AVTCore
Internet-Draft
Intended status: Standards Track
Expires: March 29, 2014

W. Kim
J. Lee
D. Kim
J. Park
D. Kwon
NSRI

September 25, 2013

The ARIA Algorithm and Its Use with the Secure Real-time Transport Protocol(SRTP)
draft-ietf-avtcore-aria-srtp-05

Abstract

This document describes the use of the ARIA block cipher algorithm within 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 RTP Control Protocol (RTCP). It details three modes of operation (CTR, CCM, GCM) and a SRTP Key Derivation Function for ARIA.

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1. Introduction

This document describes the use of the ARIA [RFC5794] 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 RTP Control Protocol (RTCP) [RFC3550].

1.1. ARIA

ARIA is a general-purpose block cipher algorithm developed by Korean cryptographers in 2003. It is an iterated block cipher with 128-, 192-, and 256-bit keys and encrypts 128-bit blocks in 12, 14, and 16 rounds, depending on the key size. It is secure and suitable for most software and hardware implementations on 32-bit and 8-bit processors. It was established as a Korean standard block cipher algorithm in 2004 [ARIAKS] and has been widely used in Korea, especially for government-to-public services. It was included in PKCS #11 in 2007 [ARIAPKCS]. The algorithm specification and object identifiers are described in [RFC5794].

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].

2. Cryptographic Transforms

Block ciphers ARIA and AES share common characteristics including mode, key size, and block size. ARIA does not have any restrictions for modes of operation that are used with this block cipher. We define three modes of running ARIA within the SRTP protocol, (1) ARIA in Counter Mode (ARIA-CTR), (2) ARIA in Counter with CBC-MAC Mode (ARIA-CCM) and (3) ARIA in Galois/Counter Mode (ARIA-GCM).

2.1. ARIA-CTR

Section 4.1.1 of [RFC3711] defines AES-128 counter mode encryption, which it refers to as "AES_CM". Section 2 of [RFC6188] defines "AES_192_CM" and "AES_256_CM" in SRTP. ARIA counter modes are defined in the same manner except that each invocation of AES is replaced by that of ARIA, and are denoted by ARIA_128_CTR, ARIA_192_CTR and ARIA_256_CTR respectively, according to the key lengths. The plaintext inputs to the block cipher are formed as in AES-CTR(AES_CM, AES_192_CM, AES_256_CM) and the block cipher outputs are processed as in AES-CTR.

When ARIA-CTR is used, it MUST be used only in conjunction with an authentication function. The ARIA-CTR crypto suites with HMAC-SHA1 as an authentication function are listed below. The authentication key length of all crypto suites is 20 octets.

Section 3.2 of [RFC6904] defines AES-CTR for SRTP header extension keystream generation. When ARIA-CTR is used, the header extension keystream SHALL be generated in the same manner except that each invocation of AES is replaced by that of ARIA.

Name	Enc. Key Length	Auth. Tag Length
ARIA_128_CTR_HMAC_SHA1_80	16 octets	10 octets
ARIA_128_CTR_HMAC_SHA1_32	16 octets	4 octets
ARIA_192_CTR_HMAC_SHA1_80	24 octets	10 octets
ARIA_192_CTR_HMAC_SHA1_32	24 octets	4 octets
ARIA_256_CTR_HMAC_SHA1_80	32 octets	10 octets
ARIA_256_CTR_HMAC_SHA1_32	32 octets	4 octets

Table 1: ARIA-CTR Crypto Suites for SRTP/SRTCP

The parameters (from Table 2 to Table 7) in each crypto suite listed in Table 1 are described for use with the SDP Security Descriptions attributes [RFC4568].

Parameter	Value
Master key length	128 bits
Master salt length	112 bits
Key Derivation Function	ARIA_128_CTR_PRF (Section 3)
Default key lifetime	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_128_CTR
SRTP authentication function	HMAC-SHA1
SRTP authentication key length	160 bits
SRTP authentication tag length	80 bits
SRTCP authentication function	HMAC-SHA1
SRTCP authentication key length	160 bits
SRTCP authentication tag length	80 bits

Table 2: The ARIA_128_CTR_HMAC_SHA1_80 Crypto Suite

Parameter	Value
Master key length	128 bits
Master salt length	112 bits
Key Derivation Function	ARIA_128_CTR_PRF (Section 3)
Default key lifetime	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_128_CTR

SRTP authentication function	HMAC-SHA1
SRTP authentication key length	160 bits
SRTP authentication tag length	32 bits
SRTCP authentication function	HMAC-SHA1
SRTCP authentication key length	160 bits
SRTCP authentication tag length	80 bits

Table 3: The ARIA_128_CTR_HMAC_SHA1_32 Crypto Suite

Parameter	Value
Master key length	192 bits
Master salt length	112 bits
Key Derivation Function	ARIA_192_CTR_PRF (Section 3)
Default key lifetime	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_192_CTR
SRTP authentication function	HMAC-SHA1
SRTP authentication key length	160 bits
SRTP authentication tag length	80 bits
SRTCP authentication function	HMAC-SHA1
SRTCP authentication key length	160 bits
SRTCP authentication tag length	80 bits

Table 4: The ARIA_192_CTR_HMAC_SHA1_80 Crypto Suite

Parameter	Value
Master key length	192 bits
Master salt length	112 bits
Key Derivation Function	ARIA_192_CTR_PRF (Section 3)
Default key lifetime	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_192_CTR
SRTP authentication function	HMAC-SHA1
SRTP authentication key length	160 bits
SRTP authentication tag length	32 bits
SRTCP authentication function	HMAC-SHA1
SRTCP authentication key length	160 bits
SRTCP authentication tag length	80 bits

Table 5: The ARIA_192_CTR_HMAC_SHA1_32 Crypto Suite

Parameter	Value

Master key length	256 bits
Master salt length	112 bits
Key Derivation Function	ARIA_256_CTR_PRF (Section 3)
Default key lifetime	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_256_CTR
SRTP authentication function	HMAC-SHA1
SRTP authentication key length	160 bits
SRTP authentication tag length	80 bits
SRTCP authentication function	HMAC-SHA1
SRTCP authentication key length	160 bits
SRTCP authentication tag length	80 bits

Table 6: The ARIA_256_CTR_HMAC_SHA1_80 Crypto Suite

Parameter	Value
Master key length	256 bits
Master salt length	112 bits
Key Derivation Function	ARIA_256_CTR_PRF (Section 3)
Default key lifetime	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_256_CTR
SRTP authentication function	HMAC-SHA1
SRTP authentication key length	160 bits
SRTP authentication tag length	32 bits
SRTCP authentication function	HMAC-SHA1
SRTCP authentication key length	160 bits
SRTCP authentication tag length	80 bits

Table 7: The ARIA_256_CTR_HMAC_SHA1_32 Crypto Suite

2.2. ARIA-GCM

GCM(Galois Counter Mode) [GCM][RFC5116] is a AEAD(authenticated encryption with associated data) block cipher mode. A detailed description of ARIA-GCM is defined similarly as AES-GCM found in [RFC5116][RFC5282].

The internet draft [I-D.ietf-avtcore-srtp-aes-gcm] describes the use of AES-GCM with SRTP [RFC3711][RFC6904]. The use of ARIA-GCM with SRTP is defined the same as that of AES-GCM except that each invocation of AES is replaced by ARIA.

The ARIA-GCM algorithms in Table 8 may be used with SRTP and SRTCP:

Name	Enc. Key Length	Auth. Tag Length
AEAD_ARIA_128_GCM	16 octets	16 octets
AEAD_ARIA_256_GCM	32 octets	16 octets
AEAD_ARIA_128_GCM_8	16 octets	8 octets
AEAD_ARIA_256_GCM_8	32 octets	8 octets
AEAD_ARIA_128_GCM_12	16 octets	12 octets
AEAD_ARIA_256_GCM_12	32 octets	12 octets

Table 8: ARIA-GCM Crypto Suites for SRTP/SRTCP

The parameters (from Table 9 to Table 14) in each crypto suite listed in Table 8 are described for use with the SDP Security Descriptions attributes [RFC4568].

Parameter	Value
Master key length	128 bits
Master salt length	96 bits
Key Derivation Function	ARIA_128_CTR_PRF (Section 3)
Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_128_GCM
AEAD authentication tag length	128 bits

Table 9: The AEAD_ARIA_128_GCM Crypto Suite

Parameter	Value
Master key length	256 bits
Master salt length	96 bits
Key Derivation Function	ARIA_256_CTR_PRF (Section 3)
Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_256_GCM
AEAD authentication tag length	128 bits

Table 10: The AEAD_ARIA_256_GCM Crypto Suite

Parameter	Value

Master key length	128 bits
Master salt length	96 bits
Key Derivation Function	ARIA_128_CTR_PRF (Section 3)
Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_128_GCM
AEAD authentication tag length	64 bits

Table 11: The AEAD_ARIA_128_GCM_8 Crypto Suite

Parameter	Value
Master key length	256 bits
Master salt length	96 bits
Key Derivation Function	ARIA_256_CTR_PRF (Section 3)
Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_256_GCM
AEAD authentication tag length	64 bits

Table 12: The AEAD_ARIA_256_GCM_8 Crypto Suite

Parameter	Value
Master key length	128 bits
Master salt length	96 bits
Key Derivation Function	ARIA_128_CTR_PRF (Section 3)
Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_128_GCM
AEAD authentication tag length	96 bits

Table 13: The AEAD_ARIA_128_GCM_12 Crypto Suite

Parameter	Value
Master key length	256 bits
Master salt length	96 bits
Key Derivation Function	ARIA_256_CTR_PRF (Section 3)
Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_256_GCM

| AEAD authentication tag length | 96 bits |

Table 14: The AEAD_ARIA_256_GCM_12 Crypto Suite

2.3. ARIA-CCM

CCM(Counter with CBC-MAC) [RFC3610][RFC5116] is another AEAD block cipher mode. A detailed description of ARIA-CCM is defined similarly as AES-CCM found in [RFC5116] [RFC6655] [I-D.ietf-avtcore-srtp-aes-gcm].

The internet draft [I-D.ietf-avtcore-srtp-aes-gcm] describes the use of AES-CCM with SRTP [RFC3711][RFC6904]. The use of ARIA-CCM with SRTP is defined the same as that of AES-CCM except that each invocation of AES is replaced by ARIA.

The ARIA-CCM algorithms in Table 15 may be used with SRTP and SRTCP:

Name	Enc. Key Length	Auth. Tag Length
AEAD_ARIA_128_CCM	16 octets	16 octets
AEAD_ARIA_256_CCM	32 octets	16 octets
AEAD_ARIA_128_CCM_8	16 octets	8 octets
AEAD_ARIA_256_CCM_8	32 octets	8 octets
AEAD_ARIA_128_CCM_12	16 octets	12 octets
AEAD_ARIA_256_CCM_12	32 octets	12 octets

Table 15: ARIA-CCM Crypto Suites for SRTP/SRTCP

The parameters (from Table 16 to Table 21) in each crypto suite listed in Table 15 are described for use with the SDP Security Descriptions attributes [RFC4568].

Parameter	Value
Master key length	128 bits
Master salt length	96 bits
Key Derivation Function	ARIA_128_CTR_PRF (Section 3)
Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_128_CCM
AEAD authentication tag length	128 bits

Table 16: The AEAD_ARIA_128_CCM Crypto Suite

Parameter	Value
Master key length	256 bits
Master salt length	96 bits
Key Derivation Function	ARIA_256_CTR_PRF (Section 3)
Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_256_CCM
AEAD authentication tag length	128 bits

Table 17: The AEAD_ARIA_256_CCM Crypto Suite

Parameter	Value
Master key length	128 bits
Master salt length	96 bits
Key Derivation Function	ARIA_128_CTR_PRF (Section 3)
Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_128_CCM
AEAD authentication tag length	64 bits

Table 18: The AEAD_ARIA_128_CCM_8 Crypto Suite

Parameter	Value
Master key length	256 bits
Master salt length	96 bits
Key Derivation Function	ARIA_256_CTR_PRF (Section 3)

Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_256_CCM
AEAD authentication tag length	64 bits

Table 19: The AEAD_ARIA_256_CCM_8 Crypto Suite

Parameter	Value
Master key length	128 bits
Master salt length	96 bits
Key Derivation Function	ARIA_128_CTR_PRF (Section 3)
Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_128_CCM
AEAD authentication tag length	96 bits

Table 20: The AEAD_ARIA_128_CCM_12 Crypto Suite

Parameter	Value
Master key length	256 bits
Master salt length	96 bits
Key Derivation Function	ARIA_256_CTR_PRF (Section 3)
Default key lifetime (SRTP)	2^48 packets
Default key lifetime (SRTCP)	2^31 packets
Cipher (for SRTP and SRTCP)	ARIA_256_CCM
AEAD authentication tag length	96 bits

Table 21: The AEAD_ARIA_256_CCM_12 Crypto Suite

3. Key Derivation Functions

Section 4.3.3 of [RFC3711] defines the AES-128 counter mode key derivation function, which it refers to as "AES-CM PRF". Section 3 of [RFC6188] defines the AES-192 counter mode key derivation function and the AES-256 counter mode key derivation function, which it refers to as "AES_192_CM_PRF" and "AES_256_CM_PRF" respectively. The ARIA-CTR PRF is defined in a same manner except that each invocation of AES replaced by that of ARIA. According to the key lengths of underlying encryption algorithm, ARIA-CTR PRFs are denoted by "ARIA_128_CTR_PRF", "ARIA_192_CTR_PRF" and "ARIA_256_CTR_PRF". The usage requirements of [RFC6188][I-D.ietf-avtcore-srtp-aes-gcm]

regarding the AES-CM PRF apply to the ARIA-CTR PRF as well. The PRFs for ARIA crypto suites with SRTP are defined by ARIA-CTR PRF of the equal key length with the encryption algorithm (see Section 2). SRTP_ARIA_128_CTR_HMAC, SRTP_AEAD_ARIA_128_GCM, and SRTP_AEAD_ARIA_128_CCM MUST use the ARIA_128_CTR_PRF Key Derivation Function. SRTP_ARIA_192_CTR_HMAC MUST use that ARIA_192_CTR_PRF Key Derivation Function. And SRTP_ARIA_256_CTR_HMAC, SRTP_AEAD_ARIA_256_GCM, and SRTP_AEAD_ARIA_256_CCM MUST use the ARIA_256_CTR_PRF Key Derivation Function.

4. Security Considerations

At the time of writing this document no security problem has been found on ARIA (see [TSL]).

The security considerations in [RFC3610] [GCM] [RFC3711] [RFC5116] [RFC6188] [RFC6904] [I-D.ietf-avtcore-srtp-aes-gcm] apply to this document as well. Ciphersuites with short tag length may be considered for specific application environments stated in 7.5 of [RFC3711], but the risk of weak authentication described in Section 9.5.1 of [RFC3711] should be taken into account.

5. IANA Considerations

5.1. Security Descriptions (SDES)

SDP Security Descriptions [RFC4568] defines SRTP "crypto suites". In order to allow SDP to signal the use of the algorithms defined in this document, IANA is requested to add the below crypto suites to the "SRTP Crypto Suite Registrations" created by [RFC4568], at time of writing located on the following IANA page: http://www.iana.org/assignments/sdp-security-descriptions/sdp-security-descriptions.xml #sdp-security-descriptions-3 [1]

```
srtp-crypto-suite-ext = "ARIA_128_CTR_HMAC_SHA1_80"/
                        "ARIA_128_CTR_HMAC_SHA1_32"/
                        "ARIA_192_CTR_HMAC_SHA1_80"/
                        "ARIA_192_CTR_HMAC_SHA1_32"/
                        "ARIA_256_CTR_HMAC_SHA1_80"/
                        "ARIA_256_CTR_HMAC_SHA1_32"/
                        "AEAD_ARIA_128_GCM"        /
                        "AEAD_ARIA_256_GCM"        /
                        "AEAD_ARIA_128_GCM_8"      /
                        "AEAD_ARIA_256_GCM_8"      /
                        "AEAD_ARIA_128_GCM_12"     /
                        "AEAD_ARIA_256_GCM_12"     /
                        "AEAD_ARIA_128_CCM"        /
                        "AEAD_ARIA_256_CCM"        /
```

```
                                    "AEAD_ARIA_128_CCM_8"      /
                                    "AEAD_ARIA_256_CCM_8"      /
                                    "AEAD_ARIA_128_CCM_12"     /
                                    "AEAD_ARIA_256_CCM_12"     /
                                    srtp-crypto-suite-ext
```

5.2. DTLS-SRTP

DTLS-SRTP [RFC5764] defines a DTLS-SRTP "SRTP Protection Profile". In order to allow the use of the algorithms defined in this document in DTLS-SRTP, IANA is requested to add the below crypto suite to the "DTLS-SRTP Protection Profiles" created by [RFC5764], at time of writing located on the following IANA page: http://www.iana.org/assignments/srtp-protection/srtp-protection.xml#srtp-protection-1 [2].

```
SRTP_ARIA_128_CTR_HMAC_SHA1_80 = {TBD,TBD}
SRTP_ARIA_128_CTR_HMAC_SHA1_32 = {TBD,TBD}
SRTP_ARIA_192_CTR_HMAC_SHA1_80 = {TBD,TBD}
SRTP_ARIA_192_CTR_HMAC_SHA1_32 = {TBD,TBD}
SRTP_ARIA_256_CTR_HMAC_SHA1_80 = {TBD,TBD}
SRTP_ARIA_256_CTR_HMAC_SHA1_32 = {TBD,TBD}
SRTP_AEAD_ARIA_128_GCM = {TBD,TBD}
SRTP_AEAD_ARIA_256_GCM = {TBD,TBD}
SRTP_AEAD_ARIA_128_GCM_8 = {TBD,TBD}
SRTP_AEAD_ARIA_256_GCM_8 = {TBD,TBD}
SRTP_AEAD_ARIA_128_GCM_12 = {TBD,TBD}
SRTP_AEAD_ARIA_256_GCM_12 = {TBD,TBD}
SRTP_AEAD_ARIA_128_CCM = {TBD,TBD}
SRTP_AEAD_ARIA_256_CCM = {TBD,TBD}
SRTP_AEAD_ARIA_128_CCM_8 = {TBD,TBD}
SRTP_AEAD_ARIA_256_CCM_8 = {TBD,TBD}
SRTP_AEAD_ARIA_128_CCM_12 = {TBD,TBD}
SRTP_AEAD_ARIA_256_CCM_12 = {TBD,TBD}
```

The following list indicates the SRTP transform parameters for each protection profile. The parameters cipher_key_length, cipher_salt_length, auth_key_length, and auth_tag_length express the number of bits in the values to which they refer. The maximum_lifetime parameter indicates the maximum number of packets that can be protected with each single set of keys when the parameter profile is in use. All of these parameters apply to both RTP and RTCP, unless the RTCP parameters are separately specified.

```
SRTP_ARIA_128_CTR_HMAC_SHA1_80
    cipher:                   ARIA_128_CTR
    cipher_key_length:        128 bits
```

```
        cipher_salt_length:       112 bits
        maximum_lifetime:         2^31 packets
        key derivation function:  ARIA_128_CTR_PRF
        auth_function:            HMAC-SHA1
        auth_key_length:          160 bits
        auth_tag_length:          80 bits

    SRTP_ARIA_128_CTR_HMAC_SHA1_32
        cipher:                   ARIA_128_CTR
        cipher_key_length:        128 bits
        cipher_salt_length:       112 bits
        maximum_lifetime:         2^31 packets
        key derivation function:  ARIA_128_CTR_PRF
        auth_function:            HMAC-SHA1
        auth_key_length:          160 bits
        SRTP auth_tag_length:     32 bits
        SRTCP auth_tag_length:    80 bits

    SRTP_ARIA_192_CTR_HMAC_SHA1_80
        cipher:                   ARIA_192_CTR
        cipher_key_length:        192 bits
        cipher_salt_length:       112 bits
        maximum_lifetime:         2^31 packets
        key derivation function:  ARIA_192_CTR_PRF
        auth_function:            HMAC-SHA1
        auth_key_length:          160 bits
        auth_tag_length:          80 bits

    SRTP_ARIA_192_CTR_HMAC_SHA1_32
        cipher:                   ARIA_192_CTR
        cipher_key_length:        192 bits
        cipher_salt_length:       112 bits
        maximum_lifetime:         2^31 packets
        key derivation function:  ARIA_192_CTR_PRF
        auth_function:            HMAC-SHA1
        auth_key_length:          160 bits
        SRTP auth_tag_length:     32 bits
        SRTCP auth_tag_length:    80 bits

    SRTP_ARIA_256_CTR_HMAC_SHA1_80
        cipher:                   ARIA_256_CTR
        cipher_key_length:        256 bits
        cipher_salt_length:       112 bits
        maximum_lifetime:         2^31 packets
        key derivation function:  ARIA_256_CTR_PRF
        auth_function:            HMAC-SHA
        auth_key_length:          160 bits
        auth_tag_length:          80 bits
```

```
SRTP_ARIA_256_CTR_HMAC_SHA1_32
    cipher:                    ARIA_256_CTR
    cipher_key_length:         128 bits
    cipher_salt_length:        112 bits
    maximum_lifetime:          2^31 packets
    key derivation function:   ARIA_256_CTR_PRF
    auth_function:             HMAC-SHA1
    auth_key_length:           160 bits
    SRTP auth_tag_length:      32 bits
    SRTCP auth_tag_length:     80 bits

SRTP_AEAD_ARIA_128_CCM
    cipher:                    ARIA_128_CCM
    cipher_key_length:         128 bits
    cipher_salt_length:        96 bits
    aead_auth_tag_length:      128 bits
    auth_function:             NULL
    auth_key_length:           N/A
    auth_tag_length:           N/A
    key derivation function:   ARIA_128_CTR_PRF
    maximum_lifetime:          at most 2^31 SRTCP packets and
                               at most 2^48 SRTP packets

SRTP_AEAD_ARIA_256_CCM
    cipher:                    ARIA_256_CCM
    cipher_key_length:         256 bits
    cipher_salt_length:        96 bits
    aead_auth_tag_length:      128 bits
    auth_function:             NULL
    auth_key_length:           N/A
    auth_tag_length:           N/A
    key derivation function:   ARIA_256_CTR_PRF
    maximum_lifetime:          at most 2^31 SRTCP packets and
                               at most 2^48 SRTP packets

SRTP_AEAD_ARIA_128_CCM_8
    cipher:                    ARIA_128_CCM
    cipher_key_length:         128 bits
    cipher_salt_length:        96 bits
    aead_auth_tag_length:      64 bits
    auth_function:             NULL
    auth_key_length:           N/A
    auth_tag_length:           N/A
    key derivation function:   ARIA_128_CTR_PRF
    maximum_lifetime:          at most 2^31 SRTCP packets and
                               at most 2^48 SRTP packets

SRTP_AEAD_ARIA_256_CCM_8
```

```
        cipher:                    ARIA_256_CCM
        cipher_key_length:         256 bits
        cipher_salt_length:        96 bits
        aead_auth_tag_length:      64 bits
        auth_function:             NULL
        auth_key_length:           N/A
        auth_tag_length:           N/A
        key derivation function:   ARIA_256_CTR_PRF
        maximum_lifetime:          at most 2^31 SRTCP packets and
                                   at most 2^48 SRTP packets

    SRTP_AEAD_ARIA_128_CCM_12
        cipher:                    ARIA_128_CCM
        cipher_key_length:         128 bits
        cipher_salt_length:        96 bits
        aead_auth_tag_length:      96 bits
        auth_function:             NULL
        auth_key_length:           N/A
        auth_tag_length:           N/A
        key derivation function:   ARIA_128_CTR_PRF
        maximum_lifetime:          at most 2^31 SRTCP packets and
                                   at most 2^48 SRTP packets

    SRTP_AEAD_ARIA_256_CCM_12
        cipher:                    ARIA_256_CCM
        cipher_key_length:         256 bits
        cipher_salt_length:        96 bits
        aead_auth_tag_length:      96 bits
        auth_function:             NULL
        auth_key_length:           N/A
        auth_tag_length:           N/A
        key derivation function:   ARIA_256_CTR_PRF
        maximum_lifetime:          at most 2^31 SRTCP packets and
                                   at most 2^48 SRTP packets

    SRTP_AEAD_ARIA_128_GCM
        cipher:                    ARIA_128_GCM
        cipher_key_length:         128 bits
        cipher_salt_length:        96 bits
        aead_auth_tag_length:      128 bits
        auth_function:             NULL
        auth_key_length:           N/A
        auth_tag_length:           N/A
        key derivation function:   ARIA_128_CTR_PRF
        maximum_lifetime:          at most 2^31 SRTCP packets and
                                   at most 2^48 SRTP packets

    SRTP_AEAD_ARIA_256_GCM
```

```
        cipher:                    ARIA_256_GCM
        cipher_key_length:         256 bits
        cipher_salt_length:        96 bits
        aead_auth_tag_length:      128 bits
        auth_function:             NULL
        auth_key_length:           N/A
        auth_tag_length:           N/A
        key derivation function:   ARIA_256_CTR_PRF
        maximum_lifetime:          at most 2^31 SRTCP packets and
                                   at most 2^48 SRTP packets

    SRTP_AEAD_ARIA_128_GCM_8
        cipher:                    ARIA_128_GCM
        cipher_key_length:         128 bits
        cipher_salt_length:        96 bits
        aead_auth_tag_length:      64 bits
        auth_function:             NULL
        auth_key_length:           N/A
        auth_tag_length:           N/A
        key derivation function:   ARIA_128_CTR_PRF
        maximum_lifetime:          at most 2^31 SRTCP packets and
                                   at most 2^48 SRTP packets

    SRTP_AEAD_ARIA_256_GCM_8
        cipher:                    ARIA_256_GCM
        cipher_key_length:         256 bits
        cipher_salt_length:        96 bits
        aead_auth_tag_length:      64 bits
        auth_function:             NULL
        auth_key_length:           N/A
        auth_tag_length:           N/A
        key derivation function:   ARIA_256_CTR_PRF
        maximum_lifetime:          at most 2^31 SRTCP packets and
                                   at most 2^48 SRTP packets

    SRTP_AEAD_ARIA_128_GCM_12
        cipher:                    ARIA_128_GCM
        cipher_key_length:         128 bits
        cipher_salt_length:        96 bits
        aead_auth_tag_length:      96 bits
        auth_function:             NULL
        auth_key_length:           N/A
        auth_tag_length:           N/A
        key derivation function:   ARIA_128_CTR_PRF
        maximum_lifetime:          at most 2^31 SRTCP packets and
                                   at most 2^48 SRTP packets

    SRTP_AEAD_ARIA_256_GCM_12
```

```
cipher:                    ARIA_256_GCM
cipher_key_length:         256 bits
cipher_salt_length:        96 bits
aead_auth_tag_length:      96 bits
auth_function:             NULL
auth_key_length:           N/A
auth_tag_length:           N/A
key derivation function:   ARIA_256_CTR_PRF
maximum_lifetime:          at most 2^31 SRTCP packets and
                           at most 2^48 SRTP packets
```

Note that these SRTP Protection Profiles do not specify an auth_function, auth_key_length, or auth_tag_length because all of these profiles use AEAD algorithms, and thus do not use a separate auth_function, auth_key, or auth_tag. The term aead_auth_tag_length is used to emphasize that this refers to the authentication tag provided by the AEAD algorithm and that this tag is not located in the authentication tag field provided by SRTP/SRTCP.

5.3. MIKEY

[RFC3830] and [RFC5748] define encryption algorithms and PRFs for the SRTP policy in MIKEY. In order to allow the use of the algorithms defined in this document in MIKEY, IANA is requested to add the below crypto suites to the "MIKEY Security Protocol Parameters SRTP Type 0 (Encryption algorithm)" and to add the below PRF to the "MIKEY Security Protocol Parameters SRTP Type 5 (Pseudo Random Function)" created by [RFC3830], at time of writing located on the following IANA page: http://www.iana.org/assignments/mikey-payloads/mikey-payloads.xml#mikey-payloads-26 [3].

SRTP Enc. alg	Value
ARIA-CTR	TBD
ARIA-CCM	TBD
ARIA-GCM	TBD

Default session encryption key length is 16 octets.

SRTP PRF	Value
ARIA-CTR	TBD

MIKEY specifies the algorithm family separately from the key length (which is specified by the Session Encryption key length) and the authentication tag length.

	Encryption Algorithm	Encryption Key Length	Auth. Tag Length
SRTP_ARIA_128_CTR_HMAC_80	ARIA-CTR	16 octets	10 octets
SRTP_ARIA_128_CTR_HMAC_32	ARIA-CTR	16 octets	4 octets
SRTP_ARIA_192_CTR_HMAC_80	ARIA-CTR	24 octets	10 octets
SRTP_ARIA_192_CTR_HMAC_32	ARIA-CTR	24 octets	4 octets
SRTP_ARIA_256_CTR_HMAC_80	ARIA-CTR	32 octets	10 octets
SRTP_ARIA_256_CTR_HMAC_32	ARIA-CTR	32 octets	4 octets

Figure 1: Mapping MIKEY parameters to ARIA-CTR with HMAC algorithm

	Encryption Algorithm	Encryption Key Length	AEAD Auth. Tag Length
SRTP_AEAD_ARIA_128_GCM	ARIA-GCM	16 octets	16 octets
SRTP_AEAD_ARIA_128_CCM	ARIA-CCM	16 octets	16 octets
SRTP_AEAD_ARIA_128_GCM_12	ARIA-GCM	16 octets	12 octets
SRTP_AEAD_ARIA_128_CCM_12	ARIA-CCM	16 octets	12 octets
SRTP_AEAD_ARIA_128_GCM_8	ARIA-GCM	16 octets	8 octets
SRTP_AEAD_ARIA_128_CCM_8	ARIA-CCM	16 octets	8 octets
SRTP_AEAD_ARIA_256_GCM	ARIA-GCM	32 octets	16 octets
SRTP_AEAD_ARIA_256_CCM	ARIA-CCM	32 octets	16 octets
SRTP_AEAD_ARIA_256_GCM_12	ARIA-GCM	32 octets	12 octets
SRTP_AEAD_ARIA_256_CCM_12	ARIA-CCM	32 octets	12 octets
SRTP_AEAD_ARIA_256_GCM_8	ARIA-GCM	32 octets	8 octets
SRTP_AEAD_ARIA_256_CCM_8	ARIA-CCM	32 octets	8 octets

Figure 2: Mapping MIKEY parameters to AEAD algorithm

6. References

6.1. Normative References

[GCM] Dworkin, M., "Recommendation for Block Cipher Modes of Operation: Galois/Counter Mode (GCM) and GMAC", NIST SP 800-38D, November 2007.

[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", STD 64, RFC 3550, July 2003.

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

[RFC3830] Arkko, J., Carrara, E., Lindholm, F., Naslund, M., and K. Norrman, "MIKEY: Multimedia Internet KEYing", RFC 3830, August 2004.

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

[RFC5116] McGrew, D., "An Interface and Algorithms for Authenticated Encryption", RFC 5116, January 2008.

[RFC5282] Black, D. and D. McGrew, "Using Authenticated Encryption Algorithms with the Encrypted Payload of the Internet Key Exchange version 2 (IKEv2) Protocol", RFC 5282, August 2008.

[RFC5764] McGrew, D. and E. Rescorla, "Datagram Transport Layer Security (DTLS) Extension to Establish Keys for the Secure Real-time Transport Protocol (SRTP)", RFC 5764, May 2010.

[RFC6188] McGrew, D., "The Use of AES-192 and AES-256 in Secure RTP", RFC 6188, March 2011.

[RFC6655] McGrew, D. and D. Bailey, "AES-CCM Cipher Suites for Transport Layer Security (TLS)", RFC 6655, July 2012.

[RFC6904] Lennox, J., "Encryption of Header Extensions in the Secure Real-time Transport Protocol (SRTP)", RFC 6904, April 2013.

6.2. Informative References

[ARIAKS] Korean Agency for Technology and Standards, "128 bit block encryption algorithm ARIA - Part 1: General (in Korean)", KS X 1213-1:2009, December 2009.

[ARIAPKCS] RSA Laboratories, "Additional PKCS #11 Mechanisms", PKCS #11 v2.20 Amendment 3 Revision 1, January 2007.

[I-D.ietf-avtcore-srtp-aes-gcm] McGrew, D. and K. Igoe, "AES-GCM and AES-CCM Authenticated Encryption in Secure RTP (SRTP)", draft-ietf-avtcore-srtp-aes-gcm-10 (work in progress), September 2013.

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

[RFC5748] Yoon, S., Jeong, J., Kim, H., Jeong, H., and Y. Won, "IANA Registry Update for Support of the SEED Cipher Algorithm in Multimedia Internet KEYing (MIKEY)", RFC 5748, August 2010.

[RFC5794] Lee, J., Lee, J., Kim, J., Kwon, D., and C. Kim, "A Description of the ARIA Encryption Algorithm", RFC 5794, March 2010.

[TSL] Tang, X., Sun, B., Li, R., Li, C., and J. Yin, "A meet-in-the-middle attack on reduced-round ARIA", The Journal of Systems and Software Vol.84(10), pp. 1685-1692, October 2011.

Appendix A. Test Vectors

All values are in hexadecimal and represented by the network order (called big endian).

A.1. ARIA-CTR Test Vectors

Common values are organized as follows:

```
Rollover Counter:          00000000
Sequence Number:           315e
SSRC:                      20e8f5eb
Authentication Key:        f93563311b354748c9789137955306311645230 9
Session Salt:              cd3a7c42c671e0067a2a2639b43a
Initialization Vector:     cd3a7c42e69915ed7a2a263985640000
RTP header:                8008315ebf2e6fe020e8f5eb
```

```
RTP Payload:                f57af5fd4ae19562976ec57a5a7ad55a
                            5af5c5e5c5fdf5c55ad57a4a7272d572
                            62e9729566ed66e97ac54a4a5a7ad5e1
                            5ae5fdd5fd5ac5d56ae56ad5c572d54a
                            e54ac55a956afd6aed5a4ac562957a95
                            16991691d572fd14e97ae962ed7a9f4a
                            955af572e162f57a956666e17ae1f54a
                            95f566d54a66e16e4afd6a9f7ae1c5c5
                            5ae5d56afde916c5e94a6ec56695e14a
                            fde1148416e94ad57ac5146ed59d1cc5
```

A.1.1. ARIA_128_CTR_HMAC_SHA1_80

```
Session Key:                0c5ffd37a11edc42c325287fc0604f2e

Encrypted RTP Payload:      1bf753f412e6f35058cc398dc851aae3
                            a6ccdcb463fbed9cfb3de2fb76fdffa9
                            e481f5efb64c92487f59dabbc7cc72da
                            092485f3fbad87888820b86037311fa4
                            4330e18a59a1e1338ba2c21458493a57
                            463475c54691f91cec785429119e0dfc
                            d9048f90e07fecd50b528e8c62ee6e71
                            445de5d7f659405135aff3604c2ca4ff
                            4aaca40809cb9eee42cc4ad232307570
                            81ca289f2851d3315e9568b501fdce6d

Authenticated portion || Rollover Counter:
                            8008315ebf2e6fe020e8f5eb1bf753f4
                            12e6f35058cc398dc851aae3a6ccdcb4
                            63fbed9cfb3de2fb76fdffa9e481f5ef
                            b64c92487f59dabbc7cc72da092485f3
                            fbad87888820b86037311fa44330e18a
                            59a1e1338ba2c21458493a57463475c5
                            4691f91cec785429119e0dfcd9048f90
                            e07fecd50b528e8c62ee6e71445de5d7
                            f659405135aff3604c2ca4ff4aaca408
                            09cb9eee42cc4ad23230757081ca289f
                            2851d3315e9568b501fdce6d00000000

Authentication Tag:         f9de4e729054672b0e35
```

A.1.2. ARIA_192_CTR_HMAC_SHA1_80

```
Session Key:                0c5ffd37a11edc42c325287fc0604f2e
                            3e8cd5671a00fe32

Encrypted RTP Payload:      86f4556486642caa67e9b40fef2acda0
                            6d442517d8d58c15e3e0b5c13a78b8b2
                            838b7b96961e11acb2af81348272888c
                            fd9d168ba091fe3e4f7f83c7871570a9
                            aa9f995036e44c35cb742b601e8d8d08
                            48320bad732929103f1bfbb1ae873178
                            0479c5df2d4d41f78f6b96d6832db3db
                            6af8b3612b27e18a0a29a8a1d280437e
                            b8dad58e78658ec3b069d7329431c356
                            c5e612b3dde5bd3f6c9f42f39cf35d3a

Authenticated portion || Rollover Counter:
                            8008315ebf2e6fe020e8f5eb86f45564
                            86642caa67e9b40fef2acda06d442517
                            d8d58c15e3e0b5c13a78b8b2838b7b96
                            961e11acb2af81348272888cfd9d168b
                            a091fe3e4f7f83c7871570a9aa9f9950
                            36e44c35cb742b601e8d8d0848320bad
                            732929103f1bfbb1ae8731780479c5df
                            2d4d41f78f6b96d6832db3db6af8b361
                            2b27e18a0a29a8a1d280437eb8dad58e
                            78658ec3b069d7329431c356c5e612b3
                            dde5bd3f6c9f42f39cf35d3a00000000

Authentication Tag:         3935fa37ee96dbc550d5
```

A.1.3. ARIA_256_CTR_HMAC_SHA1_80

```
Session Key:                0c5ffd37a11edc42c325287fc0604f2e
                            3e8cd5671a00fe3216aa5eb105783b54

Encrypted RTP Payload:      c424c59fd5696305e5b13d8e8ca76566
                            17ccd7471088af9debf07b55c750f804
                            a5ac2b737be48140958a9b420524112a
                            e72e4da5bca59d2b1019ddd7dbdc30b4
                            3d5f046152ced40947d62d2c93e7b8e5
                            0f02db2b6b61b010e4c1566884de1fa9
                            702cdf8157e8aedfe3dd77c76bb50c25
                            ae4d624615c15acfdeeb5f79482aaa01
                            d3e4c05eb601eca2bd10518e9d46b021
                            16359232e9eac0fabd05235dd09e6dea
```

```
Authenticated portion || Rollover Counter:
                         8008315ebf2e6fe020e8f5ebc424c59f
                         d5696305e5b13d8e8ca7656617ccd747
                         1088af9debf07b55c750f804a5ac2b73
                         7be48140958a9b420524112ae72e4da5
                         bca59d2b1019ddd7dbdc30b43d5f0461
                         52ced40947d62d2c93e7b8e50f02db2b
                         6b61b010e4c1566884de1fa9702cdf81
                         57e8aedfe3dd77c76bb50c25ae4d6246
                         15c15acfdeeb5f79482aaa01d3e4c05e
                         b601eca2bd10518e9d46b02116359232
                         e9eac0fabd05235dd09e6dea00000000

Authentication Tag:      192f515fab04bbb4e62c
```

A.2. ARIA-GCM Test Vectors

Common values are organized as follows:

```
Rollover Counter:        00000000
Sequence Number:         315e
SSRC:                    20e8f5eb
Encryption Salt:         000000000000000000000000

Initialization Vector:   000020e8f5eb00000000315e
RTP Payload:             f57af5fd4ae19562976ec57a5a7ad55a
                         5af5c5e5c5fdf5c55ad57a4a7272d572
                         62e9729566ed66e97ac54a4a5a7ad5e1
                         5ae5fdd5fd5ac5d56ae56ad5c572d54a
                         e54ac55a956afd6aed5a4ac562957a95
                         16991691d572fd14e97ae962ed7a9f4a
                         955af572e162f57a956666e17ae1f54a
                         95f566d54a66e16e4afd6a9f7ae1c5c5
                         5ae5d56afde916c5e94a6ec56695e14a
                         fde1148416e94ad57ac5146ed59d1cc5
Associated Data:         8008315ebf2e6fe020e8f5eb
```

The length of encrypted payload is larger than that of payload by 16 octets which the length of the tag from GCM. For other GCM ciphersuites with shorter tag length than 16 octets, test vectors can be obtained by truncation from ARIA-GCM test verctors.

A.2.1. ARIA_128_GCM

```
Key:                     e91e5e75da65554a48181f3846349562
```

```
Encrypted RTP Payload:     4d8a9a0675550c704b17d8c9ddc81a5c
                           d6f7da34f2fe1b3db7cb3dfb9697102e
                           a0f3c1fc2dbc873d44bceeae8e444297
                           4ba21ff6789d3272613fb9631a7cf3f1
                           4bacbeb421633a90ffbe58c2fa6bdca5
                           34f10d0de0502ce1d531b6336e588782
                           78531e5c22bc6c85bbd784d78d9e680a
                           a19031aaf89101d669d7a3965c1f7e16
                           229d7463e0535f4e253f5d18187d40b8
                           ae0f564bd970b5e7e2adfb211e89a953
                           5abace3f37f5a736f4be984bbffbedc1
```

A.2.2. ARIA_256_GCM

```
Key:                       0c5ffd37a11edc42c325287fc0604f2e
                           3e8cd5671a00fe3216aa5eb105783b54

Encrypted RTP Payload:     6f9e4bcbc8c85fc0128fb1e4a0a20cb9
                           932ff74581f54fc013dd054b19f99371
                           425b352d97d3f337b90b63d1b082adee
                           ea9d2d7391897d591b985e55fb50cb53
                           50cf7d38dc27dda127c078a149c8eb98
                           083d66363a46e3726af217d3a00275ad
                           5bf772c7610ea4c23006878f0ee69a83
                           97703169a419303f40b72e4573714d19
                           e2697df61e7c7252e5abc6bade876ac4
                           961bfac4d5e867afca351a48aed52822
                           e210d6ced2cf430ff841472915e7ef48
```

A.3. ARIA-CCM Test Vectors

Common values are organized as follows:

```
Rollover Counter:          00000000
Sequence Number:           315e
SSRC:                      20e8f5eb
Encryption Salt:           000000000000000000000000

Initialization Vector:     000020e8f5eb00000000315e
RTP Payload:               f57af5fd4ae19562976ec57a5a7ad55a
                           5af5c5e5c5fdf5c55ad57a4a7272d572
                           62e9729566ed66e97ac54a4a5a7ad5e1
                           5ae5fdd5fd5ac5d56ae56ad5c572d54a
                           e54ac55a956afd6aed5a4ac562957a95
                           16991691d572fd14e97ae962ed7a9f4a
                           955af572e162f57a956666e17ae1f54a
```

```
                                95f566d54a66e16e4afd6a9f7ae1c5c5
                                5ae5d56afde916c5e94a6ec56695e14a
                                fde1148416e94ad57ac5146ed59d1cc5
      Associated Data:          8008315ebf2e6fe020e8f5eb
```

The length of encrypted payload is larger than that of payload by the tag length defined for each ciphersuite.

A.3.1. ARIA_128_CCM

```
      Key:                      974bee725d44fc3992267b284c3c6750

      Encrypted RTP Payload:    621e408a2e455505b39f704dcbac4307
                                daabbd6d670abc4e42f2fd2fca263f09
                                4f4683e6fb0b10c5093d42b69dce0ba5
                                46520e7c4400975713f3bde93ef13116
                                0b9cbcd6df78a1502be7c6ea8d395b9e
                                d0078819c3105c0ab92cb67b16ba51bb
                                1f53508738bf7a37c9a905439b88b7af
                                9d51a407916fdfea8d43bf253721846d
                                c1671391225fc58d9d0693c8ade6a4ff
                                b034ee6543dd4e651b7a084eae60f855
                                40f04b6467e300f6b336aedf9df4185b
```

A.3.2. ARIA_256_CCM

```
      Key:                      0c5ffd37a11edc42c325287fc0604f2e
                                3e8cd5671a00fe3216aa5eb105783b54

      Encrypted RTP Payload:    ff78128ee18ee3cb9fb0d20726a017ff
                                67fbd09d3a4c38aa32f6d306d3fdda37
                                8e459b83ed005507449d6cd981a4c1e3
                                ff4193870c276ef09b6317a01a228320
                                6ae4b4be0d0b235422c8abb001224106
                                56b75e1ffc7fb49c0d0c5d6169aa7623
                                610579968037aee8e83fc26264ea8665
                                90fd620aa3c0a5f323d953aa7f8defb0
                                d0d60ab5a9de44dbaf8eae74ea3ab5f3
                                0594154f405fd630aa4c4d5603efdfa1
                                87b6bd222c55365a9c7d0b215b77ea41
```

A.3.3. ARIA_128_CCM_8

```
      Key:                      974bee725d44fc3992267b284c3c6750
```

```
Encrypted RTP Payload:     621e408a2e455505b39f704dcbac4307
                           daabbd6d670abc4e42f2fd2fca263f09
                           4f4683e6fb0b10c5093d42b69dce0ba5
                           46520e7c4400975713f3bde93ef13116
                           0b9cbcd6df78a1502be7c6ea8d395b9e
                           d0078819c3105c0ab92cb67b16ba51bb
                           1f53508738bf7a37c9a905439b88b7af
                           9d51a407916fdfea8d43bf253721846d
                           c1671391225fc58d9d0693c8ade6a4ff
                           b034ee6543dd4e651b7a084eae60f855
                           dd2282c93a67fe4b
```

A.3.4. ARIA_256_CCM_8

```
Key:                       0c5ffd37a11edc42c325287fc0604f2e
                           3e8cd5671a00fe3216aa5eb105783b54

Encrypted RTP Payload:     ff78128ee18ee3cb9fb0d20726a017ff
                           67fbd09d3a4c38aa32f6d306d3fdda37
                           8e459b83ed005507449d6cd981a4c1e3
                           ff4193870c276ef09b6317a01a228320
                           6ae4b4be0d0b235422c8abb001224106
                           56b75e1ffc7fb49c0d0c5d6169aa7623
                           610579968037aee8e83fc26264ea8665
                           90fd620aa3c0a5f323d953aa7f8defb0
                           d0d60ab5a9de44dbaf8eae74ea3ab5f3
                           0594154f405fd630aa4c4d5603efdfa1
                           828dc0088f99a7ef
```

A.3.5. ARIA_128_CCM_12

```
Key:                       974bee725d44fc3992267b284c3c6750

Encrypted RTP Payload:     621e408a2e455505b39f704dcbac4307
                           daabbd6d670abc4e42f2fd2fca263f09
                           4f4683e6fb0b10c5093d42b69dce0ba5
                           46520e7c4400975713f3bde93ef13116
                           0b9cbcd6df78a1502be7c6ea8d395b9e
                           d0078819c3105c0ab92cb67b16ba51bb
                           1f53508738bf7a37c9a905439b88b7af
                           9d51a407916fdfea8d43bf253721846d
                           c1671391225fc58d9d0693c8ade6a4ff
                           b034ee6543dd4e651b7a084eae60f855
                           01f3dedd15238da5ebfb1590
```

A.3.6. ARIA_256_CCM_12

```
Key:                        0c5ffd37a11edc42c325287fc0604f2e
                            3e8cd5671a00fe3216aa5eb105783b54

Encrypted RTP Payload:      ff78128ee18ee3cb9fb0d20726a017ff
                            67fbd09d3a4c38aa32f6d306d3fdda37
                            8e459b83ed005507449d6cd981a4c1e3
                            ff4193870c276ef09b6317a01a228320
                            6ae4b4be0d0b235422c8abb001224106
                            56b75e1ffc7fb49c0d0c5d6169aa7623
                            610579968037aee8e83fc26264ea8665
                            90fd620aa3c0a5f323d953aa7f8defb0
                            d0d60ab5a9de44dbaf8eae74ea3ab5f3
                            0594154f405fd630aa4c4d5603efdfa1
                            3615b7f90a651de15da20fb6
```

A.4. Key Derivation Test Vector

This section provides test vectors for the default key derivation function, which uses ARIA in Counter Mode. In the following, we walk through the initial key derivation for the ARIA Counter Mode cipher, which requires a 16/24/32 octet session encryption key according to the session encryption key length and a 14 octet session salt, and an authentication function which requires a 94 octet session authentication key. These values are called the cipher key, the cipher salt, and the auth key in the following. The test vectors are generated in the same way with the test vectors of key derivation functions in [RFC3711] and [RFC6188] but with each invocation of AES replaced with an invocation of ARIA.

A.4.1. ARIA_128

The inputs to the key derivation function are the 16 octet master key and the 14 octet master salt:

```
master key:  e1f97a0d3e018be0d64fa32c06de4139
master salt: 0ec675ad498afeebb6960b3aabe6

index DIV kdr:                 000000000000
label:                       00
master salt:   0ec675ad498afeebb6960b3aabe6
-----------------------------------------------
xor:           0ec675ad498afeebb6960b3aabe6     (x, PRF input)

x*2^16:        0ec675ad498afeebb6960b3aabe60000 (ARIA-CTR input)
```

```
  cipher key:    dbd85a3c4d9219b3e81f7d942e299de4 (ARIA-CTR output)
```

ARIA-CTR crypto suite requires 14 octet cipher salt while ARIA-CCM and ARIA-GCM crypto suites require 12 octet cipher salt.

```
  index DIV kdr:                 000000000000
  label:                       02
  master salt:   0ec675ad498afeebb6960b3aabe6
  ----------------------------------------------
  xor:           0ec675ad498afee9b6960b3aabe6     (x, PRF input)

  x*2^16:        0ec675ad498afee9b6960b3aabe60000 (ARIA-CTR input)

                 9700657f5f34161830d7d85f5dc8be7f (ARIA-CTR output)

  cipher salt:   9700657f5f34161830d7d85f5dc8     (ARIA-CTR cipher
  suite)
                 9700657f5f34161830d7d85f         (ARIA-CCM or
  ARIA-GCM cipher suite)
  index DIV kdr:                 000000000000
  label:                       01
  master salt:   0ec675ad498afeebb6960b3aabe6
  ----------------------------------------------
  xor:           0ec675ad498afeeab6960b3aabe6     (x, PRF input)

  x*2^16:        0ec675ad498afeeab6960b3aabe60000 (ARIA-CTR input)
```

Below, the auth key is shown on the left, while the corresponding ARIA input blocks are shown on the right.

```
  auth key                          ARIA input blocks

  d021877bd3eaf92d581ed70ddc050e03  0ec675ad498afeeab6960b3aabe60000
  f11257032676f2a29f57b21abd3a1423  0ec675ad498afeeab6960b3aabe60001
  769749bdc5dd9ca5b43ca6b6c1f3a7de  0ec675ad498afeeab6960b3aabe60002
  4047904bcf811f601cc03eaa5d7af6db  0ec675ad498afeeab6960b3aabe60003
  9f88efa2e51ca832fc2a15b126fa7be2  0ec675ad498afeeab6960b3aabe60004
  469af896acb1852c31d822c45799      0ec675ad498afeeab6960b3aabe60005
```

A.4.2. ARIA_192

The inputs to the key derivation function are the 24 octet master key and the 14 octet master salt:

```
master key:  0c5ffd37a11edc42c325287fc0604f2e3e8cd5671a00fe32
master salt: 0ec675ad498afeebb6960b3aabe6

index DIV kdr:               000000000000
label:                     00
master salt: 0ec675ad498afeebb6960b3aabe6
-----------------------------------------------
xor:         0ec675ad498afeebb6960b3aabe6     (x, PRF input)

x*2^16:      0ec675ad498afeebb6960b3aabe60000 (ARIA-CTR input)

cipher key:  f320af2386a1cde64c3aa5f55d68002e (ARIA-CTR 1st output)
             d13cbe548b627649                 (ARIA-CTR 2nd Output)
```

ARIA-CTR cipher suite requires 14 octet cipher salt while ARIA-CCM and ARIA-GCM cipher suites require 12 octet cipher salt.

```
index DIV kdr:               000000000000
label:                     02
master salt:  0ec675ad498afeebb6960b3aabe6
-----------------------------------------------
xor:          0ec675ad498afee9b6960b3aabe6     (x, PRF input)

x*2^16:       0ec675ad498afee9b6960b3aabe60000 (ARIA-CTR input)

              55c7e3555baf0fdc91c589cfb871b098 (ARIA-CTR output)

cipher salt:  55c7e3555baf0fdc91c589cfb871     (ARIA-CTR cipher
suite)
              55c7e3555baf0fdc91c589cf         (ARIA-CCM or
ARIA-GCM cipher suite)

index DIV kdr:               000000000000
label:                     01
master salt:  0ec675ad498afeebb6960b3aabe6
-----------------------------------------------
xor:          0ec675ad498afeeab6960b3aabe6     (x, PRF input)

x*2^16:       0ec675ad498afeeab6960b3aabe60000 (ARIA-CTR input)
```

Below, the auth key is shown on the left, while the corresponding ARIA input blocks are shown on the right.

```
 auth key                           ARIA input blocks

116902524517f7e767a979ad7678d53a   0ec675ad498afeeab6960b3aabe60000
```

```
8cae05a5c9a315d1304f634c81a06617   0ec675ad498afeeab6960b3aabe60001
31fe099d4dcd2202421fe01fc12c65ad   0ec675ad498afeeab6960b3aabe60002
009e920031654855af5d9e820a7831e0   0ec675ad498afeeab6960b3aabe60003
bc2b4744d2a33053eb685138252f2d82   0ec675ad498afeeab6960b3aabe60004
9a89f4a9aa4f97fde0cce9bad3d5       0ec675ad498afeeab6960b3aabe60005
```

A.4.3. ARIA_256

The inputs to the key derivation function are the 32 octet master key and the 14 octet master salt:

```
master key:  0c5ffd37a11edc42c325287fc0604f2e
             3e8cd5671a00fe3216aa5eb105783b54
master salt: 0ec675ad498afeebb6960b3aabe6

index DIV kdr:               000000000000
label:                     00
master salt: 0ec675ad498afeebb6960b3aabe6
-----------------------------------------------
xor:         0ec675ad498afeebb6960b3aabe6     (x, PRF input)

x*2^16:      0ec675ad498afeebb6960b3aabe60000 (ARIA-CTR input)

cipher key:  0649a09d93755fe9c2b2efba1cce930a (ARIA-CTR 1st output)
             f2e76ce8b77e4b175950321aa94b0cf4 (ARIA-CTR 2nd output)
```

ARIA-CTR cipher suite requires 14 octet cipher salt while ARIA-CCM and ARIA-GCM cipher suites require 12 octet cipher salt.

```
index DIV kdr:                000000000000
label:                      02
master salt:  0ec675ad498afeebb6960b3aabe6
-----------------------------------------------
xor:          0ec675ad498afee9b6960b3aabe6     (x, PRF input)

x*2^16:       0ec675ad498afee9b6960b3aabe60000 (ARIA-CTR input)

              194abaa8553a8eba8a413a340fc80a3d (ARIA-CTR output)

cipher salt:  194abaa8553a8eba8a413a340fc8     (ARIA-CTR cipher
suite)
              194abaa8553a8eba8a413a34         (ARIA-CCM or
ARIA-GCM cipher suite)

index DIV kdr:                000000000000
label:                      01
```

```
master salt:  0ec675ad498afeebb6960b3aabe6
---------------------------------------------
xor:          0ec675ad498afeeab6960b3aabe6     (x, PRF input)

x*2^16:       0ec675ad498afeeab6960b3aabe60000 (ARIA-CTR input)
```

Below, the auth key is shown on the left, while the corresponding ARIA input blocks are shown on the right.

```
auth key                           ARIA input blocks

e58d42915873b71899234807334658f2   0ec675ad498afeeab6960b3aabe60000
0bc460181d06e02b7a9e60f02ff10bfc   0ec675ad498afeeab6960b3aabe60001
9ade3795cf78f3e0f2556d9d913470c4   0ec675ad498afeeab6960b3aabe60002
e82e45d254bfb8e2933851a3930ffe7d   0ec675ad498afeeab6960b3aabe60003
fca751c03ec1e77e35e28dac4f17d1a5   0ec675ad498afeeab6960b3aabe60004
80bdac028766d3b1e8f5a41faa3c       0ec675ad498afeeab6960b3aabe60005
```

Authors' Addresses

Woo-Hwan Kim
National Security Research Institute
P.O.Box 1, Yuseong
Daejeon 305-350
Korea

EMail: whkim5@ensec.re.kr

Jungkeun Lee
National Security Research Institute
P.O.Box 1, Yuseong
Daejeon 305-350
Korea

EMail: jklee@ensec.re.kr

Dong-Chan Kim
National Security Research Institute
P.O.Box 1, Yuseong
Daejeon 305-350
Korea

EMail: dongchan@ensec.re.kr

Je-Hong Park
National Security Research Institute
P.O.Box 1, Yuseong
Daejeon 305-350
Korea

EMail: jhpark@ensec.re.kr

Daesung Kwon
National Security Research Institute
P.O.Box 1, Yuseong
Daejeon 305-350
Korea

EMail: ds_kwon@ensec.re.kr