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The SEED Cipher Algorithm and Its Use with the Secure Real-time Transport Protocol (SRTP)
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Status of this Memo

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Abstract

This document describes the use of the SEED block cipher algorithm in the Secure Real-time Transport Protocol (SRTP) for providing confidentiality for the Real-time Transport Protocol (RTP) traffic and for the control traffic for RTP, the Real-time Transport Control Protocol (RTCP).

Table of Contents

1. Introduction

This document describes the use of the SEED [RFC4269] block cipher algorithm in the Secure Real-time Transport Protocol (SRTP) [RFC3711] for providing confidentiality for the Real-time Transport Protocol (RTP) [RFC3550] traffic and for the control traffic for RTP, the Real-time Transport Control Protocol (RTCP) [RFC3550].

1.1. SEED

SEED is a Korean National Industrial Association standard and is widely used in South Korea for electronic commerce and financial services that are operated on wired and wireless communications.

SEED is a 128-bit symmetric key block cipher that has been developed by KISA (Korea Information Security Agency) and a group of experts since 1998. The input/output block size of SEED is 128-bit and the key length is also 128-bit. SEED has a 16-round Feistel structure.

1.2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

1.3. Definitions

|| concatenation
XOR exclusive or

2. Cryptographic Transforms

All symmetric block cipher algorithms share common characteristics including mode, key size, weak keys, and block size. The following sections contain descriptions of the relevant characteristics of SEED.

SEED does not have any restrictions for modes of operation that are used with this block cipher. We define three modes of running SEED, (1) SEED in Counter Mode, (2) SEED in Counter with CBC-MAC (CCM) Mode and (3) SEED in Galois/Counter Mode (GCM) Mode.

2.1. Counter

Section 4.1.1 of [RFC3711] defines AES counter mode encryption, which it refers to as AES-CM. SEED counter mode is defined in a similar manner, and is denoted as SEED-CTR. The plaintext inputs to the block cipher are formed as in AES-CM, and the block cipher outputs are processed as in AES-CM. The only difference in the processing is that SEED-CTR uses SEED as the underlying encryption primitive. When SEED-CTR is used, it MUST be used only in conjunction with an authentication function.

2.1.1. Message Authentication/Integrity: HMAC-SHA1

HMAC-SHA1 [RFC2104], as defined in section 4.2.1 of [RFC3711], SHALL be the default message authentication code to be used with SEED-CTR. The default session authentication key-length SHALL be 160 bits, the default authentication tag length SHALL be 80 bits, and the SRTP_PREFIX_LENGTH SHALL be zero for HMAC-SHA1. For SRTP, smaller values are NOT RECOMMENDED, but MAY be used after careful consideration of the issues in section 7.5 and 9.5 of [RFC3711].

2.2. Counter with CBC-MAC (CCM)

CCM is a generic authenticate-and-encrypt block cipher mode [RFC3610]. In this specification, CCM used with the SEED block cipher is denoted as SEED-CCM.

Section 3.3 of [RFC3711] defines procedures to construct or to authenticate and decrypt SRTP packets. For SEED-CCM however, the sender performs Step 7 before Step 5 and the receiver performs the second half of Step 5 (performs verification) after Step 6. This means that authentication is performed on the plaintext rather than the ciphertext. This applies equally to SRTCP.

All SRTP packets MUST be authenticated and encrypted. Unlike SRTP, SRTCP packet encryption is optional (but authentication is

mandatory). A sender can select which packets to encrypt, and indicates this choice with a 1-bit encryption flag (located in the leftmost bit of the 32-bit word that contains the SRTCP index).

SEED-CCM has two parameters:

M M indicates the size of the authentication tag. In SRTP, a full 80-bit authentication-tag SHOULD be used and implementation of this specification MUST support M values of 10 octets.

L L indicates the size of the length field in octets. The number of octets in the nonce MUST be 12, i.e., L is 3.

SEED-CCM has four inputs:

Key

A single key is used to calculate the authentication tag using CBC-MAC and to perform payload encryption using counter mode. SEED only supports a key size of 128 bits.

Nonce

The size of the nonce depends on the value selected for the parameter L. It is 15-L octets. L equals 3 and hence the nonce size equals 12 octets.

Plaintext

In case of SRTP, the payload of the RTP packet and the RTP padding and RTP pad count field (if the latter two fields are present).

In case of SRTCP, when the encryption flag is set to 1, the Encrypted Portion described in Fig.2 of [RFC3711] is treated as plaintext. When the encryption flag is set to 0, the plaintext is zero-length.

Additional Authentication Data (AAD)

In case of SRTP, the header of the RTP packet including contributing source (CSRC) identifier (if present) and the RTP header extension (if present).

In case of SRTCP, when the encryption flag is set to 0, the Authentication Portion described in Fig.2 of [RFC3711] is treated as AAD. When the encryption flag is set to 1, the first 8-octets, the encryption flag and SRTCP index are treated as AAD.

SEED-CCM accepts these four inputs and returns a ciphertext field.

2.3. Galois/Counter Mode (GCM)

GCM is a block cipher mode of operation providing both confidentiality and data origin authentication [GCM]. GCM used with the SEED block cipher is denoted as SEED-GCM.

SEED-GCM has four inputs: a key, a plaintext, a nonce and the additional authenticated data (AAD) all described in section 2.2.

The bit length of the tag, denoted t, is 12, and an authentication tag with a length of 12 octets (96 bits) is used.

3. Nonce Format for CCM and GCM

3.1. Nonce for SRTP

The nonce for SRTP SHALL be formed in the following way:

```
Nonce = (16 bits of zeroes || SSRC || ROC || SEQ) XOR Salt
```

The 4-octet SSRC and the 2-octet SEQ SHALL be taken from the RTP header. The 4-octet ROC is from the cryptographic context. The 12-octet Salt SHALL be produced by the SRTP Key Derivation Function.

3.2. Nonce for SRTCP

The nonce for SRTCP SHALL be formed in the following way:

```
Nonce = (16 bits of zeroes || SSRC || 16 bits of zeroes ||
         SRTCP index) XOR Salt
```

The 4-octet SSRC SHALL be taken from the RTCP header and The 31-bit SRTCP index (packed zero-filled, right justified into a 4-octet

field) is from each packet. The 12-octet Salt SHALL be produced by the SRTP Key Derivation Function.

4. Key Derivation: SEED-CTR PRF

Section 4.3.3 of [RFC3711] defines the AES-128 counter mode key derivation function, which it refers to as "AES-CM PRF". The SEED-CTR PRF is defined in a similar manner, but with each invocation of AES replaced with an invocation of SEED.

The currently defined PRF, keyed by the 128-bit master key, has input block size m = 128 and can produce n-bit outputs for n up to 2^23. SEED-PRF_n(k_master, x) SHALL be SEED in Counter Mode as described in section 2.1, applied to key k_master, and IV equal to (x*2^16), and with the output keystream truncated to the n first (left-most) bits.

5. Mandatory-to-implement Transforms

"Mandatory-to-implement" means conformance to the specification, and that Table 1 does not supersede a similar table in Section 5 of [RFC3711]. An RTP implementation that supports SEED MUST implement the modes listed in Table 1.

	mandatory-to-implement	optional
encryption	SEED-CTR	SEED-CCM,SEED-GCM
message integrity	HMAC-SHA1	SEED-CCM,SEED-GCM
key derivation (PRF)	SEED-CTR	-

Table 1: Mandatory-to-implement and optional transforms in SRTP and SRTCP.

6. Security Considerations

No security problem has been found on SEED. SEED is secure against all known attacks including Differential cryptanalysis, linear cryptanalysis, and related key attacks. The best known attack is only an exhaustive search for the key. For further security considerations, the reader is encouraged to read [SEED-EVAL].

See [RFC3610] and [GCM] for security considerations regarding the CCM and GCM Modes of Operation, respectively. In the context of SRTP, the procedures in [RFC3711] ensure the critical property of non-reuse of counter values.

7. IANA Considerations

[RFC4568] defines SRTP "crypto suites". In order to allow SDP to signal the use of the algorithms defined in this document, IANA will register the following crypto suites into the subregistry for SRTP crypto suites under the SRTP transport of the SDP Security Descriptions:

```
srtp-crypto-suite-ext = "SEED_CTR_128_HMAC_SHA1_80"/
                        "SEED_128_CCM_80"/
                        "SEED_128_GCM_96"/
                        srtp-crypto-suite-ext
```

8. References

8.1. Normative References

[GCM] Dworkin, M., "NIST Special Publication 800-38D: Recommendation for Block Cipher Modes of Operation: Galois/Counter Mode (GCM) and GMAC", U.S. National Institute of Standards and Technology http://csrc.nist.gov/publications/nistpubs/800-38D/SP-800-38D.pdf

[RFC2104] Krawczyk, H.,Bellare, M. and R. Canetti, "HMAC: keyed-Hashing for Message Authentication", RFC 2104, February 1997.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC3550] Schulzrinne, H., Casner, S., Frederick, R. and V. Jacobson, "RTP: A Transport Protocol for Real-time Applications", RFC3550, July 2003

[RFC3610] Whiting, D., Housley, R., and N. Ferguson, "Counter with CBC-MAC (CCM)", RFC 3610, September 2003.

[RFC3711] M. Baugher, D. McGrew, M. Naslund, E.Carrara, K. Norrman, "The Secure Real-time Transport Protocol (SRTP)", RFC 3711, March 2004.

[RFC4269] H. Lee, S. Lee, J. Yoon, D. Cheon, J. Lee, "The SEED Encryption Algorithm", RFC 4269, December 2005.

[RFC4568] F. Andreasen, M. Baugher, D. Wing, "Session Description Protocol (SDP) Security Descriptions for Media Streams", RFC 4568, July 2006.

8.2. Informative References

[SEED-EVAL] KISA, "Self Evaluation Report", http://www.kisa.or.kr/kisa/seed/down/SEED_Evaluation_Report_by_CRYPTREC.pdf

APPENDIX A: Test Vectors

All values are in hexadecimal.

A.1. SEED-CTR Test Vectors

Session Key:	0c5ffd37a11edc42c325287fc0604f2e
Rollover Counter:	00000000
Sequence Number:	315e
SSRC:	20e8f5eb
Session Salt:	cd3a7c42c671e0067a2a2639b43a
Initialization Vector:	cd3a7c42e69915ed7a2a263985640000
RTP Payload:	f57af5fd4ae19562976ec57a5a7ad55a 5af5c5e5c5fdf5c55ad57a4a7272d572 62e9729566ed66e97ac54a4a5a7ad5e1 5ae5fdd5fd5ac5d56ae56ad5c572d54a e54ac55a956afd6aed5a4ac562957a95 16991691d572fd14e97ae962ed7a9f4a 955af572e162f57a956666e17ae1f54a 95f566d54a66e16e4afd6a9f7ae1c5c5 5ae5d56afde916c5e94a6ec56695e14a fde1148416e94ad57ac5146ed59d1cc5
Encrypted RTP Payload:	df5a89291e7e383e9beff765e691a737 70d5b9319162589956544855ce99a71f 48c90e413272cbb576447855e691a78c 70c58101a9c56889666458ca7999a727 cf6ab98ec1f55036e1db78dade7e08f8 3cb96a4581ed5048e5fbdb7d5191ed27 bf7a89a6b5fd582699e754fec60a8727 bfd51a011ef94c32467c5880c60ab7a8 70c5a9bea976bb99e5cb5cdada7e9327 d7c168504276e7897644267169766ea8
Authentication Tag:	28b7a194b1e3df3c573d

A.2. SEED-CCM Test Vectors

Key:	974bee725d44fc3992267b284c3c6750
Rollover Counter:	00000000
Sequence Number:	315e
SSRC:	20e8f5eb
Nonce:	000020e8f5eb00000000315e
Payload:	f57af5fd4ae19562976ec57a5a7ad55a 5af5c5e5c5fdf5c55ad57a4a7272d572 62e9729566ed66e97ac54a4a5a7ad5e1 5ae5fdd5fd5ac5d56ae56ad5c572d54a e54ac55a956afd6aed5a4ac562957a95 16991691d572fd14e97ae962ed7a9f4a 955af572e162f57a956666e17ae1f54a 95f566d54a66e16e4afd6a9f7ae1c5c5 5ae5d56afde916c5e94a6ec56695e14a fde1148416e94ad57ac5146ed59d1cc5
AAD:	8008315ebf2e6fe020e8f5eb
Encrypted RTP Payload:	39b63931862d59ae5ba209b696b61996 9639092909313909961 9b686bebe19be ae25be59aa21aa25b609868696b6192d 9629311931960919a629a61909be1986 2986099659a631a621968609ae59b659 da55da5d19be31d825b625ae21b65386 599639be2dae39b659aaaa2db62d3986 5939aa1986aa2da28631a653b62d0909 962919a63125da092586a209aa592d86 312dd848da258619b609d8a21951d009
Authentication Tag:	1eb0e7008c838b19c8fc

A.3. SEED-GCM Test Vectors

Key:	e91e5e75da65554a48181f3846349562
Rollover Counter:	00000000
Sequence Number:	315e
SSRC:	20e8f5eb
Nonce:	000020e8f5eb00000000315e
Payload:	f57af5fd4ae19562976ec57a5a7ad55a 5af5c5e5c5fdf5c55ad57a4a7272d572 62e9729566ed66e97ac54a4a5a7ad5e1 5ae5fdd5fd5ac5d56ae56ad5c572d54a e54ac55a956afd6aed5a4ac562957a95 16991691d572fd14e97ae962ed7a9f4a 955af572e162f57a956666e17ae1f54a 95f566d54a66e16e4afd6a9f7ae1c5c5 5ae5d56afde916c5e94a6ec56695e14a fde1148416e94ad57ac5146ed59d1cc5
AAD:	8008315ebf2e6fe020e8f5eb
Encrypted RTP Payload:	8a5363682c6b1bbf13c0b09cf747a551 2543cb2f129b8bd0e92dfadf735cda8f 88c4bbf90288f5e58d20c4f1bb0d5844 6ea009103ee57ba99cdeabaaa18d4a9a 05ddb46e7e5290a5a2284fe50b1f6fe9 ad3f1348c354181e85b24f1a552a1193 cf0e13eed5ab95ae854fb4f5b0edb2d3 ee5eb238c8f4bfb136b2eb6cd7876042 0680ce1879100014f140a15e07e70133 ed9cbb6d57b75d574acb0087eefbac99
Authentication Tag:	36cd9ae602be3ee2cd8d5d9d

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