Val>1.0.0</Val>
                     </DAI>
                     <DAI name="d">
                        <Val>Proxy/Gateway</Val>
                     </DAI>
                  </DOI>
                  <DOI name="Pos">
                     <DAI name="ctlModel">
                        <Val>sbo-with-enhanced-security</Val>
                     </DAI>
                  </DOI>
                  <DOI name="Mir">
                     <DAI name="stVal">
                        <Val>true</Val>
                     </DAI>
                  </DOI>
               </LN>
               <LN lnClass="CILO" lnType="CILO" inst="1" prefix="Q0">
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                     <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED3"
ldInst="CTRL" lnClass="CILO" lnInst="1"/>
                  </Private>
                  <DOI name="NamPlt">
                     <DAI name="vendor">
                        <Val>IEC</Val>
                     </DAI>
                     <DAI name="swRev">
                        <Val>1.0.0</Val>
                     </DAI>
                     <DAI name="d">
                        <Val>Proxy/Gateway</Val>
                     </DAI>
                  </DOI>
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                        </DAI>
                     </DOI>
                  </LN>
                  <LN lnClass="XCBR" lnType="XCBR" inst="1" prefix="Q0">
                     <Private type="eTr-IEC61850-90-2">
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ldInst="CTRL" lnClass="XCBR" lnInst="1"/>
                     </Private>
                     <DOI name="NamPlt">
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                        </DAI>
                        <DAI name="swRev">
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                        </DAI>
                        <DAI name="d">
                           <Val>Proxy/Gateway</Val>
                        </DAI>
                     </DOI>
                     <DOI name="Pos">
                        <DAI name="ctlModel">
                           <Val>sbo-with-enhanced-security</Val>
                        </DAI>
                     </DOI>
                     <DOI name="BlkOpn">
                        <DAI name="ctlModel">
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                        </DAI>
                     </DOI>
                     <DOI name="BlkCls">
                        <DAI name="ctlModel">
                           <Val>direct-with-normal-security</Val>
                        </DAI>
                     </DOI>
                     <DOI name="Mir">
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                        </DAI>
                     </DOI>
                  </LN>
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ldInst="MEAS" lnClass="MMXU" lnInst="1" doName="Beh"/>
                           <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED4"
ldInst="MEAS" lnClass="MMXU" lnInst="2" doName="Beh"/>
                        </Private>
                     </DOI>
                     <DOI name="Health">
                        <Private type="eTr-IEC61850-90-2">
                           <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED4"
ldInst="MEAS" lnClass="MMXU" lnInst="1" doName="Health"/>
                           <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED4"
ldInst="MEAS" lnClass="MMXU" lnInst="2" doName="Health"/>
                        </Private>
                     </DOI>
                     <DOI name="Hz">
                        <Private type="eTr-IEC61850-90-2">
                           <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED4"
ldInst="MEAS" lnClass="MMXU" lnInst="2" doName="Hz"/>
                        </Private>
                     </DOI>
                     <DOI name="A">
                        <Private type="eTr-IEC61850-90-2">
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                        <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED4"
ldInst="MEAS" lnClass="MMXU" lnInst="1" doName="A"/>
                     </Private>
                  </DOI>
                  <DOI name="PPV">
                     <Private type="eTr-IEC61850-90-2">
                        <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED4"
ldInst="MEAS" lnClass="MMXU" lnInst="2" doName="PPV"/>
                     </Private>
                  </DOI>
                  <DOI name="Mir">
                     <DAI name="stVal">
                        <Val>false</Val>
                     </DAI>
                  </DOI>
               </LN>
               <LN lnClass="PTOC" lnType="PTOC" inst="1">
                  <Private type="eTr-IEC61850-90-2">
                     <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED4"
ldInst="PROT" lnClass="PTOC" lnInst="1"/>
                  </Private>
                  <DOI name="Mir">
                     <DAI name="stVal">
                        <Val>true</Val>
                     </DAI>
                  </DOI>
               </LN>
               <LN lnClass="MMXN" lnType="MMXN" inst="1">
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                     <Private type="eTr-IEC61850-90-2">
                        <eTr-IEC61850-90-2:ProxyOf iedName="IED5" ldInst="COUNT"
lnClass="MMTR" lnInst="1" doName="Beh"/>
                     </Private>
                  </DOI>
                  <DOI name="Health">
                     <Private type="eTr-IEC61850-90-2">
                        <eTr-IEC61850-90-2:ProxyOf iedName="IED5" ldInst="COUNT"
lnClass="MMTR" lnInst="1" doName="Health"/>
                     </Private>
                  </DOI>
                  <DOI name="TotVAhMV">
                     <SDI name="cVal">
                        <SDI name="mag">
                           <DAI name="f">
                              <Private type="eTr-IEC61850-90-2">
                                 <eTr-IEC61850-90-2:ProxyOf externalScl="Substation"
iedName="IED5" ldInst="COUNT" lnClass="MMTR" lnInst="1" doName="TotVAh" daName="frVal"/>
                              </Private>
                           </DAI>
                        </SDI>
                     </SDI>
                     <DAI name="q">
                        <Private type="eTr-IEC61850-90-2">
                           <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED5"
ldInst="COUNT" lnClass="MMTR" lnInst="1" doName="TotVAh" daName="q"/>
                        </Private>
                     </DAI>
                     <DAI name="t">
                        <Private type="eTr-IEC61850-90-2">
                           <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED5"
ldInst="COUNT" lnClass="MMTR" lnInst="1" doName="TotVAh" daName="frTm"/>
                        </Private>
                     </DAI>
                  </DOI>
                  <DOI name="TotWhMV">
                     <SDI name="cVal">
                        <SDI name="mag">
                           <DAI name="f">
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                                 <eTr-IEC61850-90-2:ProxyOf externalScl="Substation"
iedName="IED5" ldInst="COUNT" lnClass="MMTR" lnInst="1" doName="TotVAh" daName="frVal"/>
                              </Private>
                           </DAI>
                        </SDI>
                     </SDI>
                     <DAI name="q">
                        <Private type="eTr-IEC61850-90-2">
                           <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED5"
ldInst="COUNT" lnClass="MMTR" lnInst="1" doName="TotWh" daName="q"/>
                        </Private>
                     </DAI>
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ldInst="COUNT" lnClass="MMTR" lnInst="1" doName="TotWh" daName="frTm"/>
                        </Private>
                     </DAI>
                  </DOI>
                  <DOI name="TotVArhMV">
                     <SDI name="cVal">
                        <SDI name="mag">
                           <DAI name="f">
                              <Private type="eTr-IEC61850-90-2">
                                 <eTr-IEC61850-90-2:ProxyOf externalScl="Substation"
iedName="IED5" ldInst="COUNT" lnClass="MMTR" lnInst="1" doName="TotVAh" daName="frVal"/>
                              </Private>
                           </DAI>
                        </SDI>
                     </SDI>
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ldInst="COUNT" lnClass="MMTR" lnInst="1" doName="TotVArh" daName="q"/>
                        </Private>
                     </DAI>
                     <DAI name="t">
                        <Private type="eTr-IEC61850-90-2">
                           <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED5"
ldInst="COUNT" lnClass="MMTR" lnInst="1" doName="TotVArh" daName="frTm"/>
                        </Private>
                     </DAI>
                  </DOI>
                  <DOI name="Mir">
                     <DAI name="stVal">
                        <Val>false</Val>
                     </DAI>
                  </DOI>
               </LN>
               <LN lnClass="SARC" lnType="SARC" inst="1">
                  <DOI name="FADet">
                     <Private type="eTr-IEC61850-90-2">
                        <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED6"
ldInst="DIGITAL" lnClass="GGIO" lnInst="1" doName="Ind1"/>
                     </Private>
                  </DOI>
                  <DOI name="SwArcDet">
                     <Private type="eTr-IEC61850-90-2">
                        <eTr-IEC61850-90-2:ProxyOf externalScl="Substation" iedName="IED6"
ldInst="DIGITAL" lnClass="GGIO" lnInst="1" doName="Ind2"/>
                     </Private>
                  </DOI>
               </LN>
            </LDevice>
         </Server>
      </AccessPoint>
   </IED>
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   <IED desc="Proxy/GW Server 2" name="IED99_2" type="Proxy/Gateway" manufacturer="IEC"
configVersion="1">
      <Services nameLength="64">
         <DynAssociation/>
         <GetDirectory/>
         <GetDataObjectDefinition/>
         <DataObjectDirectory/>
         <GetDataSetValue/>
         <SetDataSetValue/>
         <DataSetDirectory/>
         <ConfDataSet max="32" maxAttributes="32" modify="false"/>
         <ReadWrite/>
         <ConfReportControl max="32" bufMode="both" bufConf="true"/>
         <GetCBValues/>
         <ReportSettings cbName="Conf" datSet="Conf" rptID="Conf" optFields="Dyn"
bufTime="Conf" trgOps="Conf" intgPd="Conf"/>
         <GSESettings cbName="Conf" datSet="Conf" appID="Conf"/>
         <GOOSE max="16"/>
         <GSSE max="0"/>
         <ConfLNs fixLnInst="true"/>
      </Services>
      <AccessPoint name="AP1">
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:RedundantServerTo apName="AP1" iedName="IED99_1" timeout="100">
               <eTr-IEC61850-90-2:LDeviceOverride inst="IED1CTRL">
                  <LN0 lnType="LLN0" inst="" lnClass="LLN0"/>
                  <LN lnType="LPHD" inst="1" lnClass="LPHD">
                     <DOI name="PhyNam">
                        <DAI name="hwRev">
                           <Val>1.0.0</Val>
                        </DAI>
                        <DAI name="swRev">
                           <Val>1.0.0</Val>
                        </DAI>
                        <DAI name="serNum">
                           <Val>00000002</Val>
                        </DAI>
                     </DOI>
                  </LN>
               </eTr-IEC61850-90-2:LDeviceOverride>
               <eTr-IEC61850-90-2:LDeviceOverride inst="IED1CTRL">
                  <LN0 lnType="LLN0" inst="" lnClass="LLN0"/>
                  <LN lnType="LPHD" inst="1" lnClass="LPHD">
                     <DOI name="PhyNam">
                        <DAI name="hwRev">
                           <Val>1.0.0</Val>
                        </DAI>
                        <DAI name="swRev">
                           <Val>1.0.0</Val>
                        </DAI>
                        <DAI name="serNum">
                           <Val>00000002</Val>
                        </DAI>
                     </DOI>
                  </LN>
               </eTr-IEC61850-90-2:LDeviceOverride>
               <eTr-IEC61850-90-2:LDeviceOverride inst="IED2PROT">
                  <LN0 lnType="LLN0" inst="" lnClass="LLN0"/>
                  <LN lnType="LPHD" inst="1" lnClass="LPHD">
                     <DOI name="PhyNam">
                        <DAI name="hwRev">
                           <Val>1.0.0</Val>
                        </DAI>
                        <DAI name="swRev">
                           <Val>1.0.0</Val>
                        </DAI>
                        <DAI name="serNum">
                           <Val>00000002</Val>
```

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            </DAI>
         </DOI>
      </LN>
   </eTr-IEC61850-90-2:LDeviceOverride>
   <eTr-IEC61850-90-2:LDeviceOverride inst="IED2MEAS">
      <LN0 lnType="LLN0" inst="" lnClass="LLN0"/>
      <LN lnType="LPHD" inst="1" lnClass="LPHD">
         <DOI name="PhyNam">
            <DAI name="hwRev">
               <Val>1.0.0</Val>
            </DAI>
            <DAI name="swRev">
               <Val>1.0.0</Val>
            </DAI>
            <DAI name="serNum">
               <Val>00000002</Val>
            </DAI>
         </DOI>
      </LN>
   </eTr-IEC61850-90-2:LDeviceOverride>
   <eTr-IEC61850-90-2:LDeviceOverride inst="IED3CTRL">
      <LN0 lnType="LLN0" inst="" lnClass="LLN0"/>
      <LN lnType="LPHD" inst="1" lnClass="LPHD">
         <DOI name="PhyNam">
            <DAI name="hwRev">
               <Val>1.0.0</Val>
            </DAI>
            <DAI name="swRev">
               <Val>1.0.0</Val>
            </DAI>
            <DAI name="serNum">
               <Val>00000002</Val>
            </DAI>
         </DOI>
      </LN>
   </eTr-IEC61850-90-2:LDeviceOverride>
   <eTr-IEC61850-90-2:LDeviceOverride inst="IED4PROT">
      <LN0 lnType="LLN0" inst="" lnClass="LLN0"/>
      <LN lnType="LPHD" inst="1" lnClass="LPHD">
         <DOI name="PhyNam">
            <DAI name="hwRev">
               <Val>1.0.0</Val>
            </DAI>
            <DAI name="swRev">
               <Val>1.0.0</Val>
            </DAI>
            <DAI name="serNum">
               <Val>00000002</Val>
            </DAI>
         </DOI>
      </LN>
   </eTr-IEC61850-90-2:LDeviceOverride>
   <eTr-IEC61850-90-2:LDeviceOverride inst="IED4MEAS">
      <LN0 lnType="LLN0" inst="" lnClass="LLN0"/>
      <LN lnType="LPHD" inst="1" lnClass="LPHD">
         <DOI name="PhyNam">
            <DAI name="hwRev">
               <Val>1.0.0</Val>
            </DAI>
            <DAI name="swRev">
               <Val>1.0.0</Val>
            </DAI>
            <DAI name="serNum">
               <Val>00000002</Val>
            </DAI>
         </DOI>
      </LN>
   </eTr-IEC61850-90-2:LDeviceOverride>
```

```
                <eTr-IEC61850-90-2:LDeviceOverride inst="IED5COUNT">
                   <LN0 lnType="LLN0" inst="" lnClass="LLN0"/>
                   <LN lnType="LPHD" inst="1" lnClass="LPHD">
                      <DOI name="PhyNam">
                         <DAI name="hwRev">
                            <Val>1.0.0</Val>
                         </DAI>
                         <DAI name="swRev">
                            <Val>1.0.0</Val>
                         </DAI>
                         <DAI name="serNum">
                            <Val>00000002</Val>
                         </DAI>
                      </DOI>
                   </LN>
                </eTr-IEC61850-90-2:LDeviceOverride>
                <eTr-IEC61850-90-2:LDeviceOverride inst="IED6DIGITAL">
                   <LN0 lnType="LLN0" inst="" lnClass="LLN0"/>
                   <LN lnType="LPHD" inst="1" lnClass="LPHD">
                      <DOI name="PhyNam">
                         <DAI name="hwRev">
                            <Val>1.0.0</Val>
                         </DAI>
                         <DAI name="swRev">
                            <Val>1.0.0</Val>
                         </DAI>
                         <DAI name="serNum">
                            <Val>00000002</Val>
                         </DAI>
                      </DOI>
                   </LN>
                </eTr-IEC61850-90-2:LDeviceOverride>
                <eTr-IEC61850-90-2:LDeviceOverride inst="AA1E1Q1">
                   <LN0 lnType="LLN0" inst="" lnClass="LLN0"/>
                   <LN lnType="LPHD" inst="1" lnClass="LPHD">
                      <DOI name="PhyNam">
                         <DAI name="hwRev">
                            <Val>1.0.0</Val>
                         </DAI>
                         <DAI name="swRev">
                            <Val>1.0.0</Val>
                         </DAI>
                         <DAI name="serNum">
                            <Val>00000002</Val>
                         </DAI>
                      </DOI>
                   </LN>
                </eTr-IEC61850-90-2:LDeviceOverride>
                <eTr-IEC61850-90-2:LDeviceOverride inst="AA1E1Q2">
                   <LN0 lnType="LLN0" inst="" lnClass="LLN0"/>
                   <LN lnType="LPHD" inst="1" lnClass="LPHD">
                      <DOI name="PhyNam">
                         <DAI name="hwRev">
                            <Val>1.0.0</Val>
                         </DAI>
                         <DAI name="swRev">
                            <Val>1.0.0</Val>
                         </DAI>
                         <DAI name="serNum">
                            <Val>00000002</Val>
                         </DAI>
                      </DOI>
                   </LN>
                </eTr-IEC61850-90-2:LDeviceOverride>
                <eTr-IEC61850-90-2:Association iedName="CC_FE1_2" lnInst="1" lnClass="ITCI"
ldInst="LD0" kind="predefined"/>
             </eTr-IEC61850-90-2:RedundantServerTo>
          </Private>
```

```
      </AccessPoint>
   </IED>
   <IED desc="Control Centre Frontend 1" name="CC_FE1_1" type="SCADA Frontend"
manufacturer="IEC" configVersion="1">
      <Services nameLength="64">
         <ClientServices bufReport="true" unbufReport="true" maxAttributes="50000"
maxReports="200" supportsLdName="true">
            <TimeSyncProt/>
         </ClientServices>
      </Services>
      <AccessPoint name="AP1">
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:ClientRedundancyServices>
               <eTr-IEC61850-90-2:RedundancyModes noRedundancy="false"
acccessPointRedundancy="false" deviceRedundancy="true" multipleRedundancy="false"/>
               <eTr-IEC61850-90-2:LinkModes off="true" standby="true" supervised="true"
active="true"/>
               <eTr-IEC61850-90-2:CooperatingClients>false</eTr-IEC61850-90-
2:CooperatingClients>
            </eTr-IEC61850-90-2:ClientRedundancyServices>
         </Private>
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:StandbyLinkMode>Standby</eTr-IEC61850-90-2:StandbyLinkMode>
         </Private>
         <LN lnClass="ITCI" inst="1" lnType="ITCI">
            <DOI name="NamPlt">
               <DAI name="vendor">
                  <Val>IEC</Val>
               </DAI>
               <DAI name="swRev">
                  <Val>1.0.0</Val>
               </DAI>
               <DAI name="d">
                  <Val>Telecontrol interface</Val>
               </DAI>
               <DAI name="configRev">
                  <Val>1.0.0</Val>
               </DAI>
            </DOI>
         </LN>
      </AccessPoint>
   </IED>
   <IED desc="Control Centre Frontend 2" name="CC_FE1_2" type="SCADA Frontend"
manufacturer="IEC" configVersion="1">
      <Services nameLength="64">
         <ClientServices bufReport="true" unbufReport="true" maxAttributes="50000"
maxReports="200" supportsLdName="true">
            <TimeSyncProt/>
         </ClientServices>
      </Services>
      <AccessPoint name="AP1">
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:ClientRedundancyServices>
               <eTr-IEC61850-90-2:RedundancyModes noRedundancy="false"
acccessPointRedundancy="false" deviceRedundancy="true" multipleRedundancy="false"/>
               <eTr-IEC61850-90-2:LinkModes off="true" standby="true" supervised="true"
active="true"/>
               <eTr-IEC61850-90-2:CooperatingClients>false</eTr-IEC61850-90-
2:CooperatingClients>
            </eTr-IEC61850-90-2:ClientRedundancyServices>
            <eTr-IEC61850-90-2:RedundantClientTo iedName="IED99_1" apName="AP1"/>
         </Private>
         <Private type="eTr-IEC61850-90-2">
            <eTr-IEC61850-90-2:StandbyLinkMode>Standby</eTr-IEC61850-90-2:StandbyLinkMode>
         </Private>
         <LN lnClass="ITCI" inst="1" lnType="ITCI">
            <DOI name="NamPlt">
               <DAI name="vendor">
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                <Val>IEC</Val>
              </DAI>
              <DAI name="swRev">
                <Val>1.0.0</Val>
              </DAI>
              <DAI name="d">
                <Val>Telecontrol interface</Val>
              </DAI>
              <DAI name="configRev">
                <Val>1.0.0</Val>
              </DAI>
            </DOI>
          </LN>
        </AccessPoint>
      </IED>
      <DataTypeTemplates>
        <LNodeType id="CILO" desc="Circuit switch interlocking" lnClass="CILO">
          <DO desc="Name Plate" name="NamPlt" type="LPL"/>
          <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
          <DO desc="Health" name="Health" type="ENSHealth"/>
          <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
          <DO desc="Enable open" name="EnaOpn" type="SPS"/>
          <DO desc="Enable close" name="EnaCls" type="SPS"/>
          <DO desc=" LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
        </LNodeType>
        <LNodeType id="CSWI" desc="Circuit breaker controller" lnClass="CSWI">
          <DO desc="Name Plate" name="NamPlt" type="LPL"/>
          <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
          <DO desc="Health" name="Health" type="ENSHealth"/>
          <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
          <DO desc="Switch, general" name="Pos" type="DPC"/>
          <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
        </LNodeType>
        <LNodeType id="GGIO" desc="Process I/O" lnClass="GGIO">
          <DO desc="Name Plate" name="NamPlt" type="LPL"/>
          <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
          <DO desc="Health" name="Health" type="ENSHealth"/>
          <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
          <DO name="Ind01" type="SPS"/>
          <DO name="Ind02" type="SPS"/>
          <DO name="Ind03" type="SPS"/>
          <DO name="Ind04" type="SPS"/>
          <DO name="Ind05" type="SPS"/>
          <DO name="Ind06" type="SPS"/>
          <DO name="Ind07" type="SPS"/>
          <DO name="Ind08" type="SPS"/>
          <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
        </LNodeType>
        <LNodeType id="ITCI" desc="Telecontrol Interface" lnClass="ITCI">
          <DO desc="Name Plate" name="NamPlt" type="LPL_client"/>
          <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
          <DO desc="Health" name="Health" type="ENSHealth"/>
          <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
          <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
        </LNodeType>
        <LNodeType id="KVLV" desc="Valve Control" lnClass="KVLV">
          <DO desc="Name Plate" name="NamPlt" type="LPL"/>
          <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
          <DO desc="Health" name="Health" type="ENSHealth"/>
          <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
          <DO desc="Closed end position reached" name="ClsPos" type="SPS"/>
          <DO desc="Open end position reached" name="OpnPos" type="SPS"/>
          <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
        </LNodeType>
        <LNodeType id="SARC" desc="Monitoring and diagnostic for arcs" lnClass="SARC">
          <DO desc="Name Plate" name="NamPlt" type="LPL"/>
          <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
          <DO desc="Health" name="Health" type="ENSHealth"/>
```

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    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Fault arc detected" name="FADet" type="SPS"/>
    <DO desc="Switch arc detected" name="SwArcDet" type="SPS"/>
    <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="LLN0" desc="Logical node zero" lnClass="LLN0">
    <DO desc="Name Plate" name="NamPlt" type="LPL_4_LLN0"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Local control behaviour" name="Loc" type="SPS"/>
    <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="LPHD" desc="Physical device information" lnClass="LPHD">
    <DO desc="Physical device name plate" name="PhyNam" type="DPL"/>
    <DO desc="Physical device health" name="PhyHealth" type="ENSHealth"/>
    <DO desc=" LN represents a LN in another IED" name="Mir" type="SPS"/>
  </LNodeType>
  <LNodeType id="MMTR" desc="Metering 3 Phase" lnClass="MMTR">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Net apparent energy" name="TotVAh" type="BCR"/>
    <DO desc="Net real energy" name="TotWh" type="BCR"/>
    <DO desc="Net reactive energy" name="TotVArh" type="BCR"/>
    <DO desc="Real energy supply" name="SupWh" type="BCR"/>
    <DO desc="Reactive energy supply" name="SupVArh" type="BCR"/>
    <DO desc="Real energy demand" name="DmdWh" type="BCR"/>
    <DO desc="Reactive energy demand" name="DmdVArh" type="BCR"/>
    <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="MMXN" desc="Measurement not phase related" lnClass="MMXN">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Net apparent energy" name="TotVAhMV" type="CMV_With_dataNs"/>
    <DO desc="Net real energy" name="TotWhMV" type="CMV_With_dataNs"/>
    <DO desc="Net reactive energy" name="TotVArhMV" type="CMV_With_dataNs"/>
    <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="MMXU" desc="Measurement" lnClass="MMXU">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Total active power (total P)" name="TotW" type="MV"/>
    <DO desc="Total reactive power (total Q)" name="TotVAr" type="MV"/>
    <DO desc="Total apparent power (total S)" name="TotVA" type="MV"/>
    <DO desc="Total power factor (total PF)" name="TotPF" type="MV"/>
    <DO desc="Frequency" name="Hz" type="MV"/>
    <DO desc="Phase to phase voltages (VL1, VL2, ...)" name="PPV" type="DEL"/>
    <DO desc="Phase to ground voltages (VL1ER, ...)" name="PhV" type="WYE"/>
    <DO desc="Phase currents (IL1, IL2, IL3)" name="A" type="WYE"/>
    <DO desc="Phase active power (P)" name="W" type="WYEabc"/>
    <DO desc="Phase reactive power (Q)" name="VAr" type="WYEabc"/>
    <DO desc="Phase apparent power (S)" name="VA" type="WYEabc"/>
    <DO desc="Phase power factor" name="PF" type="WYEabc"/>
    <DO desc="Phase impedance" name="Z" type="WYEabc"/>
    <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
  </LNodeType>
  <LNodeType id="MMXU_Current" desc="Measurement" lnClass="MMXU">
    <DO desc="Name Plate" name="NamPlt" type="LPL"/>
    <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
    <DO desc="Health" name="Health" type="ENSHealth"/>
    <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
    <DO desc="Phase currents (IL1, IL2, IL3)" name="A" type="WYE"/>
```

```
      <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
    </LNodeType>
    <LNodeType id="MMXU_Voltage" desc="Measurement" lnClass="MMXU">
      <DO desc="Name Plate" name="NamPlt" type="LPL"/>
      <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
      <DO desc="Health" name="Health" type="ENSHealth"/>
      <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
      <DO desc="Frequency" name="Hz" type="MV"/>
      <DO desc="Phase to phase voltages (VL1, VL2, ...)" name="PPV" type="DEL"/>
      <DO desc="Phase to ground voltages (VL1ER, ...)" name="PhV" type="WYE"/>
      <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
    </LNodeType>
    <LNodeType id="PTOC" desc="Time overcurrent" lnClass="PTOC">
      <DO desc="Name Plate" name="NamPlt" type="LPL"/>
      <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
      <DO desc="Health" name="Health" type="ENSHealth"/>
      <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
      <DO name="Str" type="ACD"/>
      <DO name="Op" type="ACT"/>
      <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
    </LNodeType>
    <LNodeType id="XCBR" desc="Circuit breaker " lnClass="XCBR">
      <DO desc="Name Plate" name="NamPlt" type="LPL"/>
      <DO desc="Behaviour" name="Beh" type="ENSBeh"/>
      <DO desc="Health" name="Health" type="ENSHealth"/>
      <DO desc="Mode" name="Mod" type="ENCModStatusOnly"/>
      <DO desc="Local control behaviour" name="Loc" type="SPS"/>
      <DO desc="Operation counter" name="OpCnt" type="INS"/>
      <DO desc="Switch position" name="Pos" type="DPC"/>
      <DO desc="Block opening" name="BlkOpn" type="SPC"/>
      <DO desc="Block closing" name="BlkCls" type="SPC"/>
      <DO desc="LN represents a LN in another IED" name="Mir" type="SPS_with_dataNs"/>
    </LNodeType>
    <DOType id="ACD" cdc="ACD">
      <DA name="general" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="dirGeneral" bType="Enum" type="dir" fc="ST" dchg="true"/>
      <DA name="phsA" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="dirPhsA" bType="Enum" type="dir" fc="ST" dchg="true"/>
      <DA name="phsB" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="dirPhsB" bType="Enum" type="dir" fc="ST" dchg="true"/>
      <DA name="phsC" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="dirPhsC" bType="Enum" type="dir" fc="ST" dchg="true"/>
      <DA name="q" bType="Quality" fc="ST" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="ST"/>
    </DOType>
    <DOType id="ACT" cdc="ACT" desc="Protection activation information">
      <DA name="general" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="q" bType="Quality" fc="ST" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="ST"/>
      <DA name="origin" bType="Struct" type="Originator" fc="ST"/>
      <DA name="operTm" bType="Timestamp" type="" fc="CF" dchg="true"/>
    </DOType>
    <DOType id="BCR" cdc="BCR" desc="Binary counter reading">
      <DA name="actVal" bType="INT64" fc="ST"/>
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      <DA name="frTm" bType="Timestamp" fc="ST"/>
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      <DA name="pulsQty" bType="FLOAT32" fc="CF" dchg="true"/>
      <DA name="frEna" bType="BOOLEAN" fc="CF" dchg="true"/>
      <DA name="strTm" bType="Timestamp" fc="CF" dchg="true"/>
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      <DA name="frRs" bType="BOOLEAN" fc="CF" dchg="true"/>
    </DOType>
    <DOType id="CMV" cdc="CMV" desc="Complex measured value">
      <DA name="instCVal" bType="Struct" type="Vector" fc="MX"/>
      <DA name="cVal" bType="Struct" type="Vector" fc="MX" dchg="true"/>
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      <DA name="range" bType="Enum" type="range" fc="MX"/>
      <DA name="q" bType="Quality" fc="MX" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="MX"/>
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      <DA name="zeroDb" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="rangeC" bType="Struct" type="RangeConfig" fc="CF" dchg="true"/>
    </DOType>
    <DOType id="CMV_With_dataNs" cdc="CMV" desc="Complex measured value">
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      <DA name="range" bType="Enum" type="range" fc="MX"/>
      <DA name="q" bType="Quality" fc="MX" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="MX"/>
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      <DA name="db" bType="INT32U" fc="CF" dchg="true"/>
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      <DA name="zeroDb" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="rangeC" bType="Struct" type="RangeConfig" fc="CF" dchg="true"/>
      <DA name="dataNs" bType="VisString255" valKind="RO" fc="EX">
        <Val>IEC Private Extension</Val>
      </DA>
    </DOType>
    <DOType id="DEL" cdc="DEL" desc="Phase to phase related measured values of a three phase
system">
      <SDO name="phsAB" type="CMV"/>
      <SDO name="phsBC" type="CMV"/>
      <SDO name="phsCA" type="CMV"/>
    </DOType>
    <DOType id="DPC" cdc="DPC" desc="Controllable double point">
      <DA name="origin" bType="Struct" type="Originator" fc="ST"/>
      <DA name="stVal" bType="Dbpos" fc="ST" dchg="true"/>
      <DA name="q" bType="Quality" fc="ST" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="ST"/>
      <DA name="stSeld" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="pulseConfig" bType="Struct" type="PulseConfig" fc="CF" dchg="true"/>
      <DA name="ctlModel" bType="Enum" type="ctlModel" fc="CF" dchg="true"/>
      <DA name="sboTimeout" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="sboClass" bType="Enum" type="sboClass" fc="CF" dchg="true"/>
      <DA name="operTimeout" bType="INT32U" fc="CF" dchg="true"/>
    </DOType>
    <DOType id="DPL" cdc="DPL" desc="Device name plate">
      <DA name="vendor" bType="VisString255" fc="DC"/>
      <DA name="hwRev" bType="VisString255" fc="DC"/>
      <DA name="swRev" bType="VisString255" fc="DC"/>
      <DA name="serNum" bType="VisString255" fc="DC"/>
      <DA name="model" bType="VisString255" fc="DC"/>
      <DA name="location" bType="VisString255" fc="DC"/>
      <DA name="owner" bType="VisString255" fc="DC"/>
      <DA name="ePSName" bType="VisString255" fc="DC"/>
    </DOType>
    <DOType id="ENCModStatusOnly" cdc="ENC">
      <DA name="stVal" bType="Enum" type="Mod" fc="ST"/>
      <DA name="q" bType="Quality" fc="ST"/>
      <DA name="t" bType="Timestamp" fc="ST"/>
      <DA name="ctlModel" bType="Enum" type="ctlModel" fc="CF">
        <Val>status-only</Val>
      </DA>
      <DA name="d" bType="VisString255" fc="DC"/>
    </DOType>
    <DOType id="ENSBeh" cdc="ENS" desc="Behaviour">
      <DA name="stVal" bType="Enum" type="Beh" fc="ST" dchg="true"/>
      <DA name="q" bType="Quality" fc="ST" qchg="true"/>
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      <DA name="q" bType="Quality" fc="ST"/>
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      <DA name="d" bType="VisString255" fc="DC"/>
    </DOType>
    <DOType id="ENSSwTyp" cdc="ENS" desc="Switch Type">
      <DA name="stVal" bType="Enum" type="SwTyp" fc="ST" dchg="true"/>
      <DA name="q" bType="Quality" fc="ST" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="ST"/>
      <DA name="d" bType="VisString255" fc="DC"/>
    </DOType>
    <DOType id="INC" cdc="INC" desc="Controllable integer status">
      <DA name="origin" bType="Struct" type="Originator" fc="ST"/>
      <DA name="stVal" bType="INT32" fc="ST" dchg="true"/>
      <DA name="q" bType="Quality" fc="ST" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="ST"/>
      <DA name="stSeld" bType="BOOLEAN" fc="ST" dchg="true"/>
      <DA name="ctlModel" bType="Enum" type="ctlModel" fc="CF" dchg="true"/>
      <DA name="sboTimeout" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="sboClass" bType="Enum" type="sboClass" fc="CF" dchg="true"/>
      <DA name="minVal" bType="INT32" fc="CF" dchg="true"/>
      <DA name="maxVal" bType="INT32" fc="CF" dchg="true"/>
      <DA name="stepSize" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="operTimeout" bType="INT32U" fc="CF" dchg="true"/>
    </DOType>
    <DOType id="INS" cdc="INS" desc="Integer status">
      <DA name="stVal" bType="INT32" fc="ST" dchg="true"/>
      <DA name="q" bType="Quality" fc="ST" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="ST"/>
    </DOType>
    <DOType id="LPL" cdc="LPL" desc="Logical node name plate">
      <DA name="vendor" bType="VisString255" fc="DC"/>
      <DA name="swRev" bType="VisString255" fc="DC"/>
      <DA name="d" bType="VisString255" fc="DC"/>
      <DA name="configRev" bType="VisString255" fc="DC"/>
    </DOType>
    <DOType id="LPL_4_LLN0" cdc="LPL" desc="Logical node name plate">
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        <Val>IEC 61850-7-4:2007</Val>
      </DA>
      <DA name="d" bType="VisString255" fc="DC"/>
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    <DOType id="LPL_client" cdc="LPL" desc="Logical node name plate">
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      <DA name="swRev" bType="VisString255" fc="DC"/>
      <DA name="lnNs" bType="VisString255" fc="DC">
        <Val>IEC 61850-7-4:2007</Val>
      </DA>
      <DA name="d" bType="VisString255" fc="DC"/>
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    </DOType>
    <DOType id="MV" cdc="MV" desc="Measured value">
      <DA name="instMag" bType="Struct" type="AnalogueValue" fc="MX"/>
      <DA name="mag" bType="Struct" type="AnalogueValue" fc="MX" dchg="true" dupd="true"/>
      <DA name="range" bType="Enum" type="range" fc="MX" dchg="true"/>
      <DA name="q" bType="Quality" fc="MX" qchg="true"/>
      <DA name="t" bType="Timestamp" fc="MX"/>
      <DA name="units" bType="Struct" type="Unit" fc="CF" dchg="true"/>
      <DA name="db" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="zeroDb" bType="INT32U" fc="CF" dchg="true"/>
      <DA name="rangeC" bType="Struct" type="RangeConfig" fc="CF" dchg="true"/>
    </DOType>
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      <DA name="seqT" bType="Enum" type="seqT" fc="MX"/>
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        <SDO name="c2" type="CMV"/>
        <SDO name="c3" type="CMV"/>
      </DOType>
      <DOType id="SPC" cdc="SPC" desc="Controllable single point">
        <DA name="origin" bType="Struct" type="Originator" fc="ST"/>
        <DA name="stVal" bType="BOOLEAN" fc="ST" dchg="true"/>
        <DA name="q" bType="Quality" fc="ST" qchg="true"/>
        <DA name="t" bType="Timestamp" fc="ST"/>
        <DA name="stSeld" bType="BOOLEAN" fc="ST" dchg="true"/>
        <DA name="pulseConfig" bType="Struct" type="PulseConfig" fc="CF" dchg="true"/>
        <DA name="ctlModel" bType="Enum" type="ctlModel" fc="CF" dchg="true"/>
        <DA name="sboTimeout" bType="INT32U" fc="CF" dchg="true"/>
        <DA name="sboClass" bType="Enum" type="sboClass" fc="CF" dchg="true"/>
        <DA name="operTimeout" bType="INT32U" fc="CF" dchg="true"/>
      </DOType>
      <DOType id="SPS" cdc="SPS" desc="Single point status">
        <DA name="stVal" bType="BOOLEAN" fc="ST"/>
        <DA name="q" bType="Quality" fc="ST"/>
        <DA name="t" bType="Timestamp" fc="ST"/>
      </DOType>
      <DOType id="SPS_with_dataNs" cdc="SPS" desc="Single point status">
        <DA name="stVal" bType="BOOLEAN" fc="ST"/>
        <DA name="q" bType="Quality" fc="ST"/>
        <DA name="t" bType="Timestamp" fc="ST"/>
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          <Val>(TR)IEC61850-90-2:2015</Val>
        </DA>
      </DOType>
      <DOType id="WYE" cdc="WYE" desc="Phase to ground related measured values of a three
phase system">
        <SDO name="phsA" type="CMV"/>
        <SDO name="phsB" type="CMV"/>
        <SDO name="phsC" type="CMV"/>
        <SDO name="neut" type="CMV"/>
        <SDO name="res" type="CMV"/>
      </DOType>
      <DOType id="WYEabc" cdc="WYE" desc="Phase to ground related measured values of a three
phase system">
        <SDO name="phsA" type="CMV"/>
        <SDO name="phsB" type="CMV"/>
        <SDO name="phsC" type="CMV"/>
      </DOType>
      <DAType id="AnalogueValue" desc="Analogue value">
        <BDA desc="Floating point representation of the measured value" name="f"
bType="FLOAT32"/>
      </DAType>
      <DAType id="Originator" desc="Originator">
        <BDA name="orCat" bType="Enum" type="orCategory"/>
        <BDA name="orIdent" bType="Octet64"/>
      </DAType>
      <DAType id="PulseConfig" desc="Pulse configuration">
        <BDA name="cmdQual" bType="Enum" type="cmdQual"/>
        <BDA name="onDur" bType="INT32U"/>
        <BDA name="offDur" bType="INT32U"/>
        <BDA name="numPls" bType="INT32U"/>
      </DAType>
      <DAType id="RangeConfig" desc="Configuration parameters as used in the context with the
range attribute">
        <BDA name="hhLim" bType="Struct" type="AnalogueValue"/>
        <BDA name="hLim" bType="Struct" type="AnalogueValue"/>
        <BDA name="lLim" bType="Struct" type="AnalogueValue"/>
        <BDA name="llLim" bType="Struct" type="AnalogueValue"/>
        <BDA desc="Minimum process measurement for which values of i or f are considered
within process limits" name="min" bType="Struct" type="AnalogueValue"/>
        <BDA desc="Maximum process measurement for which values of i or f are considered
within process limits" name="max" bType="Struct" type="AnalogueValue"/>
      </DAType>
      <DAType id="Unit" desc="Units of the attribute(s) representing the value of the data">
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         <BDA desc="Defines an SI Unit" name="SIUnit" bType="Enum" type="SIUnit"/>
         <BDA desc="Multiplier value" name="multiplier" bType="Enum" type="Multiplier"/>
      </DAType>
      <DAType id="Vector" desc="Deadbanded complex value">
         <BDA desc="Magnitude of the complex value." name="mag" bType="Struct"
type="AnalogueValue"/>
         <BDA desc="Angle of the complex value." name="ang" bType="Struct"
type="AnalogueValue"/>
      </DAType>
      <EnumType id="Beh">
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         <EnumVal ord="2">blocked</EnumVal>
         <EnumVal ord="3">test</EnumVal>
         <EnumVal ord="4">test/blocked</EnumVal>
         <EnumVal ord="5">off</EnumVal>
      </EnumType>
      <EnumType id="cmdQual">
         <EnumVal ord="0">pulse</EnumVal>
         <EnumVal ord="1">persistent</EnumVal>
      </EnumType>
      <EnumType id="ctlModel">
         <EnumVal ord="0">status-only</EnumVal>
         <EnumVal ord="1">direct-with-normal-security</EnumVal>
         <EnumVal ord="2">sbo-with-normal-security</EnumVal>
         <EnumVal ord="3">direct-with-enhanced-security</EnumVal>
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      </EnumType>
      <EnumType id="dir">
         <EnumVal ord="0">unknown</EnumVal>
         <EnumVal ord="1">forward</EnumVal>
         <EnumVal ord="2">backward</EnumVal>
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      </EnumType>
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         <EnumVal ord="3">high-high</EnumVal>
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      </EnumType>
      <EnumType id="sboClass">
         <EnumVal ord="0">operate-once</EnumVal>
         <EnumVal ord="1">operate-many</EnumVal>
      </EnumType>
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         <EnumVal ord="2">m</EnumVal>
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<EnumVal ord="5">A</EnumVal>
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<EnumVal ord="7">mol</EnumVal>
<EnumVal ord="8">cd</EnumVal>
<EnumVal ord="9">deg</EnumVal>
<EnumVal ord="10">rad</EnumVal>
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<EnumVal ord="77">char/s</EnumVal>
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<EnumVal ord="80">J/Wh</EnumVal>
<EnumVal ord="81">W/s</EnumVal>
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            <EnumVal ord="83">dBm</EnumVal>
            <EnumVal ord="84">h</EnumVal>
            <EnumVal ord="85">min</EnumVal>
         </EnumType>
         <EnumType id="Multiplier">
            <EnumVal ord="-24">y</EnumVal>
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            <EnumVal ord="-18">a</EnumVal>
            <EnumVal ord="-15">f</EnumVal>
            <EnumVal ord="-12">p</EnumVal>
            <EnumVal ord="-9">n</EnumVal>
            <EnumVal ord="-6">µ</EnumVal>
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            <EnumVal ord="0"/>
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            <EnumVal ord="3">k</EnumVal>
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            <EnumVal ord="9">G</EnumVal>
            <EnumVal ord="12">T</EnumVal>
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            <EnumVal ord="18">E</EnumVal>
            <EnumVal ord="21">Z</EnumVal>
            <EnumVal ord="24">Y</EnumVal>
         </EnumType>
         <EnumType id="SwTyp">
            <EnumVal ord="1">Load Break</EnumVal>
            <EnumVal ord="2">Disconnector</EnumVal>
            <EnumVal ord="3">Earthing Switch</EnumVal>
            <EnumVal ord="4">High Speed Earthing Switch</EnumVal>
         </EnumType>
      </DataTypeTemplates>
   </SCL>
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Bibliography

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[13] Under consideration.

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