A hybrid cryptographic system for file security

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Outline

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Hybrid Cryptography

The ISO/LEC JTCI/SC27 standardization committee suggests that hybrid cryptography can be defined as the branch of asymmetric cryptography that makes use of convenient symmetric techniques to remove some of the problems inherent in normal asymmetric cryptosystem.

Hybrid Cryptography

Hybrid Cryptography is the combination of both the symmetric key cryptography and Asymmetric or Public key cryptography.

Hybrid Cryptography

Our Goal: to build a hybrid cryptosystem using the following algorithms:

- RSA Algorithm (Asymmetric)
- KASUMI Cipher (Symmetric)

RSA Algorithm

- Public Key Cryptosystem
- Invented by Rivest, Shamir and Adleman [1977]
- It is based on the principle that it is easy to multiply large numbers but factoring large number is very difficult.
- Public key is generated by multiplying two large prime numbers and private key is generated by using a mathematical functions.
- Key Size : 512 bits to 4096 bits

RSA: Advantages

- RSA Algorithm involves a lot of complex mathematics which makes it more difficult to crack.
- Fast Encryption as compare to other encryption algorithm.
- No need of sharing secrets key
- Proof of owner's authenticity
- Data cannot be modified at transit

RSA: Disadvantages

- Key generation is very slow.
- Speed of encrypting of text is slow.
- High processing is required at receiver's end for decryption

KASUMI Cipher

- It is a Fiestel Cipher
- Based on the MISTY1 Cipher
- Mostly used in Universal Mobile Telecomm. System(UMTS), Global System for Mobile Comm. (GSM) and GPRS Mobile Comm.
- Key size: 128 bits
- Block Size: 64 bits
- The core of KASUMI is an 8-round Feistel network.
- In each round the round function uses a round key which consists of eight 16-bit sub keys derived from the original 128-bit key using a fixed key schedule.

Working of Round Function: Let's consider key, K is 32 bit and is divided into eight 4 bit values $K_1, K_2, \ldots K_8$ i.e,

$$K = K_1||K_2||\ldots||K_8$$

Take $k = 0111$ then subkeys :

$$K_1 = 0111$$
$$K_2 = 1011$$
$$K_3 = 1101$$
$$K_4 = 1110$$
$$K_5 = 0111$$
$$K_6 = 1011$$
$$K_7 = 1101$$
$$K_8 = 1110$$

where, $K_1 = K_5$, $K_2 = K_6$, $K_3 = K_7$ and $K_4 = K_8$

KASUMI Cipher

In KASUMI, round keys are :

$$KL_{i,1} = ROL(K_i, 1)$$
$$KL_{i,2} = K'_{i+2}$$
$$KO_{i,1} = ROL(K_{i+1}, 5)$$
$$KO_{i,2} = ROL(K_{i+5}, 8)$$
$$KO_{i,3} = ROL(K_{i+6}, 13)$$
$$KI_{i,1} = K'_{i+4}$$
$$KI_{i,2} = K'_{i+3}$$
$$KI_{i,3} = K'_{i+7}$$

KASUMI Cipher

Round	$KL_{i,1}$	$KL_{i,2}$	$KO_{i,1}$	$KO_{i,2}$	$KO_{i,3}$	$KI_{i,1}$	$KI_{i,2}$	$KI_{i,3}$
1	$K_1 \lll 1$	K'_3	$K_2 \lll 5$	$K_2 \lll 8$	$K_3 \lll 13$	K'_1	K'_4	K'_8
2	$K_2 \lll 1$	K'_4	$K_3 \lll 5$	$K_3 \lll 8$	$K_4 \lll 13$	K'_2	K'_1	K'_1
3	$K_3 \lll 1$	K'_1	$K_4 \lll 5$	$K_4 \lll 8$	$K_1 \lll 13$	K'_3	K'_2	K'_2
4	$K_4 \lll 1$	K'_2	$K_1 \lll 5$	$K_1 \lll 8$	$K_2 \lll 13$	K'_4	K'_3	K'_3
5	$K_1 \lll 1$	K'_3	$K_2 \lll 5$	$K_2 \lll 8$	$K_3 \lll 13$	K'_1	K'_4	K'_4
6	$K_2 \lll 1$	K'_4	$K_3 \lll 5$	$K_3 \lll 8$	$K_4 \lll 13$	K'_2	K'_5	K'_5
7	$K_3 \lll 1$	K'_1	$K_4 \lll 5$	$K_4 \lll 8$	$K_1 \lll 13$	K'_3	K'_6	K'_6
8	$K_4 \lll 1$	K'_2	$K_1 \lll 5$	$K_1 \lll 8$	$K_2 \lll 13$	K'_4	K'_7	K'_7

Table 1: Round subkeys

KASUMI: Advantages and Disadvantages

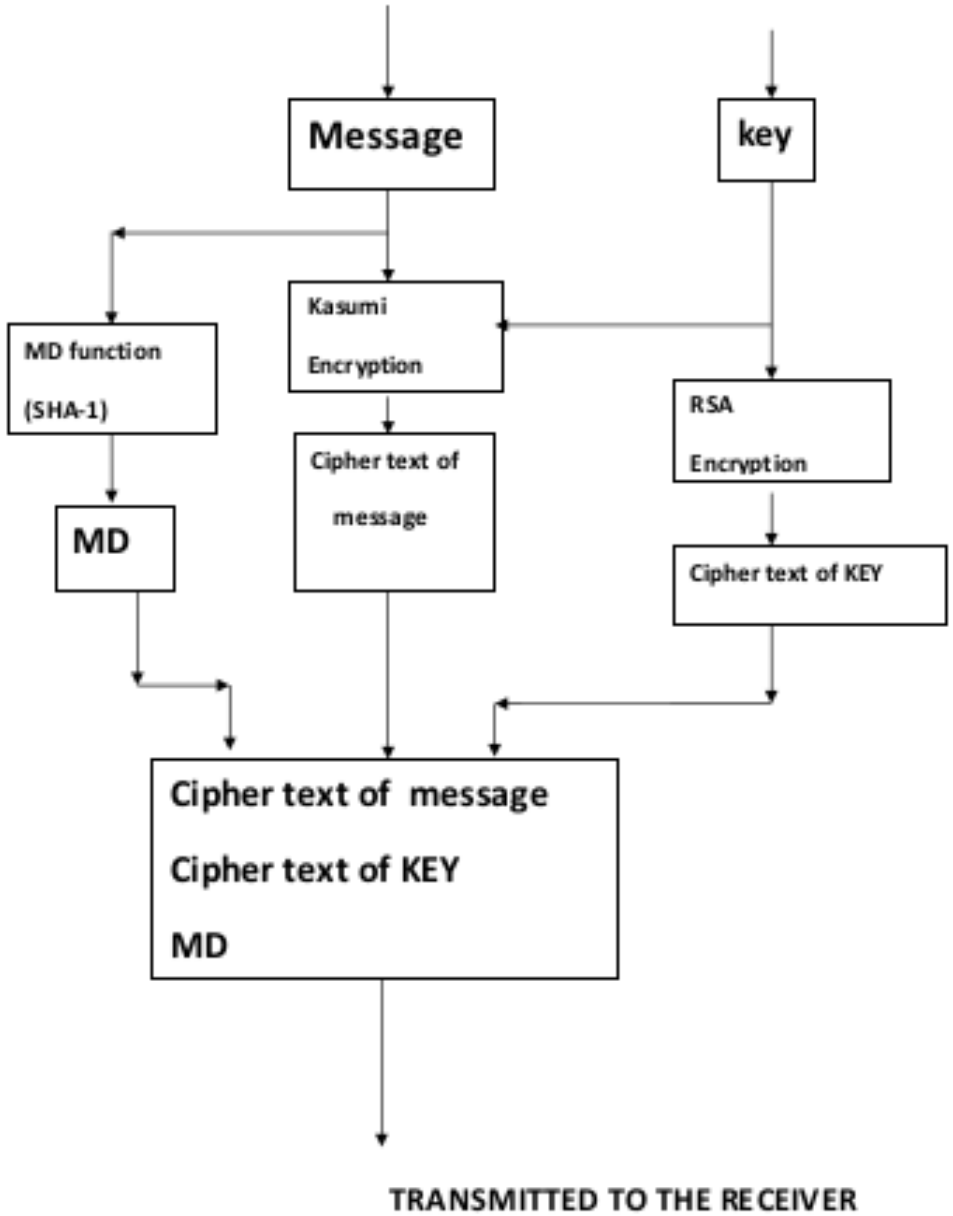
Advantages:

- High diffusion and strong tamper resistance without detection
- More secure as compare to MISTY1

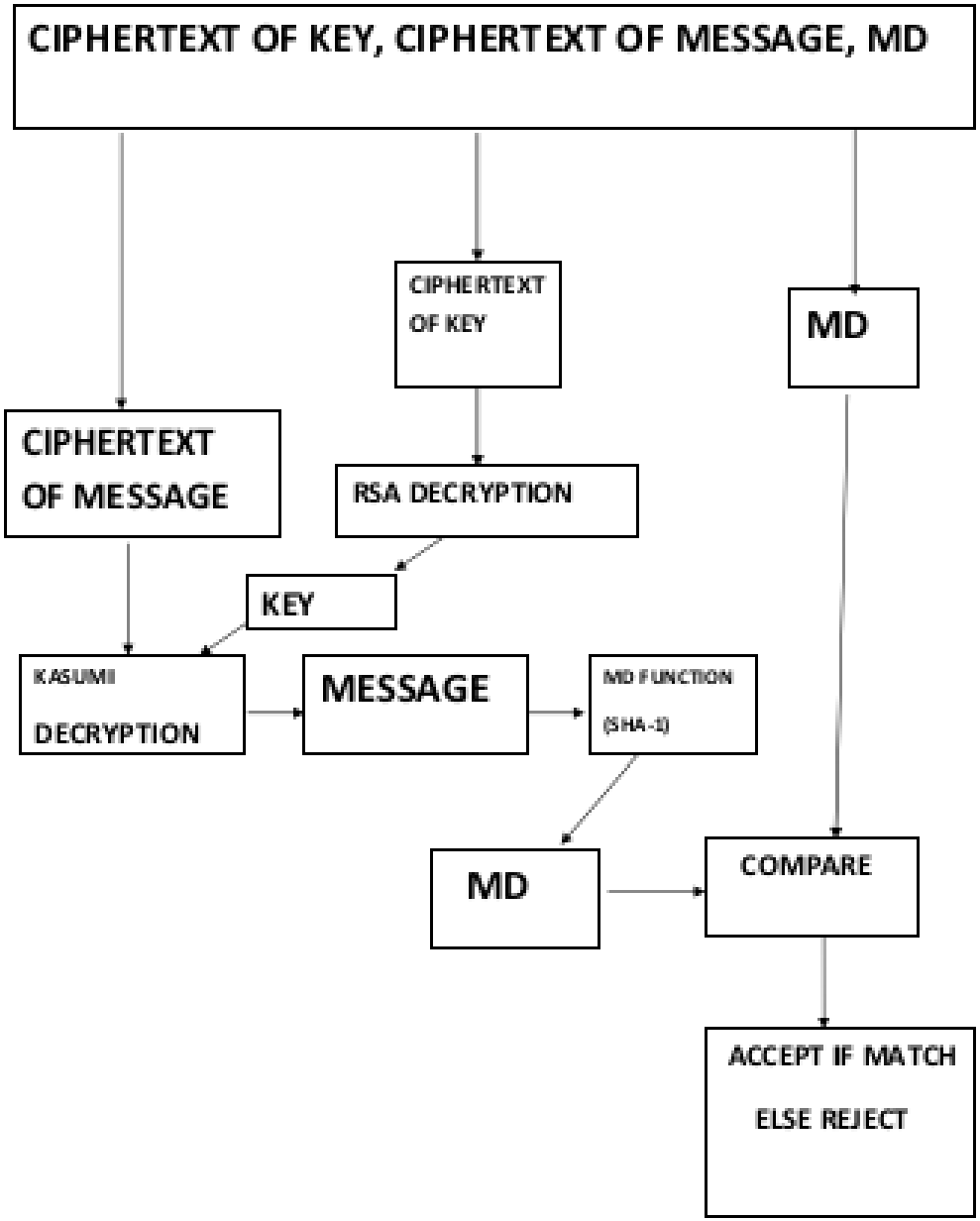
Disadvantages:

- An impossible differential attack[1] on six rounds of KASUMI was presented by Kühn [2001]
- A related-key rectangle (boomerang) attack[2] on KASUMI that can break all 8 rounds faster than exhaustive search was published by Eli Biham, Orr Dunkelman and Nathan Keller[2005]

Proposed System Design: Encryption



Proposed System Design: Decryption



Advantages of proposed system

- File is secure as the file is being encrypted not by just using one but two highly algorithms RSA and KASUMI.
- The key used for encryption is also safe as it is encrypted by RSA
- Confidentiality and integrity of a file is being maintain securely as Hasing algorithm is used for generating checksum

Implementation

For the proof of concept and for the demonstration we will be considering:

- Key Size: 32-bit instead of 128-bit
- Block Size: 16-bit instead of 64-bit

Technologies used: PHP and SQL

Further Work

- Improving the Fiestel Round of the KASUMI Cipher for better security
- Introduction of another secret key to be used along with MD Function for maximum security.

References

[1] Kühn, Ulrich. Cryptanalysis of Reduced Round MISTY. EUROCRYPT 2001.
[2] Orr Dunkelman, Nathan Keller, Adi Shamir (2010-01-10). "A Practical-Time Attack on the A5/3 Cryptosystem Used in Third Generation GSM Telephony"
[3] https://en.wikipedia.org/wiki/KASUMI

Thank You !