Tiny Encryption Algorithm

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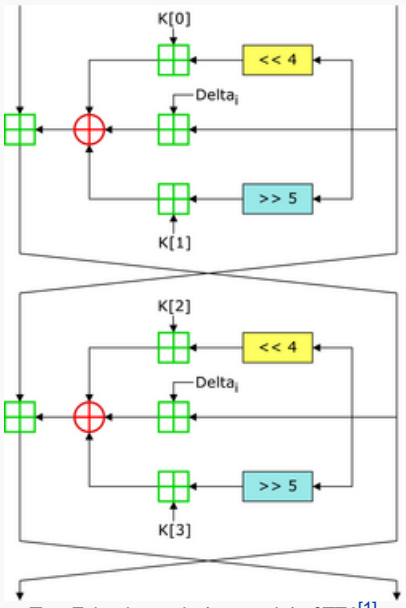
In cryptography, the **Tiny Encryption Algorithm** (**TEA**) is a block cipher notable for its simplicity of description and implementation, typically a few lines of code. It was designed by David Wheeler and Roger Needham of the Cambridge Computer Laboratory; it was first presented at the Fast Software Encryption workshop in Leuven in 1994, and first published in the proceedings of that workshop.[4]

The cipher is not subject to any patents.

TEA



Two Feistel rounds (one cycle) of TEA[1]

General

Designers	Roger Needham, David Wheeler
First published	1994
Successors	XTEA

Cipher detail

Key sizes	128 bits
Block sizes	64 bits
Structure	Feistel network
Rounds	variable; recommended 64 Feistel rounds (32 cycles)

Best public cryptanalysis

TEA suffers from equivalent keys (Kelsey et al., 1996) and can be broken using a related-key attack requiring 2^{23} chosen plaintexts and a time complexity of 2^{32}.[2] The best structural cryptanalysis of TEA in the standard single secret key setting is the zero-correlation cryptanalysis breaking 21 rounds in $2^{121.5}$ time with less than the full code book.[3]

Properties [edit]

TEA operates on two 32-bit unsigned integers (could be derived from a 64-bit data block) and uses a 128-bit key. It has a Feistel structure with a suggested 64 rounds, typically implemented in pairs termed *cycles*. It has an extremely simple key schedule, mixing all of the key material in exactly the same way for each cycle. Different multiples of a magic constant are used to prevent simple attacks based on the symmetry of the rounds. The magic constant, 2654435769 or $9E3779B9_{16}$ is chosen to be $\lfloor 2^{32}/\phi \rfloor$, where ϕ is the golden ratio.[4]

TEA has a few weaknesses. Most notably, it suffers from equivalent keys—each key is equivalent to three others, which means that the effective key size is only 126 bits.[5] As a result, TEA is especially bad as a cryptographic hash function. This weakness led to a method for hacking Microsoft's Xbox game console, where the cipher was used as a hash function.[6] TEA is also susceptible to a related-key attack which requires 2^{23} chosen plaintexts under a related-key pair, with 2^{32} time complexity.[2] Because of these weaknesses, the XTEA cipher was designed.

Versions [edit]

The first published version of TEA was supplemented by a second version that incorporated extensions to make it more secure. *Block TEA* (sometimes referred to as XTEA) operates on arbitrary-size blocks in place of the 64-bit blocks of the original.

A third version (XXTEA), published in 1998, described further improvements for enhancing the security of the Block TEA algorithm.

Reference code [edit]

Following is an adaptation of the reference encryption and decryption routines in C, released into the public domain by David Wheeler and Roger Needham:[4]

```c
#include <stdint.h>

void encrypt (uint32_t* v, uint32_t* k) {
    uint32_t v0=v[0], v1=v[1], sum=0, i;           /* set up */
    uint32_t delta=0x9e3779b9;                     /* a key schedule constant */
    uint32_t k0=k[0], k1=k[1], k2=k[2], k3=k[3];   /* cache key */
    for (i=0; i < 32; i++) {                       /* basic cycle start */
        sum += delta;
        v0 += ((v1<<4) + k0) ^ (v1 + sum) ^ ((v1>>5) + k1);
        v1 += ((v0<<4) + k2) ^ (v0 + sum) ^ ((v0>>5) + k3);
    }                                              /* end cycle */
    v[0]=v0; v[1]=v1;
}

void decrypt (uint32_t* v, uint32_t* k) {
    uint32_t v0=v[0], v1=v[1], sum=0xC6EF3720, i;  /* set up */
    uint32_t delta=0x9e3779b9;                     /* a key schedule constant */
    uint32_t k0=k[0], k1=k[1], k2=k[2], k3=k[3];   /* cache key */
    for (i=0; i<32; i++) {                         /* basic cycle start */
        v1 -= ((v0<<4) + k2) ^ (v0 + sum) ^ ((v0>>5) + k3);
        v0 -= ((v1<<4) + k0) ^ (v1 + sum) ^ ((v1>>5) + k1);
        sum -= delta;
    }                                              /* end cycle */
    v[0]=v0; v[1]=v1;
}
```

Note that the reference implementation acts on multi-byte numeric values. The original paper does not specify how to derive the numbers it acts on from binary or other content.

See also [edit]

- RC4 - A stream cipher that, just like TEA, is designed to be very simple to implement.
- XTEA - First version of Block TEA's successor.
- XXTEA - Corrected Block TEA's successor.
- Treyfer - A simple and compact encryption algorithm with 64 bit key size and block size.

Notes [edit]

1. ^ Matthew D. Russell (27 Feb 2004). "Tinyness: An Overview of TEA and Related Ciphers". Archived from the original on 12 August 2007.
2. ^ [a] [b] Kelsey, John; Schneier, Bruce; Wagner, David (1997). "Related-key cryptanalysis of 3-WAY, Biham-DES, CAST, DES-X NewDES, RC2, and TEA". *Lecture Notes in Computer Science* **1334**: 233–246. doi:10.1007/BFb0028479.
3. ^ Bogdanov, Andrey; Wang, Meiqin (2012). "Zero-Correlation Linear Cryptanalysis with Reduced Data Complexity" (PDF). *Lecture Notes in Computer Science* (Fast Software Encryption 2012) **7549**: 29–48. doi:10.1007/978-3-642-34047-5_3.
4. ^ [a] [b] [c] Wheeler, David J.; Needham, Roger M. (1994-12-16). "TEA, a tiny encryption algorithm". *Lecture Notes in Computer Science* (Leuven, Belgium: Fast Software Encryption: Second International Workshop) **1008**: 363–366. doi:10.1007/3-540-60590-8_29.
5. ^ Kelsey, John; Schneier, Bruce; Wagner, David (1996). "Key-schedule cryptanalysis of IDEA, G-DES, GOST, SAFER, and Triple-DES" (PDF). *Lecture Notes in Computer Science* **1109**: 237–251. doi:10.1007/3-540-68697-5_19.
6. ^ Michael Steil. "17 Mistakes Microsoft Made in the Xbox Security System". Archived from the original on 16 April 2009.

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External links [edit]

- Test vectors for TEA
- JavaScript implementation of XXTEA with Base64
- PHP implementation of XTEA (German language)
- JavaScript implementation of TEA
- JavaScript and PHP implementations of XTEA (Dutch text)
- LGPL Java/J2ME implementation of TEA
- AVR ASM implementation
- Common Lisp implementation of TEA

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Less common algorithms	Camellia · CAST-128 · IDEA · RC2 · RC5 · SEED · ARIA · Skipjack · **TEA** · XTEA
Other algorithms	3-Way · Akelarre · Anubis · BaseKing · BassOmatic · BATON · BEAR and LION · CAST-256 · Chiasmus · CIKS-1 · CIPHERUNICORN-A · CIPHERUNICORN-E · CLEFIA · CMEA · Cobra · COCONUT98 · Crab · Cryptomeria/C2 · CRYPTON · CS-Cipher · DEAL · DES-X · DFC · E2 · FEAL · FEA-M · FROG · G-DES · GOST · Grand Cru · Hasty Pudding cipher · Hierocrypt · ICE · IDEA NXT · Intel Cascade Cipher · Iraqi · KASUMI · KeeLoq · KHAZAD · Khufu and Khafre · KN-Cipher · Ladder-DES · Libelle · LOKI (97, 89/91) · Lucifer · M6 · M8 · MacGuffin · Madryga · MAGENTA · MARS · Mercy · MESH · MISTY1 · MMB · MULTI2 · MultiSwap · New Data Seal · NewDES · Nimbus · NOEKEON · NUSH · PRESENT · Q · RC6 · REDOC · Red Pike · S-1 · SAFER · SAVILLE · SC2000 · SHACAL · SHARK · Simon · SMS4 · Speck · Spectr-H64 · Square · SXAL/MBAL · Threefish · Treyfer · UES · Xenon · xmx · XXTEA · Zodiac
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