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Communication networks and systems for power utility automation – Part 90-4: Network engineering guidelines

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-4: Network engineering guidelines

FOREWORD

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IEC TR 61850-90-4, which is a technical report, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This second edition cancels and replaces the first edition published in 2013. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- New object model for bridges and clocks based on UML autogeneration.
- An example of SCL configuration with a topology
- Extensions to the time distribution and clock
- Extension of the testing

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

Enquiry draft	Report on voting
57/2088/DTR	57/2159/RVDTR

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

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

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

This IEC standard includes Code Components i.e. components that are intended to be directly processed by a computer. Such content is any text found between the markers <CODE BEGINS> and <CODE ENDS>, or otherwise is clearly labeled in this standard as a Code Component. In the current version of this document, such indication is made at the beginning of each concerned top-level clauses

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This publication contains attached.nsd files which compose the Code Component of this part. These files are intended to be used as a complement and do not form an integral part of this standard.

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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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INTRODUCTION

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

This Technical Report provides definitions, guidelines and specifications for the engineering of IEC 61850-based substation networks, which consists of one or several local area networks. It is also applicable to local area networks outside of the substation, e.g. substation-to-substation links or differential protection links, to which IEDs are directly connected. Data communication over Wide Area Networks is treated in IEC TR 61850-90-12.

This Technical Report addresses issues such as Ethernet technology, network topology, redundancy, traffic latency and quality of service, traffic management by multicast and VLAN filtering, network-based clock synchronization and testing of the network.

This Technical Report is based on existing standards for semantics, services, protocols, system configuration language and architecture. It relies on work done by IEC TC 57 WG 10 (Power system IED communication and associated data models) and IEC TC 57 WG 15 (Data and communications security), on IEC 61918 (*Industrial communication networks – Installation of communication networks in industrial premises*), IEC SC65C WG15 IEC 62439 (*Industrial communication networks – High-availability automation networks*) and IEC 61588 (*Precision clock synchronization protocol for networked measurement and control systems*), on the work of the IEEE 802.1 Working Group, the UCA International Users Group 9-2LE, the IEEE Power System Relaying Committee (PSRC) and on contributions by different companies.

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-4: Network engineering guidelines

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1 Scope

1.1 General

This part of IEC 61850, which is a Technical Report, is intended for an audience familiar with network communication and/or IEC 61850-based systems and particularly for substation protection and control equipment vendors, network equipment vendors and system integrators.

This document focuses on engineering a local area network limited to the requirements of IEC 61850-based substation automation. It outlines the advantages and disadvantages of different approaches to network topology, redundancy, clock synchronization, etc. so that the network designer can make educated decisions. In addition, this document outlines possible improvements to both substation automation and networking equipment.

This document addresses data transfer over the network in IEC 61850, such as transmitting tripping commands for protection via GOOSE messages, and in particular the multicast data transfer of large volumes of sampled values (SV) from merging units (MUs).

This document considers seamless redundancy to increase the network availability under failure conditions and the high precision clock synchronization that is central to the process bus and synchrophasor operation.

This document is not intended as a tutorial on networking or on IEC 61850. Rather, it references and summarizes standards and publications to assist the engineers. Many publications discuss the Ethernet technology but do not address the networks in terms of substation automation. Therefore, many technologies and options have been ignored since they were not considered relevant for a future-proof substation automation network design.

This document does not address network-based security, which is the subject of IEC 62351 and IEC 62443.

This document does not address technologies for wide area networks; these are covered by IEC TR 61850-90-12. Guidelines for communication outside of the substation that uses exclusively the routable Internet Protocol have been published, especially in documents IEC TR 61850-90-1 (substation to substation), IEC TR 61850-90-2 (substation to control center) and IEC TR 61850-90-5 (synchrophasor transmission). However, data flows used in substation-to-substation communication, or substation-to-control centre communication such as R-GOOSE and R-SV are covered when they transit over Ethernet links within the substation.

This document does not dispense the responsible system integrator from an analysis of the actual application configuration, which is the base for a dependable system.

1.2 Namespace name and version

This subclause is mandatory for any IEC 61850 namespace (as defined by IEC 61850-7-1:2011).

Table 1 shows all attributes of (Tr)IEC 61850-90-4:2018A namespace.

Table 1 – Attributes of (Tr)IEC 61850-90-4:2018A namespace

Attribute	Content
Namespace nameplate	
Namespace Identifier	(Tr)IEC 61850-90-4
Version	2018
Revision	A
Full Namespace Name	(Tr)IEC 61850-90-4:2018A
Namespace Type	transitional
Namespace dependencies	
extends	IEC 61850-7-4:2007B version:2007 revision:B
Namespace transitional status	
Future handling of namespace content	The name space (Tr)IEC 61850-90-4:2018A is considered as "transitional" since the models are expected to be included in further editions IEC 61850-7-4xx. Potential extensions/modifications may happen if/when the models are moved to the International Standard status

The table below provides an overview of all published versions of this namespace.

Edition	Publication date	Webstore	Namespace
Edition 1.0	2013-08	IEC TR 61850-90-4:2013	(Tr)IEC 61850-90-4:2013
Edition 2.0	2020-05	IEC TR 61850-90-4:2020	(Tr)IEC 61850-90-4:2018A

1.3 Code Component distribution

The Code Components are in light and full version:

- The full version is named: *IEC_TR_61850-90-4.NSD.2018A.Full*. It contains definition of the whole data model defined in this document with the documentation associated and access is restricted to purchaser of this part
- The light version is named: *IEC_TR_61850-90-4.NSD.2018A.Light*. It does not contain any documentations but contains the whole data model as per full version, and this light version is freely accessible on the IEC website for download at: http://www.iec.ch/tc57/supportdocuments, but the usage remains under the licensing conditions

The Code Components for IEC 61850 data models are formated in compliance with the NSD format defined by the standard IEC 61850-7-7. Each Code Component is a ZIP package containing:

- the electronic representation of the Code Component itself (possibly multiple files)
- the grammar files (XSD) enabling to check the consistency of the associated files against the defined version of NSD, but as well against the IEC 61850 flexibility rules in case of private extension
- a file describing the content of the package (IECManifest.xml)

The IECManifest contains different sections giving information on:

- The copyright notice
- The identification of the code component
- The publication related to the code component

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- The list of the electronic files which compose the code component
- An optional list of history files to track changes during the evolution process of the code component

The life cycle of a code component is not restricted to the life cycle of the related publication. The publication life cycle goes through two stages, Version (corresponding to an edition) and Revision (corresponding to an amendment). A third publication stage (Release) allows publication of Code Component in case of urgent fixes of InterOp Tissues, thus without need to publish an amendment.

Consequently new release(s) of the Code Component may be released, which supersede(s) the previous release, and will be distributed through the IEC TC57 web site at: http://www.iec.ch/tc57/supportdocuments.

The latest version/release of the document will be found by selecting the file named *IEC_TR_61850-90-4.NSD.{VersionStateInfo}.Light* with the filed VersionStateInfo of the highest value.

2 Normative references

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

IEC 60050-191:1990, *International Electrotechnical Vocabulary (IEV) - Part 191: Dependability and quality of service* (available at: http://www.electropedia.org)

IEC/IEEE 60255-118-1, *Measuring relays and protection equipment - Part 118-1: Synchrophasor for power systems - Measurements*

IEC 60834-1, *Teleprotection equipment of power systems - Performance and testing - Part 1: Command systems*

IEC 60870-2-2, *Telecontrol equipment and systems - Part 2: Operating conditions - Section 2: Environmental conditions (climatic, mechanical and othernon electrical influences)*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments*

IEC 61508-4, *Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 4: Definitions and abbreviations (see http://www.iec.ch/functionalsafety)*

IEC 61588:2009, *Precision clock synchronization protocol for networked measurement and control systems*

IEC 61754-20, *Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 20: Type LC connector family*

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IEC 61800-3, *Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods*

IEC 61850-3, *Communication networks and systems for power utility automation - Part 3: General requirements*

IEC 61850-4, *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 61850-7-1:2011/AMD1:2020

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 61850-7-2:2010/AMD1:2020

IEC 61850-7-3, *Communication networks and systems for power utility automation - Part 7-3: Basic communication structure - Common data classes*

IEC 61850-7-4, *Communication networks and systems for power utility automation - Part 7-4: Basic communication structure - Compatible logical node classes and data object classes*

IEC 61850-8-1:2011, *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 61850-8-1:2011/AMD1:2020

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 61850-9-2:2011/AMD1:2020

IEC/IEEE 61850-9-3:2016, *Communication networks and systems for power utility automation - Part 9-3: Precision time protocol profile for power utility automation*

IEC TR 61850-90-1, *Communication networks and systems for power utility automation - Part 90-1: Use of IEC 61850 for the communication between substations*

IEC TR 61850-90-5, *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 61869-9, *Instrument transformers - Part 9: Digital interface for instrument transformers*

IEC 62351 (all parts), *Power systems management and associated information exchange – Data and communications security*

IEC TS 62351-6, *Power systems management and associated information exchange - Data and communications security - Part 6: Security for IEC 61850*

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IEC 62439-1:2010, *Industrial communication networks - High availability automation networks - Part 1: General concepts and calculation methods*

IEC 62439-3:2020[1], *Industrial communication networks - High availability automation networks - Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)*

IEC 81346 (all parts), *Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations*

ISO/IEC 8802-2, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical link control*

ISO/IEC 8824-1, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*

ISO 9506-1:2003*, Industrial automation systems – Manufacturing Message Specification – Part 1: Service definition*

ISO 9506-2:2003*, Industrial automation systems – Manufacturing Message Specification – Part 2: Protocol specification*

IEEE 802-2014, *IEEE standard for local and metropolitan area networks – Overview and Architecture*

IEEE 802.1AB-2005*, IEEE standard for local and metropolitan area networks – Station and Media Access Control Connectivity Discovery*

IEEE 802.1Q-2018, *IEEE standard for local and metropolitan area networks – Media Access Control (MAC) Bridges and Virtual Bridge Local Area Networks*

IEEE 802.3-2012, *IEEE Standard for Ethernet*

IEEE 1613-2009, *IEEE Standard – Environmental and testing requirements for communications networking devices installed in electric power substations*

IEEE 1588-2019, *Precision clock synchronization protocol for networked measurement and control systems*

IEEE C37.118.2-2011, *IEEE standard for synchrophasor data transfer for power systems*

NOTE IETF references are dated with the original Request For Comment (RFC). Subsequent versions receive a new RFC number. Since IETF amends or extends documents and publishes errata on-line, the valid version is available on the internet at *https://tools.ietf.org/*.

IETF RFC 791, *Internet Protocol (IP)*

IETF RFC 792, *Internet Control Message Protocol (ICMP)*

IETF RFC 793, *Transmission Control Protocol (TCP)*

IETF RFC 826, *Address Resolution Protocol (ARP)*

IETF RFC 959, *File Transfer Protocol (FTP)*

[1] Under preparation. Stage at the time of publication: IEC/CCDV 62439-3:2020.

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IETF RFC 2328, *OSPF Version 2*

IETF RFC 2661, *Layer Two Tunneling Protocol "L2TP"*

IETF RFC 3416, *Version 2 of the Protocol Operations for the Simple Network Management Protocol (SNMP)*

IETF RFC 4836, *Definitions of Managed Objects for IEEE 802.3 Medium Attachment Units (MAUs)*

IETF RFC 5903, *Network Time Protocol and Algorithms Specification (NTP/SNTP)*

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