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Contact Information

The URL for the 4C Entity, LLC web site is http://www.4Centity.com.
Introduction

The Cryptomeria Cipher (C2) is a Feistel network-based block cipher designed for use in the area of digital entertainment content protection. The cipher was designed for cryptographic robustness, efficiency when implemented in software, and small size when implemented in hardware. The C2 cipher has the following basic characteristics:

<table>
<thead>
<tr>
<th>Input Block Size</th>
<th>64 bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Block Size</td>
<td>64 bits</td>
</tr>
<tr>
<td>Input Key Size</td>
<td>56 bits</td>
</tr>
<tr>
<td>Number of Rounds</td>
<td>10</td>
</tr>
</tbody>
</table>

This document contains a description of the cipher algorithm, provided as code written in the C programming language. Four functions are provided, which define the cipher’s four basic modes of operation, as follows:

- **C2_E:** Encryption in Electronic Codebook (ECB) Mode, as defined in ISO 8372 or ISO/IEC 10116
- **C2_D:** Decryption in ECB Mode
- **C2_ECBC:** Encryption in Converted Cipher Block Chaining (C-CBC) Mode
- **C2_DCBC:** Decryption in C-CBC Mode

Unless explicitly noted otherwise, the functions assume big-endian ordering for multiple-byte values, meaning that byte 0 is the most significant byte.
Prologue

/*
This source assumes a Big Endian machine (most significant byte first), where the "long" is 32 bits:
*/

typedef unsigned long WORD32;
typedef unsigned char BYTE;

/*
Logical left rotate macros:
*/
#define lrot8(x,n)   (((x)<<((n))||(x)>>((32-((n)))))
#define lrot32(x,n)   (((WORD32)(x)<<((n))||(WORD32)(x)>>((32-((n)))))

/*
The secret constant is available under license from the 4C Entity, LLC.
*/
extern const BYTE SecretConstant[256];

/*
The cipher has 10 rounds:
*/
#define MaxRound 10

/*
F is the Feistel round function:
*/
static WORD32 F(WORD32 data, WORD32 key)
{
    WORD32 t;
    BYTE v[4], u;

    /* Key Insertion */
    t = data+key;

    /* Secret Constant */
    v[3] = (BYTE)((t>>24)&0xff);
    v[2] = (BYTE)((t>>16)&0xff);
    v[1] = (BYTE)((t>> 8)&0xff);
    v[0] = SecretConstant[t&0xff];
    u = v[0]^0x65; v[1] ^= lrot8(u,1);
    u = v[0]^0x2b; v[2] ^= lrot8(u,5);
    u = v[0]^0xc9; v[3] ^= lrot8(u,2);

    /* Rotate */
    t ^= lrot32(t,9) ^ lrot32(t,22);

    return t;
}
Encryption in ECB Mode

/*
C2 encryption in ECB (Electronic Code Book) mode:
*/
void C2_E(BYTE key[7], WORD32 *inout)
{
    WORD32  L, R, t;
    WORD32  ktma, ktmb, ktmc, ktmd;
    WORD32  sk[MaxRound];
    int     round;

    /* Input Conversion */
    L = inout[0];
    R = inout[1];

    /* Key Schedule Generation */
    ktma = ((WORD32)key[0]<<16)|((WORD32)key[1]<<8)|(WORD32)key[2];
    for(round=0; round<MaxRound; round++) {
        ktma &= 0x00ffffff;
        sk[round] = ktmb + ((WORD32)SecretConstant[(ktma&0xff)^round]<<<4); /* This is a 56 bit rotate: */
        ktmb = ktma >> (32-17);
        ktmc = ktmb >> (24-17);
        ktma = (ktma << 17)|ktmc;
        ktmb = (ktmb << 17)|ktmc;
    }

    for(round=0; round<MaxRound; round++) {
        /* Feistel net: */
        t = L;  L = R;  R = t;  // swap
    }
    t = L;  L = R;  R = t;  // swap cancel

    /* Output */
    *inout++ = L;
    *inout++ = R;
    return;
}
Decryption in ECB Mode

void C2_D(BYTE key[7], WORD32 *inout)
{
    WORD32  L, R, t ;
    WORD32  ktmpa, ktmpb, ktmpc, ktmpd;
    WORD32  sk[MaxRound];
    int      round;

    /* Input Conversion */
    L = inout[0];
    R = inout[1];

    /* Key Generation */
    ktmpa = ((WORD32)key[0]<<16)|((WORD32)key[1]<<8)|(WORD32)key[2];

    for(round=0; round<MaxRound; round++) {
        ktmpa &= 0x00ffffff;
        sk[round] = ktmpb + ((WORD32)SecretConstant[(ktmpa&0xff)^round]<<4);
        /* 56 bit left rotate */
        ktmpc = ktmpb >> (32-17);
        ktmpd = ktmpa >> (24-17);
        ktmpa = (ktmpa << 17)|ktmpc;
        ktmpb = (ktmpb << 17)|ktmpd;
    }

    for(round=MaxRound-1; round>=0; round--) {
        /* Feistel net */
        t = L;
        L = R;  R = t;
    }

    t = L;  L = R;  R = t;   // swap cancel

    /* Output */
    *inout++ = L;
    *inout++ = R;

    return;
}
Encryption in C-CBC Mode

/*
C2 encryption in C-CBC (Converted Cipher Block Chaining) mode:
*/
void C2_ECBC(const BYTE key[7], WORD32 *inout, int length)
{
    WORD32 L, R, t;
    WORD32 ktmpa, ktmpb, ktmpc, ktmpd;
    WORD32 sk[MaxRound];
    BYTE inkey[7];
    int keyRound = MaxRound; /* first time through, then becomes 2 */
    int round, i; /* loop variables */

    memcpy(inkey, key, 7);
    for (i=0; i < length; i+=8) {
        /* Input Conversion */
        L = inout[0];
        R = inout[1];

        /* Key Schedule Generation */
        ktmpa = ((WORD32)inkey[0]<<16)|((WORD32)inkey[1]<<8)|(WORD32)inkey[2];
        for(round=0; round<keyRound; round++) {
            ktmpa &= 0x00ffffff;
            sk[round] = ktmpb + ((WORD32)SecretConstant[(ktmpa&0xff)^round]<<4);
            /* This is a 56 bit rotate: */
            ktmpc = ktmpb >> (32-17);
            ktmpd = ktmpa >> (24-17);
            ktmpa = (ktmpa << 17)|ktmpc;
            ktmpb = (ktmpb << 17)|ktmpd;
        }
        for(round=0; round<MaxRound; round++) {
            /* Feistel net: */
            L += F(R, sk[round % keyRound]);
            if (round == 4) {
                /* key chaining */
                inkey[0] = key[0] ^ (R >> 16);
                inkey[1] = key[1] ^ (R >> 8);
                inkey[3] = key[3] ^ (L >> 24);
                inkey[4] = key[4] ^ (L >> 16);
                inkey[5] = key[5] ^ (L >> 8);
            }
            t = L;  L = R; R = t; // swap
        }
        t = L;  L = R; R = t; // swap cancel

        /* Output */
        *inout++ = L;
        *inout++ = R;

        /* Subsequent blocks after the first use a truncated key schedule: */
        keyRound = 2;
    }
    return;
}
Decryption in C-CBC Mode

/*
 * C2 decryption in C-CBC (Converted Cipher Block Chaining) mode:
 */
void C2_DCBC(const BYTE key[7], WORD32 *inout, int length)
{
    WORD32 L, R, t;
    WORD32 ktmpa, ktmpb, ktmpc, ktmpd;
    WORD32 sk[MaxRound];
    BYTE inkey[7];
    int keyRound = MaxRound;
    int i, round;

    memcpy(inkey, key, 7);

    for (i=0; i < length; i+=8) {
        /* Input Conversion */
        L = inout[0];
        R = inout[1];

        /* Key Generation */
        ktmpa = ((WORD32)inkey[0]<<16)|((WORD32)inkey[1]<<8)|(WORD32)inkey[2];

        for(round=0; round < keyRound; round++) {
            ktmpa &= 0x00ffffff;
            sk[round] = ktmpb + ((WORD32)SecretConstant[(ktmpa&0xff)^round]<<4);
            /* 56 bit left rotate */
            ktmpc = ktmpb >> (32-17);
            ktmpd = ktmpa >> (24-17);
            ktmpa = (ktmpa << 17)|ktmpc;
            ktmpb = (ktmpb << 17)|ktmpd;
        }

        for(round=MaxRound-1; round >= 0; round--) {
            /* Feistel net */
            L -= F(R, sk[round%keyRound]);
            t = L;  L = R; R = t;
            if (round == 5) {
                /* key chaining */
                inkey[0] = key[0] ^ (R >> 16);
                inkey[1] = key[1] ^ (R >> 8);
                inkey[3] = key[3] ^ (L >> 24);
                inkey[4] = key[4] ^ (L >> 16);
                inkey[5] = key[5] ^ (L >> 8);
            }
        }

        t = L;  L = R; R = t; // swap cancel

        /* Output */
        *inout++ = L;
        *inout++ = R;

        /* Subsequent blocks after the first use a truncated key schedule: */
        keyRound = 2;
    }
    return;
}
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