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Information technology — Security techniques — Hash-functions —

Part 2: Hash-functions using an *n*-bit block cipher

Technologies de l'information — Techniques de sécurité — Fonctions de brouillage —
Partie 2: Fonctions de brouillage utilisant un chiffrement par blocs de n *bits*

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

ISO/IEC 10118-2 was prepared by Joint 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 10118-2:2000), which has been technically revised. It also incorporates the Technical Corrigendum ISO/IEC 10118-2:2000/Cor.2:2007. The major change is that in the second edition the underlying block cipher used in the hash-functions was assumed to be Data Encryption Algorithm (DEA), whereas in the third edition it is assumed to be more secure block ciphers like Advanced Encryption Standard (AES) and other ciphers included in ISO/IEC 18033-3.

ISO/IEC 10118 consists of the following parts, under the general title *Information technology — Security techniques — Hash-functions*:

— *Part 1: General*

— *Part 2: Hash-functions using an n-bit block cipher*

— *Part 3: Dedicated hash-functions*

— *Part 4: Hash-functions using modular arithmetic*

Introduction

The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this document may involve the use of patents.

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Information technology — Security techniques — Hash-functions —

Part 2: Hash-functions using an *n*-bit block cipher

1 Scope

This part of ISO/IEC 10118 specifies hash-functions which make use of an n-bit block cipher algorithm. They are therefore suitable for an environment in which such an algorithm is already implemented.

Four hash-functions are specified. The first provides hash-codes of length less than or equal to n, where n is the block-length of the underlying block cipher algorithm used. The second provides hash-codes of length less than or equal to $2n$; the third provides hash-codes of length equal to $2n$; and the fourth provides hash-codes of length $3n$. All four of the hash-functions specified in this part of ISO/IEC 10118 conform to the general model specified in ISO/IEC 10118-1.

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.

ISO/IEC 10118-1:2000, *Information technology — Security techniques — Hash-functions — Part 1: General*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 10118-1 and the following apply.

3.1
block
string of bits of defined length

3.2
***n*-bit block cipher**
block cipher with the property that plaintext blocks and ciphertext blocks are n bits in length

[ISO/IEC 18033-3:2005]

3.3
round function
function $\phi(.,.)$ that transforms two binary strings of lengths L_1 and L_2 to a binary string of length L_2

NOTE The round function is used iteratively.

4 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms given in ISO/IEC 10118-1 and the following apply.

B^L	When n is even, the string composed of the $n/2$ leftmost bits of the block B. When n is odd, the string composed of the $(n+1)/2$ leftmost bits of the block B
B^R	When n is even, the string composed of the $n/2$ rightmost bits of the block B. When n is odd, the string composed of the $(n-1)/2$ rightmost bits of the block B
B_x	When B is a sequence of blocks and each block has m bits, B_x ($x \geq 0$) represents the x-th block of B.
$E_K(P)$	n-bit block cipher algorithm taking the key K and plaintext P as input. It is recommended that the block cipher algorithms specified in ISO/IEC 18033-3 are used in the hash-functions.
K	Key for the algorithm E
u or u'	Function which takes as input an n-bit block and gives as output a key for the algorithm E.

5 Use of the general model

The hash-functions specified in the next four clauses provide hash-codes H of length L_H. The hash-functions conform to the general model specified in ISO/IEC 10118-1. For each of the four hash-functions that follow, it is therefore only necessary to specify

— the parameters L_1, L_2, L_H,

— the padding method,

— the initializing value IV,

— the round function ϕ,

— the output transformation T.

6 Hash-function 1

6.1 General

The hash-function specified in this clause provides hash-codes of length L_1 and L_2 where L_1 and L_2 are equal to n. Some specific definitions that are required to specify hash-function 1 follow.

NOTE This hash-function is described in [5].

6.2 Parameter selection

The parameters L_1, L_2 and L_H for the hash-function specified in this clause shall satisfy $L_1 = L_2 = n$, and L_H is less than or equal to n.

6.3 Padding method

The selection of the padding method for use with this hash-function is beyond the scope of this part of ISO/IEC 10118. As minimum requirements, the padding method shall output a set of q blocks D_1, D_2, ..., D_q where each block D_j is of length n and shall be such that each possible input produces distinct outputs. Examples of padding methods are presented in ISO/IEC 10118-1:2000, Annex A.

6.4 Initializing value

The selection of the *IV* for use with this hash-function is beyond the scope of this part of ISO/IEC 10118. The *IV* shall be a bit-string of length n and the value of the *IV* shall be agreed upon and fixed by users of the hash-function.

6.5 Round function

Transformation *u*:

Define a mapping u from the ciphertext space.

The round function ϕ combines a padded data block D_j (of $L_1 = n$-bits) with H_{j-1}, the previous output of the round function (of $L_2 = n$ bits), to yield H_j. As part of the round function it is necessary to choose a function u, which transforms an n-bit block into a key for use with the block cipher algorithm E. The selection of the function u for use with this hash-function is outside the scope of this part of ISO/IEC 10118.

The round function itself is defined as follows:

Set H_0 equal to *IV*

$\phi (D_j, H_{j-1}) = E_{Kj} (D_j) \oplus D_j$

where $K_j = u (H_{j-1})$. The round function is shown in Figure 1.

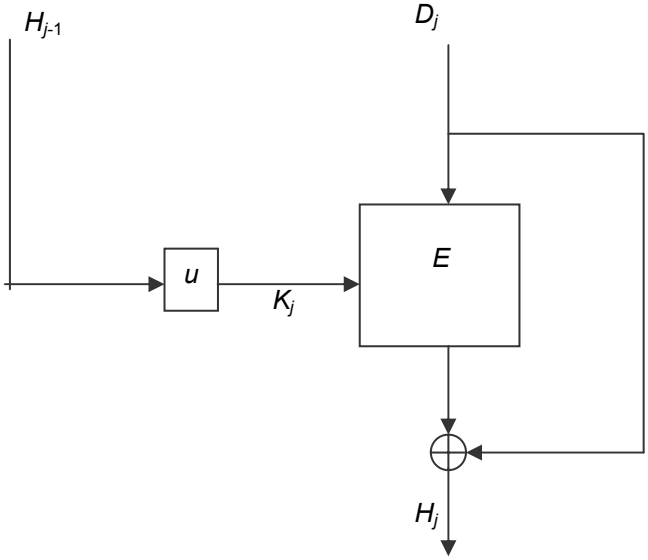

Figure 1 — Round function of hash-function 1

6.6 Output transformation

The output transformation T is simply truncation, i.e., the hash-code H is derived by taking the leftmost L_H bits of the final output block H_q.

7 Hash-function 2

7.1 General

The hash-function specified in this clause provides hash-codes of length L_1 and L_2 where L_1 is equal to n and L_2 is equal to $2n$. Some specific definitions that are required to specify hash-function 2 follow.

NOTE 1 This hash-function is described in [4].

NOTE 2 In [6], theoretical attacks on hash-function 2 have been reported: a collision attack, with $n = 128$, which has complexity $2^{124.5}$, and a preimage attack requiring complexity and space about 2^n.

The only reason to keep hash-function 2 in this part of ISO/IEC 10118 is for compatibility with the existing applications.

7.2 Parameter selection

The parameters L_1, L_2 and L_H for the hash-function specified in this clause shall satisfy $L_1 = n$, $L_2 = 2n$, and L_H is less than or equal to $2n$.

7.3 Padding method

The selection of the padding method for use with this hash-function is beyond the scope of this part of ISO/IEC 10118. As minimum requirements, the padding method shall output a set of q blocks D_1, D_2, ..., D_q where each block D_j is of length n and shall be such that each possible input produces distinct outputs. Examples of padding methods are presented in ISO/IEC 10118-1:2000, Annex A.

7.4 Initializing value

The selection of the IV (of length $2n$) for use with this hash-function is beyond the scope of this part of ISO/IEC 10118. The IV shall be a bit-string of length $2n$ and the value of the IV shall be agreed upon and fixed by users of the hash-function. However, the IV shall be selected such that $u(IV^L)$ and $u'(IV^R)$ are different.

7.5 Round function

The round function ϕ combines a padded data block D_j (of $L_1 = n$ bits) with H_{j-1}, the previous output of the round function (of $L_2 = 2n$ bits), to yield H_j. As part of the round function it is necessary to choose two transformations u and u'. These transformations are used to transform an output block into two suitable L_K bit keys for the algorithm E. The specification of u and u' is beyond the scope of this part of ISO/IEC 10118. However, it should be taken into consideration that the selection of u and u' is important for the security of the hash-function.

Set H_0^L and H_0^R equal to IV^L and IV^R respectively. The round function is defined in the following way, for $j = 1$ to q:

$$H_j = \phi(D_j, H_{j-1})$$

$$X = u(H_{j-1}^L) \text{ and } Y = u'(H_{j-1}^R)$$

$$B_j = E_X(D_j) \oplus D_j, \text{ and } B'_j = E_Y(D_j) \oplus D_j$$

$H_j^L = B_j^L \,||\, B'^R_j$ and $H_j^R = B'^L_j \,||\, B_j^R$

The round function is shown in Figure 2 where X and Y are replaced with K^L_j and K^R_j respectively.

7.6 Output transformation

If L_H is even, the hash-code is the concatenation of the $L_H/2$ leftmost bits of H_q^L and the $L_H/2$ leftmost bits of H_q^R. If L_H is odd, the hash-code is the concatenation of the $(L_H+1)/2$ leftmost bits of H_q^L and the $(L_H-1)/2$ leftmost bits of H_q^R.

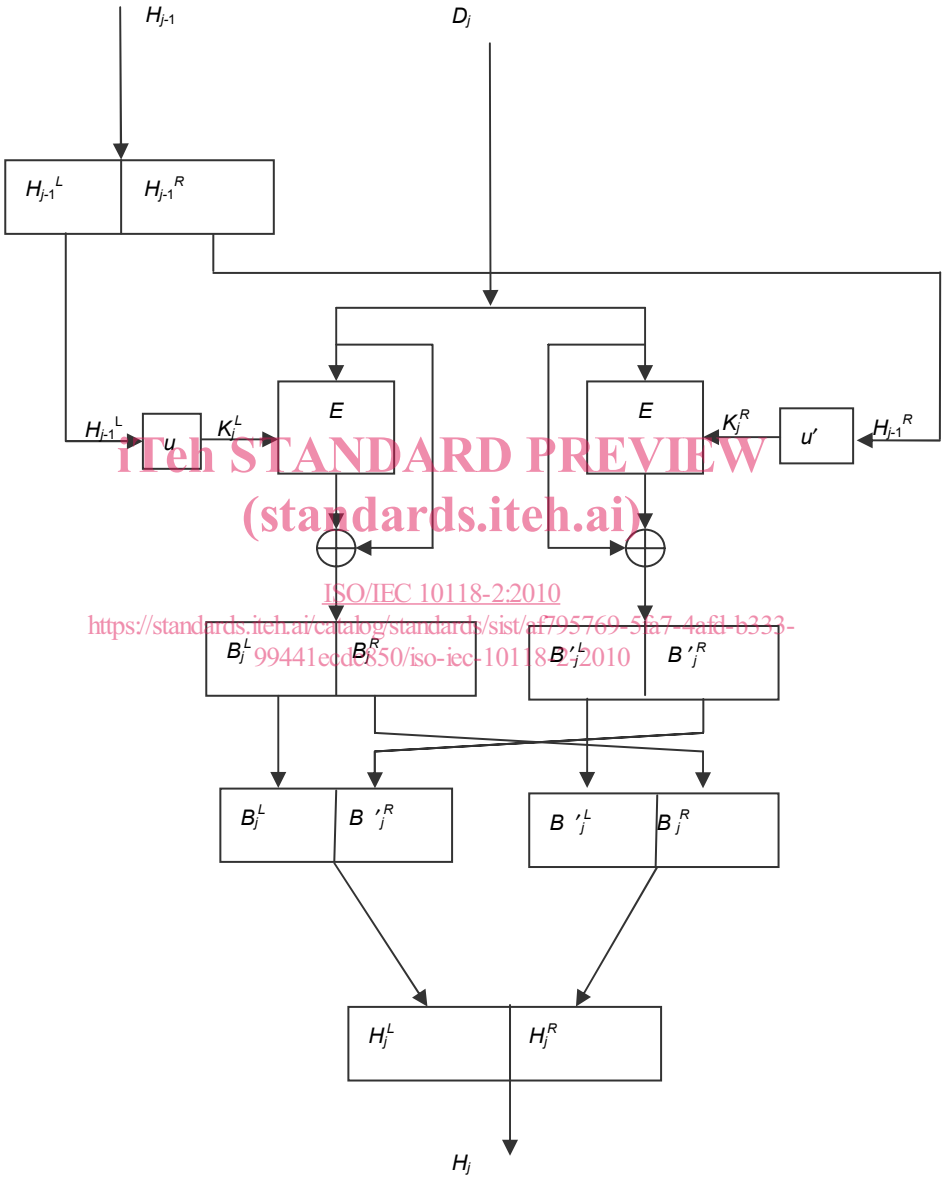

Figure 2 — Round function of hash-function 2

8 Hash-function 3

8.1 General

The hash-function specified in this clause provides hash-codes of length L_H, where L_H is equal to $2n$ for even values of n. Some specific definitions that are required to specify hash-function 3 follow.

NOTE This hash-function is described in [1].

8.2 Parameter selection

The parameters L_1, L_2 and L_H for the hash-function specified in this clause shall satisfy $L_1 = 4n$, $L_2 = 8n$, and $L_H = 2n$.

8.3 Padding method

The padding method for use with this hash-function shall be that specified in ISO/IEC 10118-1:2000, A.3, such that $r = n$.

8.4 Initializing value

The selection of the *IV* for use with this hash-function is beyond the scope of this part of ISO/IEC 10118. The *IV* shall be a bit-string of length $8n$ and the value of the *IV* shall be agreed upon and fixed by users of the hash-function.

8.5 Round function

Transformation *u*:

Define eight mappings u_1, u_2,…, u_8 from the ciphertext space to the key space, such that:

$u_i(C) \neq u_j(C)$, for all i, j from the set {1,2,…, 8}, $j \neq i$, and for all values of C

This can be achieved by fixing specific key bits: e.g., One can fix three key bits to the values 000, 001, ..., 111. Additional conditions might be imposed upon the mappings u_i, for example, to avoid the problems related to weak keys or complementation properties of the block cipher. Let $u_{j,i} = u_j(X_{j,i})$.

Function f_i:

Define the eight functions f_i as follows:

$f_i(X,Y) = E_{ui(X)}(Y) \oplus Y$, $1 \leq i \leq 8$.

Linear mapping β:

Define the linear mapping β that takes as input a $2n$-bit string $X = x_0||x_1||x_2||x_3$ and maps it to a $2n$-bit string $Y = y_0||y_1||y_2||y_3$ as follows:

$y_0 := x_0 \oplus x_3$

$y_1 := x_0 \oplus x_1 \oplus x_3$

$y_2 := x_1 \oplus x_2$

$y_3 := x_2 \oplus x_3$

Here x_i and y_j are $n/2$-bit strings.

