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Information technology — Security techniques — Key management —

Part 4: **Mechanisms based on weak secrets**

Technologies de l'information — Techniques de sécurité — Gestion de clés —

Partie 4: Mécanismes basés sur des secrets faibles

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Foreword

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

This second edition cancels and replaces the first edition (ISO/IEC 11770-4:2006), which has been technically revised. It also incorporates the Technical Corrigendum ISO/IEC 11770-4:2006/Cor1:2009.

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

— revision of the Balanced Key Agreement Mechanism 1 (BKAM1) to address the attacks reported in Reference [6];

— addition of a new Balanced Key Agreement Mechanism 2 (BKAM2) based on the J-PAKE scheme of Reference [5];

— addition of a new Augmented Key Agreement Mechanism 3 (AKAM3) based on the AugPAKE scheme of Reference [23].

A list of all parts in the ISO/IEC 11770 series can be found on the ISO website.

Introduction

The mechanisms specified in this document are designed to achieve one of the following three goals.

a) **Balanced password-authenticated key agreement:** Establish one or more shared secret keys between two entities that share a common weak secret. In a balanced password-authenticated key agreement mechanism, the shared secret keys are the result of a data exchange between the two entities; the shared secret keys are established if, and only if, the two entities have used the same weak secret; and neither of the two entities can predetermine the values of the shared secret keys.

b) **Augmented password-authenticated key agreement:** Establish one or more shared secret keys between two entities *A* and *B*, where *A* has a weak secret and *B* has verification data derived from a one-way function of *A*'s weak secret. In an augmented password-authenticated key agreement mechanism, the shared secret keys are the result of a data exchange between the two entities; the shared secret keys are established if, and only if, the two entities have used the weak secret and the corresponding verification data; and neither of the two entities can predetermine the values of the shared secret keys.

NOTE 1 This type of key agreement mechanism is unable to protect *A*'s weak secret being discovered by *B*, but only increases the cost for an adversary to get *A*'s weak secret from *B*. A typical application scenario would involve use between a client (*A*) and a server (*B*).

c) **Password-authenticated key retrieval:** Establish one or more secret keys for an entity, *A*, associated with another entity, *B*, where *A* has a weak secret and *B* has a strong secret associated with *A*'s weak secret. In an authenticated key retrieval mechanism, the secret keys, retrievable by *A* (not necessarily derivable by *B*), are the result of a data exchange between the two entities, and the secret keys are established if, and only if, the two entities have used the weak secret and the associated strong secret. However, although *B*'s strong secret is associated with *A*'s weak secret, the strong secret does not (in itself) contain sufficient information to permit either the weak secret or the secret keys established in the mechanism to be determined.

NOTE 2 This type of key retrieval mechanism is used in those applications where *A* does not have secure storage for a strong secret, and requires *B*'s assistance to retrieve the strong secret. Such a mechanism is appropriate for use between a client (*A*) and a server (*B*).

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Information technology — Security techniques — Key management —

Part 4: Mechanisms based on weak secrets

1 Scope

This document defines key establishment mechanisms based on weak secrets, i.e. secrets that can be readily memorized by a human, and hence, secrets that will be chosen from a relatively small set of possibilities. It specifies cryptographic techniques specifically designed to establish one or more secret keys based on a weak secret derived from a memorized password, while preventing offline brute-force attacks associated with the weak secret. This document is not applicable to the following aspects of key management:

— life-cycle management of weak secrets, strong secrets, and established secret keys;

— mechanisms to store, archive, delete, destroy, etc. weak secrets, strong secrets, and established secret keys.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
augmented password-authenticated key agreement
password-authenticated key agreement where entity *A* uses a password-based weak secret and entity *B* uses verification data derived from a one-way function of *A*'s weak secret to negotiate and authenticate one or more shared secret keys

3.2
balanced password-authenticated key agreement
password-authenticated key agreement where two entities *A* and *B* use a shared common password-based weak secret to negotiate and authenticate one or more shared secret keys

3.3
brute-force attack
attack on a cryptosystem that employs an exhaustive search of a set of keys, passwords or other data

3.4
collision-resistant hash-function
hash-function satisfying the following property: it is computationally infeasible to find any two distinct inputs which map to the same output

Note 1 to entry: Computational feasibility depends on the specific security requirements and environment. Refer to ISO/IEC 10118-1:2016, Annex C.

[SOURCE: ISO/IEC 10118-1:2016, 3.1]

3.5
dictionary attack
(on a password-based system) attack on a cryptosystem that employs a search of a given list of passwords

Note 1 to entry: A dictionary attack on a password-based system can use a stored list of specific password values or a stored list of words from a natural language dictionary.

3.6
domain parameter
data item which is common to and known by or accessible to all entities within the domain

Note 1 to entry: The set of domain parameters may contain data items such as hash-function identifier, length of the hash-token, length of the recoverable part of the message, finite field parameters, elliptic curve parameters, or other parameters specifying the security policy in the domain.

[SOURCE: ISO/IEC 9796-3:2006, 3.2]

3.7
elliptic curve
cubic curve E without a singular point

Note 1 to entry: The set of points E together with an appropriately defined operation for a field that includes all coefficients of the equation describing E is called the definition field of E. In ISO/IEC 15946-1, only finite fields F are dealt with as the definition field. When it is necessary to describe the definition field F of E explicitly, the curve is denoted as E/F.

Note 2 to entry: The form of a cubic curve equation used to define an elliptic curve varies depending on the field. The general form of an appropriate cubic equation for all possible finite fields is defined in ISO/IEC 15946-1:2016, 6.1.

[SOURCE: ISO/IEC 15946-1:2016, 3.3, modified]

3.8
explicit key authentication
<from entity A to entity B> assurance for entity B that entity A is the only other entity that is in possession of the correct key

Note 1 to entry: Implicit key authentication from entity A to entity B and key confirmation from entity A to entity B together imply explicit key authentication from entity A to entity B.

[SOURCE: ISO/IEC 11770-3:2015, 3.12, modified]

3.9
hash-function
function which maps strings of bits of variable (but usually upper bounded) length to fixed-length strings of bits, satisfying the following two properties:

— for a given output, it is computationally infeasible to find an input which maps to this output;

— for a given input, it is computationally infeasible to find a second input which maps to the same output.

Note 1 to entry: Computational feasibility depends on the specific security requirements and environment. Refer to ISO/IEC 10118-1:2016, Annex C.

[SOURCE: ISO/IEC 10118-1:2016, 3.4]

3.10
hashed password
result of applying a hash-function to a password

3.11
implicit key authentication
<from entity *A* to entity *B*> assurance for entity *B* that entity *A* is the only other entity that can possibly be in possession of the correct key

[SOURCE: ISO/IEC 11770-3:2015, 3.16, modified]

3.12
key
sequence of symbols that controls the operation of a cryptographic transformation (e.g. encryption, decryption, cryptographic check function computation, signature calculation, or signature verification)

[SOURCE: ISO/IEC 11770-3:2015, 3.17]

3.13
key agreement
process of establishing a shared secret key between entities in such a way that neither of them can predetermine the value of that key

Note 1 to entry: By predetermine, it is meant that neither entity *A* nor entity *B* can, in a computationally efficient way, choose a smaller key space and force the computed key in the protocol to fall into that key space.

[SOURCE: ISO/IEC 11770-3:2015, 3.18]

3.14
key confirmation
<from entity *A* to entity *B*> assurance for entity *B* that entity *A* is in possession of the correct key

[SOURCE: ISO/IEC 11770-3:2015, 3.20, modified]

3.15
key control
ability to choose the key or the parameters used in the key computation

[SOURCE: ISO/IEC 11770-3:2015, 3.21]

3.16
key derivation function
function which takes as input a number of parameters, at least one of which shall be secret, and which gives as output keys appropriate for the intended algorithm(s) and applications

3.17
key establishment
process of making available a shared secret key to one or more entities

Note 1 to entry: Key establishment includes key agreement, key transport and key retrieval.

3.18
key management
administration and use of generation, registration, certification, deregistration, distribution, installation, storage, archiving, revocation, derivation and destruction of keying material in accordance with a security policy

[SOURCE: ISO/IEC 11770-1:2010, 2.28]

3.19
key retrieval
process of establishing a key for one or more entities known as the retrieving entities with the involvement of one or more other entities who are not necessarily able to access the key after the process, and which normally requires authentication of the retrieving entity/entities by the other entity/entities

3.20
key token
key establishment message sent from one entity to another entity during the execution of a key establishment mechanism

3.21
key token check function
function that utilizes a key token and other publicly known parameters as input and outputs a Boolean value during the execution of a key establishment mechanism

3.22
key token factor
value that is kept secret and that is used, possibly in conjunction with a weak secret, to create a key token

3.23
key token generation function
function that utilizes a key token factor and other parameters as input and outputs a key token during the execution of a key establishment mechanism

3.24
message authentication code algorithm
algorithm for computing a function which maps strings of bits and a secret key to fixed-length strings of bits, satisfying the following two properties:

— for any key and any input string, the function can be computed efficiently;

— for any fixed key, and given no prior knowledge of the key, it is computationally infeasible to compute the function value on any new input string, even given knowledge of a set of input strings and corresponding function values, where the value of the *i*th input string may have been chosen after observing the value of the first *i*-1 function values (for integers $i > 1$)

[SOURCE: ISO/IEC 9797-1:2011, 3.10, modified]

3.25
mutual key authentication
assurance for two entities that only the other entity is in possession of the correct key

3.26
one-way function
function with the property that it is easy to compute the output for a given input but it is computationally infeasible to find an input which maps to a given output

[SOURCE: ISO/IEC 11770-3:2015, 3.30]

3.27
password
secret word, phrase, number, or character sequence used for entity authentication, which is a memorized weak secret

3.28
password-authenticated key agreement
process of establishing one or more shared secret keys between two entities using prior shared password-based information (which means that either both of them have the same shared password or one has the password and the other has password verification data) and neither of them can predetermine the values of the shared secret keys

3.29
password-authenticated key retrieval
key retrieval process where one entity *A* has a weak secret derived from a password and the other entity *B* has a strong secret associated with *A*'s weak secret; these two entities, using their own secrets, negotiate a secret key which is retrievable by *A*, but not (necessarily) derivable by *B*

3.30
password-entangled key token
key token which is derived from both a weak secret and a key token factor

3.31
password verification data
data that is used to verify an entity's knowledge of a specific password

3.32
random element derivation function
function that utilizes a password and other parameters as input and outputs a random element

3.33
salt
random variable incorporated as secondary input to a one-way or encryption function that is used to derive password verification data

3.34
secret
value known only to authorized entities

3.35
secret key
key used with symmetric cryptographic techniques by a specified set of entities

[SOURCE: ISO/IEC 11770-3:2015, 3.36]

3.36
secret value derivation function
function that utilizes a key token factor, a key token, and other parameters as input and outputs a secret value which is used to compute one or more secret keys

3.37
strong secret
secret with a sufficient degree of entropy that conducting an exhaustive search for the secret is infeasible, even given knowledge that would enable a correct guess for the secret to be distinguished from an incorrect guess

Note 1 to entry: This may, for example, be achieved by randomly choosing the secret from a sufficiently large set of possible values under uniform distribution.

3.38
weak secret
secret that can be conveniently memorized by a human being

Note 1 to entry: Typically, this means that the entropy of the secret is limited, so that an exhaustive search for the secret (or, a dictionary attack) may be feasible, given knowledge that would enable a correct guess for the secret to be distinguished from an incorrect guess.

4 Symbols and abbreviated terms

A, *B*	distinguishing identities of entities represented as octet strings
a_1, a_2	elliptic curve coefficients
BS2I	a function that converts a bit string into an integer (described in Annex A)
b, b_i	bits (i.e. either 0 or 1)
C, C_{DL}, C_{EC}	functions for generating a key token based on a password and a key token factor
c	an integer satisfying $1 \le c \le q - 1$
D, D_{DL}, D_{EC}	functions for generating a key token based on only a key token factor
E	an elliptic curve defined by two elliptic curve coefficients, a_1 and a_2. For the purpose of this document, an elliptic curve is not only the set of points on the curve, but also a group operation defined on these points as specified in ISO/IEC 15946-1[13].
FE2I	a function that converts a field element into an integer (described in Annex A)
FE2OS	a function that converts a field element into an octet string (described in Annex A)
F(*q*)	the finite field with *q* elements
G,G_a,G_b	points of order *r* on *E* over *F*(*q*)
$GE2OS_X$	a function that converts a group element into an octet string; when the group element is a point on *E*, this function converts the x-coordinate of the point into an octet string and ignores the y-coordinate (described in Annex A)
g, g_1, g_a, g_b	elements of multiplicative order *r* in *F*(*q*)
$g_{q\text{-}1}$	an element of multiplicative order *q* – 1 in *F*(*q*)
H	a collision-resistant hash-function taking an octet string as input and giving a bit string as output, e.g. based on one of the dedicated hash-functions specified in ISO/IEC 10118-3[11]
h(x, L_K)	a collision-resistant hash-function taking an octet string x and an integer L_K as input and giving a bit string of length L_K (in bits) as output, e.g. based on one of the dedicated hash-functions specified in ISO/IEC 10118-3[11]
I2FE	a function that converts an integer into a field element (described in Annex A)
I2OS	a function that converts an integer into an octet string (described in Annex A)
I2P	a function that converts an integer into a point on the curve *E* (described in Annex A)
J, J_{DL}, J_{EC}	functions for generating a password verification element from a password
K	a function for deriving a key from a secret value and a key derivation parameter
KC_1_U	an octet string of the constant value “KC_1_U” that literally means unilateral key confirmation
K_1, K_2, ...	secret keys established using a key establishment mechanism
k	the cofactor that is either the value $(q - 1)/r$ in DL domain parameters or the value of $\#E/r$ in EC domain parameters

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