PD IEC/TR 61850-90-2:2016

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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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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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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

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

FOREWORD

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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

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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

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- replaced by a revised edition, or
- amended.

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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”.

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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

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

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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.

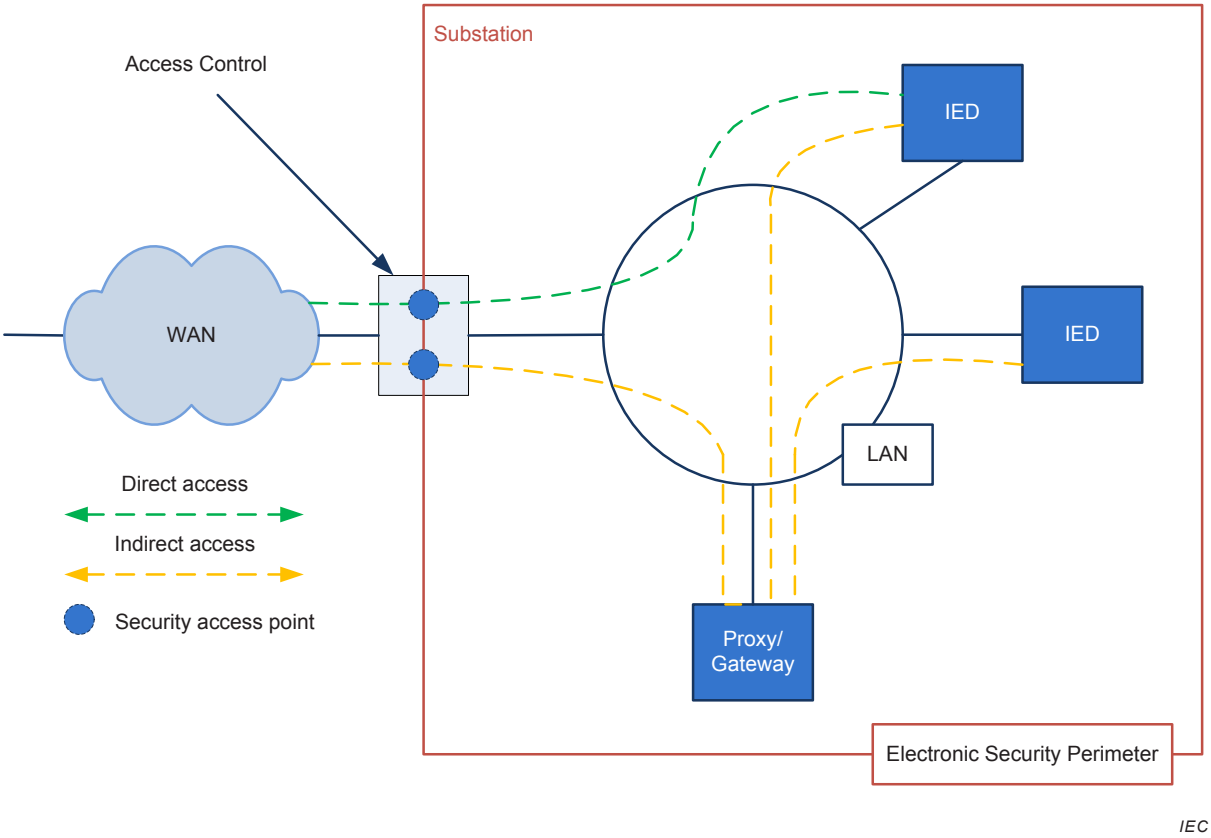

Figure 1 – Connectivity and communication paths of a substation

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*

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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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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

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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)

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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.

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5.1.3 Use case diagram

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

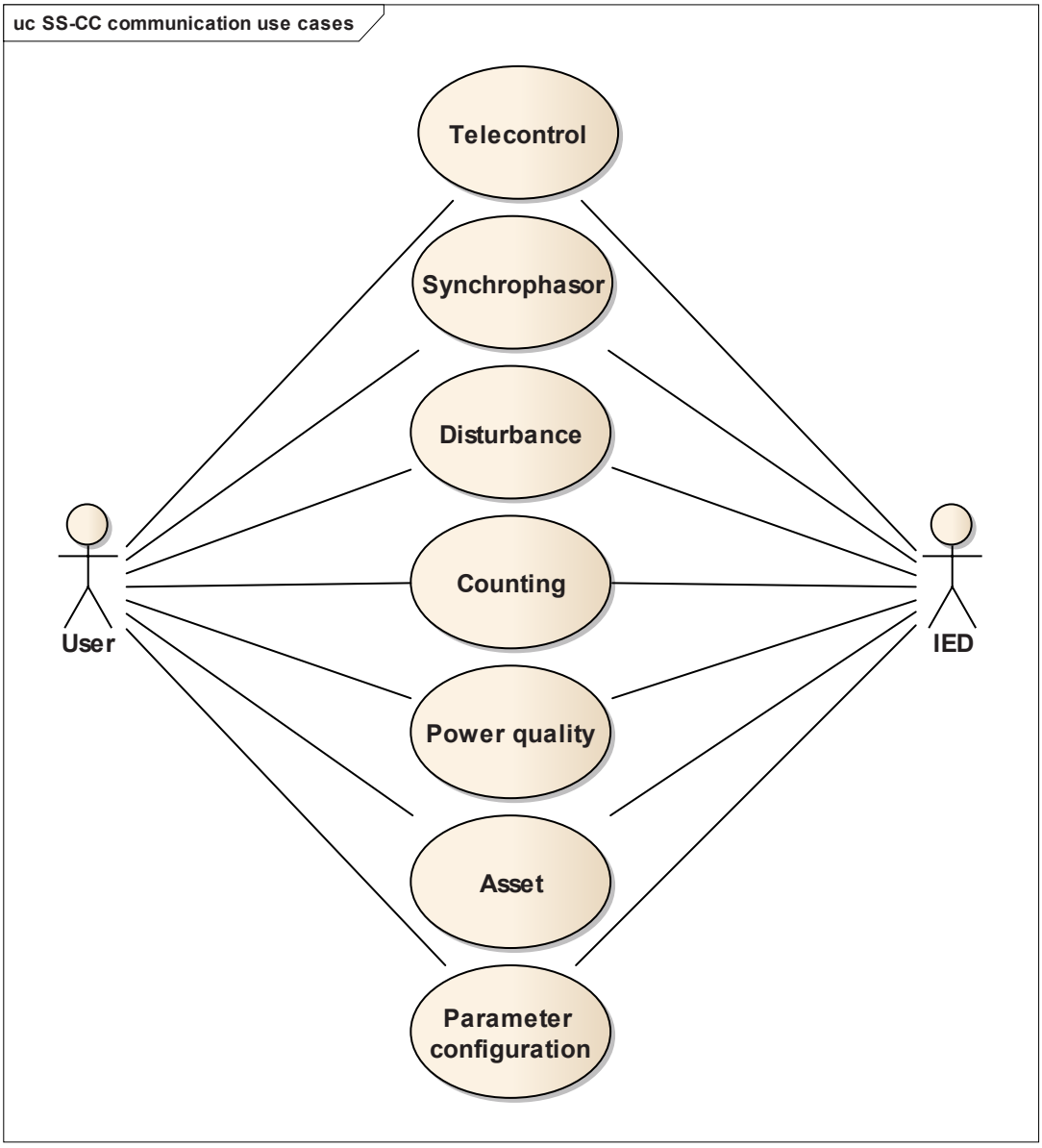

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Figure 2 – Use case diagram for substation to control centre communication

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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: ○ Status of the process/stations buses ○ 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:

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- 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.

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5.2.4 Use cases diagram

Figure 3 shows a telecontrol use diagram.

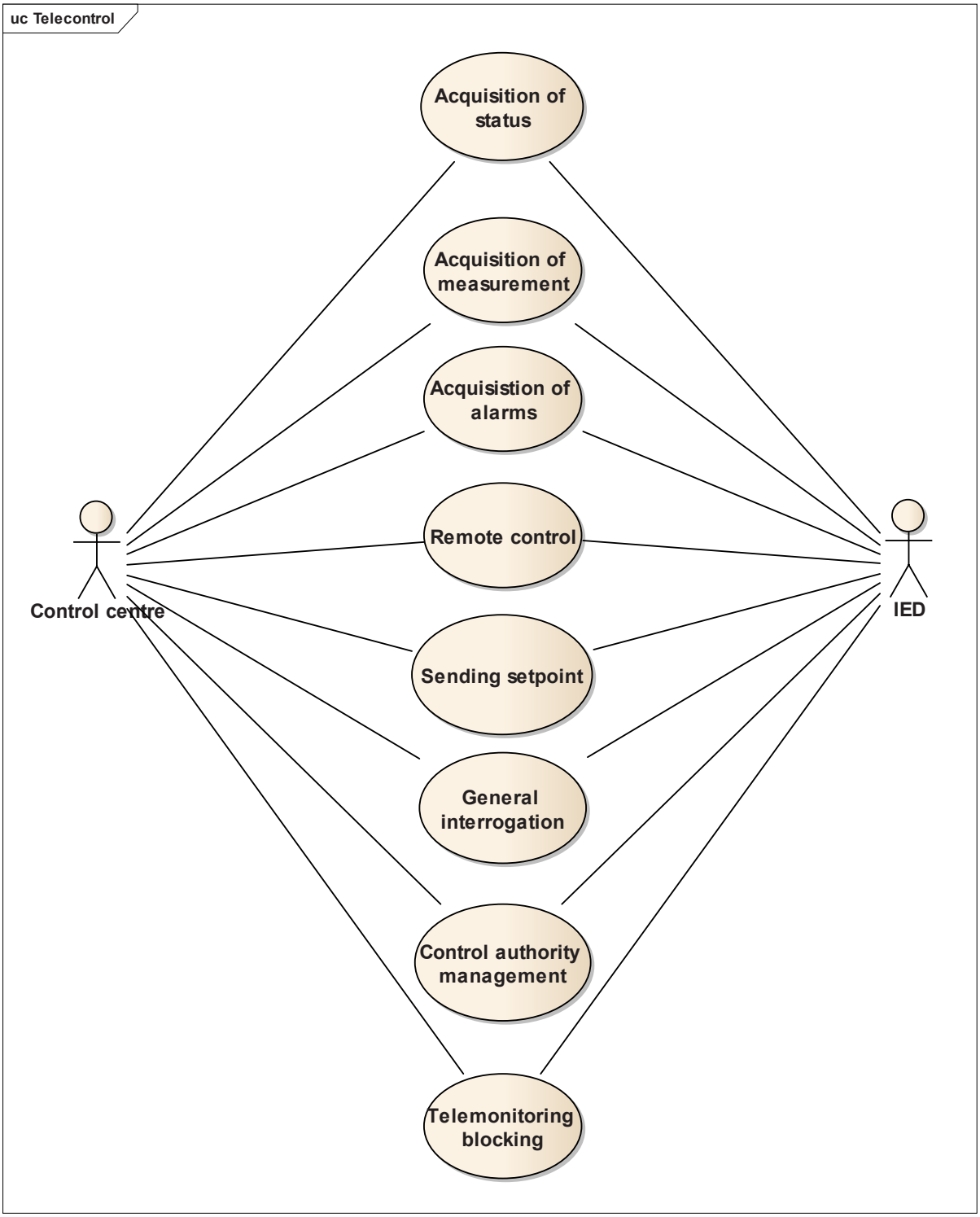

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Figure 3 – Telecontrol use case diagram

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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.

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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.

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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

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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.

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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

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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

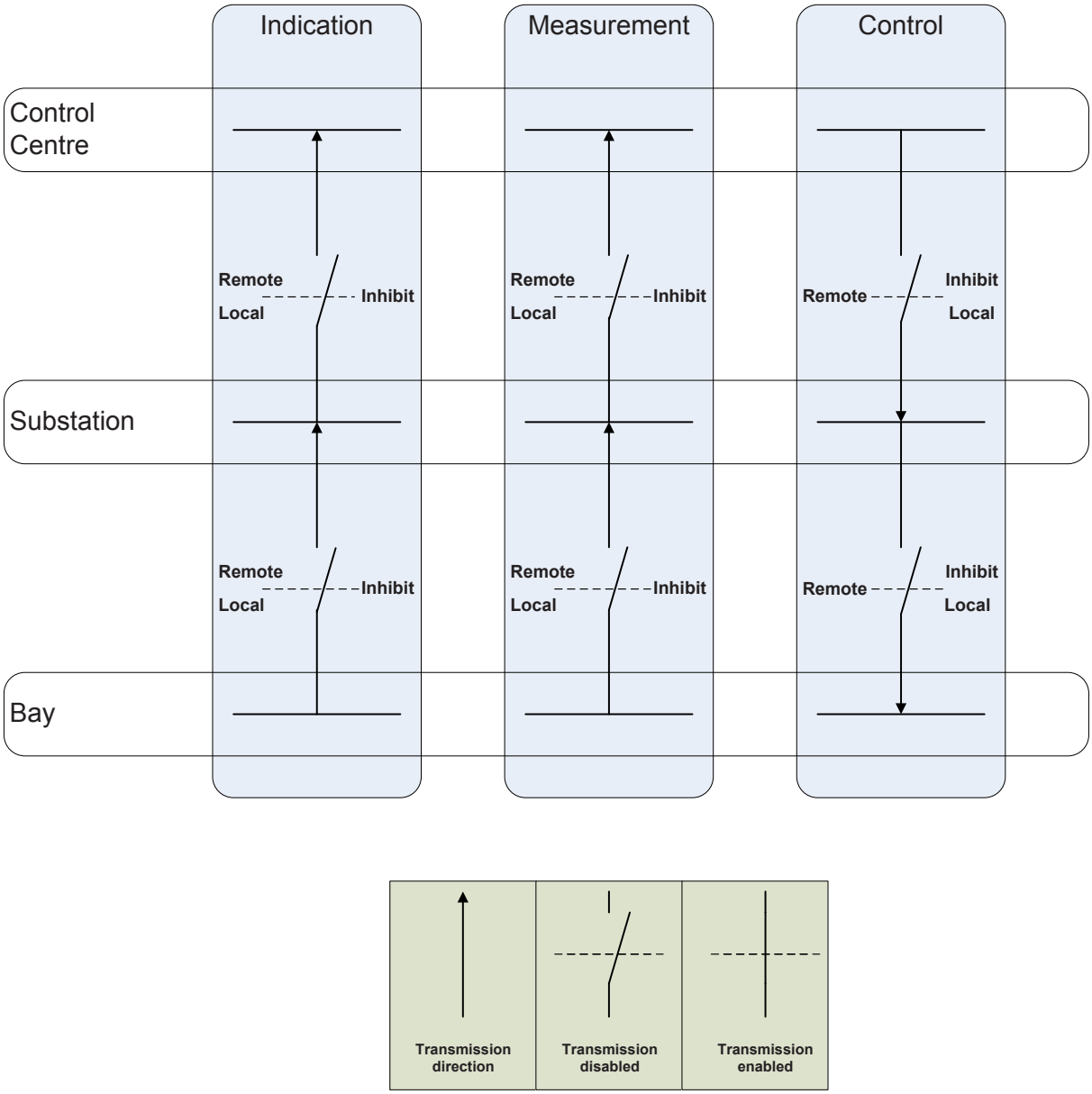

Figure 4 – Principle of data forwarding, depending on the operation mode

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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.

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5.4.4 Use case diagram

Figure 5 shows a disturbance use cases diagram.

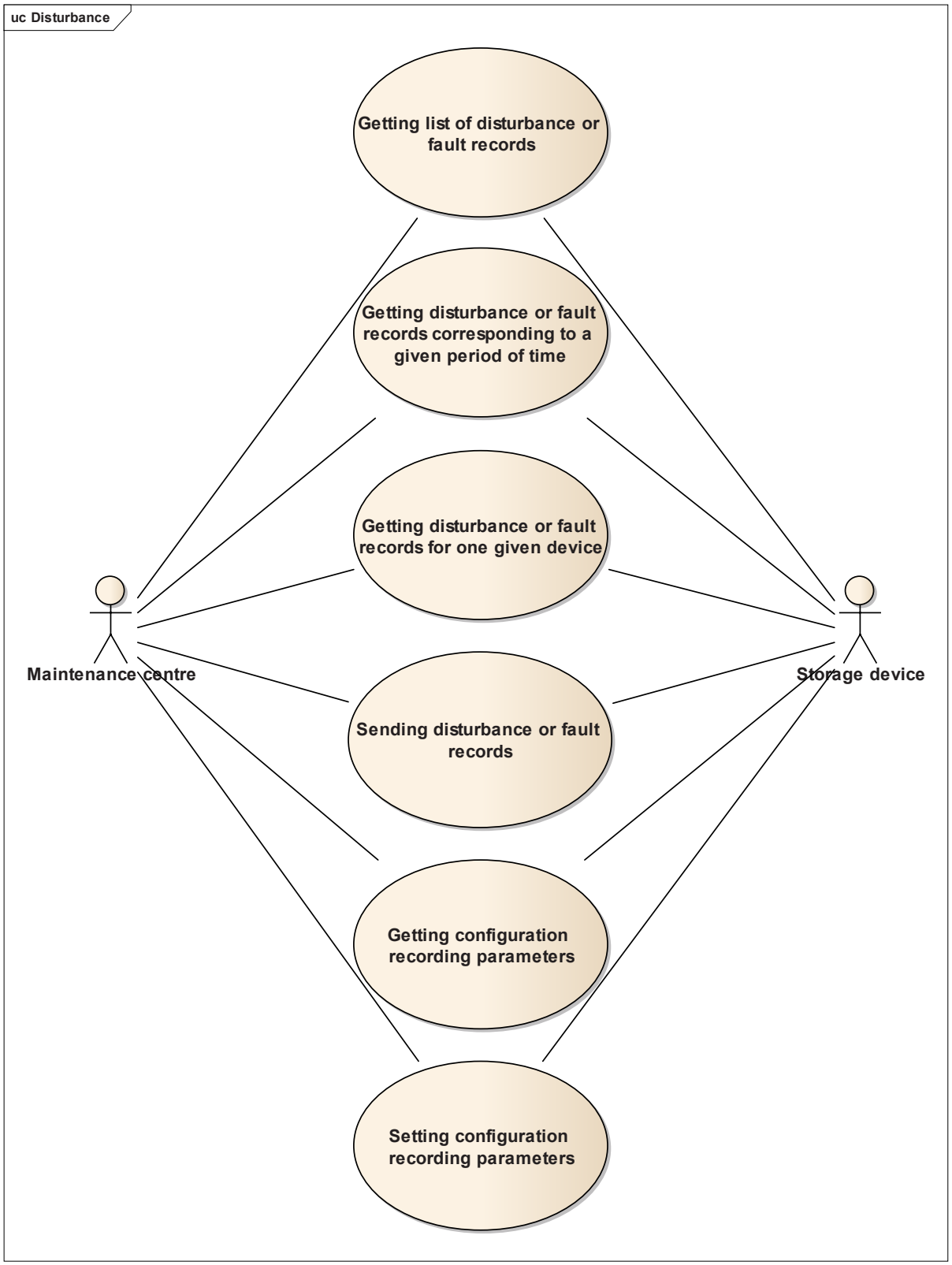

Figure 5 – Disturbance use cases diagram

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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.

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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.

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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.

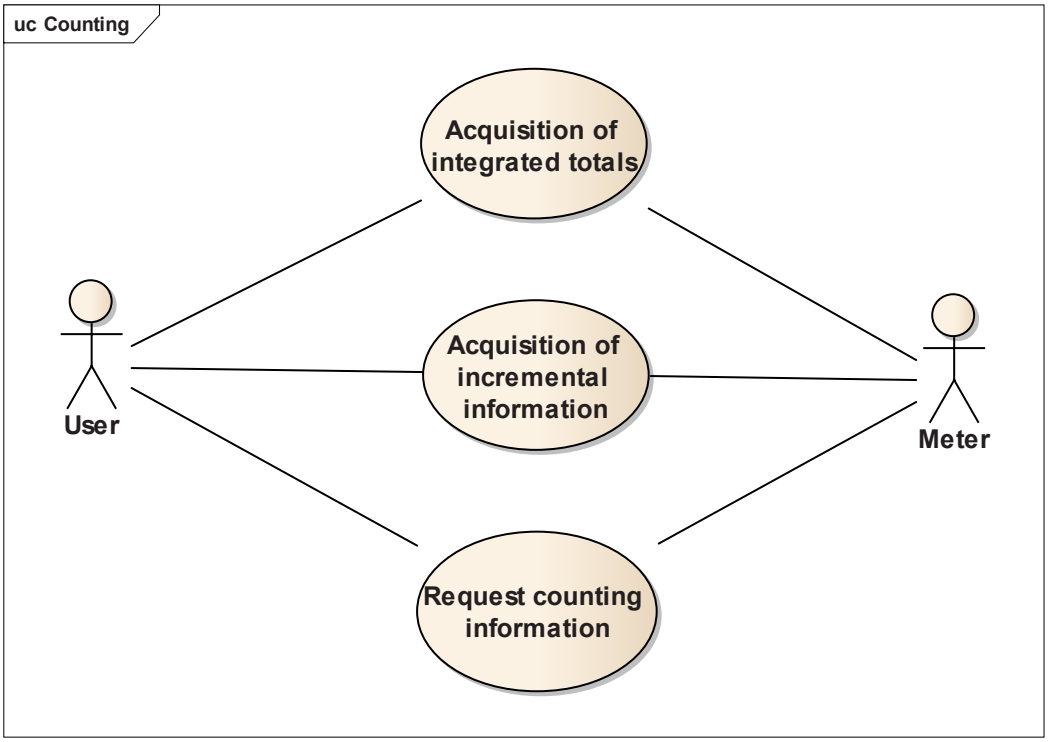

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Figure 6 – Counting use cases diagram

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.

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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.

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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.

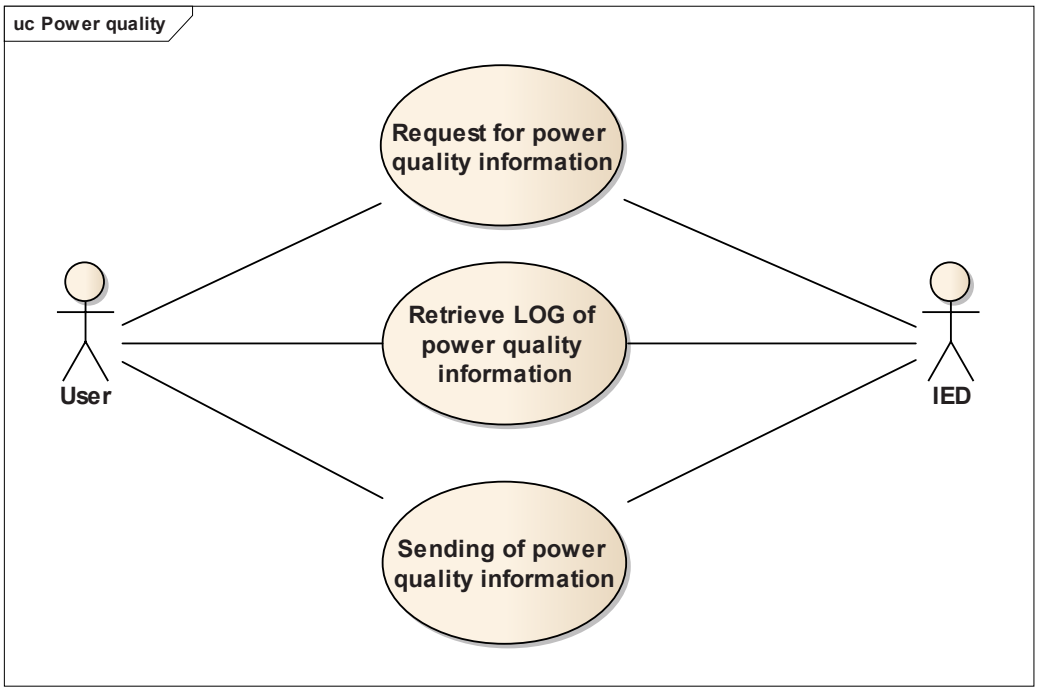

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Figure 7 – Power quality use cases diagram

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.

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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.

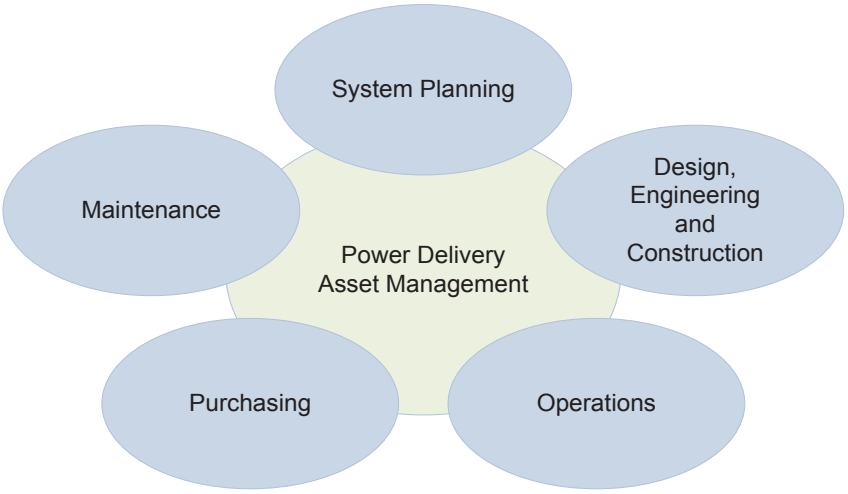

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Figure 8 – Asset management touches a broad range of core electric utility processes

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.

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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.

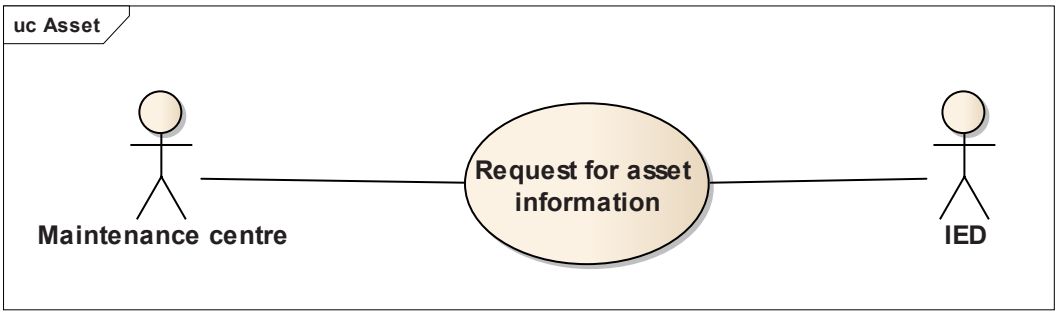

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Figure 9 – Asset supervision use cases diagram

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

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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.

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5.8.4 Use cases diagram

Figure 10 shows a parameter configuration use cases diagram.

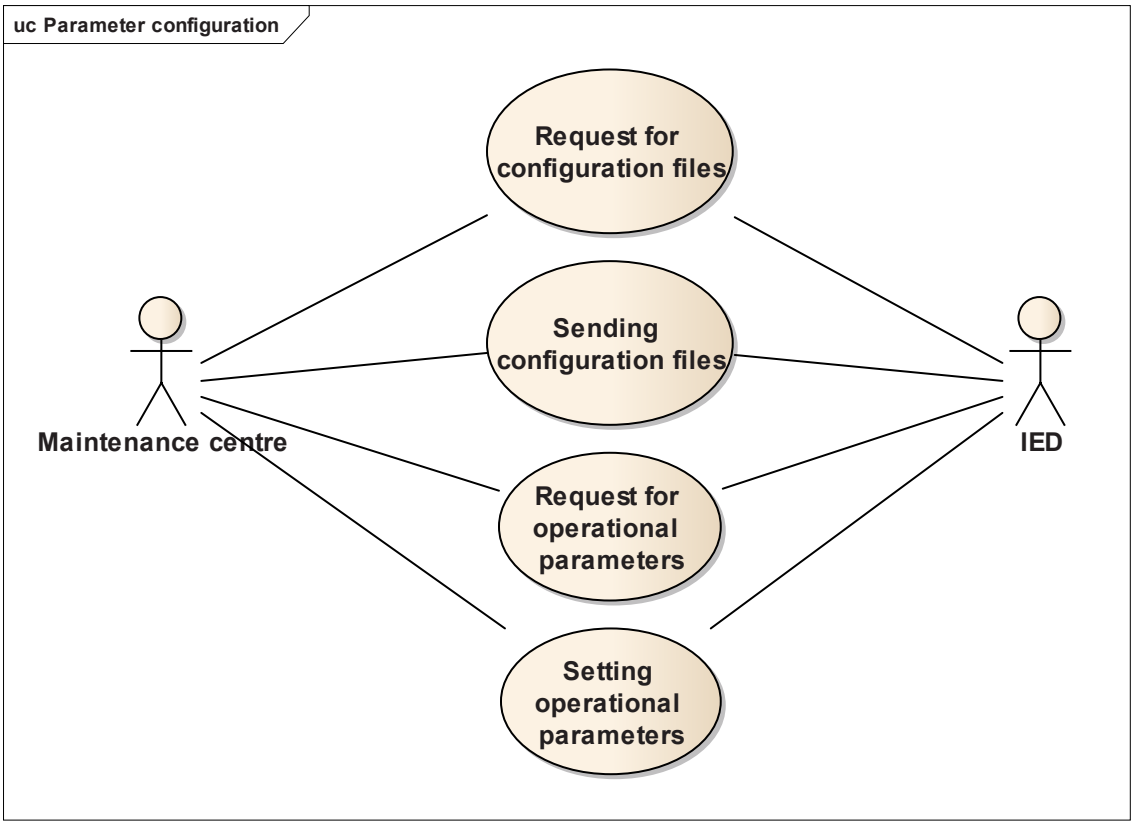

Figure 10 – Parameter configuration use cases diagram

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.

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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.

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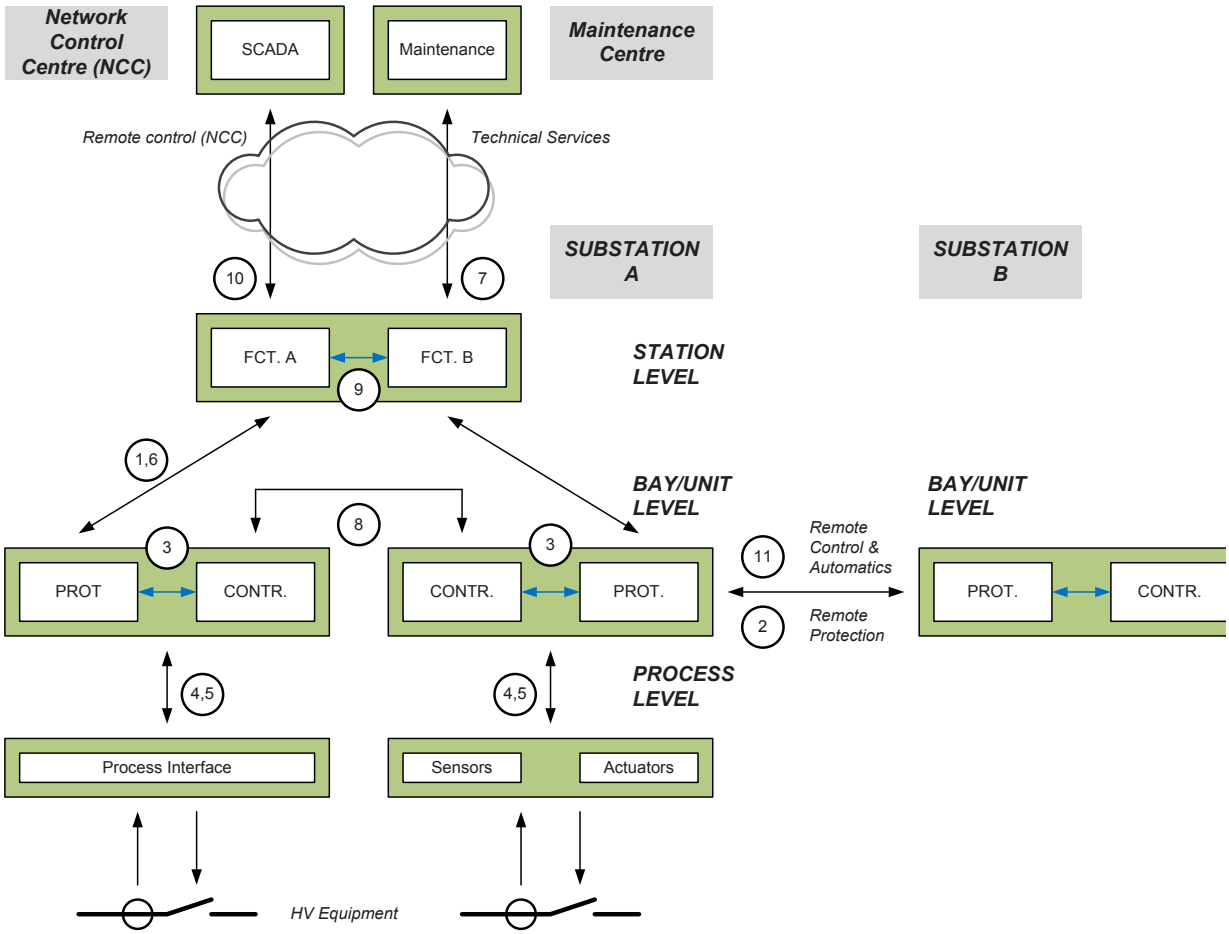

Figure 11 – Levels and logical interfaces in substation automation systems

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.

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- 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.

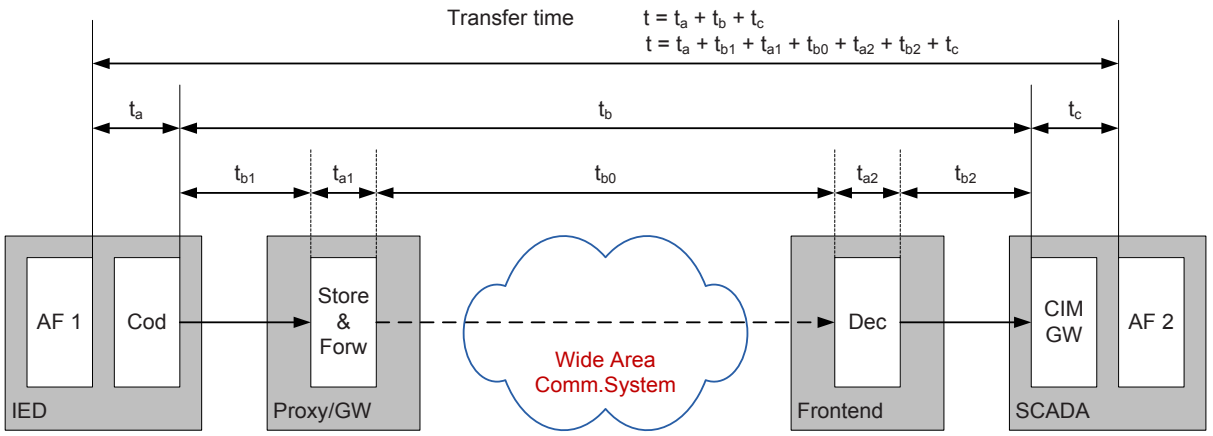

Figure 12 – Definition of transfer time t

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.

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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.

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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.

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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.

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- 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.

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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.

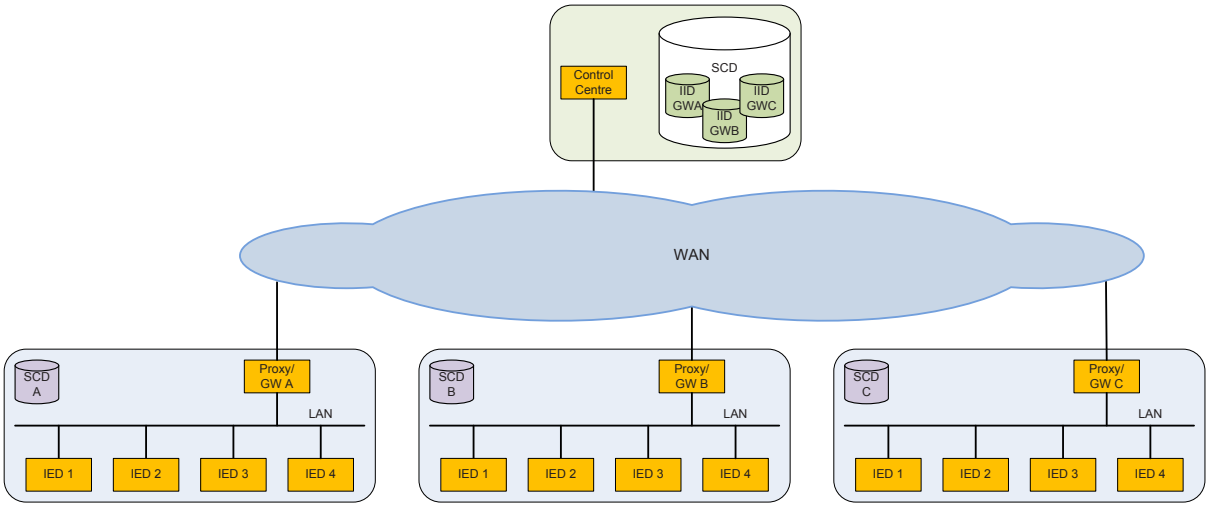

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Figure 13 – Scope of separated engineering workflow

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

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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.

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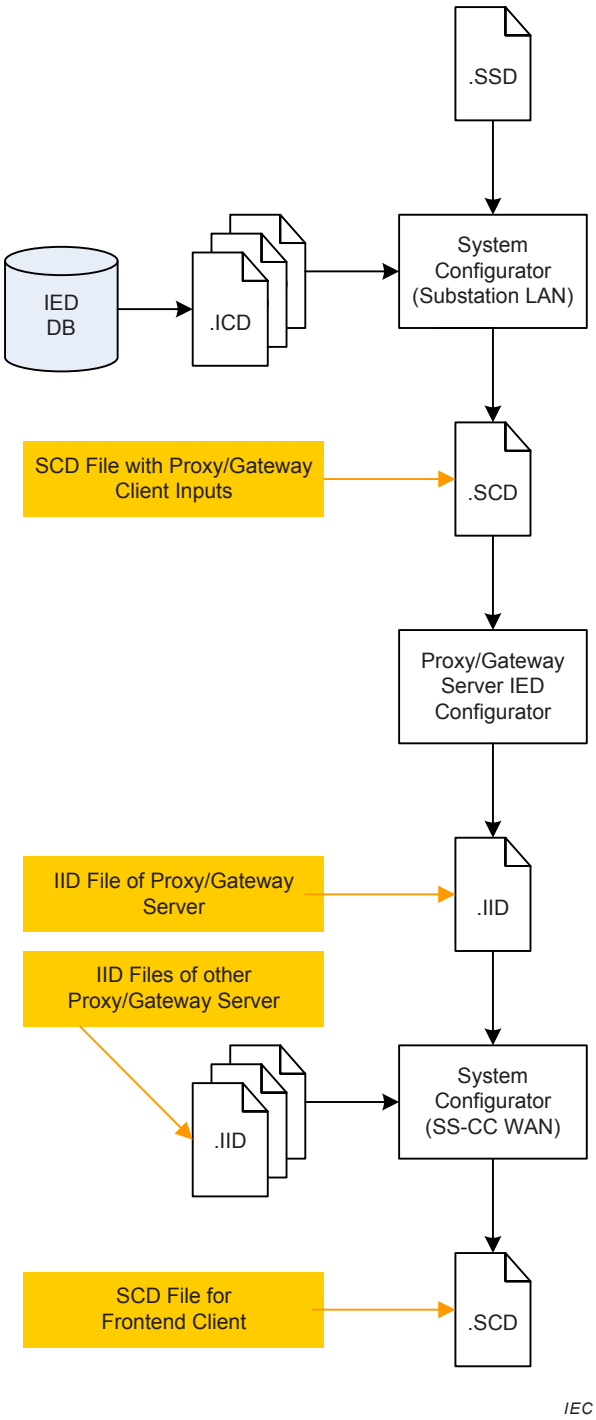

Figure 14 – Engineering workflow

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.

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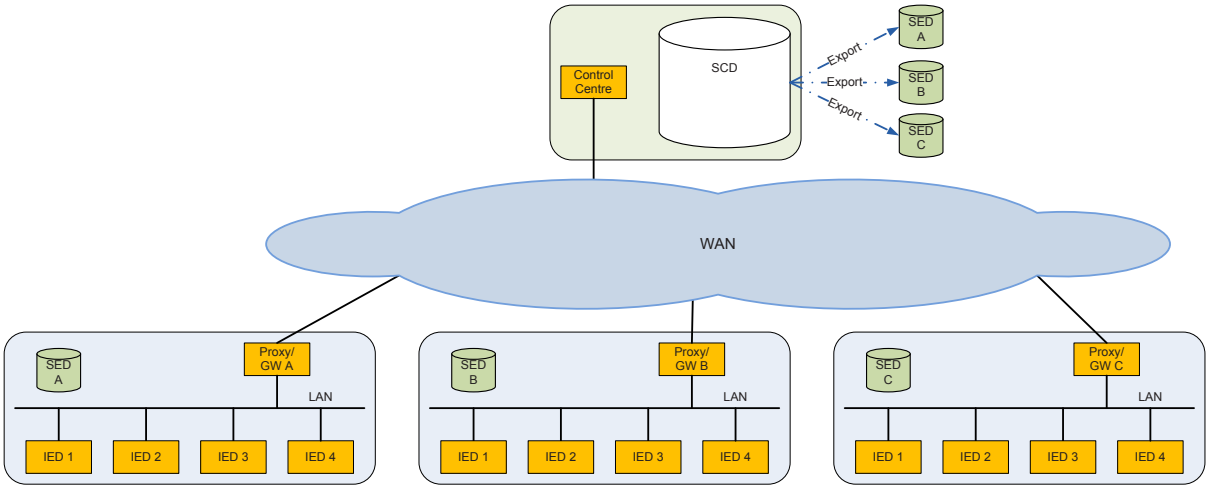

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Figure 15 – Scope of integrated workflow

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.

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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.

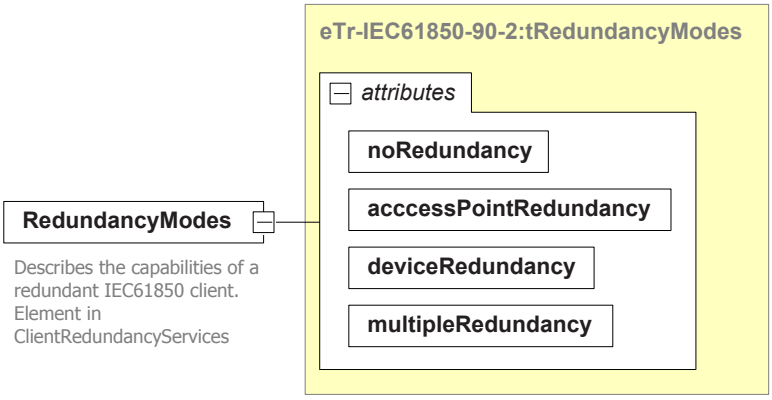

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Figure 16 – Diagram of eTr-IEC61850-90-2:RedundancyModes

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

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