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**DTLS Tunnel between a Media Distributor and Key Distributor to  
Facilitate Key Exchange**

**Abstract**

This document defines a protocol for tunneling DTLS traffic in multimedia conferences that enables a Media Distributor to facilitate key exchange between an endpoint in a conference and the Key Distributor. The protocol is designed to ensure that the keying material used for hop-by-hop encryption and authentication is accessible to the Media Distributor, while the keying material used for end-to-end encryption and authentication is inaccessible to the Media Distributor.

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## Table of Contents

- [1. Introduction](#)
- [2. Conventions Used In This Document](#)
- [3. Tunneling Concept](#)
- [4. Example Message Flows](#)
- [5. Tunneling Procedures](#)
  - [5.1. Endpoint Procedures](#)
  - [5.2. Tunnel Establishment Procedures](#)
  - [5.3. Media Distributor Tunneling Procedures](#)
  - [5.4. Key Distributor Tunneling Procedures](#)
  - [5.5. Versioning Considerations](#)
- [6. Tunneling Protocol](#)
  - [6.1. TunnelMessage Structure](#)
  - [6.2. SupportedProfiles Message](#)
  - [6.3. UnsupportedVersion Message](#)
  - [6.4. MediaKeys Message](#)
  - [6.5. TunneledDtls Message](#)
  - [6.6. EndpointDisconnect Message](#)
- [7. Example Binary Encoding](#)
- [8. IANA Considerations](#)
- [9. Security Considerations](#)
- [10. Acknowledgments](#)
- [11. Normative References](#)
- [12. Informative References](#)
- [Authors' Addresses](#)

## 1. Introduction

An objective of Privacy-Enhanced RTP Conferencing (PERC) [[RFC8871](#)] is to ensure that endpoints in a multimedia conference have access to the end-to-end (E2E) and hop-by-hop (HBH) keying material used to encrypt and authenticate Real-time Transport Protocol (RTP) [[RFC3550](#)] packets, while the Media Distributor has access only to the HBH keying material for encryption and authentication.

[RFC EDITOR: References to RFC 6347 can be changed to the RFC for DTLS 1.3 if available.]

This specification defines a tunneling protocol that enables the Media Distributor to tunnel DTLS [[RFC6347](#)] messages between an endpoint and a Key Distributor, thus allowing an endpoint to use DTLS-SRTP [[RFC5764](#)] for establishing encryption and authentication keys with the Key Distributor.

The tunnel established between the Media Distributor and Key Distributor is a TLS [[RFC8446](#)] connection that is established before any messages are forwarded by the Media Distributor on behalf of endpoints. DTLS packets received from an endpoint are encapsulated by the Media Distributor inside this tunnel as data to be sent to the Key Distributor. Likewise, when the Media Distributor receives data from the Key Distributor over the tunnel, it extracts the DTLS message inside and forwards the DTLS message to the endpoint. In this way, the DTLS association for the DTLS-SRTP procedures is established between an endpoint and the Key Distributor, with the Media Distributor forwarding DTLS messages between the two entities via the established tunnel to the Key Distributor and having no visibility into the confidential information exchanged.

Following the existing DTLS-SRTP procedures, the endpoint and Key Distributor will arrive at a selected cipher and keying material, which are used for HBH encryption and authentication by both the endpoint and the Media Distributor. However, since the Media Distributor would not have direct access to this information, the Key Distributor explicitly shares the HBH key information with the Media Distributor via the tunneling protocol defined in this document. Additionally, the endpoint and Key Distributor will agree on a cipher for E2E encryption and authentication. The Key Distributor will transmit keying material to the endpoint for E2E operations, but will not share that information with the Media Distributor.

By establishing this TLS tunnel between the Media Distributor and Key Distributor and implementing the protocol defined in this document, it is possible for the Media Distributor to facilitate the establishment of a secure DTLS association between an endpoint and the Key Distributor in order for the endpoint to generate E2E and HBH keying material. At the same time, the Key Distributor can securely provide the HBH keying material to the Media Distributor.

## 2. Conventions Used In This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [[RFC2119](#)] [[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

This document uses the terms "endpoint", "Media Distributor", and "Key Distributor" defined in [[RFC8871](#)].

### 3. Tunneling Concept

A TLS connection (tunnel) is established between the Media Distributor and the Key Distributor. This tunnel is used to relay DTLS messages between the endpoint and Key Distributor, as depicted in [Figure 1](#):

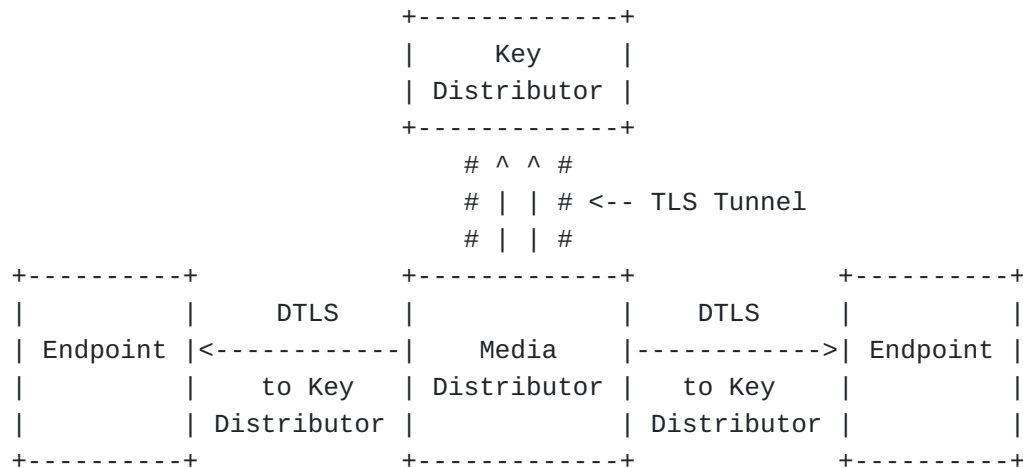


Figure 1: TLS Tunnel to Key Distributor

The three entities involved in this communication flow are the endpoint, the Media Distributor, and the Key Distributor. The behavior of each entity is described in [Section 5](#).

The Key Distributor is a logical function that might be co-resident with a key management server operated by an enterprise, reside in one of the endpoints participating in the conference, or elsewhere that is trusted with E2E keying material.

### 4. Example Message Flows

This section provides an example message flow to help clarify the procedures described later in this document. It is necessary that the Key Distributor and Media Distributor establish a mutually authenticated TLS connection for the purpose of sending tunneled messages, though the complete TLS handshake for the tunnel is not shown in [Figure 2](#) since there is nothing new this document introduces with regard to those procedures.

Once the tunnel is established, it is possible for the Media Distributor to relay the DTLS messages between the endpoint and the Key Distributor. [Figure 2](#) shows a message flow wherein the endpoint uses DTLS-SRTP to establish an association with the Key Distributor. In the process, the Media Distributor shares its supported SRTP protection profile information (see [[RFC5764](#)]) and the Key

Distributor shares HBH keying material and selected cipher with the Media Distributor.

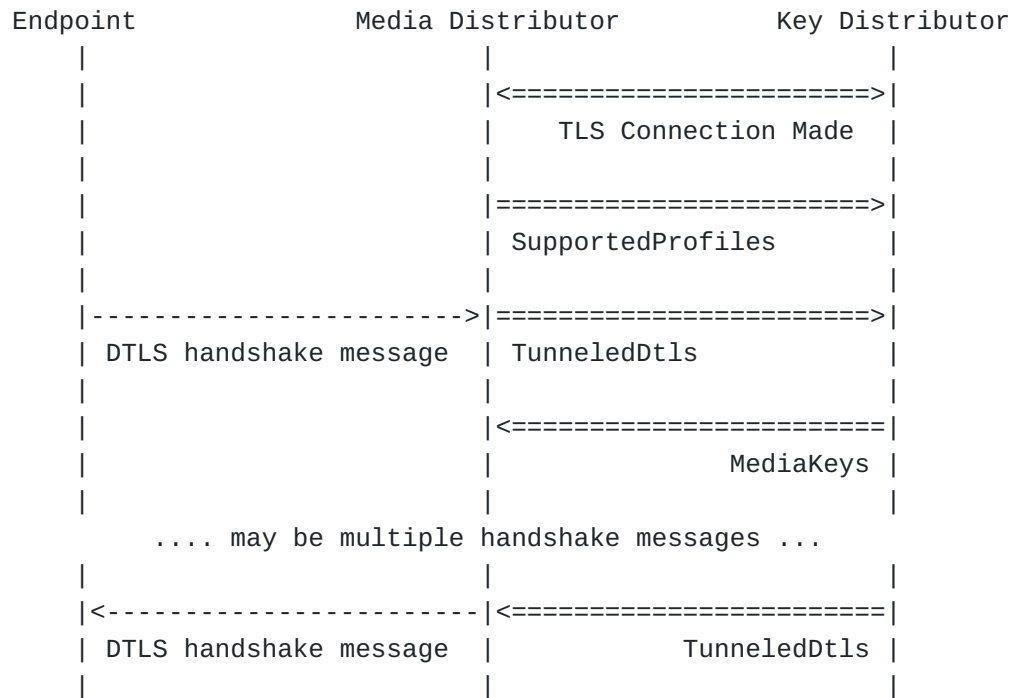


Figure 2: Sample DTLS-SRTP Exchange via the Tunnel

After the initial TLS connection has been established each of the messages on the right-hand side of [Figure 2](#) is a tunneling protocol message as defined in [Section 6](#).

SRTP protection profiles supported by the Media Distributor will be sent in a SupportedProfiles message when the TLS tunnel is initially established. The Key Distributor will use that information to select a common profile supported by both the endpoint and the Media Distributor to ensure that HBH operations can be successfully performed.

As DTLS messages are received from the endpoint by the Media Distributor, they are forwarded to the Key Distributor encapsulated inside a TunneledDtls message. Likewise, as TunneledDtls messages are received by the Media Distributor from the Key Distributor, the encapsulated DTLS packet is forwarded to the endpoint.

The Key Distributor will provide the SRTP [\[RFC3711\]](#) keying material to the Media Distributor for HBH operations via the MediaKeys message. The Media Distributor will extract this keying material from the MediaKeys message when received and use it for HBH encryption and authentication.

## 5. Tunneling Procedures

The following sub-sections explain in detail the expected behavior of the endpoint, the Media Distributor, and the Key Distributor.

It is important to note that the tunneling protocol described in this document is not an extension to TLS [RFC8446] or DTLS [RFC6347]. Rather, it is a protocol that transports DTLS messages generated by an endpoint or Key Distributor as data inside of the TLS connection established between the Media Distributor and Key Distributor.

### 5.1. Endpoint Procedures

The endpoint follows the procedures outlined for DTLS-SRTP [RFC5764] in order to establish the cipher and keys used for encryption and authentication, with the endpoint acting as the client and the Key Distributor acting as the server. The endpoint does not need to be aware of the fact that DTLS messages it transmits toward the Media Distributor are being tunneled to the Key Distributor.

The endpoint **MUST** include a unique identifier in the `tls-id` SDP [RFC4566] attribute in all offer and answer messages [RFC3264] that it generates as per [RFC8842]. Further, the endpoint **MUST** include this same unique identifier in the `external_session_id` extension [RFC8844] in the ClientHello message when establishing a DTLS association.

When receiving a `external_session_id` value from the Key Distributor, the client **MUST** check to ensure that value matches the `tls-id` value received in SDP. If the values do not match, the endpoint **MUST** consider any received keying material to be invalid and terminate the DTLS association.

### 5.2. Tunnel Establishment Procedures

Either the Media Distributor or Key Distributor initiates the establishment of a TLS tunnel. Which entity acts as the TLS client when establishing the tunnel and what event triggers the establishment of the tunnel are outside the scope of this document. Further, how the trust relationships are established between the Key Distributor and Media Distributor are also outside the scope of this document.

A tunnel **MUST** be a mutually authenticated TLS connection.

The Media Distributor or Key Distributor **MUST** establish a tunnel prior to forwarding tunneled DTLS messages. Given the time-sensitive nature of DTLS-SRTP procedures, a tunnel **SHOULD** be established prior to the Media Distributor receiving a DTLS message from an endpoint.

A single tunnel **MAY** be used to relay DTLS messages between any number of endpoints and the Key Distributor.

A Media Distributor **MAY** have more than one tunnel established between itself and one or more Key Distributors. When multiple tunnels are established, which tunnel or tunnels to use to send messages for a given conference is outside the scope of this document.

### 5.3. Media Distributor Tunneling Procedures

The first message transmitted over the tunnel is the SupportedProfiles (see [Section 6](#)). This message informs the Key Distributor about which DTLS-SRTP profiles the Media Distributor supports. This message **MUST** be sent each time a new tunnel connection is established or, in the case of connection loss, when a connection is re-established. The Media Distributor **MUST** support the same list of protection profiles for the duration of any endpoint-initiated DTLS association and tunnel connection.

The Media Distributor **MUST** assign a unique association identifier for each endpoint-initiated DTLS association and include it in all messages forwarded to the Key Distributor. The Key Distributor will subsequently include this identifier in all messages it sends so that the Media Distributor can map messages received via a tunnel and forward those messages to the correct endpoint. The association identifier **MUST** be randomly assigned UUID value as described Section 4.4 of [[RFC4122](#)].

When a DTLS message is received by the Media Distributor from an endpoint, it forwards the UDP payload portion of that message to the Key Distributor encapsulated in a TunneledDtls message. The Media Distributor is not required to forward all messages received from an endpoint for a given DTLS association through the same tunnel if more than one tunnel has been established between it and a Key Distributor.

When a MediaKeys message is received, the Media Distributor **MUST** extract the cipher and keying material conveyed in order to subsequently perform HBH encryption and authentication operations for RTP and RTCP packets sent between it and an endpoint. Since the HBH keying material will be different for each endpoint, the Media Distributor uses the association identifier included by the Key Distributor to ensure that the HBH keying material is used with the correct endpoint.

The Media Distributor **MUST** forward all DTLS messages received from either the endpoint or the Key Distributor (via the TunneledDtls message) to ensure proper communication between those two entities.

When the Media Distributor detects an endpoint has disconnected or when it receives conference control messages indicating the endpoint is to be disconnected, the Media Distributors **MUST** send an EndpointDisconnect message with the association identifier assigned to the endpoint to the Key Distributor. The Media Distributor **SHOULD** take a loss of all RTP and RTCP packets as an indicator that the endpoint has disconnected. The particulars of how RTP and RTCP are to be used to detect an endpoint disconnect, such as timeout period, is not specified. The Media Distributor **MAY** use additional indicators to determine when an endpoint has disconnected.

#### 5.4. Key Distributor Tunneling Procedures

Each TLS tunnel established between the Media Distributor and the Key Distributor **MUST** be mutually authenticated.

When the Media Distributor relays a DTLS message from an endpoint, the Media Distributor will include an association identifier that is unique per endpoint-originated DTLS association. The association identifier remains constant for the life of the DTLS association. The Key Distributor identifies each distinct endpoint-originated DTLS association by the association identifier.

When processing an incoming endpoint association, the Key Distributor **MUST** extract the external\_session\_id value transmitted in the ClientHello message and match that against the tls-id value the endpoint transmitted via SDP. If the values in SDP and the ClientHello do not match, the DTLS association **MUST** be rejected.

The process through which the tls-id in SDP is conveyed to the Key Distributor is outside the scope of this document.

The Key Distributor **MUST** match the certificate fingerprint [[RFC4572](#)] and external\_session\_id received from endpoint's ClientHello message with the values received from the SDP transmitted by the endpoint [[RFC8122](#)]. It is through this process that the Key Distributor can be sure to deliver the correct conference key to the endpoint.

When sending the ServerHello message, the Key Distributor **MUST** insert its own unique identifier in the external\_session\_id extension. This value **MUST** also be conveyed back to the client via SDP as a tls-id attribute.

The Key Distributor **MUST** encapsulate any DTLS message it sends to an endpoint inside a TunneledDtls message (see [Section 6](#)). The Key Distributor is not required to transmit all messages for a given DTLS association through the same tunnel if more than one tunnel has been established between it and the Media Distributor.



The Key Distributor **MUST** use the same association identifier in messages sent to an endpoint as was received in messages from that endpoint. This ensures the Media Distributor can forward the messages to the correct endpoint.

The Key Distributor extracts tunneled DTLS messages from an endpoint and acts on those messages as if that endpoint had established the DTLS association directly with the Key Distributor. The Key Distributor is acting as the DTLS server and the endpoint is acting as the DTLS client. The handling of the messages and certificates is exactly the same as normal DTLS-SRTP procedures between endpoints.

The Key Distributor **MUST** send a MediaKeys message to the Media Distributor as soon as a HBH encryption key is computed. The MediaKeys message includes the selected cipher (i.e. protection profile), MKI [[RFC3711](#)] value (if any), SRTP master keys, and SRTP master salt values. The Key Distributor **MUST** use the same association identifier in the MediaKeys message as is used in the TunneledDtls messages for the given endpoint.

The Key Distributor uses the certificate fingerprint of the endpoint along with the unique identifier received in the external\_session\_id extension to determine which conference a given DTLS association is associated.

The Key Distributor **MUST** select a cipher that is supported itself, the endpoint, and the Media Distributor to ensure proper HBH operations.

When the DTLS association between the endpoint and the Key Distributor is terminated, regardless of which entity initiated the termination, the Key Distributor **MUST** send an EndpointDisconnect message with the association identifier assigned to the endpoint to the Media Distributor.

## 5.5. Versioning Considerations

Since the Media Distributor sends the first message over the tunnel, it effectively establishes the version of the protocol to be used. If that version is not supported by the Key Distributor, the Key Distributor **MUST** transmit an UnsupportedVersion message containing the highest version number supported, and close the TLS connection.

The Media Distributor **MUST** take note of the version received in an UnsupportedVersion message and use that version when attempting to re-establish a failed tunnel connection. Note that it is not necessary for the Media Distributor to understand the newer version of the protocol to understand that the first message received is UnsupportedVersion. The Media Distributor can determine from the first four octets received what the version number is and that the

message is `UnsupportedVersion`. The rest of the data received, if any, would be discarded and the connection closed (if not already closed).

## 6. Tunneling Protocol

Tunneled messages are transported via the TLS tunnel as application data between the Media Distributor and the Key Distributor. Tunnel messages are specified using the format described in [\[RFC8446\]](#) section 3. As in [\[RFC8446\]](#), all values are stored in network byte (big endian) order; the uint32 represented by the hex bytes 01 02 03 04 is equivalent to the decimal value 16909060.

This protocol defines several different messages, each of which contains the following information:

- \*Message type identifier

- \*Message body length

- \*The message body

Each of the tunnel messages is a `TunnelMessage` structure with the message type indicating the actual content of the message body.

### 6.1. TunnelMessage Structure

The `TunnelMessage` defines the structure of all messages sent via the tunnel protocol. That structure includes a field called `msg_type` that identifies the specific type of message contained within `TunnelMessage`.

```

enum {
    supported_profiles(1),
    unsupported_version(2),
    media_keys(3),
    tunneled_dtls(4),
    endpoint_disconnect(5),
    (255)
} MsgType;

opaque uuid[16];

struct {
    MsgType msg_type;
    uint16 length;
    select (MsgType) {
        case supported_profiles: SupportedProfiles;
        case unsupported_version: UnsupportedVersion;
        case media_keys:         MediaKeys;
        case tunneled_dtls:      TunneledDtls;
        case endpoint_disconnect: EndpointDisconnect;
    } body;
} TunnelMessage;

```

The elements of TunnelMessage include:

\*msg\_type: the type of message contained within the structure body.

\*length: the length in octets of the following body of the message.

\*body: the actual message being conveyed within this TunnelMessage structure.

## 6.2. SupportedProfiles Message

The SupportedProfiles message is defined as:

```

uint8 SRTTPProtectionProfile[2]; /* from RFC5764 */

struct {
    uint8 version;
    SRTTPProtectionProfile protection_profiles<2..2^16-1>;
} SupportedProfiles;

```

This message contains this single element:

\*version: This document specifies version 0x00.

\***protection\_profiles**: The list of two-octet SRTP protection profile values as per [[RFC5764](#)] supported by the Media Distributor.

### 6.3. UnsupportedVersion Message

The UnsupportedVersion message is defined as follows:

```
struct {  
    uint8 highest_version;  
} UnsupportedVersion;
```

The elements of UnsupportedVersion include:

\***highest\_version**: indicates the highest version of the protocol supported by the Key Distributor.

### 6.4. MediaKeys Message

The MediaKeys message is defined as:

```
struct {  
    uuid association_id;  
    SRTPProtectionProfile protection_profile;  
    opaque mki<0..255>;  
    opaque client_write_SRTP_master_key<1..255>;  
    opaque server_write_SRTP_master_key<1..255>;  
    opaque client_write_SRTP_master_salt<1..255>;  
    opaque server_write_SRTP_master_salt<1..255>;  
} MediaKeys;
```

The fields are described as follows:

\***association\_id**: A value that identifies a distinct DTLS association between an endpoint and the Key Distributor.

\***protection\_profiles**: The value of the two-octet SRTP protection profile value as per [[RFC5764](#)] used for this DTLS association.

\***mki**: Master key identifier [[RFC3711](#)]. A zero-length field indicates that no MKI value is present.

\***client\_write\_SRTP\_master\_key**: The value of the SRTP master key used by the client (endpoint).

\***server\_write\_SRTP\_master\_key**: The value of the SRTP master key used by the server (Media Distributor).

\***client\_write\_SRTP\_master\_salt**: The value of the SRTP master salt used by the client (endpoint).

\*server\_write\_SRTP\_master\_salt: The value of the SRTP master salt used by the server (Media Distributor).

### 6.5. TunneledDtls Message

The TunneledDtls message is defined as:

```
struct {  
    uuid association_id;  
    opaque dtls_message<0..2^16-1>;  
} TunneledDtls;
```

The fields are described as follows:

\*association\_id: A value that identifies a distinct DTLS association between an endpoint and the Key Distributor.

\*dtls\_message: the content of the DTLS message received by the endpoint or to be sent to the endpoint.

### 6.6. EndpointDisconnect Message

The EndpointDisconnect message is defined as:

```
struct {  
    uuid association_id;  
} EndpointDisconnect;
```

The fields are described as follows:

\*association\_id: An value that identifies a distinct DTLS association between an endpoint and the Key Distributor.

## 7. Example Binary Encoding

The TunnelMessage is encoded in binary following the procedures specified in [[RFC8446](#)]. This section provides an example of what the bits on the wire would look like for the SupportedProfiles message that advertises support for both DOUBLE\_AEAD\_AES\_128\_GCM\_AEAD\_AES\_128\_GCM and DOUBLE\_AEAD\_AES\_256\_GCM\_AEAD\_AES\_256\_GCM [[RFC8723](#)].

```
TunnelMessage:  
    message_type: 0x01  
    length: 0x0007  
SupportedProfiles:  
    version: 0x00  
    protection_profiles: 0x0004 (length)  
                        0x0009000A (value)
```

Thus, the encoding on the wire presented here in network bytes order would be this stream of octets:

0x01000700000040009000A

## 8. IANA Considerations

This document establishes a new registry to contain message type values used in the DTLS Tunnel protocol. These message type values are a single octet in length. This document defines the values shown in [Table 1](#) below, leaving the balance of possible values reserved for future specifications:

MsgType	Description
0x01	Supported SRTP Protection Profiles
0x02	Unsupported Version
0x03	Media Keys
0x04	Tunneled DTLS
0x05	Endpoint Disconnect

Table 1: Message Type Values for the DTLS Tunnel Protocol

The value 0x00 is reserved and all values in the range 0x06 to 0xFF are available for allocation. The procedures for updating this table are those defined as "IETF Review" in section 4.8 of [\[RFC8126\]](#).

The name for this registry is "Datagram Transport Layer Security (DTLS) Tunnel Protocol Message Types for Privacy Enhanced Conferencing".

## 9. Security Considerations

Since the procedures in this document relies on TLS [\[RFC8446\]](#) for transport security, the security considerations for TLS should be reviewed when implementing the protocol defined in this document.

While the tunneling protocol defined in this document does not use DTLS-SRTP [\[\[RFC5764\]](#) directly, it does convey and negotiate some of the same information (e.g., protection profile data). As such, a review of the security considerations found in that document may be useful.

This document describes a means of securely exchanging keying material and cryptographic transforms for both E2E and HBH encryption and authentication of media between an endpoint and a Key Distributor via a Media Distributor. Additionally, the procedures result in delivering HBH information to the intermediary Media Distributor. The Key Distributor and endpoint are the only two

entities with access to both the E2E and HBH keys, while the Media Distributor has access to only HBH information. Section 8.2 of [\[RFC8871\]](#) enumerates various attacks against which one must guard when implementing a Media Distributor and are important to note.

A requirement in this document is that a TLS connection between the Media Distributor and the Key Distributor be mutually authenticated. The reason for this requirement is to ensure that only an authorized Media Distributor receives the HBH keying material. If an unauthorized Media Distributor gains access to the HBH keying material, it can easily cause service degradation or denial by transmitting HBH-valid packets that ultimately fail E2E authentication or replay protection checks (see Section 3.3.2 of [\[RFC3711\]](#)). Even if service does not appear degraded in any way, transmitting and processing bogus packets are a waste of both computational and network resources.

While E2E keying material passes through the Media Distributor via the protocol defined in this document, the Media Distributor has no means of gaining access to that information and therefore cannot affect the E2E media processing function in the endpoint except to present it with invalid or replayed data. That said, any entity along the path that interferes with the DTLS exchange between the endpoint and the Key Distributor, including a malicious Media Distributor that is not properly authorized, could prevent an endpoint from properly communicating with the Key Distributor and, therefore, prevent successful conference participation.

The Key Distributor should be aware of the possibility that a malicious Media Distributor might transmit an EndpointDisconnect message to the Key Distributor when the endpoint is, in fact, still connected.

While the Security Considerations section of [\[RFC8871\]](#) describes various attacks one needs to consider with respect to the Key Distributor and denial-of-service, use of this protocol introduces another possible attack vector. Consider the case where a malicious endpoint sends unsolicited DTLS-SRTP messages to a Media Distributor. The Media Distributor will normally forward those messages to the Key Distributor and, if found invalid, such messages only serve to consume resources on both the Media Distributor and Key Distributor.

## **10. Acknowledgments**

The author would like to thank David Benham and Cullen Jennings for reviewing this document and providing constructive comments.

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