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# Space data and information transfer systems — Space link extension — Internet protocol for transfer services

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## National foreword

This British Standard is the UK implementation of ISO 18440:2016. It supersedes BS ISO 18440:2013 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/68, Space systems and operations.

A list of organizations represented on this committee can be obtained on request to its secretary.

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INTERNATIONAL STANDARD

# ISO 18440

Second edition
2016-11-15

# Space data and information transfer systems — Space link extension — Internet protocol for transfer services

*Systèmes de transfert des informations et données spatiales — Extension de liaisons spatiales — Protocole Internet pour services de transfert*

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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ISO 18440 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 913.1-B-2, September 2015) and was adopted (without modifications except those stated in clause 2 of this International Standard) by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 13, *Space data and information transfer systems*.

This second edition cancels and replaces the first edition (ISO 18440:2013), which has been technically revised.

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In those instances when a new version of a **Recommended Standard** is issued, existing CCSDS-related member standards and implementations are not negated or deemed to be non-CCSDS compatible. It is the responsibility of each member to determine when such standards or implementations are to be modified. Each member is, however, strongly encouraged to direct planning for its new standards and implementations towards the later version of the Recommended Standard.


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# DOCUMENT CONTROL

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|---|---|---|---|
| CCSDS 913.1-B-1 | Space Link Extension—Internet Protocol for Transfer Services, Recommended Standard, Issue 1 | September 2008 | Original issue, superseded |
| CCSDS 913.1-B-2 | Space Link Extension—Internet Protocol for Transfer Services, Recommended Standard, Issue 2 | September 2015 | Current issue:<br>– changes the recommended algorithm for secure one-way hash function from SHA-1 to SHA-256;<br>– updates references. |

NOTE – Substantive changes from the previous issue are marked with change bars in the inside margin.


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# 1 INTRODUCTION

## 1.1 PURPOSE

The Space Link Extension (SLE) Reference Model (reference [1]) identifies a set of SLE Transfer Services that enable missions to send forward space link data units to a spacecraft and to receive return space link data units from a spacecraft. A subset of these services is specified by the SLE Transfer Service Recommended Standards (references [2], [3], [4], [5], and [6]). The SLE Transfer Service Recommended Standards specify

a) the operations necessary to provide the transfer service;

b) the parameter data associated with each operation;

c) the behaviors that result from the invocation of each operation; and

d) the relationship between, and the valid sequence of, the operations and resulting behaviors.

However, they deliberately do not specify the methods or technologies required for communications.

The purpose of this Recommended Standard is to define a protocol for transfer of SLE Protocol Data Units (PDUs) defined in the SLE Transfer Service Recommended Standards using the Internet protocols TCP (Transmission Control Protocol, reference [7]) and IP (Internet Protocol, reference [8]) for data transfer and the Abstract Syntax Notation One (ASN.1, references [9] and [10]) for data encoding. This protocol is referred to as the Internet SLE Protocol One (ISP1).

## 1.2 SCOPE

This Recommended Standard defines a protocol for transfer of SLE PDUs between an SLE user and an SLE provider system in terms of:

a) the procedures used to establish and release associations;

b) the messages exchanged on an established association;

c) the procedures used to monitor the status of data communication connections; and

d) the methods used to ensure that data are converted between different formats and representations on different platforms.

It does not specify:

a) individual designs, implementations, or products;

b) the configuration of the data communications infrastructure, including configuration of the TCP and IP protocols;


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c) the means by which addresses (IP addresses and TCP port numbers) are agreed, assigned, and communicated.

This Recommended Standard responds to the requirements imposed by the Recommended Standards for SLE transfer services that were available when this Recommended Standard was released. The protocol specified in this Recommended Standard conforms to the requirements on data communication services set forth in those Recommended Standards.

## 1.3 APPLICABILITY

### 1.3.1 APPLICABILITY OF THIS RECOMMENDED STANDARD

This Recommended Standard provides a basis for the development of real systems that implement the Internet SLE Protocol. It is applicable for systems acting as an SLE service user or SLE service provider.

### 1.3.2 LIMITS OF APPLICABILITY

This Recommended Standard specifies the Internet SLE Protocol that may be applied by an SLE System for inter-Agency cross support. It is neither a specification of, nor a design for, real systems that may be implemented for the control and monitoring of existing or future missions.

## 1.4 RATIONALE

The goal of this Recommended Standard is to create a standard for interoperability between the tracking stations and/or ground data handling systems of various agencies and the users of SLE transfer services based on the technologies TCP/IP and ASN.1.

## 1.5 DOCUMENT STRUCTURE

### 1.5.1 ORGANIZATION

This document is organized as follows:

a) section 1 presents the purpose, scope, applicability and rationale of this Recommended Standard and lists the definitions, conventions, and references used throughout the Recommended Standard;

b) section 2 describes the Internet SLE Protocol by means of an architectural model identifying individual protocol layers and the interfaces to higher layers;

c) section 3 specifies the messages exchanged via ISP1 and the procedures to be applied for connection establishment and release and for data transfer;


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d) section 4 specifies the state table for the protocol;

e) annex A provides ISP1-specific diagnostic codes for the SLE PEER-ABORT operation;

f) annex B describes differences with earlier implementations of ISP1;

g) annex C lists all terms used in this document and identifies where they are defined;

h) annex D lists all acronyms used within this document;

i) annex E contains a list of informative reference documents.

### 1.5.2 SLE SERVICES DOCUMENTATION TREE

This Recommended Standard is part of a suite of documents specifying the SLE services. The SLE services constitute one of the three types of Cross Support Services:

a) Part 1: SLE Services;

b) Part 2: Ground Domain Services;

c) Part 3: Ground Communications Services.

The basic organization of the SLE services documentation is shown in figure 1-1. The various documents are described in the following subsections.

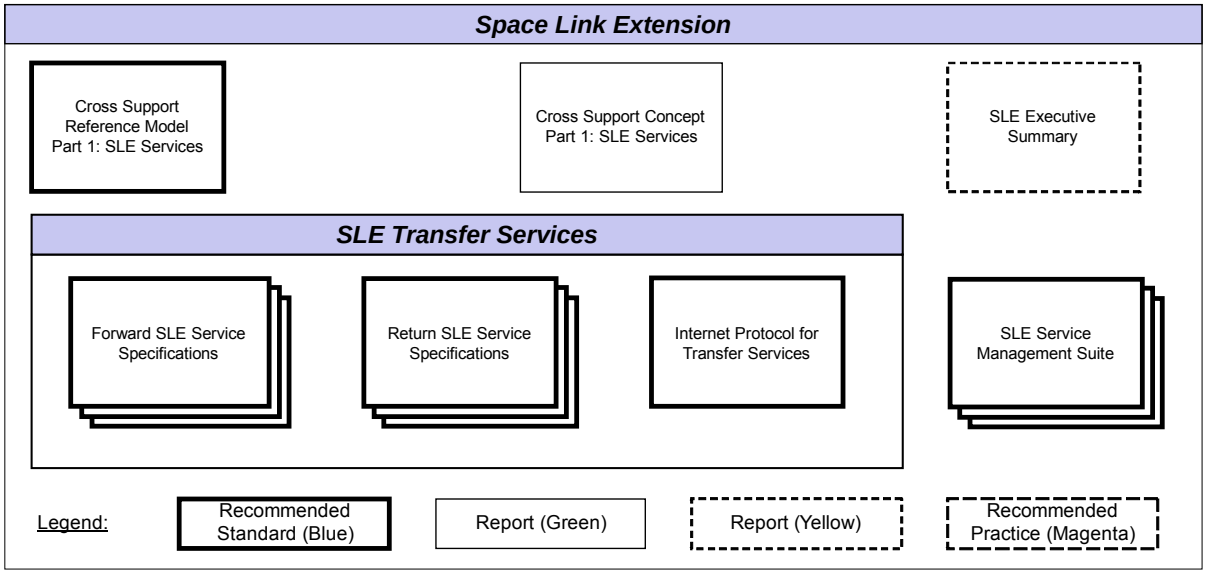


**Figure 1-1: SLE Services and SLE API Documentation**

a) *Cross Support Concept—Part 1: Space Link Extension Services* (reference [E1]), a Report introducing the concepts of cross support and the SLE services;


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b) *Cross Support Reference Model—Part 1: Space Link Extension Services* (reference [1]), a Recommended Standard that defines the framework and terminology for the specification of SLE services;

c) *Forward SLE Service Specifications*, a set of Recommended Standards that will provide specification of all forward link SLE services;

d) *Return SLE Service Specifications*, a set of Recommended Standards that will provide specification of all return link SLE services;

e) *Internet Protocol for Transfer Services*, this Recommended Standard;

f) *SLE Service Management Specifications*, a set of Recommended Standards that establish the basis of SLE service management.

## 1.6 DEFINITIONS, NOMENCLATURE, AND CONVENTIONS

### 1.6.1 DEFINITIONS

#### 1.6.1.1 Definitions from the SLE Reference Model

This Recommended Standard makes use of the following terms defined in reference [1]:

a) initiator;

b) operation;

c) responder;

d) service user (user);

e) service provider (provider);

f) SLE protocol data unit (SLE-PDU);

g) SLE transfer service instance (service instance).

#### 1.6.1.2 Definitions from SLE Transfer Service Specifications

This Recommended Standard makes use of the following terms defined in references [2], [3], [4], [5], and [6]:

a) association;

b) communications service;

c) confirmed operation;

d) invocation;



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e) parameter (of an operation);

f) port identifier;

g) return;

h) unconfirmed operation.

#### 1.6.1.3 Definitions from TCP/IP

This Recommended Standard makes use of the following terms defined in references [7] and [8]:

a) Internet Protocol (IP);

b) IP address;

c) port (of TCP);

d) port number;

e) Transmission Control Protocol (TCP);

f) segment (of TCP);

g) socket.

#### 1.6.1.4 Definitions from Abstract Syntax Notation One

This Recommended Standard makes use of the following terms defined in references [9] and [10]:

a) Abstract Syntax Notation One (ASN.1);

b) Basic Encoding Rules (BER);

c) Distinguished Encoding Rules (DER);

d) encoding rules (of ASN.1);

e) encoding;

f) module (of ASN.1).

#### 1.6.1.5 Definitions from OSI Basic Reference Model

This Recommended Standard makes use of the following terms defined in reference [14]:

a) abstract syntax;

b) primitive;


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c) (protocol) layer;

d) transfer syntax.

#### 1.6.1.6 Additional Definitions

##### 1.6.1.6.1 General

For the purposes of this Recommended Standard, the following definitions also apply.

##### 1.6.1.6.2 (SLE) Application

An application is a software entity in an SLE user system or an SLE provider system that makes use of the ISP1 protocol, as distinguished from the software implementing the protocol layers defined in this Recommended Standard. The application is considered to implement the 'higher layers' defined in the architectural model in section 2.

##### 1.6.1.6.3 Local Application

The local application is the application implementing the higher layers interfacing with a given instance of an ISP1 implementation.

##### 1.6.1.6.4 Peer Application

The peer application is the application that communicates with the local application via the ISP1 protocol. The peer application is typically located on a remote network, but may also be located on the local network, or even on the same host as the local application.

##### 1.6.1.6.5 Application Identifier

The application identifier is the authority identifier of the application by which the application is identified in the BIND invocation and the BIND return.

NOTE – For an initiating SLE application, the application identifier is the initiator-identifier, and for a responding SLE application, the application identifier is the responder-identifier.

### 1.6.2 NOMENCLATURE

#### 1.6.2.1 Normative Text

The following conventions apply for the normative specifications in this Recommended Standard:

a) the words 'shall' and 'must' imply a binding and verifiable specification;



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b) the word 'should' implies an optional, but desirable, specification;

c) the word 'may' implies an optional specification;

d) the words 'is', 'are', and 'will' imply statements of fact.

NOTE – These conventions do not imply constraints on diction in text that is clearly informative in nature.

#### 1.6.2.2 Informative Text

In the normative sections of this document, informative text is set off from the normative specifications either in notes or under one of the following subsection headings:

– Overview;

– Background;

– Rationale;

– Discussion.

### 1.6.3 CONVENTIONS

The Internet SLE Protocol is specified by a layered architecture model in which the interfaces between the layers are defined using abstract service primitives, roughly following the concepts in the OSI Basic Reference Model (reference [14]).

A service primitive is a signal optionally associated with a set of parameters that is generated by one layer and consumed by another (adjacent) layer. The direction in which the information is passed is defined by one of the following:

| | |
|---|---|
| request | a primitive that is passed from the higher layer to the lower layer; |
| indication | a primitive that is passed from the lower layer to the higher layer; |
| response | a primitive generated by the higher layer in response to an indication of the same type; |
| confirmation | a primitive generated by the lower layer in response to a request of the same type. |

For every service primitive, the following specifications are provided:

a) the name of the primitive;

b) the uses of the primitive (request, indication, response, confirmation);

c) the parameters associated with each of these uses.


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In addition, the conditions under which the source emits a primitive and the tasks that the receiver shall perform are described.

In this Recommended Standard, primitive names are capitalized and are followed by the specific use in lowercase letters. The primitive name is prefixed by the identifier of the layer that defines the interface, e.g., 'TML-CONNECT-indication'. In the state table in section 4, the prefix is omitted in order to avoid clashes with the notation used in these tables.

## 1.7 REFERENCES

The following documents contain provisions which, through reference in this text, constitute provisions of this Recommended Standard. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this Recommended Standard are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS Recommended Standards.

NOTE – A list of informative references is provided in annex E.

[1] *Cross Support Reference Model—Part 1: Space Link Extension Services*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 910.4-B-2. Washington, D.C.: CCSDS, October 2005.

[2] *Space Link Extension—Return All Frames Service Specification*. Issue 3. Recommendation for Space Data System Standards (Blue Book), CCSDS 911.1-B-3. Washington, D.C.: CCSDS, January 2010.

[3] *Space Link Extension—Return Channel Frames Service Specification*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 911.2-B-2. Washington, D.C.: CCSDS, January 2010.

[4] *Space Link Extension—Return Operational Control Fields Service Specification*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 911.5-B-2. Washington, D.C.: CCSDS, January 2010.

[5] *Space Link Extension—Forward CLTU Service Specification*. Issue 3. Recommendation for Space Data System Standards (Blue Book), CCSDS 912.1-B-3. Washington, D.C.: CCSDS, July 2010.

[6] *Space Link Extension—Forward Space Packet Service Specification*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 912.3-B-2. Washington, D.C.: CCSDS, July 2010.

[7] J. Postel. *Transmission Control Protocol*. STD 7. Reston, Virginia: ISOC, September 1981.

[8] J. Postel. *Internet Protocol*. STD 5. Reston, Virginia: ISOC, September 1981.



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[9] *Information Technology—Abstract Syntax Notation One (ASN.1): Specification of Basic Notation*. 4th ed. International Standard, ISO/IEC 8824-1:2008. Geneva: ISO, 2008.

[10] *Information Technology—ASN.1 Encoding Rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER)*. 4th ed. International Standard, ISO/IEC 8825-1:2008. Geneva: ISO, 2008.

[11] *Information Technology—Open Systems Interconnection—The Directory—Part 8: Public-Key and Attribute Certificate Frameworks*. 7th ed. International Standard, ISO/IEC 9594-8:2014. Geneva: ISO, 2014.

[12] *Secure Hash Standard (SHS)*. Federal Information Processing Standards Publication 180-4. Gaithersburg, Maryland: NIST, March 2012.

[13] *Time Code Formats*. Issue 4. Recommendation for Space Data System Standards (Blue Book), CCSDS 301.0-B-4. Washington, D.C.: CCSDS, November 2010.

[14] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. 2nd ed. International Standard, ISO/IEC 7498-1:1994. Geneva: ISO, 1994.



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# 2 DESCRIPTION OF THE INTERNET SLE PROTOCOL

## 2.1 INTRODUCTION

This section describes a layered model of a system supporting the Internet SLE Protocol One and introduces the main concepts by describing each layer and the interfaces between the layers. Detailed specifications are provided in section 3, which references the concepts, layers, and interfaces described by this model. It is stressed that this model has the sole purpose of supporting the specifications in this Recommended Standard and is not intended to suggest any specific design of a real implementation.

The discussion in this section assumes that the reader is familiar with the CCSDS Recommended Standards for Space Link Extension transfer services provided by references [2], [3], [4], [5], and [6], and assumes a general background on the Internet protocols, especially on TCP (reference [7]).

## 2.2 ARCHITECTURAL MODEL

The architectural model used to specify the Internet SLE Protocol is shown in figure 2-1.

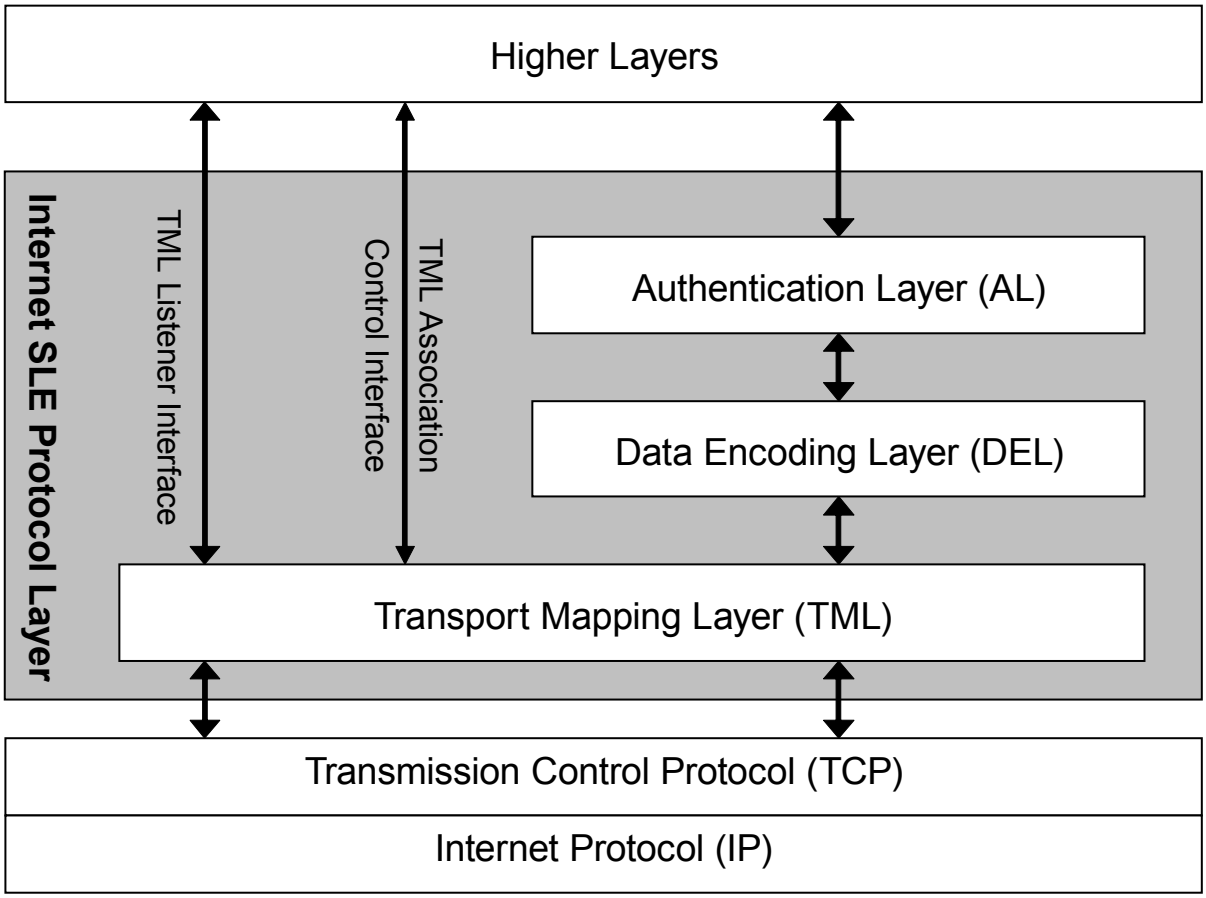



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**Figure 2-1: ISP1 Architecture Model**

The Higher Layers represent the functionality specified by the Recommended Standards for SLE transfer services (references [2], [3], [4], [5], and [6]), including in particular:

a) preparation of SLE protocol data units to be sent to the peer application;

b) analysis and processing of the SLE protocol data units received from the peer application;

c) implementation of the state tables defined in the applicable Recommended Standard for the SLE transfer service being provided or used.

The Internet SLE Protocol Layer is further decomposed into the following sub-layers:

a) The Authentication Layer (AL) is responsible for generating and analyzing the credentials specified in the Recommended Standards for SLE transfer services. For this purpose this Recommended Standard specifies use of the simple authentication scheme defined in reference [11] and the Secure Hash Function (SHA-256) defined in reference [12].

b) The Data Encoding Layer (DEL) is responsible for encoding of SLE protocol data units received from higher layers and decoding of protocol data units received from the peer application. For this purpose, this Recommended Standard specifies use of the ASN.1 syntax defined by reference [9] and of the ASN.1 Basic Encoding Rules (BER) defined by reference [10].

c) The Transport Mapping Layer (TML) handles the interface to the Transmission Control Protocol (TCP) specified by reference [7].

ISP1 maps one TCP connection to one ISP1 association, which is used by the higher layers for one SLE association as specified by the Recommended Standards for SLE transfer services. ISP1 provides data encoding and decoding services but does not process SLE protocol data units in any other respect.

For implementations assuming the responder role, the Transport Mapping Layer provides a service to listen for incoming TCP connection requests. It therefore provides an interface by which higher layers can request to start and stop listening for a specified SLE responder port identifier, which the TML maps to an IP address and a TCP port number.

Except for the interface to control listening, all interfaces refer to one association only. ISP1 association establishment and release involves only the Transport Mapping Layer. Once the association has been established, all SLE protocol data units are passed through the Data Encoding Layer and the Authentication Layer.

ISP1 requires a number of configuration parameters for its operation, which are identified in the following subsections. This Recommended Standard does not specify how these parameters are defined, agreed, stored, and made available to the implementation of the ISP1.



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## 2.3 AUTHENTICATION LAYER

The ISP1 Authentication Layer (AL) receives SLE protocol data units from the higher layers and adds the credentials parameter if required. Likewise, it receives decoded protocol data units from the Data Encoding Layer and verifies that the credentials match the security attributes of the peer application. If authentication is not used for a given service instance or for a given PDU, the Authentication Layer passes the protocol data unit to the next layer without modification or analysis.

For generation and analysis of the credentials, the Authentication Layer uses the simple authentication scheme specified by reference [11], which is based on a secret password and a message digest generated from that password, the time at which the credentials were generated, and a random number. For the secure one-way hash function, required for this scheme, the Secure Hash Function (SHA-256) specified by reference [12] is used.

If authentication fails for a PDU received from the peer application, the Authentication Layer informs the higher layers, which are expected to handle this event as specified by the Recommended Standards for SLE transfer services.

The Authentication Layer requires the following service instance configuration parameter for its operation:

– authentication-level, defined by the Recommended Standards for SLE transfer services, which can have the values

  a) ‘all’: all invocations and returns, except the invocation of PEER-ABORT, shall be authenticated;

  b) ‘bind’: only the BIND invocation and return shall be authenticated;

  c) ‘none’: no invocation or return shall be authenticated.

If the authentication-level is set to ‘all’ or ‘bind’ the Authentication Layer requires the following additional configuration parameters:

a) the identifier of the local application;

b) the password of the local application;

c) the identifier of the peer application;

d) the password of the peer application;

e) the maximum time allowed between generation of the credentials by the invoker of an SLE operation and verification of the credentials by the performer.


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NOTE – If the local application assumes the initiator role for the BIND operation, the identifier of the local application is the initiator-identifier and the identifier of the peer application is the responder-identifier defined by the Recommended Standards for SLE transfer services. Otherwise, the identifier of the local application is the responder-identifier and the identifier of the peer application is the initiator-identifier.

## 2.4 DATA ENCODING LAYER

The ISP1 Data Encoding Layer (DEL) is responsible for the encoding and decoding of all SLE protocol data units, except for the PEER-ABORT invocation PDU. For this purpose it uses the ASN.1 types defined by the Recommended Standards for SLE transfer services and applies the Basic Encoding Rules (BER) defined by reference [10].

NOTE – This Recommended Standard assumes that the PEER-ABORT operation is implemented by direct interaction between the TML and higher layers. Handling of the PEER-ABORT operation by the TML is described in 2.5.5.

The DEL receives SLE PDUs from the Authentication Layer, encodes the PDU and passes the encoded PDU as a data buffer to the Transport Mapping Layer. Likewise, it receives encoded PDUs from the Transport Mapping Layer, decodes them, and passes the decoded PDU to the Authentication Layer.

When receiving a BIND invocation PDU from either the AL or the TML, DEL uses the parameters service-type and version-number to identify the ASN.1 modules to use for all PDUs subsequently exchanged on the same association. If the service type or version number is not supported, the DEL informs the higher layers, which are expected to apply the procedures specified by the Recommended Standards for SLE transfer services.

NOTE – This Recommended Standard assumes that the DEL uses the parameters of the BIND operation to identify the ASN.1 modules to use for encoding and decoding, because no additional configuration parameters are then needed. However, the intention is not to prevent an implementation from applying any other suitable approach as long as it is ensured that the ASN.1 specification used is the one specified in the Recommended Standard that is identified by the service-type and version-number parameters in the BIND invocation.

In case of errors (e.g., decoding failure), the DEL informs the higher layers, which are expected to abort the association using the PEER-ABORT operation.



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