

Network Working Group D. McGrew
Internet-Draft F. Andreasen
Intended status: Standards
Track D. Wing

Expires: April 29, 2010 Cisco Systems,
 Inc.
 L. Dondeti
 QUALCOMM
 October 26, 2009

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**Encrypted Key Transport for Secure RTP
draft-mcgrew-srtp-ekt-06.txt**

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Abstract

SRTP Encrypted Key Transport (EKT) is an extension to SRTP that provides for the secure transport of SRTP master keys, Rollover Counters, and other information, within SRTP or SRTCP. This facility

enables SRTP to work for decentralized conferences with minimal control, and to handle situations caused by early media. This note defines EKT, and also describes how to use it with SDP Security Descriptions, DTLS-SRTP Key Transport (KTR), and MIKEY. These other key management protocols provide an EKT key to everyone in a session, and EKT coordinates the keys within the session.

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1. Introduction

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RTP is designed to allow decentralized groups with minimal control to establish sessions, e.g. for multimedia conferences. Unfortunately, Secure RTP (SRTP, [\[RFC3711\]](#) ([Baugher, M., McGrew, D., Naslund, M., Carrara, E., and K. Norrman, "The Secure Real-time Transport Protocol \(SRTP\)," March 2004.](#))) cannot be used in many minimal-control scenarios, because it requires that SSRC values and other data be coordinated among all of the participants in a session. For example, if a participant joins a session that is already in progress, the SRTP rollover counter (ROC) of each SRTP source in the session needs to be provided to that participant.

The inability of SRTP to work in the absence of central control was well understood during the design of that protocol; that omission was considered less important than optimizations such as bandwidth conservation. Additionally, in many situations SRTP is used in conjunction with a signaling system that can provide most of the central control needed by SRTP. However, there are several cases in which conventional signaling systems cannot easily provide all of the coordination required. It is also desirable to eliminate the layer violations that occur when signaling systems coordinate certain SRTP parameters, such as SSRC values and ROCs.

This document defines Encrypted Key Transport (EKT) for SRTP, an extension to SRTP that fits within the SRTP framework and reduces the amount of signaling control that is needed in an SRTP session. EKT securely distributes the SRTP master key and other information for each SRTP source, using SRTCP or SRTP to transport that information. With this method, SRTP entities are free to choose SSRC values as they see fit, and to start up new SRTP sources with new SRTP master keys (see Section 2.2) within a session without coordinating with other entities via signaling or other external means. This fact allows to reinstate the RTP collision detection and repair mechanism, which is nullified by the current SRTP specification because of the need to control SSRC values closely. An SRTP endpoint using EKT can generate new keys whenever an existing SRTP master key has been overused, or start up a new SRTP source to replace an old SRTP source that has reached the packet-count limit. EKT also solves the problem in which the burst loss of the N initial SRTP packets can confuse an SRTP receiver, when the

initial RTP sequence number is greater than or equal to $2^{16} - N$. These features simplify many architectures that implement SRTP.

EKT provides a way for an SRTP session participant, either sender or receiver, to securely transport its SRTP master key and current SRTP rollover counter to the other participants in the session. This data, possibly in conjunction with additional data provided by an external signaling protocol, furnishes the information needed by the receiver to instantiate an SRTP/SRTCP receiver context.

EKT does not control the manner in which the SSRC and master key are generated; it is concerned only with their secure transport. Those values may be generated on demand by the SRTP endpoint, or may be dictated by an external mechanism such as a signaling agent or a secure group controller.

EKT is not intended to replace external key establishment mechanisms such as DTLS-SRTP Key Transport [[I-D.wing-avt-dtls-srtp-key-transport](#)] ([Wing, D., "DTLS-SRTP Key Transport \(KTR\)," March 2009.](#)), SDP Security Descriptions [[RFC4568](#)] ([Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.](#)), or MIKEY [[RFC3830](#)] ([Arkko, J., Carrara, E., Lindholm, F., Naslund, M., and K. Norrman, "MIKEY: Multimedia Internet KEYing," August 2004.](#)). Instead, it is used in conjunction with those methods, and it relieves them of the burden of tightly coordinating every SRTP source among every SRTP participant.

This document is organized as follows. A complete normative definition of EKT is provided in [Section 2 \(Encrypted Key Transport\)](#). It consists of packet processing algorithms ([Section 2.2 \(Packet Processing and State Machine\)](#)) and cryptographic definitions ([Section 2.3 \(Ciphers\)](#)). In [Section 3 \(EKT and SDP Security Descriptions\)](#), the use of EKT with SDP Security Descriptions is defined, and in [Section 4 \(Use of EKT with DTLS-SRTP Key Transport\)](#) its use with DTLS-SRTP Key Transport is defined. In [Section 5 \(Use of EKT with MIKEY\)](#) we outline the use of EKT with MIKEY. [Section 7 \(Design Rationale\)](#) provides a design rationale. Security Considerations are provided in [Section 8 \(Security Considerations\)](#), and IANA considerations are provided in [Section 9 \(IANA Considerations\)](#).

1.1. Conventions Used In This Document

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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](#)] ([Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels," March 1997.](#)).

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2. Encrypted Key Transport

In EKT, an SRTP master key is encrypted with a Key Encrypting Key (KEK), and the resulting ciphertext is transported in every SRTCP packet, or in selected SRTP packets. A single KEK suffices for a single SRTP session, regardless of the number of participants in the session. However, there can be multiple KEKs used within a particular session. We use terms "KEK" or "EKT key" to mean the same thing; the latter term is used when describing the relation of EKT to external key management. In order to convey the ciphertext of the SRTP master key, and other additional information, the Authentication Tag field is subdivided as defined in [Section 2.1 \(Authentication Tag Format\)](#). EKT defines new SRTP and SRTCP authentication functions, which uses this format. It incorporates a conventional authentication function, which is called the base authentication function in this specification. Any authentication function, such as the default one of HMAC-SHA1 with a 160-bit key and an 80-bit authentication tag, can be used as a base authentication function. EKT also defines a new method of providing SRTP master keys to an endpoint.

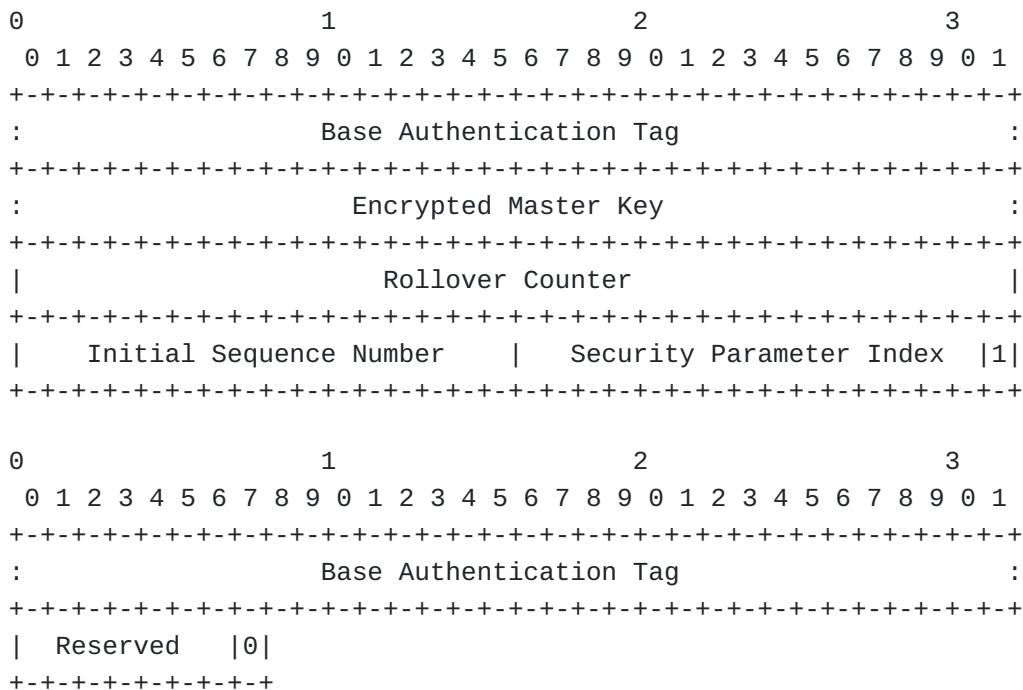


Figure 1: The EKT Authentication Tag format.

2.1. Authentication Tag Format

EKT uses the Authentication Tag format shown in [Figure 1 \(The EKT Authentication Tag format.\)](#). The top diagram shows the format in the case that the final bit is set to one, in which case all of the EKT fields are present. The bottom diagram shows the format in the case that the final bit is set to zero, in which case the Encrypted Master Key, Rollover Counter, Initial Sequence Number, and Security Parameter Index fields are absent, and the Reserved field is present; the latter field MUST be set to the all-zero value. These two cases can always be unambiguously distinguished by the final bit, or by checking to see if the final byte in the packet has the all-zero value.

The Authentication Tag field contains the following sub-fields:

Base Authentication Tag This field contains the authentication tag computed by the base authentication function. The value of this field is used to check the authenticity of the packet.

Encrypted Master Key The length of this field is variable, and is equal to the ciphertext size N defined in [Section 2.3 \(Ciphers\)](#). Note that the length of the field is inferable from the SPI field, since the particular EKT cipher used by the sender of a packet is inferable from that field. The Encrypted Master Key field is included outside of the authenticated portion of the SRTCP packet, immediately following the Authentication Tag. It contains the ciphertext value resulting from the encryption of the SRTP master key corresponding to the SSRC contained in the packet. The encryption and decryption of this value is done using a cipher as defined in [Section 2.3 \(Ciphers\)](#).

Rollover Counter The length of this field is fixed at 32 bits. This field is set to the current value of the SRTP rollover counter in the SRTP context associated with the SSRC in the SRTCP packet. This field immediately follows the Encrypted Master Key field.

Initial Sequence Number (ISN) The length of this field is fixed at 16 bits. If this field is nonzero, then it indicates the RTP sequence number of the initial RTP packet that is protected using the SRTP master key conveyed (in encrypted form) by the Encrypted Master Key field of this packet. If this field is zero, it indicates that the initial RTP packet protected using the SRTP master key conveyed in this packet preceded, or was concurrent with, the last roll-over of the RTP sequence number. The ISN field follows the Rollover Counter field.

Security Parameter Index (SPI) The length of this field is fixed at 16 bits. This field indicates the appropriate Key Encrypting Key and other parameters for the receiver to use when processing the packet. It is an "index" into a table of possibilities (which are

established via signaling or some other out-of-band means), much like the IPsec Security Parameter Index [\[RFC4301\] \(Kent, S. and K. Seo, "Security Architecture for the Internet Protocol," December 2005.\)](#). The parameters that are identified by this field are:

The Key Encrypting Key used to process the packet.

The EKT cipher used to process the packet.

The Secure RTP parameters associated with the SRTP Master Key carried by the packet and the SSRC value in the packet. Section 8.2. of [\[RFC3711\] \(Baugher, M., McGrew, D., Naslund, M., Carrara, E., and K. Norrman, "The Secure Real-time Transport Protocol \(SRTP\)," March 2004.\)](#) summarizes the parameters defined by that specification.

The Master Salt associated with the Master Key. (This value is part of the parameters mentioned above, but we call it out for emphasis.) The Master Salt is communicated separately, via signaling, typically along with the EKT Key Encrypting Key.

Together, these elements are called an EKT parameter set. Within each SRTP session, each distinct EKT parameter set that may be used MUST be associated with a distinct SPI value, to avoid ambiguity. The SPI field follows the Initial Sequence Number. Since it appears at the end of the packet, and has a fixed length, it is always possible to unambiguously parse this field.

The final bit of the EKT Authentication Tag format is a flag that indicates the presence or absence of the Encrypted Master Key, Rollover Counter, Initial Sequence Number, and Security Parameter Index fields, as shown in [Figure 1 \(The EKT Authentication Tag format.\)](#).

2.2. Packet Processing and State Machine

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At any given time, each SRTP/SRTCP source has associated with it a single EKT parameter set. This parameter set is used to process all outbound packets, and is called the outbound parameter set. There may be other EKT parameter sets that are used by other SRTP/SRTCP sources in the same session. All of these EKT parameter sets SHOULD be stored by all of the participants in an SRTP session, for use in processing inbound SRTCP traffic.

We next review SRTP authentication and show how the EKT authentication method is built on top of a base authentication method. An SRTP or

SRTCP authentication method consists of a tag-generation function and a verification function. The tag-generation function takes as input a secret key, the data to be authenticated, and the packet index. It provides an authentication tag as its sole output, and is used in the processing of outbound packets. The verification function takes as input a secret key, the data to be authenticated, the packet index, and the authentication tag. It returns an indication of whether or not the data, index, and tag are valid or not. It is used in the processing of inbound packets. EKT defines a tag-generation function in terms of the base tag-generation function, and defines a verification function in terms of the base verification function. The tag-generation function is used to process outbound packets, and the verification function is used to process inbound packets.

2.2.1. Outbound (Tag Generation)

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When an SRTP or SRTCP packet needs to be sent, the EKT tag generation function works as follows. The Rollover Counter field in the packet is set to the current value of the SRTP rollover counter (represented as an unsigned integer in network byte order).

The Initial Sequence Number field is set to zero, if the initial RTP packet protected using the current SRTP master key for this source preceded, or was concurrent with, the last roll-over of the RTP sequence number. Otherwise, that field is set to the value of the RTP sequence number of the initial RTP packet that was or will be protected by that key. When the SRTP master key corresponding to a source is changed, the new key SHOULD be communicated in advance via EKT. (Note that the ISN field allows the receiver to know when it should start using the new key to process SRTP packets.) This enables the rekeying event to be communicated before any RTP packets are protected with the new key. The rekeying event MUST not change the value of ROC (otherwise, the current value of the ROC would not be known to late joiners of existing sessions).

The Security Parameter Index field is set to the value of the Security Parameter Index that is associated with the outbound parameter set.

The Encrypted Master Key field is set to the ciphertext created by encrypting the SRTP master key with the EKT cipher, using the KEK as the encryption key. The encryption process is detailed in [Section 2.3 \(Ciphers\)](#). Implementations MAY cache the value of this field to avoid recomputing it for each packet that is sent.

2.2.1.1. Base Authentication Tag

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The Base Authentication Tag field is computed using the base tag-generation function as follows. It can only be computed after all of

the other fields have been set. The authenticated input consists of the following elements, in order:

- the SRTP or SRTCP authenticated portion,
- a string of zero bits whose length exactly matches that of the Base Authentication Tag field,
- the Encrypted Master Key field,
- the Rollover Counter field,
- the Initial Sequence Number field, and
- the Security Parameter Index field.

Implementation note: the string of zero bits is included in the authenticated input in order to allow implementations to compute the base authentication tag using a single pass of the base authentication function. Implementations MAY write zeros into the Base Authentication Tag field prior to computing that function, on the sending side.

2.2.2. Inbound (Tag Verification)

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The EKT verification function proceeds as follows (see [Figure 2 \(EKT inbound processing.\)](#)), or uses an equivalent set of steps. Recall that the verification function is a component of SRTP and SRTCP processing. When a packet does not pass the verification step, the function indicates this fact to the SRTCP packet processing function when it returns control to that function.

1. The Security Parameter Index field is checked to determine which EKT parameter set should be used when processing the packet. If multiple parameter sets been defined for the SRTP session, then the one that is associated with the Security Parameter Index value that matches the Security Parameter Index field in the packet is used. This parameter set is called the matching parameter set below. If there is no matching SPI, then the verification function MUST return an indication of authentication failure, and the steps described below are not performed.
2. If there is already an SRTP crypto context associated with the SSRC in the packet, and replay protection is in use, then the receiver performs the replay check described in Section 3.3.2 of [\[RFC3711\] \(Baugher, M., McGrew, D., Naslund, M., Carrara,](#)

[E., and K. Norrman, "The Secure Real-time Transport Protocol \(SRTP\)," March 2004.](#)) If the EKT fields are conveyed in an RTCP packet, then the packet index used in that check is formed from the Rollover Counter and the Initial Sequence Number fields in that packet. If the EKT fields are conveyed in an SRTP packet, then the packet index used in that check is formed from the EKT Rollover Counter field and the RTP Sequence Number in that packet.

3. The Encrypted Master Key field is decrypted using the EKT cipher's decryption function. That field is used as the ciphertext input, and the Key Encrypting Key in the matching parameter set is used as the decryption key. The decryption process is detailed in [Section 2.3 \(Ciphers\)](#). The plaintext resulting from this decryption is provisionally accepted as the SRTP master key corresponding to the SSRC in the packet. If an MKI is present in the packet, then the provisional key corresponds to the particular SSRC and MKI combination. A provisional key MUST be used only to process one single packet. A provisional SRTP or SRTCP authentication key is generated from the provisional master key, and the SRTP master salt from the matching parameter set, using the SRTP key derivation algorithm (see Section 4.3 of [\[RFC3711\] \(Baugher, M., McGrew, D., Naslund, M., Carrara, E., and K. Norrman, "The Secure Real-time Transport Protocol \(SRTP\)," March 2004.\)](#)).
4. An authentication check is performed on the packet, using the provisional SRTP or SRTCP authentication key. This key is provided to the base authentication function (see [Figure 2 \(EKT inbound processing.\)](#)), which is evaluated as described in [Section 2.2.1.1 \(Base Authentication Tag\)](#). If the Base Authentication Tag field matches the tag computed by the base authentication function, then the packet passes the check.

Implementation note: a receiver MAY copy the Base Authentication Tag field into temporary storage, then write zeros into that field, prior to computing the base authentication tag value. This step allows the base authentication function to be computed in a single pass over the data in the packet.

5. If the base authentication check using the provisional key fails, then the provisional key MUST be discarded and it MUST NOT affect any subsequent processing. The verification function MUST return an indication of authentication failure, and the steps described below are not performed.
6. Otherwise, if the base authentication check is passed, the provisional key is also accepted as the SRTP master key

corresponding to the SRTP source that sent the packet. If an MKI is present in the packet, then the master key corresponds to the particular SSRC and MKI combination. If there is no SRTP crypto context corresponding to the SSRC in the packet, then a new crypto context is created. The rollover counter in the context is set to the value of the Rollover Counter field. If the crypto context is not new, then the rollover counter in the context MUST NOT be set to a value lower than its current value. (If the replay protection step described above is performed, it ensures that this requirement is satisfied.)

7. If the Initial Sequence Number field is nonzero, then the initial sequence number for the SRTP master key is set to the packet index created by appending that field to the current rollover counter and treating the result as a 48-bit unsigned integer. The initial sequence number for the master key is equivalent to the "From" value of the < From, To > pair of indices (Section 8.1.1 of [\[RFC3711\] \(Baugher, M., McGrew, D., Naslund, M., Carrara, E., and K. Norrman, "The Secure Real-time Transport Protocol \(SRTP\)," March 2004.\)](#)) that can be associated with a master key.
8. The newly accepted SRTP master key, the SRTP parameters from the matching parameter set, the SSRC from the packet, and the MKI from the packet, if one is present, are stored in the crypto context associated with the SRTP source. The SRTP Key Derivation algorithm is run in order to compute the SRTP encryption and authentication keys, and those keys are stored for use in SRTP processing of inbound packets. The Key Derivation algorithm takes as input the newly accepted SRTP master key, along with the Master Salt from the matching parameter set.

Implementation note: the receiver may want to retain old master keys for some brief period of time, so that out-of-order packets can be processed.

9. The verification function then returns an indication that the packet passed the verification.

Implementation note: the value of the Encrypted Master Key field is identical in successive packets protected by the same KEK and SRTP master key. This value MAY be cached by an SRTP receiver to minimize computational effort, by allowing it to recognize when the SRTP master key is unchanged, and thus avoid repeating Steps 2, 6, and 7.

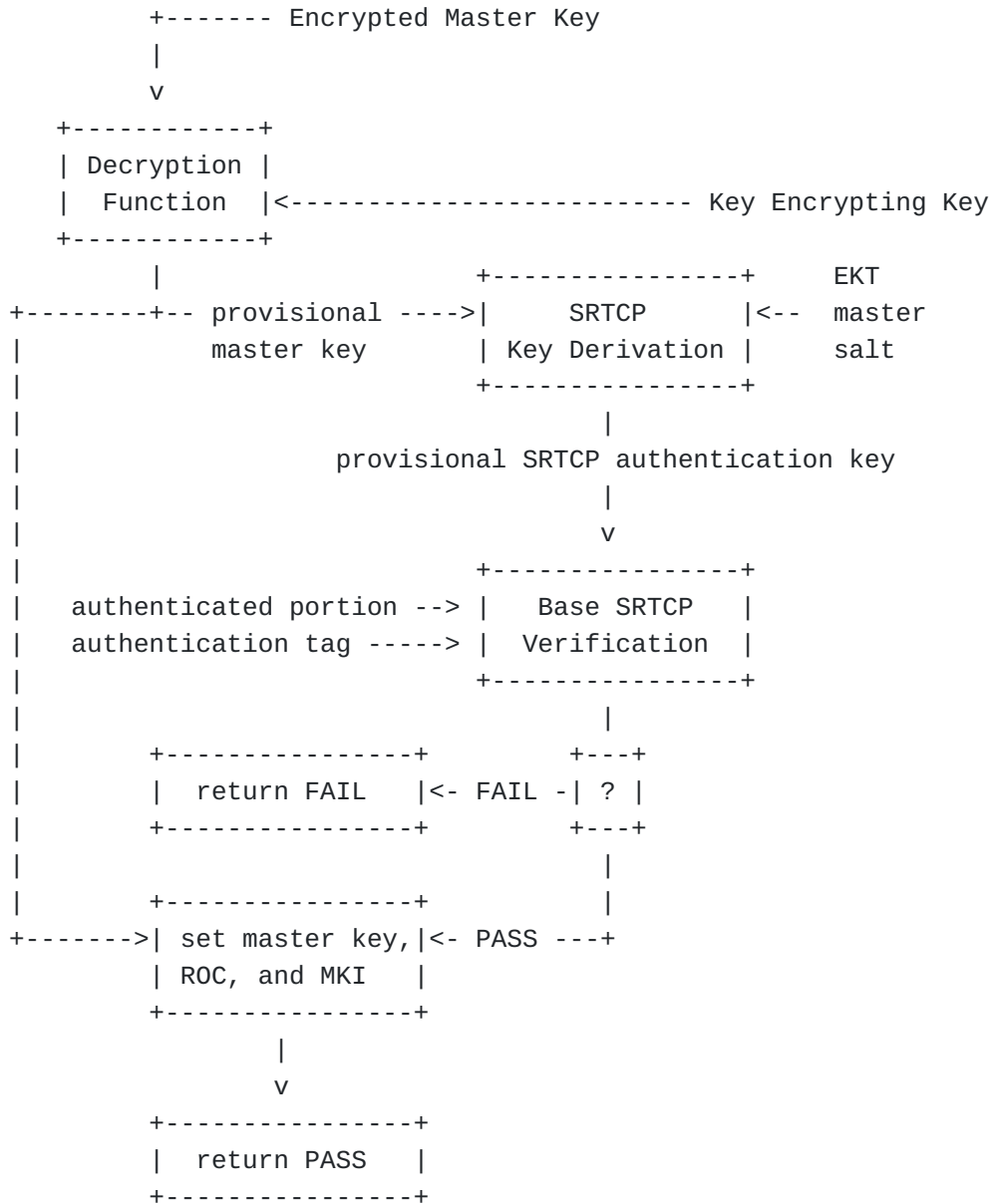


Figure 2: EKT inbound processing.

2.3. Ciphers

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EKT uses a cipher to encrypt the SRTP master keys. We first specify the interface to the cipher, in order to abstract the interface away from the details of that function. We then define the cipher that is used in EKT by default. This cipher **MUST** be implemented, but another cipher that conforms to this interface **MAY** be used, in which case its use **MUST** be coordinated by external means (e.g. call signaling).

An EKT cipher consists of an encryption function and a decryption function. The encryption function $E(K, P)$ takes the following inputs:

- a secret key K with a length of L bytes, and
- a plaintext value P with a length of M bytes.

The encryption function returns a ciphertext value C whose length is N bytes, where N is at least M . The decryption function $D(K, C)$ takes the following inputs:

- a secret key K with a length of L bytes, and
- a ciphertext value C with a length of N bytes.

The decryption function returns a plaintext value P that is M bytes long. These functions have the property that $D(K, E(K, P)) = P$ for all values of K and P . Each cipher also has a limit T on the number of times that it can be used with any fixed key value. For each key, the encryption function MUST NOT be invoked on more than T distinct values of P , and the decryption function MUST NOT be invoked on more than T distinct values of C .

An EKT cipher MUST resist attacks in which both ciphertexts and plaintexts can be adaptively chosen. For each randomly chosen key, the encryption and decryption functions cannot be distinguished from a random permutation and its inverse with non-negligible advantage. This must be true even for adversaries that can query both the encryption and decryption functions adaptively. The advantage is defined as the difference between the probability that the adversary will identify the cipher as such and the probability that the adversary will identify the random permutation as the cipher, when each case is equally likely.

2.3.1. The Default Cipher

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The default cipher is the Advanced Encryption Standard (AES) [\[FIPS197\]](#) ([, "The Advanced Encryption Standard \(AES\)," .](#)) with 128-bit keys, in Electronic Codebook (ECB) Mode. Its parameters are fixed at $L=16$, $M=16$, and $T=2^{48}$. Note that M matches the size of the SRTP master keys used by the default SRTP key derivation function; if an SRTP cipher with a different SRTP master key length is to be used with EKT, then another EKT cipher must be used. ECB is the simplest mode of operation of a block cipher, in which the block cipher is used in its raw form.

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2.3.2. The AES Key Wrap Cipher

The AES Key Wrap [\[RFC3394\] \(Schaad, J. and R. Housley, "Advanced Encryption Standard \(AES\) Key Wrap Algorithm," September 2002.\)](#) defines a cipher that can be used with plaintexts larger than 16 bytes in length. It requires a plaintext length M that is a multiple of eight bytes, and it returns a ciphertext with a length of $N = M + 8$ bytes. It can be used with key sizes of $L = 16, 24,$ and 32 . The key size determines the length of the AES key used by the Key Wrap algorithm. With this cipher, $T=2^{48}$.

2.3.3. Other EKT Ciphers

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Other specification MAY extend this one by defining other EKT ciphers. This section defines how those ciphers interact with this specification.

An EKT cipher determines how the Encrypted Master Key field is written, and how it is processed when it is read. This field is opaque to the other aspects of EKT processing. EKT ciphers are free to use this field in any way, but they SHOULD NOT use other EKT or SRTP fields as an input. The values of the parameters $L, M, N,$ and T MUST be defined by each EKT cipher, and those values MUST be inferable from the EKT parameter set.

2.4. Synchronizing Operation

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A participant in a session MAY opt to use a particular EKT key to protect outbound packets after it accepts that EKT key for protecting inbound traffic. In this case, the fact that one participant has changed to using a new EKT key for outbound traffic can trigger other participants to switch to using the same key.

An SRTP/SRTCP source SHOULD change its SRTP master key after its EKT key has been changed. This will ensure that the set of participants able to decrypt the traffic will be limited to those who know the current EKT key.

EKT can be transported over SRTCP, but some of the information that it conveys is used for SRTP processing; some elements of the EKT parameter set apply to both SRTP and SRTCP. Furthermore, SRTCP packets can be lost and both SRTP and SRTCP packets may be delivered out-of-order.

This can lead to various race conditions, which we review below.

When joining an SRTP session, SRTP packets may be received before any EKT over SRTCP packets, which implies the crypto context has not been established, unless other external signaling mechanism has done so.

Rather than automatically discarding such SRTP packets, the receiver MAY want to provisionally place them in a jitter buffer and delay discarding them until playout time.

When an SRTP source using EKT over SRTCP performs a rekeying operation, there is a race between the actual rekeying signaled via SRTCP and the SRTP packets secured by the new keying material. If the SRTP packets are received first, they will fail authentication; alternatively, if authentication is not being used, they will decrypt to unintelligible random-looking plaintext. (Note, however, that [\[RFC3711\] \(Baugher, M., McGrew, D., Naslund, M., Carrara, E., and K. Norrman, "The Secure Real-time Transport Protocol \(SRTP\)," March 2004.\)](#) says that SRTP "SHOULD NOT be used without message authentication".) In order to address this problem, the rekeying event can be sent before packets using the new SRTP master key are sent (by use of the ISN field). Another solution involves using an MKI at the expense of added overhead in each SRTP packet. Alternatively, receivers MAY want to delay discarding packets from known SSRCs that fail authentication in anticipation of receiving a rekeying event via EKT (SRTCP) shortly. The ROC signaled via EKT over SRTCP may be off by one when it is received by the other party(ies) in the session. In order to deal with this, receivers should simply follow the SRTP packet index estimation procedures defined in [SRTP] Section 3.3.1.

2.5. Transport

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EKT MUST be used over SRTCP, whenever RTCP is in use. EKT MAY be used over SRTP. When EKT over SRTP is used in an SRTP session in which SRTCP is available, then EKT MUST be used for both SRTP and SRTCP. The packet processing, state machine, and Authentication Tag format for EKT over SRTP are nearly identical to that for EKT over SRTCP. Differences are highlighted in [Section 2.2.1 \(Outbound \(Tag Generation\)\)](#) and [Section 2.2.2 \(Inbound \(Tag Verification\)\)](#).

2.6. Timing and Reliability Consideration

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SRTCP communicates the master key and ROC for the SRTP session. Thus, as explained above, if SRTP packets are received prior to the corresponding SRTCP (EKT) packet, a race condition occurs. From an EKT point of view, it is therefore desirable for an SRTP sender to send an EKT packet as soon as possible, and in no case any later than when the initial SRTP packet is sent. SRTCP however MUST obey the timing rules associated with the profile under which it runs (e.g. RTP/SAVP or RTP/SAVPF). Subject to that constraint, SRTP senders using EKT over SRTCP SHOULD send an SRTCP packet as soon as possible after joining a session. Note that there is no need for SRTP receivers to do so. Also note, that per RFC 3550, Section 6.2, it is permissible to send a compound RTCP packet immediately after joining a unicast session (but not a multicast session).

SRTCP is not reliable and hence SRTCP packets may be lost. This is obviously a problem for endpoints joining an SRTP session and receiving SRTP traffic (as opposed to SRTCP), or for endpoints receiving SRTCP traffic following a rekeying event. To reduce the impact of lost packets, SRTP senders using EKT over SRTCP SHOULD send SRTCP packets as often as allowed by the profile under which they operate.

3. EKT and SDP Security Descriptions

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The SDP Security Descriptions (SDS) [\[RFC4568\] \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#) specification defines a generic framework for negotiating security parameters for media streams negotiated via the Session Description Protocol by use of a new SDP "crypto" attribute and the Offer/Answer procedures defined in [\[RFC3264\] \(Rosenberg, J. and H. Schulzrinne, "An Offer/Answer Model with Session Description Protocol \(SDP\)," June 2002.\)](#). In addition to the general framework, SDS also defines how to use that framework specifically to negotiate security parameters for Secure RTP. Below, we first provide a brief recap of the crypto attribute when used for SRTP and we then explain how it is complementary to EKT. In the rest of this Section, we provide extensions to the crypto attribute and associated offer/answer procedures to define its use with EKT.

3.1. SDP Security Descriptions Recap

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The SRTP crypto attribute defined for SDP Security Descriptions contains a tag followed by three types of parameters (refer to [\[RFC4568\] \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#) for details):

Crypto-suite. Identifies the encryption and authentication transform

Key parameters. SRTP keying material and parameters.

Session parameters. Additional (optional) SRTP parameters such as Key Derivation Rate, Forward Error Correction Order, use of unencrypted SRTP, etc.

The crypto attributes in the example SDP in [Figure 3 \(SDP Security Descriptions example. Line breaks are included for formatting purposes only.\)](#) illustrate these parameters.


```

v=0
o=sam 2890844526 2890842807 IN IP4 192.0.2.5
s=SRTP Discussion
i=A discussion of Secure RTP
u=http://www.example.com/seminars/srtp.pdf
e=marge@example.com (Marge Simpson)
c=IN IP4 192.0.2.12
t=2873397496 2873404696
m=audio 49170 RTP/SAVP 0
a=crypto:1 AES_CM_128_HMAC_SHA1_80
  inline:WVnFX19zZW1jdGwgKCKgewkyMjA7fQp9CnVubGVz|2^20|1:4
  FEC_ORDER=FEC_SRTP
a=crypto:2 F8_128_HMAC_SHA1_80
  inline:MTIzNDU2Nzg5QUJDREUwMTIzNDU2Nzg5QUJjZGVm|2^20|1:4;
  inline:QUJjZGVmMTIzNDU2Nzg5QUJDREUwMTIzNDU2Nzg5|2^20|2:4
  FEC_ORDER=FEC_SRTP

```

Figure 3: SDP Security Descriptions example. Line breaks are included for formatting purposes only.

The first crypto attribute has the tag "1" and uses the crypto-suite "AES_CM_128_HMAC_SHA1_80". The "inline" parameter provides the SRTP master key and salt, the master key lifetime (number of packets), and the (optional) Master Key Identifier (MKI) whose value is "1" and has a byte length of "4" in the SRTP packets. Finally, the FEC_ORDER session parameter indicates the order of Forward Error Correction used (FEC is applied before SRTP processing by the sender of the SRTP media). The second crypto attribute has the tag "2" and uses the crypto-suite "F8_128_HMAC_SHA1_80". It includes two SRTP master keys and associated salts. The first one is used with the MKI value 1, whereas the second one is used with the MKI value 2. Finally, the FEC_ORDER session parameter indicates the order of Forward Error Correction used.

3.2. Relationship between EKT and SDP Security Descriptions

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SDP Security Descriptions [\[RFC4568\] \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#) define a generic framework for negotiating security parameters for media streams negotiated via the Session Description Protocol by use of the Offer/Answer procedures defined in [\[RFC3264\] \(Rosenberg, J. and H. Schulzrinne, "An Offer/Answer Model with Session Description Protocol \(SDP\)," June 2002.\)](#). In addition to the general framework, SDP Security Descriptions (SDS) also defines how to use it specifically to negotiate security parameters for Secure RTP.

EKT and SDESC are complementary. SDP Security Descriptions can negotiate several of the SRTP security parameters (e.g. cipher and use of Master Key Identifier/MKI) as well as SRTP master keys. SDP Security Descriptions however does not negotiate SSRCs and their associated Rollover Counter (ROC). Instead, SDESC relies on a so-called "late binding", where a newly observed SSRC will have its crypto context initialized to a ROC value of zero. Clearly, this does not work for participants joining an SRTP session that has been established for a while and hence has a non-zero ROC. It is impossible to use SDESC to join an SRTP session that is already in progress. In this case, EKT on the endpoint running SDP Security can provide the additional signaling necessary to communicate the ROC (Section 6.4.1 of [\[RFC4568\]](#) ([Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.](#))). The use of EKT solves this problem by communicating the ROC associated with the SSRC in the media plane.

SDP Security Descriptions negotiates different SRTP master keys in the send and receive direction. The offer contains the master key used by the offerer to send media, and the answer contains the master key used by the answerer to send media. Consequently, if media is received by the offerer prior to the answer being received, the offerer does not know the master key being used. Use of SDP security preconditions can solve this problem, however it requires an additional round-trip as well as a more complicated state machine. EKT solves this problem by simply sending the master key used in the media plane thereby avoiding the need for security preconditions.

If multiple crypto-suites were offered, the offerer also will not know which of the crypto-suites offered was selected until the answer is received. EKT solves this problem by using a correlator, the Security Parameter Index (SPI), which uniquely identifies each crypto attribute in the offer.

One of the primary call signaling protocols using offer/answer is the Session Initiation Protocol (SIP) [\[RFC3261\]](#) ([Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., Handley, M., and E. Schooler, "SIP: Session Initiation Protocol," June 2002.](#)). SIP uses the INVITE message to initiate a media session and typically includes an offer SDP in the INVITE. An INVITE may be "forked" to multiple recipients which potentially can lead to multiple answers being received. SDP Security Descriptions however does not properly support this scenario, mainly because SDP and RTP/RTCP does not contain sufficient information to allow for correlation of an incoming RTP/RTCP packet with a particular answer SDP. Note that extensions providing this correlation do exist, e.g. Interactive Connectivity Establishment (ICE). SDP Security Descriptions addresses this point-to-multipoint problem by moving each answer to a separate RTP transport address thereby turning a point-to-multipoint scenario into multiple point-to-point scenarios. There are however significant disadvantages to doing so. As long as the crypto attribute in the answer does not contain any declarative parameters that differ from

those in the offer, EKT solves this problem by use of the SPI correlator and communication of the answerer's SRTP master key in EKT. As can be seen from the above, the combination of EKT and SDES provides a better solution to SRTP negotiation for offer/answer than either of them alone. SDES negotiates the various SRTP crypto parameters (which EKT does not), whereas EKT addresses the shortcomings of SDES.

3.3. Overview of Combined EKT and SDP Security Description Operation

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We define three session extension parameters to SDES to communicate the EKT cipher, EKT key, and Security Parameter Index to the peer. The original SDES parameters are used as defined in [\[RFC4568\] \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#), however the procedures associated with the SRTP master key differ slightly, since both SDES and EKT communicate an SRTP master key. In particular, the SRTP master key communicated via SDES is used only if there is currently no crypto context established for the SSRC in question. This will be the case when an entity has received only the offer or answer, but has yet to receive a valid EKT message from the peer. Once a valid EKT message is received for the SSRC, the crypto context is initialized accordingly, and the SRTP master key will then be derived from the EKT message. Subsequent offer/answer exchanges do not change this: The most recent SRTP master key negotiated via EKT will be used, or, if none is available for the SSRC in question, the most recent SRTP master key negotiated via offer/answer will be used. Note that with these rules, once a valid EKT message has been received for a given SSRC, rekeying for that SSRC can only be done via EKT. The associated SRTP crypto parameters however can be changed via SDES.

3.4. EKT Extensions to SDP Security Descriptions

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In order to use EKT and SDES in conjunction, we now define the following new SDES session parameters, each of which MUST NOT appear more than once in a given crypto attribute:

EKT_Cipher	The EKT cipher used to encrypt the SRTP Master Key
EKT_Key	The EKT key used to encrypt the SRTP Master Key
EKT_SPI	The EKT Security Parameter Index

Below, we provide additional detail on each of these attributes.

3.4.1. EKT_Cipher

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The (optional) EKT_Cipher parameter defines the EKT cipher used to encrypt the EKT key within SRTP packets. The default value is "AES_128" in accordance with [Section 2.3.1 \(The Default Cipher\)](#). For the AES Key Wrap cipher (see [Section 2.3.2 \(The AES Key Wrap Cipher\)](#)), the values "AESKW_128", "AESKW_192", and "AESKW_256" are defined for values of L=16, 24, and 32 respectively. In the Offer/Answer model, the EKT_Cipher parameter is a negotiated parameter.

3.4.2. EKT_Key

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The (mandatory) EKT_Key parameter is the key K used to encrypt the SRTP Master Key in SRTP packets. The value is base64 encoded (see [\[RFC3548\] \(Josefsson, S., "The Base16, Base32, and Base64 Data Encodings," July 2003.\)](#), Section 3). When base64 decoding the key, padding characters (i.e., one or two "=" at the end of the base64 encoded data) are discarded (see [\[RFC3548\] \(Josefsson, S., "The Base16, Base32, and Base64 Data Encodings," July 2003.\)](#) for details). Base64 encoding assumes that the base64 encoding input is an integral number of octets. If a given EKT cipher requires the use of a key with a length that is not an integral number of octets, said cipher MUST define a padding scheme that results in the base64 input being an integral number of octets. For example, if the length defined was 250 bits, then 6 padding bits would be needed, which could be defined to be the last 6 bits in a 256 bit input. In the Offer/Answer model, the EKT_Key parameter is a negotiated parameter.

3.4.3. EKT_SPI

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The (mandatory) EKT_SPI parameter is the Security Parameter Index. It is encoded as an ASCII string representing the hexadecimal value of the Security Parameter Index. The SPI identifies the *offer* crypto attribute (including the EKT Key and Cipher) being used for the associated SRTP session. A crypto attribute corresponds to an EKT Parameter Set and hence the SPI effectively identifies a particular EKT parameter set. Note that the scope of the SPI is the SRTP session, which may or may not be limited to the scope of the associated SIP dialog. In particular, if one of the participants in an SRTP session is an SRTP translator, the scope of the SRTP session is not limited to the scope of a single SIP dialog. However, if all of the participants in the session are endpoints or mixers, the scope of the SRTP session will correspond to a single SIP dialog. In the Offer/Answer model, the EKT_SPI parameter is a negotiated parameter.

3.5. Offer/Answer Procedures

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In this section, we provide the offer/answer procedures associated with use of the three new SDES parameters defined in Section [Section 3.4 \(EKT Extensions to SDP Security Descriptions\)](#). Since SDES is defined only for unicast streams, we provide only offer/answer procedures for unicast streams here as well.

3.5.1. Generating the Initial Offer - Unicast Streams

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When the initial offer is generated, the offerer MUST follow the steps defined in [\[RFC4568\] \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#) Section 7.1.1 as well as the following steps.

For each unicast media line using SDES and where use of EKT is desired, the offerer MUST include one EKT_Key parameter and one EKT_SPI parameter in at least one "crypto" attribute (see [\[RFC4568\] \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#)). The EKT_SPI parameter serves to identify the EKT parameter set used for a particular SRTP packet. Consequently, within a single media line, a given EKT_SPI value MUST NOT be used with multiple crypto attributes. Note that the EKT parameter set to use for the session is not yet established at this point; each offered crypto attribute contains a candidate EKT parameter set. Furthermore, if the media line refers to an existing SRTP session, then any SPI values used for EKT parameter sets in that session MUST NOT be remapped to any different EKT parameter sets. When an offer describes an SRTP session that is already in progress, the offer SHOULD use an EKT parameter set (incl. EKT_SPI and EKT_KEY) that is already in use.

If an EKT_Cipher other than the default cipher is to be used, then the EKT_Cipher parameter MUST be included as well.

If a given crypto attribute includes more than one set of SRTP key parameters (SRTP master key, salt, lifetime, MKI), they MUST all use the same salt. (EKT requires a single shared salt between all the participants in the direct SRTP session).

Important Note: The scope of the offer/answer exchange is the SIP dialog(s) established as a result of the INVITE, however the scope of EKT is the direct SRTP session, i.e. all the participants that are able to receive SRTP and SRTCP packets directly. If an SRTP session spans multiple SIP dialogs, the EKT parameter sets MUST be synchronized between all the SIP dialogs where SRTP and SRTCP packets can be exchanged. In the case where the SIP entity operates as an RTP mixer (and hence re-originates SRTP and SRTCP packets with its own SSRC), this is not an issue, unless the mixer receives traffic from the various participants on the same destination IP address and port, in

which case further coordination of SPI values and crypto parameters may be needed between the SIP dialogs (note that SIP forking with multiple early media senders is an example of this). However if it operates as an RTP translator, synchronized negotiation of the EKT parameter sets on *all* the involved SIP dialogs will be needed. This is non-trivial in a variety of use cases, and hence use of the combined SDES/EKT mechanism with RTP translators should be considered very carefully. It should be noted, that use of SRTP with RTP translators in general should be considered very carefully as well.

The EKT session parameters can either be included as optional or mandatory parameters, however within a given crypto attribute, they MUST all be either optional or mandatory.

3.5.2. Generating the Initial Answer - Unicast Streams

[TOC](#)

When the initial answer is generated, the answerer MUST follow the steps defined in [\[RFC4568\] \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#) Section 7.1.2 as well as the following steps. For each unicast media line using SDES, the answerer examines the associated crypto attribute(s) for the presence of EKT parameters. If mandatory EKT parameters are included with a "crypto" attribute, the answerer MUST support those parameters in order to accept that offered crypto attribute. If optional EKT parameters are included instead, the answerer MAY accept the offered crypto attribute without using EKT. However, doing so will prevent the offerer from processing any packets received before the answer. If neither optional nor mandatory EKT parameters are included with a crypto attribute, and that crypto attribute is accepted in the answer, EKT MUST NOT be used. If a given a crypto attribute includes a mixture of optional and mandatory EKT parameters, or an incomplete set of mandatory EKT parameters, that crypto attribute MUST be considered invalid.

When EKT is used with SDES, the offerer and answerer MUST use the same SRTP master salt. Thus, the SRTP key parameter(s) in the answer crypto attribute MUST use the same master salt as the one accepted from the offer.

When the answerer accepts the offered media line and EKT is being used, the crypto attribute included in the answer MUST include the same EKT parameter values as found in the accepted crypto attribute from the offer (however, if the default EKT cipher is being used, it may be omitted). Furthermore, the EKT parameters included MUST be mandatory (i.e. no "-" prefix).

Acceptance of a crypto attribute with EKT parameters leads to establishment of the EKT parameter set for the corresponding SRTP session. Consequently, the answerer MUST send packets in accordance with that particular EKT parameter set only. If the answerer wants to enable the offerer to process SRTP packets received by the offerer

before it receives the answer, the answerer MUST NOT include any declarative session parameters that either were not present in the offered crypto attribute, or were present but with a different value. Otherwise, the offerer's view of the EKT parameter set would differ from the answerer's until the answer is received. Similarly, unless the offerer and answerer has other means for correlating an answer with a particular SRTP session, the answer SHOULD NOT include any declarative session parameters that either were not present in the offered crypto attribute, or were present but with a different value. If this recommendation is not followed and the offerer receives multiple answers (e.g. due to SIP forking), the offerer may not be able to process incoming media stream packets correctly.

3.5.3. Processing of the Initial Answer - Unicast Streams

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When the offerer receives the answer, it MUST perform the steps in [\[RFC4568\] \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#) Section 7.1.3 as well as the following steps for each SRTP media stream it offered with one or more crypto lines containing EKT parameters in it.

If the answer crypto line contains EKT parameters, and the corresponding crypto line from the offer contained the same EKT values, use of EKT has been negotiated successfully and MUST be used for the media stream. When determining whether the values match, optional and mandatory parameters MUST be considered equal. Furthermore, if the default EKT cipher is being used, it MAY be either present or absent in the offer and/or answer.

If the answer crypto line does not contain EKT parameters, then EKT MUST NOT be used for the corresponding SRTP session. Note that per [\[RFC4568\] \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#) Section 5.1.3, if the accepted crypto attribute contained mandatory EKT parameters in the offer, and the crypto attribute in the answer does not contain EKT parameters, then negotiation has failed. If the answer crypto line contains EKT parameters but the corresponding offered crypto line did not, or if the parameters don't match or are invalid, then the offerer MUST consider the crypto line invalid (see [\[RFC4568\] \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#) Section 7.1.3 for further operation).

The EKT parameter set is established when the answer is received, however there are a couple of special cases to consider here. First of all, if an SRTCP packet is received prior to the answer, then the EKT parameter set is established provisionally based on the SPI included. Once the answer (which may include declarative session parameters) is received, the EKT parameter set is fully established. The second case

involves receipt of multiple answers due to SIP forking. In this case, there will be multiple EKT parameter sets; one for each SRTP session. As mentioned earlier, reliable correlation of SIP dialogs to SRTP sessions requires extensions, and hence if one or more of the answers include declarative session parameters, it may be difficult to fully establish the EKT parameter set for each SRTP session. In the absence of a specific correlation mechanism, it is RECOMMENDED, that such correlation be done based on the signaled receive IP-address in the SDP and the observed source IP-address in incoming SRTP/SRTCP packets, and, if necessary, the signaled receive UDP port and the observed source UDP port.

3.6. SRTP-Specific Use Outside Offer/Answer

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SDES use for SRTP is not defined outside offer/answer and hence neither is SDES with EKT.

3.7. Modifying the Session

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When a media stream using the SRTP security descriptions has been established, and a new offer/answer exchange is performed, the offerer and answerer MUST follow the steps in [\[RFC4568\] \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#) Section 7.1.4 as well as the following steps. SDES allows for all parameters of the session to be modified, and the EKT session parameters are no exception to that, however, there are a few additional rules to be adhered to when using EKT.

It is permissible to start a session without the use of EKT, and then subsequently start using EKT, however the converse is not. Thus, once use of EKT has been negotiated on a particular media stream, EKT MUST continue to be used on that media stream in all subsequent offer/answer exchanges.

The reason for this is that both SDES and EKT communicate the SRTP Master Key with EKT Master Keys taking precedence. Reverting back to an SDES controlled master key in a synchronized manner is difficult. Once EKT is being used, the salt for the direct SRTP session MUST NOT be changed. Thus, a new offer/answer which does not create a new SRTP session (e.g. because it reuses the same IP address and port) MUST use the same salt for all crypto attributes as is currently used for the direct SRTP session.

Finally, subsequent offer/answer exchanges MUST NOT remap a given SPI value to a different EKT parameter set until 2^{32} other mappings have been used within the SRTP session. In practice, this requirements is most easily met by using a monotonically increasing SPI value (modulo 2^{32} and starting with zero) per direct SRTP session. Note that a

direct SRTP session may span multiple SIP dialogs, and in such cases coordination of SPI values across those SIP dialogs will be required. In the simple point-to-point unicast case without translators, the requirement simply applies within each media line in the SDP. In the point-to-multipoint case, the requirement applies across all the associated SIP dialogs.

3.8. Backwards Compatibility Considerations

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Backwards compatibility can be achieved in a couple of ways. First of all, SDP allows for session parameters to be prefixed with "-" to indicate that they are optional. If the answerer does not support the EKT session parameters, such optional parameters will simply be ignored. When the answer is received, absence of the parameters will indicate that EKT is not being used. Receipt of SRTP packets prior to receipt of such an answer will obviously be problematic (as is normally the case for SDP without EKT).

Alternatively, SDP allows for multiple crypto lines to be included for a particular media stream. Thus, two crypto lines that differ in their use of EKT parameters (presence in one, absence in the other) can be used as a way to negotiate use of EKT. When the answer is received, the accepted crypto attribute will indicate whether EKT is being used or not.

3.9. Grammar

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The Augmented Backus-Naur Form (ABNF) syntax [\[RFC4234\] \(Crocker, D., Ed. and P. Overell, "Augmented BNF for Syntax Specifications: ABNF," October 2005.\)](#) for the three new SDP session parameters is as in [Figure 4 \(ABNF for the EKT session parameters.\)](#).

```
EKT_Cipher = "EKT_Cipher=" EKT_Cipher_Name
EKT_Cipher_Name = 1*(ALPHA / DIGIT / "_") ; "AES_128", "AESKW_128"
                                           ; "AESKW_192" and "AESKW_256"
                                           ; defined in this document.
EKT_Key = 1*(base64) ; See Section 3 in RFC3548
base64 = ALPHA / DIGIT / "+" / "/" / "="
EKT_SPI = 4HEXDIG ; See RFC4234
```

Figure 4: ABNF for the EKT session parameters.

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4. Use of EKT with DTLS-SRTP Key Transport

DTLS-SRTP Key Transport (KTR) [[I-D.wing-avt-dtls-srtp-key-transport](#)] ([Wing, D., "DTLS-SRTP Key Transport \(KTR\)," March 2009.](#)) uses DTLS to securely transport SRTP keying material from one DTLS-SRTP peer to another, so the same SRTP keying material can be used by multiple DTLS-SRTP peers. This extension can be used to establish EKT keys. This combination of protocols is valuable because it combines the advantages of DTLS (strong authentication of the endpoint, flexibility) with the advantages of EKT (allowing secure multiparty RTP with loose coordination and efficient communication of per-source keys).

4.1. DTLS-SRTP Extension

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This document adds a new TLS negotiated extension called "ekt". This adds a new TLS content type, EKT, and a new negotiated extension EKT. The negotiated extension MUST only be requested in conjunction with the "use_srtp" extension (Section 3.2 of [[I-D.ietf-avt-dtls-srtp](#)] ([McGrew, D. and E. Rescorla, "Datagram Transport Layer Security \(DTLS\) Extension to Establish Keys for Secure Real-time Transport Protocol \(SRTP\)," February 2009.](#))). The DTLS server indicates its support for EKT by including "ekt" in its ServerHello message. If a DTLS client includes "ekt" in its ClientHello, but does not receive "ekt" in the ServerHello, the DTLS client MUST NOT send DTLS packets with the "ekt" content-type.

Using the syntax described in [DTLS \(Rescorla, E. and N. Modadugu, "Datagram Transport Layer Security version 1.2," October 2009.\)](#) [[I-D.ietf-tls-rfc4347-bis](#)], the following structures are used:

```

enum {
    ekt_key(0),
    ekt_key_ack(1),
    ekt_key_error(254),
    (255)
} SRTPKeyTransportType;

struct {
    SRTPKeyTransportType keytrans_type;
    uint24 length;
    uint16 message_seq;
    uint24 fragment_offset;
    uint24 fragment_length;
    select (SRTPKeyTransportType) {
        case ekt_key:                                EKTkey;
    };
} KeyTransport;

enum {
    AES_128(0),
    AESKW_128(1),
    AESKW_192(2),
    AESKW_256(3),
} ektcipher;

struct {
    ektcipher EKT_Cipher;
    uint EKT_Key_Value<1..256>;
    uint EKT_Master_Salt<1..256>;
    uint16 EKT_SPI;
} EKTkey;

```

Figure 5: Additional TLS Data Structure

A message flow showing a DTLS client and DTLS server using the EKT extension. The first set of SRTP packets, if present, are encrypted using the normal DTLS-SRTP key derivation function. The second set of SRTP packets, after the ekt_key message, can be encrypted using the EKT key. Reliability of the ekt_key is achieved _____ (how?).

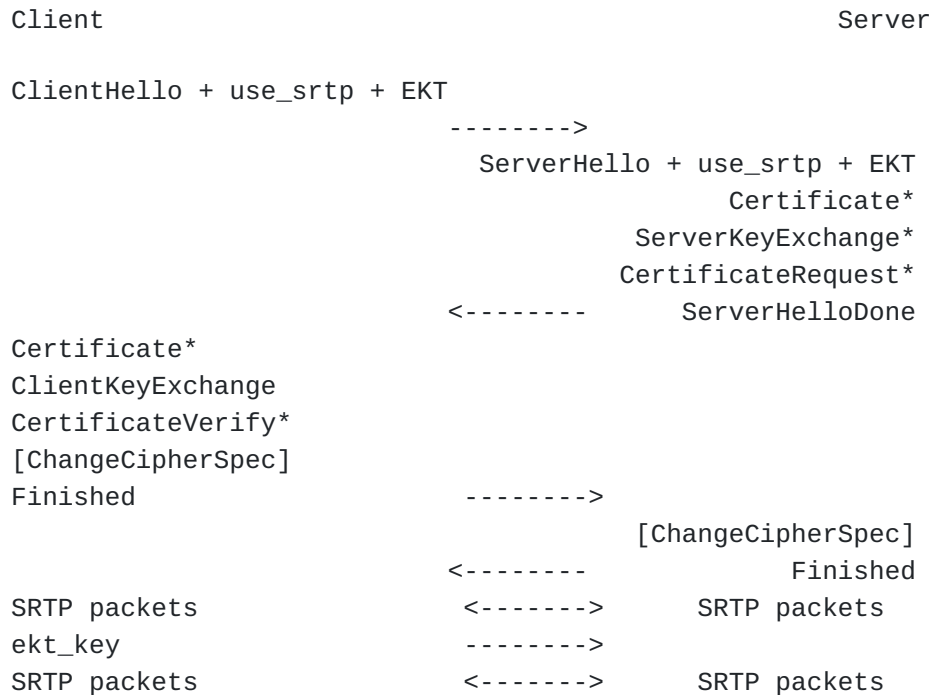


Figure 6: Handshake Message Flow

5. Use of EKT with MIKEY

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The advantages outlined in Section 1 are useful in some scenarios in which MIKEY is used to establish SRTP sessions. In this section, we briefly review MIKEY and related work, and discuss these scenarios. A n SRTP sender or a group controller can use MIKEY to establish a SRTP cryptographic context. This capability includes the distribution of the TEK or a TEK generation key (TGK) , security policy payload, crypto session bundle ID (CSB_ID), and a crypto session ID (CS_ID). The TEK directly maps to an SRTP master key, whereas the TGK is used along with the CSB_ID and a CS_ID to generate a TEK. The CS_ID can be used to generate multiple TEKS from a single TGK. For group communication, the sender or group controller sends the same TGK, CSB_ID, and CS_ID to all the members. For interactive conferencing, each sender distributes the same SRTP crypto context to the rest of the members.

The MIKEY specification [\[RFC3830\] \(Arkko, J., Carrara, E., Lindholm, F., Naslund, M., and K. Norrman, "MIKEY: Multimedia Internet KEYing," August 2004.\)](#) suggests the use of unicast for rekeying. This method does not scale well to large groups or interactive groups. MIKEY also provides a way to provide ROC values to members when they join the group. It is desirable to not require the group controller to track the ROC values of each member. For example, in mobile and wireless environments, members may go in and out of coverage, and in those

cases, key management based ROC synchronization is not reliable or sufficient. A better alternative to support ROC synchronization is to send ROC values via SRTP, as EKT does. A separate SRTP extension is being proposed [[RFC4771](#)] ([Lehtovirta, V., Naslund, M., and K. Norrman, "Integrity Transform Carrying Roll-Over Counter for the Secure Real-time Transport Protocol \(SRTP\)," January 2007.](#)) to include the ROC as part of a modified authentication tag. Unlike EKT, this extension uses SRTP and not SRTCP as its transport. A new MIKEY extension [[RFC4563](#)] ([Carrara, E., Lehtovirta, V., and K. Norrman, "The Key ID Information Type for the General Extension Payload in Multimedia Internet KEYing \(MIKEY\)," June 2006.](#)) specifies the use of MIKEY to update group keys via multicast or broadcast for 3GPP MBMS networks.

The EKT extension of SRTP/SRTCP provides a combined solution for rekeying and ROC synchronization. It also offers several advantages. With EKT, an SRTP session participant can start a new SRTP source without coordinating with a group controller about the selection of keys or SSRC values. With EKT, SRTP can handle early media, since its SPI allows the receiver to identify the cryptographic keys and parameters used by the source. EKT also allows SRTP to work with SIP forking.

MIKEY can readily be extended so that it can establish the EKT key, cipher and SPI values.

5.1. EKT transform attribute mapping in MIKEY

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Interactive group communication using MIKEY currently requires each member to send its own TGK and SSRC information to the other members, resulting in $O(n^2)$ MIKEY sessions. That is not desirable. With EKT, the conference organizer or only one of the members needs to distribute the EKT parameters to all the members. After that, each member can distribute its SRTP master key and ROC values using EKT. Cryptographic policy initially distributed via MIKEY will apply to all sessions. MIKEY specifies a security policy (SP) payload to negotiate or distribute SRTP security policy. Policy payload attributes include Session Encryption key length, Authentication algorithm, Session Authentication key length, Session Salt key length, SRTP PRF, Authentication tag length and other fields (see Section 6.10.1 of RFC 3830).

For the EKT_Cipher parameter, we propose to specify a new SRTP Policy Type in the Security Policy (SP) payload of MIKEY (see Section 6.10 of RFC 3830). The SP payload contains a number of Policy Param TLVs. We define Type = TBD: (will be requested from IANA) for EKT_Cipher. As with other payloads specifying cryptographic algorithms, we only specify Type and Values only.

EKT_Cipher	Value
AES_128	0
AESKW_128	1
AESKW_192	2
AESKW_256	3

Figure 7: EKT_Cipher Table

We propose to use the KEMAC payload to transport the two mandatory EKT parameters: EKT_Key and EKT_SPI MIKEY KEMAC payload, as specified in RFC 3830 carries the Traffic Encryption Key (TEK) or the TEK Generation Key (TGK). One or more TEKs or TGKs are carried in individual Key Data sub-payloads within the KEMAC payload. The KEMAC payload is encrypted as part of MIKEY. The Key Data sub- payload, specified in Section 6.13 of RFC 3830, has the following format:

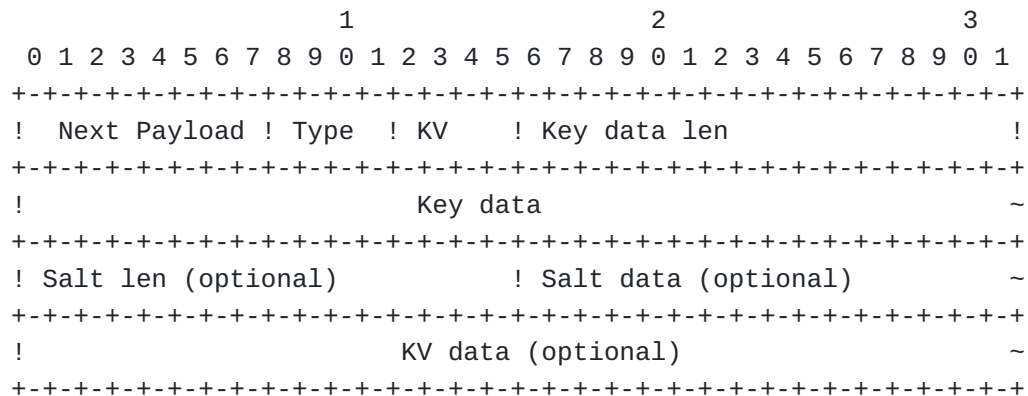


Figure 8: Key Data Sub-Payload of MIKEY

The Type field, 4 bits in length, indicates the type of key included in the payload. We define Type = TBD (will be requested from IANA) to indicate transport of EKT_Key.

KV (4 bits): indicates the type of key validity period specified. KV=1 is currently specified as an SPI. We propose to use that value to indicate the KV_data contains the ETK_SPI. KV_data would be 16 octets in length, but it is also possible to interpret the length from the 'Key data len' field.

KV data MUST NOT be optional when KV = 1.

6. Interworking with Other SRTP Key Management Systems

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6.1. Security Descriptions

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Today, [Security Descriptions \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#) [RFC4568] is used for distributing SRTP keys in several different IP PBX systems and is expected to be used by 3GPP's Long Term Evolution (LTE). The IP PBX systems are typically used within a single enterprise, and LTE is used within the confines of a mobile operator's network. A Session Border Controller is a reasonable solution to interwork between Security Descriptions in one network and DTLS-SRTP in another network. For example, a mobile operator (or an Enterprise) could operate Security Descriptions within their network and DTLS-SRTP towards the Internet.

However, due to the way Security Descriptions and DTLS-SRTP manage their SRTP keys, such an SBC has to authenticate, decrypt, re-encrypt, and re-authenticate the SRTP (and SRTCP) packets in one direction, as shown in [Figure 9 \(Interworking Security Descriptions and DTLS-SRTP\)](#), below. This is computationally expensive.

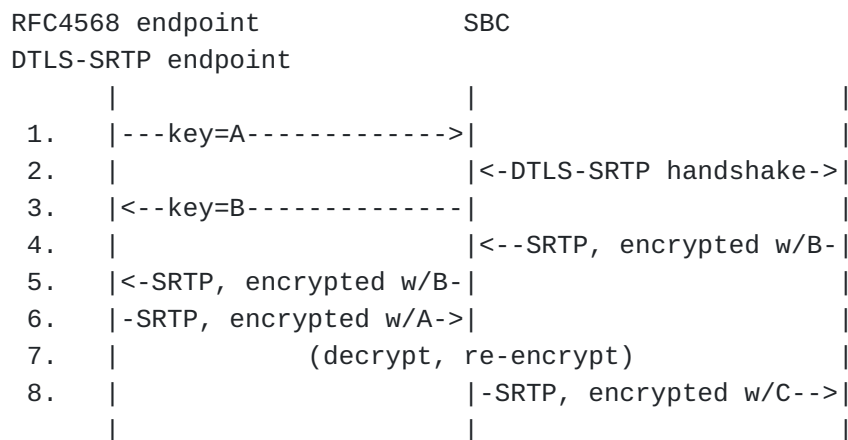


Figure 9: Interworking Security Descriptions and DTLS-SRTP

The message flow is as follows (similar steps occur with SRTCP):

1. The [Security Descriptions \(Andreasen, F., Baugher, M., and D. Wing, "Session Description Protocol \(SDP\) Security Descriptions for Media Streams," July 2006.\)](#) [RFC4568] endpoint discloses its SRTP key to the SBC, using a=crypto in its SDP.

2. SBC completes DTLS-SRTP handshake. From this handshake, the SBC derives the SRTP key for traffic from the DTLS-SRTP endpoint (key B) and to the DTLS-SRTP endpoint (key C).
3. The SBC communicates the SRTP encryption key (key B) to the Security Descriptions endpoint (using a=crypto). (There is no way, with DTLS-SRTP, to communicate the Security Descriptions key to the DTLS-SRTP key endpoint.)
4. The DTLS-SRTP endpoint sends an SRTP key, encrypted with its key B. This is received by the SBC.
5. The received SRTP packet is simply forwarded; the SBC does not need to do anything with this packet as its key (key B) was already communicated in step 3.
6. The Security Descriptions endpoint sends an SRTP packet, encrypted with its key A.
7. The SBC has to authenticate and decrypt the SRTP packet (using key A), and re-encrypt it and generate an HMAC (using key C).
8. The SBC sends the new SRTP packet.

If EKT is deployed on the DTLS-SRTP endpoints, EKT helps to avoid the computationally expensive operation so the SBC does not need to perform any per-packet operations on the SRTP (or SRTCP) packets in either direction. With EKT the SBC can simply forward the SRTP (and SRTCP) packets in both directions without per-packet HMAC or cryptographic operations.

To accomplish this interworking, DTLS-SRTP EKT must be supported on the DTLS-SRTP endpoint, which allows the SBC to transport the Security Description key to the EKT endpoint and send the DTLS-SRTP key to the Security Descriptions endpoint. This works equally well for both incoming and outgoing calls. An abbreviated message flow is shown in [Figure 10 \(Interworking Security Descriptions and EKT\)](#), below.

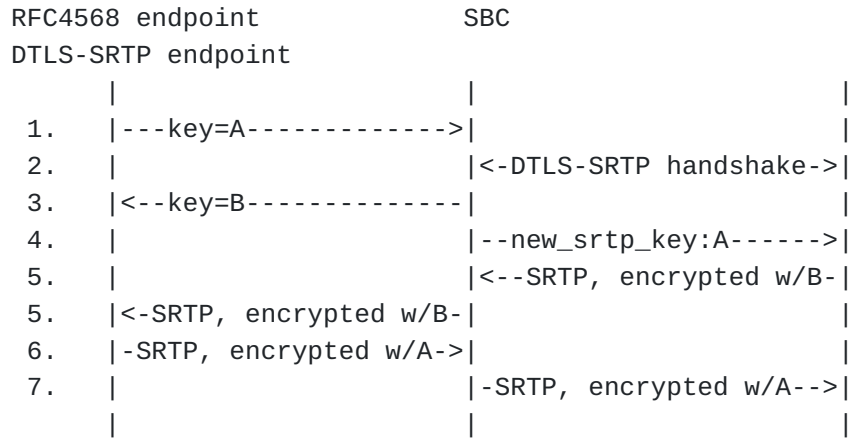


Figure 10: Interworking Security Descriptions and EKT

The message flow is as follows (similar steps occur with SRTCP):

1. Security Descriptions endpoint discloses its SRTP key to the SBC (a=crypto).
2. SBC completes DTLS-SRTP handshake. From this handshake, the SBC derives the SRTP key for traffic from the DTLS-SRTP endpoint (key B) and to the DTLS-SRTP endpoint (key C).
3. The SBC communicates the SRTP encryption key (key B) to the Security Descriptions endpoint.
4. The SBC uses the EKT to indicate that SRTP packets will be encrypted with 'key A' towards the DTLS-SRTP endpoint.
5. The DTLS-SRTP endpoint sends an SRTP key, encrypted with its key B. This is received by the SBC.
6. The received SRTP packet is simply forwarded; the SBC does not need to do anything with this packet as its key (key B) was communicated in step 3.
7. The Security Descriptions endpoint sends an SRTP packet, encrypted with its key A.
8. The received SRTP packet is simply forwarded; the SBC does not need to do anything with this packet as its key (key A) was communicated in step 4.

7. Design Rationale

From [\[RFC3550\] \(Schulzrinne, H., Casner, S., Frederick, R., and V. Jacobson, "RTP: A Transport Protocol for Real-Time Applications," July 2003.\)](#), a primary function of RTCP is to carry the CNAME, a "persistent transport-level identifier for an RTP source" since "receivers require the CNAME to keep track of each participant." EKT works in much the same way, using SRTCP to carry information needed for the proper processing of the SRTP traffic.

With EKT, SRTP gains the ability to synchronize the creation of cryptographic contexts across all of the participants in a single session. This feature provides some, but not all, of the functionality that is present in IKE phase two (but not phase one). Importantly, EKT does not provide a way to indicate SRTP options.

With EKT, external signaling mechanisms provide the SRTP options and the EKT Key, but need not provide the key(s) for each individual SRTP source. EKT provides a separation between the signaling mechanisms and the details of SRTP. The signaling system need not coordinate all SRTP streams, nor predict in advance how many streams will be present, nor communicate SRTP-level information (e.g. rollover counters) of current sessions.

EKT is especially useful for multi-party sessions, and for the case where multiple RTP sessions are sent to the same destination transport address (see the example in the definition of "RTP session" in [\[RFC3550\] \(Schulzrinne, H., Casner, S., Frederick, R., and V. Jacobson, "RTP: A Transport Protocol for Real-Time Applications," July 2003.\)](#)). A SIP offer that is forked in parallel (sent to multiple endpoints at the same time) can cause multiple RTP sessions to be sent to the same transport address, making EKT useful for use with SIP.

EKT can also be used in conjunction with a scalable group-key management system like GDOI. Such a system provides a secure entity authentication method and a way to revoke group membership, both of which are out of scope of EKT.

It is natural to use SRTCP to transport encrypted keying material for SRTP, as it provides a secure control channel for (S)RTP. However, there are several different places in SRTCP in which the encrypted SRTP master key and ROC could be conveyed. We briefly review some of the alternatives in order to motivate the particular choice used in this specification. One alternative is to have those values carried as a new SDES item or RTCP packet. This would require that the normal SRTCP encryption be turned off for the packets containing that SDES item, since on the receiver's side, SRTCP processing completes before the RTCP processing starts. This tension between encryption and the desire for RTCP privacy is highly undesirable. Additionally, this alternative makes SRTCP dependent upon the parsing of the RTCP compound packet, which adds complexity. It is simpler to carry the encrypted key in a new SRTCP field. One way to do this and to be backwards compatible with the existing specification is to define a new crypto function that incorporates the encrypted key. We define a new authentication

transform because EKT relies on the normal SRTCP authentication to provide implicit authentication of the encrypted key.

An SRTP packet containing an SSRC that has not been seen will be discarded. This practice may induce a burst of packet loss at the outset of an SRTP stream, due to the loss or reorder of the first SRTCP packet with the EKT containing the key and rollover counter for that stream. However, this practice matches the conservative RTP memory-allocation strategy; many existing applications accept this risk of initial packet loss. Alternatively, implementations may wish to delay discarding such packets for a short period of time as described in [Section 2.4 \(Synchronizing Operation\)](#).

When EKT is carried in SRTCP, it adds eight additional bytes to each SRTCP packet, plus the length of the Encrypted Master Key field. Using the SRTP and EKT defaults, the total overhead is 24 bytes. This overhead does not detract from the total bandwidth used by SRTP, since it is included in the RTCP bandwidth computation. However, it will cause the control protocol to issue packets less frequently.

The main motivation for the use of the variable-length format is bandwidth conservation. If EKT is used of SRTP, there will be a loss of bandwidth due to the additional 24 bytes in each RTP packet. For some applications, this bandwidth loss is significant.

8. Security Considerations

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With EKT, each SRTP sender and receiver can generate distinct SRTP master keys. This property avoids any security concern over the re-use of keys, by empowering the SRTP layer to create keys on demand. Note that the inputs of EKT are the same as for SRTP with key-sharing: a single key is provided to protect an entire SRTP session. However, EKT provides complete security, even in the absence of further out-of-band coordination of SSRCs, and even when SSRC values collide.

EKT uses encrypted key transport with implicit authentication. A strong cipher is used to ensure the confidentiality of the master keys as they are transported. The authenticity of the master keys is ensured by the base authentication check, which uses the plaintext form of that key. If the base authentication function and the cipher cannot be defeated by a particular attacker, then that attacker will be unable to defeat the implicit authentication.

In order to avoid potential security issues, the SRTP authentication tag length used by the base authentication method MUST be at least ten octets.

9. IANA Considerations

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This section registers with IANA the following SRTP session parameters for SDP Security Descriptions [\[RFC4568\] \(Andreasen, F., Baugher, M.,](#)

and D. Wing, "[Session Description Protocol \(SDP\) Security Descriptions for Media Streams](#)," July 2006.):

```
EKT_KEY
EKT_CIPHER
EKT_SPI
```

The definition of these parameters is provided in [Section 3.4 \(EKT Extensions to SDP Security Descriptions\)](#).

We request the following IANA assignments from existing MIKEY IANA tables:

```
From the "Key Data payload name spaces:" a value to indicate the
type as the "EKT_Key."
```

```
From the "SRTP" policy table name space, a new value to be assigned
for "EKT_Cipher."
```

Furthermore, we need a new table to be defined:

EKT_Cipher	Value
AES_128	0
AESKW_128	1
AESKW_192	2
AESKW_256	3

Figure 11: EKT_Cipher Table

10. Acknowledgements

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Thanks to Rob Raymond, Nermeen Ismail, and Kai Fischer for fruitful discussions and comments.

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Authors' Addresses

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David A. McGrew
Cisco Systems, Inc.
510 McCarthy Blvd.
Milpitas, CA 95035
US
Phone: (408) 525 8651
Email: mcgrew@cisco.com
URI: <http://www.mindspring.com/~dmcgrew/dam.htm>

Flemming Andreason
Cisco Systems, Inc.
499 Thornall Street
Edison, NJ 08837
US
Email: fandreas@cisco.com

Dan Wing
Cisco Systems, Inc.
510 McCarthy Blvd.
Milpitas, CA 95035
US
Phone: (408) 853 4197
Email: dwing@cisco.com

Lakshminath Dondeti
QUALCOMM
5775 Morehouse Drive
San Diego, CA 92121
US
Email: ldondeti@qualcomm.com