
**Information technology — Security
techniques — Digital signatures with
appendix —**

**Part 3:
Discrete logarithm based mechanisms**

*Technologies de l'information — Techniques de sécurité — Signatures
numériques avec appendice —*

Partie 3: Mécanismes basés sur un logarithme discret

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Contents

Page

Foreword	vi
Introduction	vii
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Symbols and abbreviated terms	3
5 General model	5
5.1 Parameter generation process	5
5.1.1 Certificate-based mechanisms	5
5.1.2 Identity-based mechanisms	5
5.1.3 Parameter selection	6
5.1.4 Validity of domain parameters and verification key	7
5.2 Signature process	7
5.2.1 General	7
5.2.2 Producing the randomizer	8
5.2.3 Producing the pre-signature	8
5.2.4 Preparing the message for signing	8
5.2.5 Computing the witness (the first part of the signature)	8
5.2.6 Computing the assignment	8
5.2.7 Computing the second part of the signature	9
5.2.8 Constructing the appendix	9
5.2.9 Constructing the signed message	9
5.3 Verification process	10
5.3.1 General	10
5.3.2 Retrieving the witness	10
5.3.3 Preparing message for verification	11
5.3.4 Retrieving the assignment	11
5.3.5 Recomputing the pre-signature	11
5.3.6 Recomputing the witness	11
5.3.7 Verifying the witness	11
6 Certificate-based mechanisms	12
6.1 General	12
6.1 General	12
6.2 DSA	13
6.2.1 General	13
6.2.2 Parameters	13
6.2.3 Generation of signature key and verification key	14
6.2.4 Signature process	14
6.2.5 Verification process	15
6.3 KCDSA	16
6.3.1 General	16
6.3.2 Parameters	16
6.3.3 Generation of signature key and verification key	17
6.3.4 Signature process	17
6.3.5 Verification process	18
6.4 Pointcheval/Vaudenay algorithm	19
6.4.1 General	19
6.4.2 Parameters	19
6.4.3 Generation of signature key and verification key	19
6.4.4 Signature process	19
6.4.5 Verification process	20

6.5	SDSA	21
6.5.1	General	21
6.5.2	Parameters	22
6.5.3	Generation of signature key and verification key	22
6.5.4	Signature process	22
6.5.5	Verification process	23
6.6	EC-DSA	24
6.6.1	General	24
6.6.2	Parameters	24
6.6.3	Generation of signature key and verification key	25
6.6.4	Signature process	25
6.6.5	Verification process	26
6.7	EC-KCDSA	27
6.7.1	General	27
6.7.2	Parameters	27
6.7.3	Generation of signature key and verification key	28
6.7.4	Signature process	28
6.7.5	Verification process	29
6.8	EC-GDSA	30
6.8.1	General	30
6.8.2	Parameters	30
6.8.3	Generation of signature key and verification key	30
6.8.4	Signature process	30
6.8.5	Verification process	31
6.9	EC-RDSA	32
6.9.1	General	32
6.9.2	Parameters	33
6.9.3	Generation of signature key and verification key	33
6.9.4	Signature process	33
6.9.5	Verification process	34
6.10	EC-SDSA	35
6.10.1	General	35
6.10.2	Parameters	35
6.10.3	Generation of signature key and verification key	35
6.10.4	Signature process	36
6.10.5	Verification process	36
6.11	EC-FSDSA	37
6.11.1	General	37
6.11.2	Parameters	38
6.11.3	Generation of signature key and verification key	38
6.11.4	Signature process	38
6.11.5	Verification process	39
7	Identity-based mechanisms	40
7.1	General	40
7.1	7.1	
	General	40
7.2	IBS-1	41
7.2.1	General	41
7.2.2	Parameters	41
7.2.3	Generation of master key and signature/verification key	41
7.2.4	Signature process	41
7.2.5	Verification process	42
7.3	IBS-2	43
7.3.1	General	43
7.3.2	Parameters	43
7.3.3	Generation of master key and signature/verification key	43
7.3.4	Signature process	43
7.3.5	Verification process	44

Annex A (normative) Object identifier	46
Annex B (normative) Conversion functions (I)	49
Annex C (informative) Conversion functions (II)	54
Annex D (normative) Generation of DSA domain parameters	56
Annex E (informative) The Weil and Tate pairings	58
Annex F (informative) Numerical examples	61
Annex G (informative) Comparison of the signature schemes	127
Annex H (informative) Claimed features for choosing a mechanism	129
Bibliography	130

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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 document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 27, *IT Security techniques*.

This third edition cancels and replaces the second edition (ISO/IEC 14888-3:2006), which has been technically revised. It also incorporates the Amendments ISO/IEC 14888-3:2006/Amd 1:2010 and ISO/IEC 14888-3:2006/Amd 2:2012 and the Technical Corrigenda ISO/IEC 14888-3:2006/Cor 1:2007 and ISO/IEC 14888-3:2006/Cor 2:2009.

This corrected version of ISO/IEC 14888-3:2016 incorporates the following corrections:

- the formula has been changed in [5.1.1.2](#);
- “ G^{x-1} ” has been changed to “ $G^{x^{-1}}$ ” in [6.3.1](#) and [6.3.3](#);
- “ β ” has been changed to “ β' ” in [6.7.1](#), [6.7.4.4](#) and [6.7.4.5](#);
- the reference has been changed in [6.9.1](#);
- the code for K has been changed in [F.9.2.4](#).

A list of all parts in the ISO/IEC 14888 series can be found on the ISO website.

Introduction

Digital signature mechanisms can be used to provide services such as entity authentication, data origin authentication, non-repudiation and data integrity. A digital signature mechanism satisfies the following requirements.

- Given either or both of the following two things:
 - the verification key, but not the signature key;
 - a set of signatures on a sequence of messages that an attacker has adaptively chosen;
 it should be computationally infeasible for the attacker
 - to produce a valid signature on a new message,
 - in some circumstances, to produce a new signature on a previously signed message, or
 - to recover the signature key;
- it should be computationally infeasible, even for the signer, to find two different messages with the same signature.

NOTE 1 Computational feasibility depends on the specific security requirements and environment.

NOTE 2 In some applications, producing a new signature on a previously signed message without knowing the signature key is allowed. One example of such applications is a membership credential in an anonymous digital signature mechanism as specified in ISO/IEC 20008.

Digital signature mechanisms are based on asymmetric cryptographic techniques and involve the following three basic operations:

- a process for generating pairs of keys, where each pair consists of a private signature key and the corresponding public verification key;
- a process that uses the signature key, called the signature process;
- a process that uses the verification key, called the verification process.

The following are the two types of digital signature mechanisms:

- when, for a given signature key, any two signatures produced for the same message are always identical, the mechanism is said to be deterministic (or non-randomized) (see ISO/IEC 14888-1 for further details);
- when, for a given message and signature key, any two applications of the signature process produce (with high probability) two distinct signatures, the mechanism is said to be randomized (or non-deterministic).

The mechanisms specified in this part of ISO/IEC 14888 are all randomized.

Digital signature mechanisms can also be divided into the following two categories:

- when the whole message has to be stored and/or transmitted along with the signature, the mechanism is termed a "signature mechanism with appendix" (such mechanisms are the subject of ISO/IEC 14888);
- when the whole message, or part of it, can be recovered from the signature, the mechanism is termed a "signature mechanism giving message recovery" (ISO/IEC 9796 specifies mechanisms in this category).

The verification of a digital signature requires access to the signing entity's verification key. It is, thus, essential for a verifier to be able to associate the correct verification key with the signing entity, or more

precisely, with (parts of) the signing entity's identification data. This association between the signer's identification data and the signer's public verification key can either be guaranteed by an outside entity or mechanism, or the association can be somehow inherent in the verification key itself. In the former case, the scheme is said to be "certificate-based." In the latter case, the scheme is said to be "identity based." Typically, in an identity-based scheme, the verifier can calculate the signer's public verification key from the signer's identification data. The digital signature mechanisms specified in this part of ISO/IEC 14888 are classified into certificate-based and identity-based mechanisms.

NOTE 3 For certificate-based mechanisms, various PKI standards can be used as the basis of key management. For further information, see ISO/IEC 9594-8 (also known as X.509), ISO/IEC 11770-3 and ISO/IEC 15945.

The security of a signature mechanism is based on an intractable computational problem, i.e. a problem for which, given current knowledge, finding a solution is computationally infeasible, such as the factorization problem and the discrete logarithm problem. This part of ISO/IEC 14888 specifies digital signature mechanisms with appendix based on the discrete logarithm problem, and ISO/IEC 14888-2 specifies digital signature mechanisms with appendix based on the factorization problem.

NOTE 4 The first edition of ISO/IEC 14888 grouped identity-based mechanisms into ISO/IEC 14888-2 and certificate-based mechanisms into ISO/IEC 14888-3, with both parts covering mechanisms based on both the discrete logarithm and the factorization problems. Since the second edition was published, the mechanisms have been reorganized. ISO/IEC 14888-2 now contains integer factoring-based mechanisms, and this part of ISO/IEC 14888 now contains discrete logarithm based mechanisms.

This part of ISO/IEC 14888 includes 12 mechanisms, two of which were in ISO/IEC 14888-3:1998, three of which were from ISO/IEC 15946-2:2002 and three of which were added in ISO/IEC 14888-3:2006. The Elliptic Curve Russian Digital Signature Algorithm (EC-RDSA) and three mechanisms based on Schnorr digital signature are added in ISO/IEC 14888-3:2006/Amd.1:2010.

The mechanisms specified in this part of ISO/IEC 14888 use a collision resistant hash-function to hash the message being signed (possibly in more than one part). ISO/IEC 10118 specifies hash-functions.

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NOTE 5 The mechanisms of EC-DSPA, EC-GDSA, EC-RDSA and EC-FSDSPA may be vulnerable to a key substitution attack.^[10] The attack is realized if an adversary can find two distinct public keys and one signature such that the signature is valid for both public keys. There are several approaches of avoiding this attack and its possible impact on the security of a cryptographic system. For example, the public key corresponding to the private signing key can be added into the message to be signed.

Information technology — Security techniques — Digital signatures with appendix —

Part 3:

Discrete logarithm based mechanisms

1 Scope

This part of ISO/IEC 14888 specifies digital signature mechanisms with appendix whose security is based on the discrete logarithm problem.

This part of ISO/IEC 14888 provides

- a general description of a digital signature with appendix mechanism, and
- a variety of mechanisms that provide digital signatures with appendix.

For each mechanism, this part of ISO/IEC 14888 specifies

- the process of generating a pair of keys,
- the process of producing signatures, and
- the process of verifying signatures.

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.

ISO/IEC 10118-3, *Information technology — Security techniques — Hash-functions*

ISO/IEC 14888-1:2008, *Information technology — Security techniques — Digital signatures with appendix — Part 1: General*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 14888-1 and the following apply.

3.1

finite commutative group

finite set E with the binary operation “ $*$ ” such that

- for all group elements $a, b \in E$, $a * b \in E$;
- for all group elements $a, b, c \in E$, $(a * b) * c = a * (b * c)$;
- there exists a group element $e \in E$ with $e * a = a$ for all $a \in E$, where e is called the identity element of the group;
- for all group elements $a \in E$, there exists a group element $b \in E$ with $b * a = e$;