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AMENDMENT 1
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Information technology — Security techniques — Encryption algorithms —

Part 3: Block ciphers

AMENDMENT 1: SM4

Technologies de l'information — Techniques de sécurité — Algorithmes de chiffrement —

Partie 3: Chiffrement par blocs

AMENDEMENT 1: SM4

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Information technology — Security techniques — Encryption algorithms —

Part 3: **Block ciphers**

AMENDMENT 1: SM4

Clause 1

In the first paragraph, replace "seven different block ciphers" with "eight different block ciphers".

Replace Table 1 with the following:

Block length	Algorithm name (see #)	Key length
64 bits	TDEA (4.2)	128 or 192 bits
	MISTY (4.3)	128 bits
	CAST-128 (4.4)	
	HIGHT (4.5)	
128 bits	AES (5.2)	128, 192 or 256 bits
	Camellia (5.3)	
	SEED (5.4)	128 bits
	SM4 (5.5)	

5.1

Replace the sentence with the following:

> In this clause, four 128-bit block ciphers are specified: AES in 5.2, Camellia in 5.3, SEED in 5.4, and SM4 in 5.5.

5.5

Add new subclause 5.5 as follows:

5.5 SM4

5.5.1 The SM4 algorithm

The SM4 algorithm is a symmetric block cipher that can process data blocks of 128 bits, using a cipher key with length of 128 bits under 32 rounds.

5.5.2 SM4 encryption

A 128-bit block P is transformed into a 128-bit block C using the following procedure, where for i = 0, 1, 2, 3 the X_i are 32-bit variables, and for i = 0, 1, ..., 31 the rk_i are 32-bit subkeys:

(1) $P = X_0 || X_1 || X_2 || X_3$

(2) for i = 0 to 31:

$$X_{i+4} = \mathrm{F}(X_i, X_{i+1}, X_{i+2}, X_{i+3}, rk_i)$$

(3) $C = X_{35} || X_{34} || X_{33} || X_{32}$

5.5.3 SM4 decryption

The decryption operation is identical to the encryption operation, except that the rounds (and therefore the subkeys) are used in reverse order:

(1) $C = X_{35} || X_{34} || X_{33} || X_{32}$

(2) for i = 31 to 0:

$$X_i = \mathrm{F}(X_{i+4}, X_{i+1}, X_{i+2}, X_{i+3}, rk_i)$$

(3) $P = X_0 || X_1 || X_2 || X_3$

5.5.4 SM4 functions

5.5.4.1 Function F

The function F is used for both encryption and decryption. The function F is defined as follows:

$$\mathrm{F}(X_0, X_1, X_2, X_3, rk) = X_0 \oplus \mathrm{T}(X_1 \oplus X_2 \oplus X_3 \oplus rk)$$

where X_i (i = 0, 1, 2, 3) and rk are bit strings of length 32, T is a permutation defined in 5.5.4.2.

5.5.4.2 Permutation T and T'

5.5.4.2.1 General

The permutation T is used both for encryption and decryption. T is a composition of a nonlinear transformation τ and a linear transformation L, that is T(·) = L(τ(·)). The permutation T' is used for the key schedule. T' is a composition of the nonlinear transformation τ and a linear transformation L', that is T'(·) = L'(τ(·)). T, T', L, L' and τ are all transformations on 32-bit strings.

5.5.4.2.2 Nonlinear transformation τ

The nonlinear transformation τ is defined as follows, where for i = 0, 1, 2, 3 the a_i are bytes and S is an S-box defined in 5.5.4.2.4:

$$\tau(a_0 || a_1 || a_2 || a_3) = \mathrm{S}(a_0) || \mathrm{S}(a_1) || \mathrm{S}(a_2) || \mathrm{S}(a_3).$$

5.5.4.2.3 Linear transformation L and L'

The linear transformation L is defined as follows (B is a 32-bit variable):

$$\mathrm{L}(B) = B \oplus (B{<}{<}{<}_2) \oplus (B{<}{<}{<}_{10}) \oplus (B{<}{<}{<}_{18}) \oplus (B{<}{<}{<}_{24}).$$

The linear transformation L' is defined as follows (B is a 32-bit variable):

$$\mathrm{L'}(B) = B \oplus (B{<}{<}{<}_{13}) \oplus (B{<}{<}{<}_{23}).$$

5.5.4.2.4 S-box S

The S-box S used in the transformation τ is presented in hexadecimal form in Table 17.

Table 17 — SM4 S-box

	0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f
0	d6	90	e9	fe	cc	e1	3d	b7	16	b6	14	c2	28	fb	2c	05
1	2b	67	9a	76	2a	be	04	c3	aa	44	13	26	49	86	06	99
2	9c	42	50	f4	91	ef	98	7a	33	54	0b	43	ed	cf	ac	62
3	e4	b3	1c	a9	c9	08	e8	95	80	df	94	fa	75	8f	3f	a6
4	47	07	a7	fc	f3	73	17	ba	83	59	3c	19	e6	85	4f	a8
5	68	6b	81	b2	71	64	da	8b	f8	eb	0f	4b	70	56	9d	35
6	1e	24	0e	5e	63	58	d1	a2	25	22	7c	3b	01	21	78	87
7	d4	00	46	57	9f	d3	27	52	4c	36	02	e7	a0	c4	c8	9e
8	ea	bf	8a	d2	40	c7	38	b5	a3	f7	f2	ce	f9	61	15	a1
9	e0	ae	5d	a4	9b	34	1a	55	ad	93	32	30	f5	8c	b1	e3
a	1d	f6	e2	2e	82	66	ca	60	c0	29	23	ab	0d	53	4e	6f
b	d5	db	37	45	de	fd	8e	2f	03	ff	6a	72	6d	6c	5b	51
c	8d	1b	af	92	bb	dd	bc	7f	11	d9	5c	41	1f	10	5a	d8
d	0a	c1	31	88	a5	cd	7b	bd	2d	74	d0	12	b8	e5	b4	b0
e	89	69	97	4a	0c	96	77	7e	65	b9	f1	09	c5	6e	c6	84
f	18	f0	7d	ec	3a	dc	4d	20	79	ee	5f	3e	d7	cb	39	48

5.5.5 SM4 key schedule

The key scheduling part accepts a 128-bit master key $MK = MK_0 \,||\, MK_1 \,||\, MK_2 \,||\, MK_3$, and yields 32 subkeys, as shown below.

(1) $K_0 \,||\, K_1 \,||\, K_2 \,||\, K_3 = (MK_0 \oplus FK_0) \,||\, (MK_1 \oplus FK_1) \,||\, (MK_2 \oplus FK_2) \,||\, (MK_3 \oplus FK_3)$

(2) for i = 0 to 31:

$$rk_i = K_{i+4} = K_i \oplus \mathrm{T}'(K_{i+1} \oplus K_{i+2} \oplus K_{i+3} \oplus CK_i)$$

The constants FK_i (i = 0, 1, 2, 3) are as follows (in hexadecimal form):

FK_0 = `a3b1bac6`, FK_1 = `56aa3350`, FK_2 = `677d9197`, FK_3 = `b27022dc`.

The constants CK_i (i = 0, 1, ..., 31) are defined as follows. Suppose $CK_i = ck_{i,0} \,||\, ck_{i,1} \,||\, ck_{i,2} \,||\, ck_{i,3}$, where $ck_{i,j}$ are bytes, and $ck_{i,j} = (4i+j) \times 7 \pmod{256}$ (i = 0, 1, ..., 31, j = 0, 1, 2, 3).

Thus, the values of CK_i (i = 0, 1, ..., 31) are (in hexadecimal form):

```
00070e15,   1c232a31,   383f464d,   545b6269,
70777e85,   8c939aa1,   a8afb6bd,   c4cbd2d9,
e0e7eef5,   fc030a11,   181f262d,   343b4249,
50575e65,   6c737a81,   888f969d,   a4abb2b9,
c0c7ced5,   dce3eaf1,   f8ff060d,   141b2229,
30373e45,   4c535a61,   686f767d,   848b9299,
a0a7aeb5,   bcc3cad1,   d8dfe6ed,   f4fb0209,
10171e25,   2c333a41,   484f565d,   646b7279.
```

Annex B

Insert the following line after `id-bc128-seed`:

```
id-bc128-sm4 OID ::= {id-bc128 sm4(4)}
```

Replace`{ OID id-bc128-seed PARMS KeyLength }` , with the following:

```
{ OID id-bc128-seed PARMS KeyLength } |
{ OID id-bc128-sm4  PARMS KeyLength },
```

Annex D

Change the title to "Numerical examples".

Replace "test vectors" with "numerical examples".

D.1

Change the heading to "General".

Replace the text with the following *:*

> This annex provides numerical examples for TDEA, MISTY1, CAST-128, HIGHT, AES, Camellia, SEED, and SM4 ciphers. In these examples, all data are expressed in hexadecimal.

D.9

Add new clause D.9 as follows:

D.9 SM4 numerical examples

D.9.1 SM4 encryption

Given inputs (plaintext and key), output (ciphertext and subkeys) and intermediate values are described.

Input plaintext: `01 23 45 67 89 ab cd ef fe dc ba 98 76 54 32 10`.

Input key: `01 23 45 67 89 ab cd ef fe dc ba 98 76 54 32 10`.

The subkeys and the values of the output of each round:

rk_0 = `f12186f9` X_4 = `27fad345`

rk_1 = `41662b61` X_5 = `a18b4cb2`

rk_2 = `5a6ab19a` X_6 = `11c1e22a`

rk_3 = `7ba92077` X_7 = `cc13e2ee`

rk_4 = `367360f4` X_8 = `f87c5bd5`

rk_5 = `776a0c61` X_9 = `33220757`

rk_6 = b6bb89b3 X_{10} = 77f4c297

rk_7 = 24763151 X_{11} = 7a96f2eb

rk_8 = a520307c X_{12} = 27dac07f

rk_9 = b7584dbd X_{13} = 42dd0f19

rk_{10} = c30753ed X_{14} = b8a5da02

rk_{11} = 7ee55b57 X_{15} = 907127fa

rk_{12} = 6988608c X_{16} = 8b952b83

rk_{13} = 30d895b7 X_{17} = d42b7c59

rk_{14} = 44ba14af X_{18} = 2ffc5831

rk_{15} = 104495a1 X_{19} = f69e6888

rk_{16} = d120b428 X_{20} = af2432c4

rk_{17} = 73b55fa3 X_{21} = ed1ec85e

rk_{18} = cc874966 X_{22} = 55a3ba22

rk_{19} = 92244439 X_{23} = 124b18aa

rk_{20} = e89e641f X_{24} = 6ae7725f

rk_{21} = 98ca015a X_{25} = f4cba1f9

rk_{22} = c7159060 X_{26} = 1dcdfa10

rk_{23} = 99e1fd2e X_{27} = 2ff60603

rk_{24} = b79bd80c X_{28} = eff24fdc

rk_{25} = 1d2115b0 X_{29} = 6fe46b75

rk_{26} = 0e228aeb X_{30} = 893450ad

rk_{27} = f1780c81 X_{31} = 7b938f4c

rk_{28} = 428d3654 X_{32} = 536e4246

rk_{29} = 62293496 X_{33} = 86b3e94f

rk_{30} = 01cf72e5 X_{34} = d206965e

rk_{31} = 9124a012 X_{35} = 681edf34

The output ciphertext: `68 1e df 34 d2 06 96 5e 86 b3 e9 4f 53 6e 42 46`.

D.9.2 SM4 encryption 1 000 000 times

Given inputs (plaintext and key), output (ciphertext) after encryption iteratively 1 000 000 times is described.

Input plaintext: `01 23 45 67 89 ab cd ef fe dc ba 98 76 54 32 10`.