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Cisco Vendor-Specific RADIUS Attributes for the Delivery of Keying Material

Abstract

This document defines a set of vendor-specific RADIUS Attributes designed to allow both the secure transmission of cryptographic keying material and strong authentication of any RADIUS message. These attributes have been allocated from the Cisco vendor-specific space and have been implemented by multiple vendors.

Status of This Memo

This document is not an Internet Standards Track specification; it is published for informational purposes.

This is a contribution to the RFC Series, independently of any other RFC stream. The RFC Editor has chosen to publish this document at its discretion and makes no statement about its value for implementation or deployment. Documents approved for publication by the RFC Editor are not a candidate for any level of Internet Standard; see Section 2 of RFC 5741.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc6218.

IESG Note

The IESG has concluded that this work is related to IETF work done in the RADEXT WG, but this relationship does not prevent publishing. The IESG recommends that the RADEXT WG proceed with the work for an interoperable modern key wrap solution using attributes from the standard space as part of its charter.

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1. Introduction

This document defines a set of vendor-specific RADIUS Attributes, allocated from the Cisco vendor space, that can be used to securely transfer cryptographic keying material using standard techniques with well-understood security properties. In addition, the Message-Authentication-Code Attribute may be used to provide strong authentication for any RADIUS message, including those used for accounting and dynamic authorization.

These attributes were designed to provide stronger protection and more flexibility than the currently defined Vendor-Specific MS-MPPE-Send-Key and MS-MPPE-Recv-Key Attributes in [RFC2548] and the Message-Authenticator Attribute in [RFC3579].

Many remote access deployments (for example, deployments utilizing wireless LAN technology) require the secure transmission of cryptographic keying material from a RADIUS [RFC2865] server to a network access point. This material is usually produced as a by-product of an Extensible Authentication Protocol (EAP) [RFC3748] authentication and returned in the Access-Accept message following a

successful authentication process. The keying material is of a form that may be used in virtually any cryptographic algorithm after appropriate processing. These attributes may also be used in other cases where an Authentication, Authorization, and Accounting (AAA) server needs to deliver keying material to a network access point.

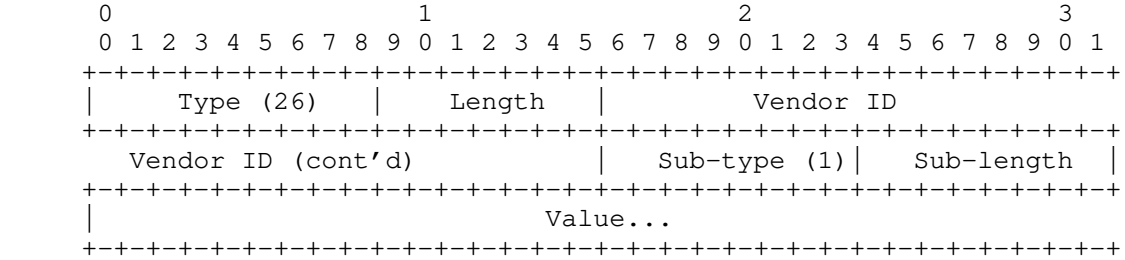
Discussion of this document may be directed to the authors.

2. Specification of Requirements

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].

3. Attributes

The following subsections describe sub-attributes that are transmitted in RADIUS Attributes of type Vendor-Specific [RFC2865]. The Vendor ID field of the Vendor-Specific Attribute(s) MUST be set to decimal 9 (Cisco). The general format of the attributes is:



Type

26 for Vendor-Specific

Length

Length of entire attribute including type and length fields

Vendor ID

4 octets encoding the Cisco Vendor ID of 9

Sub-type

Attribute sub-type of 1

Sub-length

Length of the sub-attribute including the sub-type and sub-length fields

Value

Value of the sub-attribute

This specification concerns the following sub-attributes:

- Keying-Material
- MAC-Randomizer
- Message-Authentication-Code

3.1. Keying-Material

Description

This Attribute MAY be used to transfer cryptographic keying material from a RADIUS server to a client.

It MAY be sent in request messages (e.g., Access-Request, etc.), as well; if the Keying-Material (KM) Attribute is present in a request, it SHOULD be taken as a hint by the server that the client prefers this method of key delivery over others. The server is not obligated to honor the hint, however. When the Keying-Material Attribute is included in a request message, the KM ID, key-encrypting-key (KEK) ID, Lifetime, Initialization Vector (IV), and Key Material Data fields MAY be omitted.

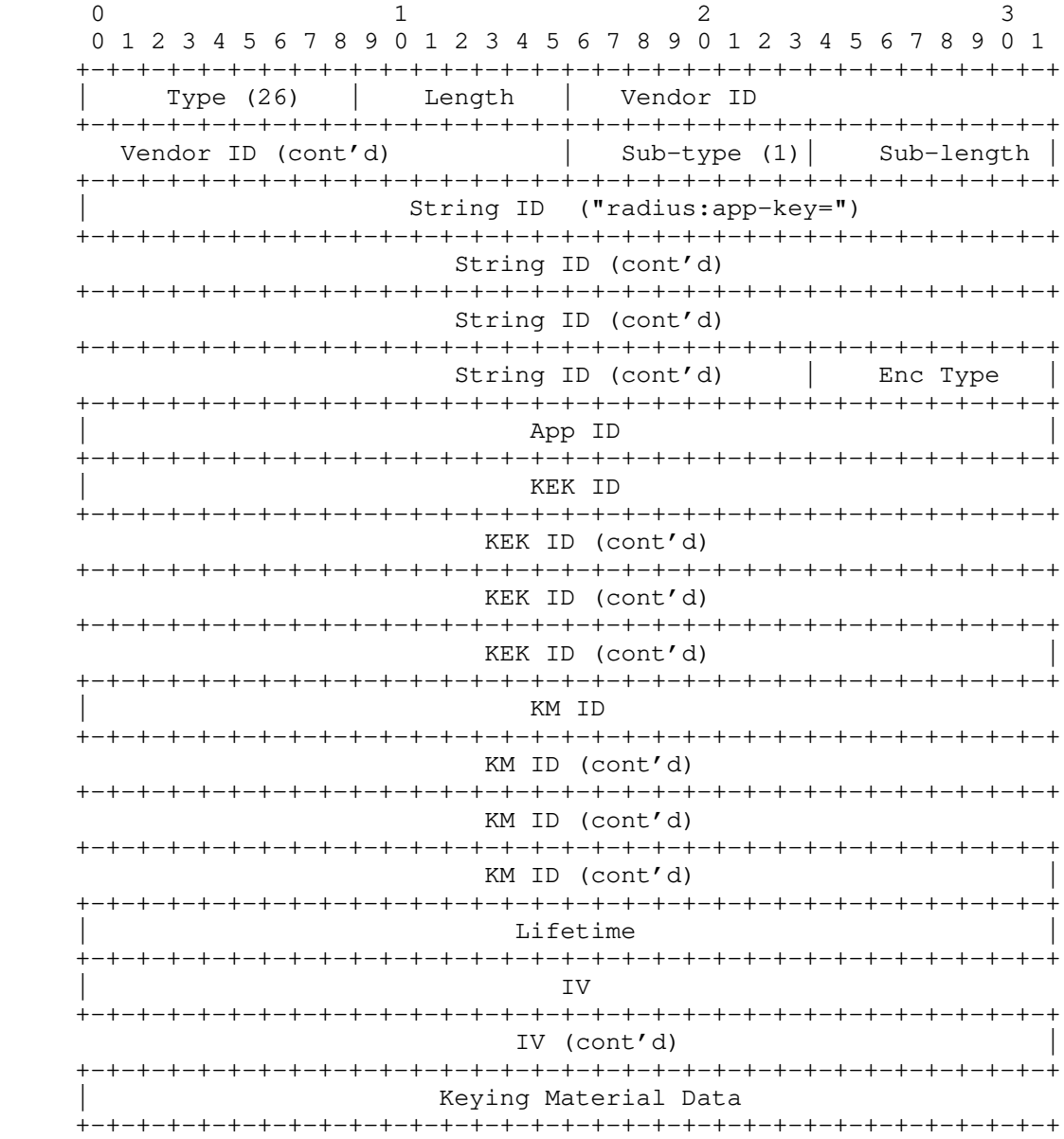
In environments where the Keying-Material Attribute is known to be supported or in cases where the client wants to avoid roll-back attacks, the client MAY be configured to require the use of the Keying-Material Attribute. If the client requires the use of the Keying-Material Attribute for keying material delivery and it is not present in the Access-Accept or Access-Challenge message, the client MAY ignore the message in question and end the user session.

Any packet that contains a Keying-Material Attribute MUST also include the Message-Authentication-Code Attribute.

Any packet that contains an instance of the Keying-Material Attribute MUST NOT contain an instance of any other attribute (e.g., MS-CHAP-MPPE-Keys [RFC2548], Tunnel-Password [RFC2868], etc.) encapsulating identical keying material.

The Keying-Material Attribute MUST NOT be used to transfer long-lived keys (i.e., passwords) between RADIUS servers and clients.

A summary of the Keying-Material Attribute format is shown below. The fields are transmitted from left to right.


0 1 2 3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
Type (26)
Length
Vendor ID
Vendor ID (cont'd)
Sub-type (1)
Sub-length
String ID ("radius:app-key=")
String ID (cont'd)
String ID (cont'd)
String ID (cont'd)
Enc Type
App ID
KEK ID
KEK ID (cont'd)
KEK ID (cont'd)
KEK ID (cont'd)
KM ID
KM ID (cont'd)
KM ID (cont'd)
KM ID (cont'd)
Lifetime
IV
IV (cont'd)
Keying Material Data

Type

26 for Vendor-Specific

Length

Length of entire attribute including type and length fields

Vendor ID

4 octets encoding the Cisco Vendor ID of 9

Sub-type

Attribute sub-type of 1

Sub-length

Length of the sub-attribute including the sub-type and sub-length fields

String-ID

The ASCII characters "radius:app-key=" without quotes or null termination

Enc Type

The Enc Type field indicates the method used to encrypt the contents of the Data field. This document defines only one value (decimal) for this field:

0 AES Key Wrap with 128-bit KEK [RFC3394]

Implementations MUST support Enc Type 0 (AES Key Wrap with 128-bit KEK).

Implementation Note

A shared secret is used as the key-encrypting-key (KEK) for the AES key wrap algorithm. Implementations SHOULD provide a means to provision a key (cryptographically separate from the normal RADIUS shared secret) to be used exclusively as a KEK.

App ID

The App ID field is 4 octets in length and identifies the type of application for which the key material is to be used. This allows for multiple keys for different purposes to be present in the same message. This document defines two values for the App ID:

0 Reserved

1 EAP MSK

KEK ID

The KEK ID field is 16 octets in length. The combination of the KEK ID and the client and server IP addresses together uniquely identify a key shared between the RADIUS client and server. As a result, the KEK ID need not be globally unique. The KEK ID MUST refer to an encryption key of a type and length appropriate for use with the algorithm specified by the Enc Type field (see above). This key is used to protect the contents of the Data field (below). The KEK ID is a constant that is configured through an out-of-band mechanism. The same value is configured on both the RADIUS client and server. If no KEK ID is configured, then the field is set to 0. If only a single KEK is configured for use between a given RADIUS client and server, then 0 can be used as the default value.

KM ID

The KM ID field is 16 octets in length and contains an identifier for the contents of the Data field. The KM ID MAY be used by communicating parties to identify the material being transmitted. The combination of App ID and KM ID MUST uniquely identify the keying material between the parties utilizing it. The KM ID is assumed to be known to the parties that derived the keying material. If the KM ID is not used, it is set to 0. The KM ID for the EAP Master Session Key (MSK) application is set to 0. Another application that uses the KM ID field can be defined in the future.

Lifetime

The Lifetime field is an integer [RFC2865] representing the period of time (in seconds) for which the keying material is valid.

Note: Applications using this value SHOULD consider the beginning of the lifetime to be the point in time when the keying material is first used.

IV

The length of the IV field depends upon the value of the Enc Type field, but is fixed for any given value thereof. When the value of the Enc Type field is 0 (decimal), the IV field MUST be 8 octets in length (as illustrated above), and the value of the IV field MUST be as specified in [RFC3394]. If the IV for Enc Type 0 does not match [RFC3394], then the receiver MUST NOT use the key material from this attribute.

Keying Material Data

The Keying Material Data field is of variable length and contains the actual encrypted keying material.

3.2. MAC-Randomizer

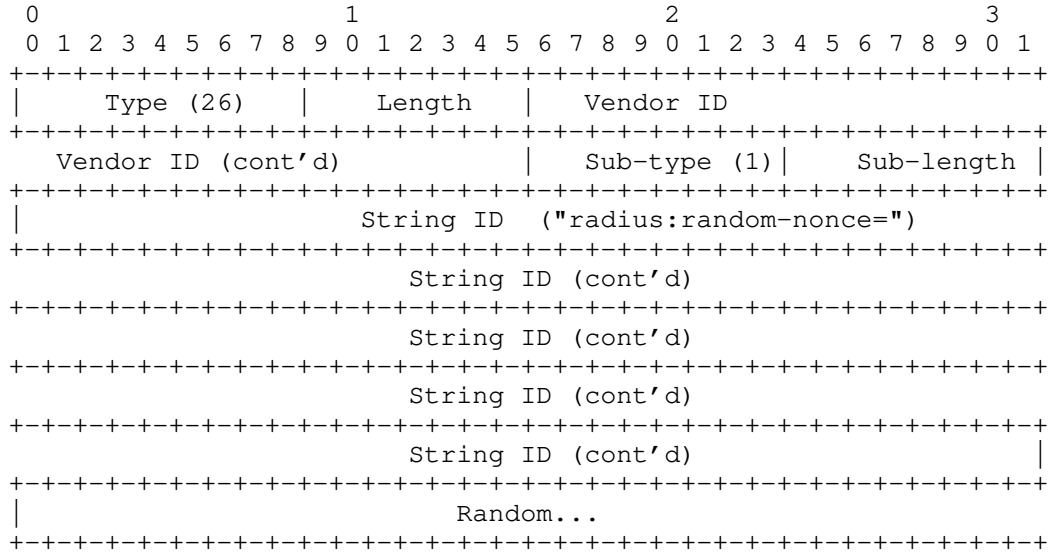
Description

The MAC-Randomizer Attribute MUST be present in any message that includes an instance of the Message-Authentication-Code Attribute. The Random field MUST contain a 32-octet random number that SHOULD satisfy the requirements of [RFC4086].

Implementation Note

The Random field MUST be filled in before the Message Authentication Code (MAC) is computed. The MAC-Randomizer Attribute SHOULD be placed at the beginning of the RADIUS message if possible.

A summary of the MAC-Randomizer Attribute format is shown below. The fields are transmitted from left to right.



Type

26 for Vendor-Specific

Length

Length of entire attribute including type and length fields

Vendor ID

4 octets encoding the Cisco Vendor ID of 9

Sub-type

Attribute sub-type of 1

Sub-length

Length of the sub-attribute including the sub-type and sub-length fields

String-ID

The ASCII characters "radius:random-nonce=" without quotes or null termination

Random

This field MUST contain a 32 octet random number that SHOULD satisfy the requirements of [RFC4086].

3.3. Message-Authentication-Code

Description

This Attribute MAY be used to "sign" messages to prevent spoofing. If it is present in a request, the receiver should take this as a hint that the sender prefers the use of this Attribute for message authentication; the receiver is not obligated to do so, however.

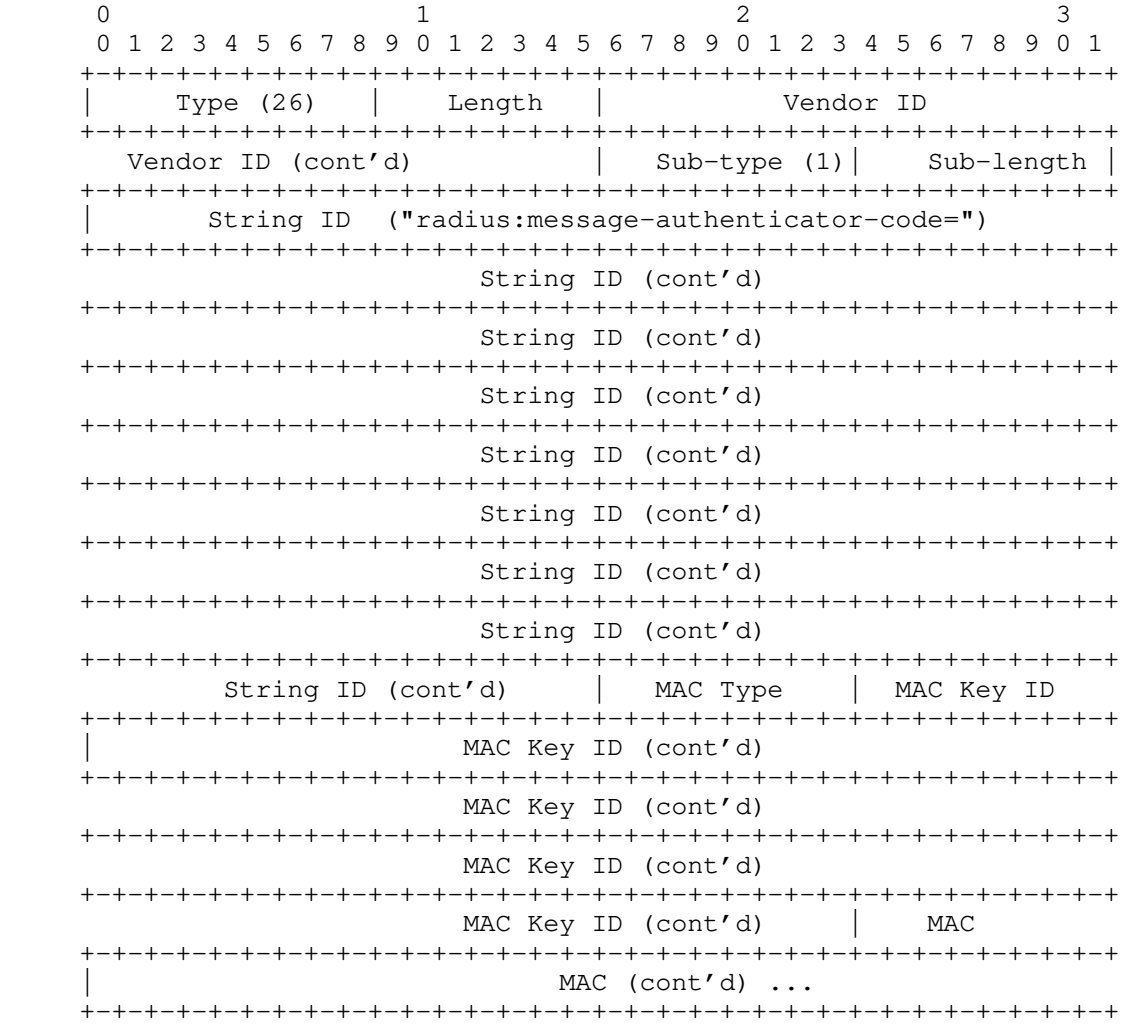
The Message-Authentication-Code Attribute MUST be included in any message that contains a Keying-Material Attribute.

If both the Message-Authentication-Code and Message-Authenticator Attributes are to be included in a message (e.g., for backward compatibility in a network containing both old and new clients), the value of the Message-Authentication-Code Attribute MUST be computed first.

If any message is received containing an instance of the Message-Authentication-Code Attribute, the receiver MUST calculate the correct value of the Message-Authentication-Code and silently discard the packet if the computed value does not match the value received.

If a received message contains an instance of the MAC-Randomizer Attribute (Section 3.2), the received MAC-Randomizer Attribute SHOULD be included in the computation of the Message-Authentication-Code Attribute sent in the response, as described below.

A summary of the Message-Authentication-Code Attribute format is shown below. The fields are transmitted from left to right.



Type

26 for Vendor-Specific

Length

Length of entire attribute including type and length fields

Vendor ID

4 octets encoding the Cisco Vendor ID of 9

Sub-type

Attribute sub-type of 1

Sub-length

Length of the sub-attribute including the sub-type and sub-length fields

String-ID

The ASCII characters "radius:message-authenticator-code=" without quotes or null termination

MAC Type

The MAC Type field specifies the algorithm used to create the value in the MAC field. This document defines six values for the MAC Type field:

0 HMAC-SHA-1 [FIPS] [RFC2104]

1 HMAC-SHA-256 [FIPS] [RFC4231]

2 HMAC-SHA-512 [FIPS] [RFC4231]

3 CMAC-AES-128 [NIST]

4 CMAC-AES-192 [NIST]

5 CMAC-AES-256 [NIST]

Implementations MUST support MAC Type 0 (HMAC-SHA-1).

MAC Key ID

The MAC Key ID field is 16 octets in length and contains an identifier for the key. The combination of the MAC Key ID and the client and server IP addresses together uniquely identify a key shared between the RADIUS client and server. As a result, the MAC Key ID need not be globally unique. The MAC Key ID MUST refer to a key of a type and length appropriate for use with the algorithm specified by the MAC Type field (see above).

The MAC Key ID is a constant that is configured through an out-of-band mechanism. The same value is configured on both the RADIUS client and server. If no MAC Key ID is configured, then the field is set to 0. If only a single MAC Key ID is configured for use between a given RADIUS client and server, then 0 can be used as the default value.

MAC

Both the length and value of the MAC field depend upon the algorithm specified by the value of the MAC Type field. If the algorithm specified is HMAC-SHA-1, HMAC-SHA-256, or HMAC-SHA-512, the MAC field MUST be 20, 32, or 64 octets in length, respectively. If the algorithm specified is CMAC-AES-128, CMAC-AES-192, or CMAC-AES-256, the MAC field SHOULD be 64 octets in length. The derivation of the MAC field value for all the algorithms specified in this document is identical, except for the algorithm used. There are differences, however, depending upon whether the MAC is being computed for a request message or a response. These differences are detailed below, with the free variable HASH-ALG representing the actual algorithm used.

Request Messages

For requests (e.g., CoA-Request [RFC5176], Accounting-Request [RFC2866], etc.), the value of the MAC field is a hash of the entire packet except the Request Authenticator in the header of the RADIUS packet, using a shared secret as the key, as follows.

MAC = MAC-ALG(Key, Type + Identifier + Length + Attributes)
where '+' represents concatenation

The MAC-Randomizer Attribute (Section 3.2) MUST be included in any request in which the Message-Authentication-Code Attribute is used. The Random field of the MAC-Randomizer Attribute MUST be filled in before the value of the MAC field is computed.

If the Message-Authenticator-Code Attribute is included in a client request, the server SHOULD ignore the contents of the Request Authenticator.

Implementation Notes

When the hash is calculated, both the MAC field of the Message-Authenticator-Code Attribute and the String field of the Message-Authenticator Attribute (if any) MUST be considered to be zero-filled.

Implementations SHOULD provide a means to provision a key (cryptographically separate from the normal RADIUS shared secret) to be used exclusively in the generation of the Message-Authentication-Code.

Response Messages

For responses (e.g., CoA-ACK [RFC5176], Accounting-Response [RFC2866], etc.), the value of the MAC field is a hash of the entire packet except the Response Authenticator in the header of the RADIUS packet using a shared secret as the key, as follows.

MAC = HASH-ALG(Key, Type + Identifier + Length + Attributes)
where '+' represents concatenation

If the request contained an instance of the MAC-Randomizer Attribute and the responder wishes to include an instance of the Message-Authentication-Code Attribute in the corresponding response, then the MAC-Randomizer Attribute from the request MUST be included in the response.

If the Message-Authenticator-Code Attribute is included in a server response, the client SHOULD ignore the contents of the Response Authenticator.

Implementation Notes

When the hash is calculated, both the MAC field of the Message-Authenticator-Code Attribute and the String field of the Message-Authenticator Attribute (if any) MUST be considered to be zero-filled.

The Message-Authentication-Code Attribute MUST be created and inserted in the packet before the Response Authenticator is calculated.

Implementations SHOULD provide a means to provision a key (cryptographically separate from the normal RADIUS shared secret) to be used exclusively in the generation of the Message-Authentication-Code.

4. Security Considerations

It is RECOMMENDED in this memo that two new keys, a key encrypting key and a message authentication key, be shared by the RADIUS client and server. If implemented, these two keys MUST be different from each other and SHOULD NOT be based on a password. These two keys MUST be cryptographically independent of the RADIUS shared secret used in calculating the Response Authenticator [RFC2865], Request Authenticator [RFC2866] [RFC5176], and Message-Authenticator Attribute [RFC3579]; otherwise, if the shared secret is broken, all is lost.

To avoid the possibility of collisions, the same MAC key SHOULD NOT be used with more than 2^(n/2) messages, where 'n' is the length of the MAC value in octets.

If a packet that contains an instance of the Keying-Material Attribute also contains an instance of another, weaker key transport attribute (e.g., MS-MPPE-Recv-Key [RFC2548]) encapsulating identical keying material, then breaking the weaker attribute might facilitate a known-plaintext attack against the KEK.

5. Contributors

Hao Zhou, Nancy Cam-Winget, Alex Lam, Paul Funk, and John Fossaceca all contributed to this document.

6. Acknowledgements

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