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Power systems management and associated information exchange – Data and communications security –

Part 6:
Security for IEC 61850

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION
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POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE – DATA AND COMMUNICATIONS SECURITY –

Part 6: Security for IEC 61850

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IEC 62351-6, which is a technical specification, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

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

Enquiry draft	Report on voting
57/805/DTS	57/859/RVC

Full information on the voting for the approval of this technical specification 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 of the IEC 62351 series, published under the general title *Power systems management and associated information exchange – Data and communications security,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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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POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE – DATA AND COMMUNICATIONS SECURITY –

Part 6: Security for IEC 61850

1 Scope and object

1.1 Scope

This part of IEC 62351 specifies messages, procedures, and algorithms for securing the operation of all protocols based on or derived from the standard IEC 61850. This specification applies to at least those protocols listed in Table 1.

Table 1 – Scope of application to standards

Number	Name
IEC 61850-8-1	Communication networks and systems in substations – Part 8-1: Specific Communication Service Mapping (SCSM) – Mappings to MMS (ISO/IEC 9506-1 and ISO/IEC 9506-2) and to ISO/IEC 8802-3
IEC 61850-9-2	Communication networks and systems in substations – Part 9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3
IEC 61850-6	Communication networks and systems in substations – Part 6: Configuration description language for communication in electrical substations related to IEDs

1.2 Object

The initial audience for this specification is intended to be the members of the working groups developing or making use of the protocols listed in Table 1. For the measures described in this specification to take effect, they must be accepted and referenced by the specifications for the protocols themselves. This document is written to enable that process.

The subsequent audience for this specification is intended to be the developers of products that implement these protocols.

Portions of this specification may also be of use to managers and executives in order to understand the purpose and requirements of the work.

2 Normative references

The following referenced documents are indispensable for the application 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 61850 (all parts), *Communication networks and systems in substations*

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

IEC 61850-8-1, *Communication networks and systems in substations – 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 61850-9-1, *Communication networks and systems in substations – Part 9-1: Specific Communication Service Mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link*

IEC 61850-9-2, *Communication networks and systems in substations – Part 9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3*

IEC 62351-1, *Power systems management and associated information exchange – Data and communications security – Part 1: Communication network and system security – Introduction to security issues*

IEC 62351-2, *Power systems management and associated information exchange – Data and communications security – Part 2: Glossary of terms*

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

ISO 9506 (all parts), *Industrial automation systems – Manufacturing Message Specification*

ISO/IEC 8802-3, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

ISO/IEC 13239, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures*

IEEE Std. 802.1Q-2003, *Virtual Bridged Local Area Networks*

RFC 2030, *Simple Network Time Protocol (SNTP) Version 4 for IPv4, IPv6 and OSI*

RFC 2313, *PKCS #1: RSA Encryption Version 1.5*

RFC 3447, *Public-Key Cryptography Standards (PKCS) #1: RSA Cryptography Specifications Version 2.1*

RFC 4634, *US Secure Hash Algorithms (SHA and HMAC-SHA)*

3   Definitions

For the purposes of this document, the terms and definitions contained in IEC 62351-2 apply.

4   Security issues addressed by this specification

4.1   Operational issues affecting choice of security options

For applications using GOOSE and IEC 61850-9-2 and requiring 4 ms response times, multicast configurations and low CPU overhead, encryption is not recommended. Instead, the communication path selection process (e.g. the fact that GOOSE and SMV are supposed to be restricted to a logical substation LAN) shall be used to provide confidentiality for information exchanges. However, this specification does define a mechanism for allowing confidentiality for applications where the 4 ms delivery criterion is not a concern.

NOTE   The actual performance characteristics of an implementation claiming conformance to this technical specification is outside the scope of this specification.

With the exception of confidentiality, this specification sets forth a mechanism that allows co-existence of secure and non-secure PDUs.

4.2   Security threats countered

See IEC 62351-1 for a discussion of security threats and attack methods.

If encryption is not employed, then the specific threats countered in this part include:

- unauthorized modification of information through message level authentication of the messages.

If encryption is employed, then the specific threats countered in this part include:

- unauthorized access to information through message level authentication and encryption of the messages;
- unauthorized modification (tampering) or theft of information through message level authentication and encryption the messages.

4.3   Attack methods countered

The following security attack methods are intended to be countered through the appropriate implementation of the specification/recommendations found within this document:

- man-in-the-middle: this threat will be countered through the use of a Message Authentication Code mechanism specified within this document;
- tamper detection/message integrity: These threats will be countered through the algorithm used to create the authentication mechanism as specified within this document;
- replay: this threat will be countered through the use of specialized processing state machines specified within IEC 62351-4 and this document.

5   Correlation of IEC 61850 parts and IEC 62351 parts

5.1   IEC 61850 security for profiles using ISO 9506 (MMS)

5.1.1   General

IEC 61850 implementations claiming conformance to this specification and declaring support for the IEC 61850-8-1 profile utilizing TCP/IP and ISO 9506 (MMS) shall implement Clauses 5 and 6 of IEC 62351-4. In addition to the IEC 62351-4 specification, extensions to IEC 61850-6 (the Substation Configuration Language) shall be supported as prescribed in 7.2.3.

IEC 61850-8-1 specifies the use of MMS within a substation. However, the scope of this specification provides security specifications for use within the substation and external to the substation (e.g. Control Centre to Substation).

5.1.2   Control centre to substation

The IEC 62351-4 standard shall be used without any other additions.

5.1.3   Substation communications

The following cipher suite shall be supported in addition to those specified in IEC 62351-4.

TLS_DH_RSA_WITH_AES_128_SHA

NOTE   This additional cipher suite is suggested in order to allow less CPU utilization when the communication environment is within a substation.

5.2   IEC 61850 security for profiles using VLAN IDs

For the IEC 61850 profiles specified that make use of VLAN IDs (e.g. IEC 61850-8-1 GOOSE, IEC 61850-9-1, and IEC 61850-9-2) profile security shall be provided as specified in Clause 7.

6   IEC 61850 security for SNTP

RFC 2030, including mandatory use of the authentication algorithms, shall be used.

7   IEC 61850 security for profiles using VLAN technologies

7.1   Overview of VLAN usage and IEC 61850 (informative)

This specification extends the normal IEC 61850 GOOSE and SMV PDUs. The outline of a PDU for GSE Management and GOOSE is given in Annex C of IEC 61850-8-1.

7.2   Extended PDU

7.2.1   General format of extended PDU
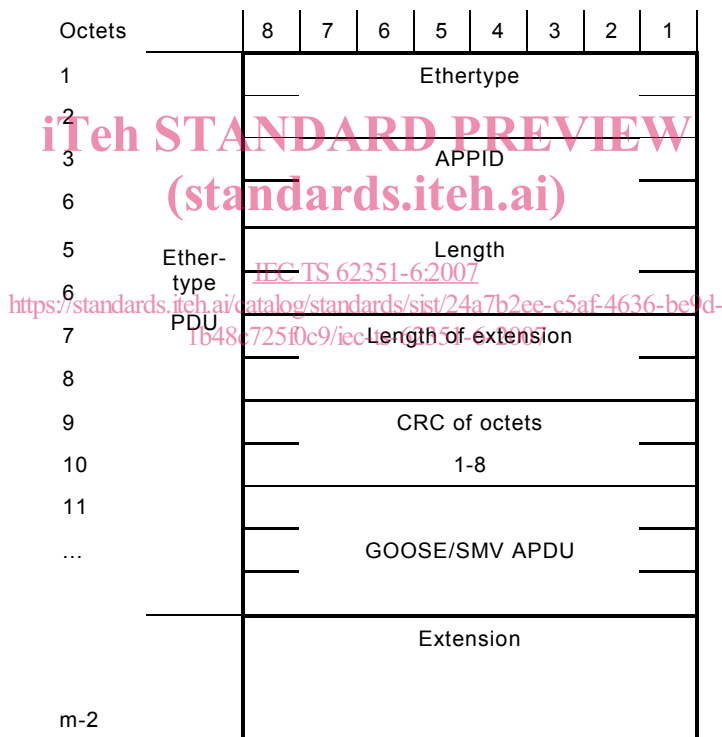
IEC   1053/07

Figure 1 – General format of extended PDU

Figure 1 depicts the fact that the Reserved1 and Reserved2 fields are to be used for implementations claiming conformance to this specification in regards to GOOSE and SMV. This specification specifies that the:

- **Reserved1 field** shall be used to specify the number of octets conveyed by the extension octets. This value shall be contained in the first octet of the Reserved1 field. The valid range of values is zero(0) through 255. A value of zero(0) shall indicate that no extension octets are present.

  The second octet of the Reserved1 field shall be reserved for future use;

- **Reserved2** field shall contain a 16-bit CRC, as calculated per ISO/IEC 13239 (ISO HDLC). The CRC shall be calculated over Octets 1-8 of the VLAN information of the Extended PDU.

  The CRC shall be present if the Extension Length has a non-zero value.

7.2.2   Format of extension octets

The format of the extension octet area shall be:

```
Extension::= {
   [0] IMPLICIT SEQUENCE {
        [1] IMPLICIT SEQUENCE Reserved OPTIONAL,
        [2] IMPLICIT OCTETSTRING Private  OPTIONAL,
        [3] IMPLICIT AuthenticationValue OPTIONAL,
        …
                    }
}
```

Extension shall be encoded per ASN.1 Basic Encoding Rules.

The Reserved SEQUENCE is used to reserve future standardized extension per this specification. If no extension, besides Authentication and Encryption is defined in this specification, this SEQUENCE shall not be present.

Therefore a SEQUENCE of NULL length shall be considered non-conformant to this specification.

The Private SEQUENCE is provided to allow vendors to convey Private information. The scope of the semantics and syntax of the contents of this SEQUENCE is out-of-scope of this specification and shall only be interoperable via prior agreement. This SEQUENCE shall only be present if there are actual contents being conveyed.

7.2.2.1   &AuthenticationValue Algorithm

The algorithm for AuthenticationValue generation is based upon the generation of a reproducible Message Authentication Code (MAC).

The MAC shall be generated through the computation of a SHA256 hash per RFC 4634. The hash shall contain all octets of the Extended PDU with the exception of the Tag, Length, Value of the

AuthenticationValue.

The value of the hash shall then be digitally signed.

The definition for digital signature is found in RFC 2313:

> "For digital signatures, the content to be signed   is first reduced to a message digest with a message-digest algorithm (such as MD5), and then an octet string containing the message digest is encrypted with the RSA private key of the signer of the content. The content and the encrypted message digest are represented together according to the syntax in PKCS #7 to yield a digital signature."

> NOTE   The reference to MD5, in the definition, is not normative. It is an example given in the RFC 2313 quoted text.

RFC 3447 (specification for PKCS#1 Version 2.1) specifies RSASA-PSS. This is the algorithm that shall be used by implementations claiming conformance to this specification. The use of RFC 3447 shall be restricted to those abilities/capabilities that are compatible with PKCS Version 1.5 (RFC 2313). The Hash algorithm shall be SHA256