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Cisco Vendor Specific RADIUS Attributes for the Delivery of Keying Material
draft-zorn-radius-keywrap-18.txt

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. This attributes have been allocated from the Cisco vendor specific space and have been implemented by multiple vendors.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.
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This Internet-Draft will expire on July 16, 2011.

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1. Introduction

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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] (Zorn, G., "Microsoft Vendor-specific RADIUS Attributes," March 1999.) and the Message-Authenticator attribute in [RFC3579] (Aboba, B. and P. Calhoun, "RADIUS (Remote Authentication Dial In User Service) Support For Extensible Authentication Protocol (EAP)," September 2003.).
Many remote access deployments (for example, deployments utilizing wireless LAN technology) require the secure transmission of cryptographic keying material from a RADIUS [RFC2865] (Rigney, C., Willens, S., Rubens, A., and W. Simpson, "Remote Authentication Dial In User Service (RADIUS)," June 2000.) server to a network access point. This material is usually produced as a by-product of an EAP [RFC3748] (Aboba, B., Blunk, L., Vollbrecht, J., Carlson, J., and H. Levkowetz, "Extensible Authentication Protocol (EAP)," June 2004.) 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 a AAA server needs to deliver keying material to a network access point. Discussion of this document may be directed to the authors.

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2. Specification of Requirements

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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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3. Attributes

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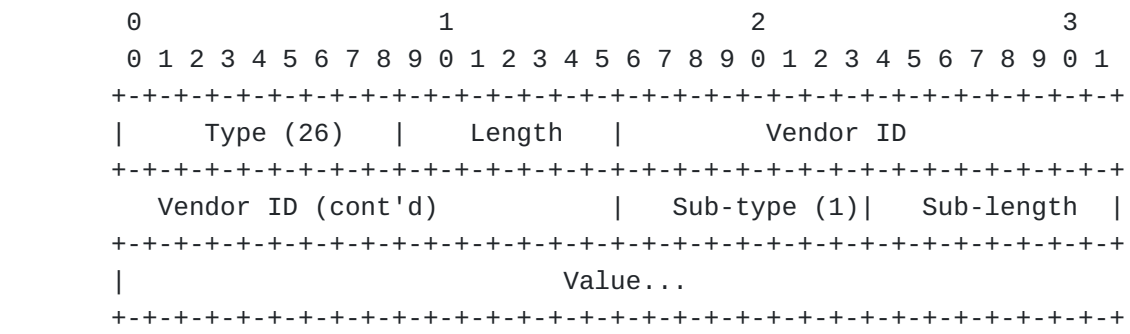
The following subsections describe sub-attributes which are transmitted in RADIUS attributes of type Vendor-Specific [RFC2865] (Rigney, C., Willens, S., Rubens, A., and W. Simpson, "Remote Authentication Dial In User Service (RADIUS)," June 2000.). The Vendor-ID field of the Vendor-Specific Attribute(s) 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 field

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

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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 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, KEK ID, Lifetime, IV and Key Material Data fields MAY be omitted.

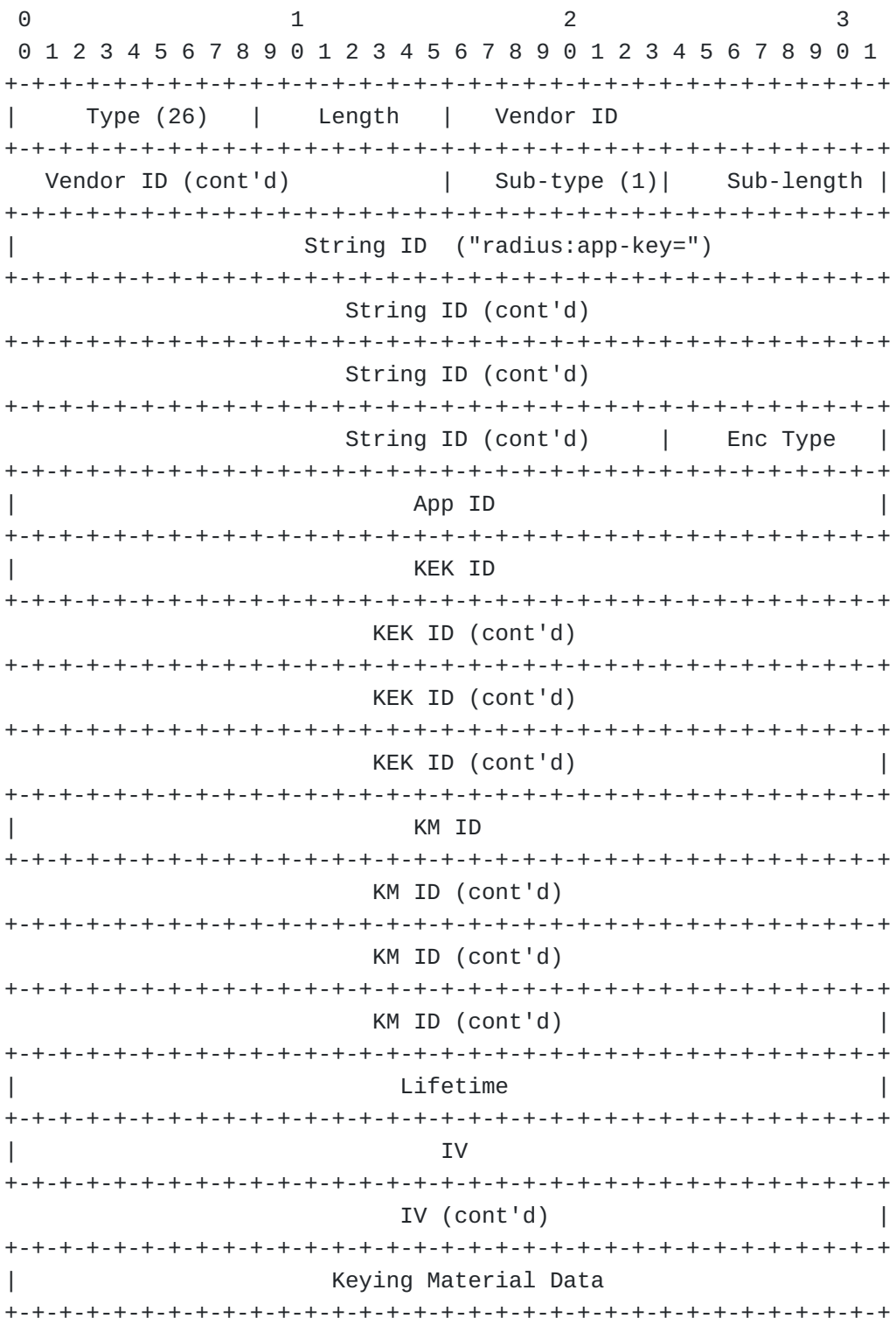
In environments where the the Keying-Material attribute is known to be supported or in cases where the client wants to avoid roll-back attacks the client MAY be configured to require the use of the Keying-Material Attribute. If the client requires the use of the Keying-Material Attribute for keying material 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] (Zorn, G., “Microsoft Vendor-specific RADIUS Attributes,” March 1999.), Tunnel-Password [RFC2868] (Zorn, G., Leifer, D., Rubens, A., Shriver, J., Holdrege, M., and I. Goyret, “RADIUS Attributes for Tunnel Protocol Support,” June 2000.), 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 field

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] (Schaad, J. and R. Housley, “Advanced Encryption Standard (AES) Key Wrap Algorithm,” September 2002.)

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 MSK application is set to 0. Another application can be defined in the future which uses the KM ID field.

Lifetime

The Lifetime field is an integer [RFC2865] (Rigney, C., Willens, S., Rubens, A., and W. Simpson, "Remote Authentication Dial In User Service (RADIUS)," June 2000.) 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] (Schaad, J. and R. Housley, "Advanced Encryption Standard (AES) Key Wrap Algorithm," September 2002.). If the IV for Enc Type 0 does not match [RFC3394] (Schaad, J. and R. Housley, "Advanced Encryption Standard (AES) Key Wrap Algorithm,"

September 2002.) then the receiver MUST NOT use the key material from this attribute.

Keying Material Data

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

3.2. MAC-Randomizer

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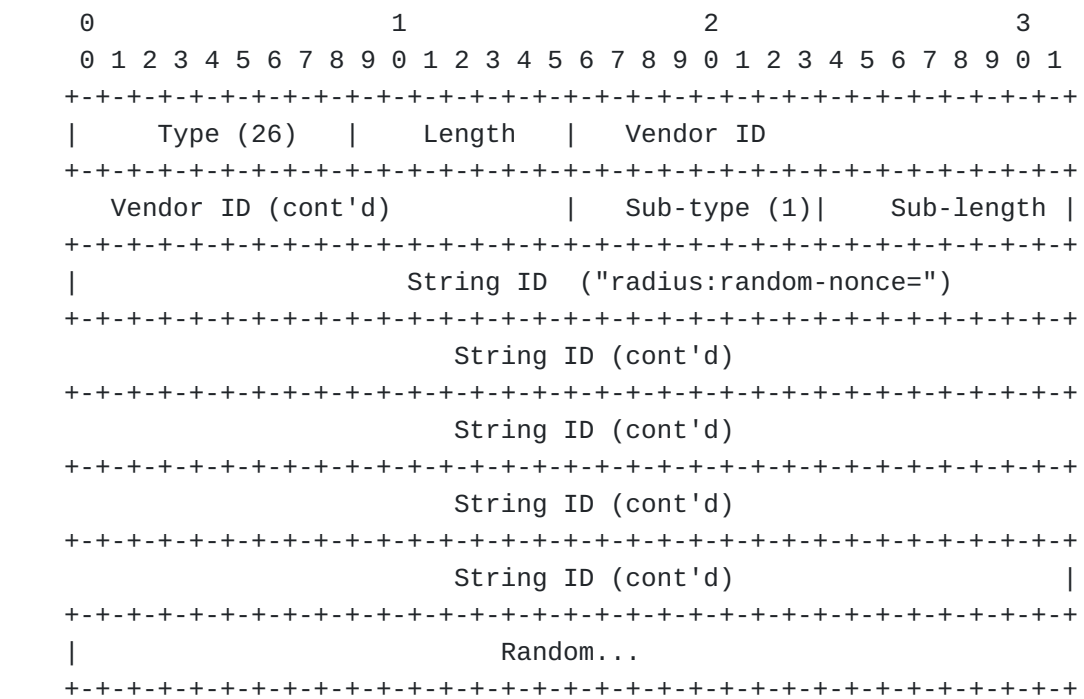
Description

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 which SHOULD satisfy the requirements of [RFC4086] (Eastlake, D., Schiller, J., and S. Crocker, "Randomness Requirements for Security," June 2005.).

Implementation Note

The Random field MUST be filled in before the 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 field

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 which SHOULD satisfy the requirements of [RFC4086] (Eastlake, D., Schiller, J., and S. Crocker, “Randomness Requirements for Security,” June 2005.).

3.3. Message-Authentication-Code

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Description

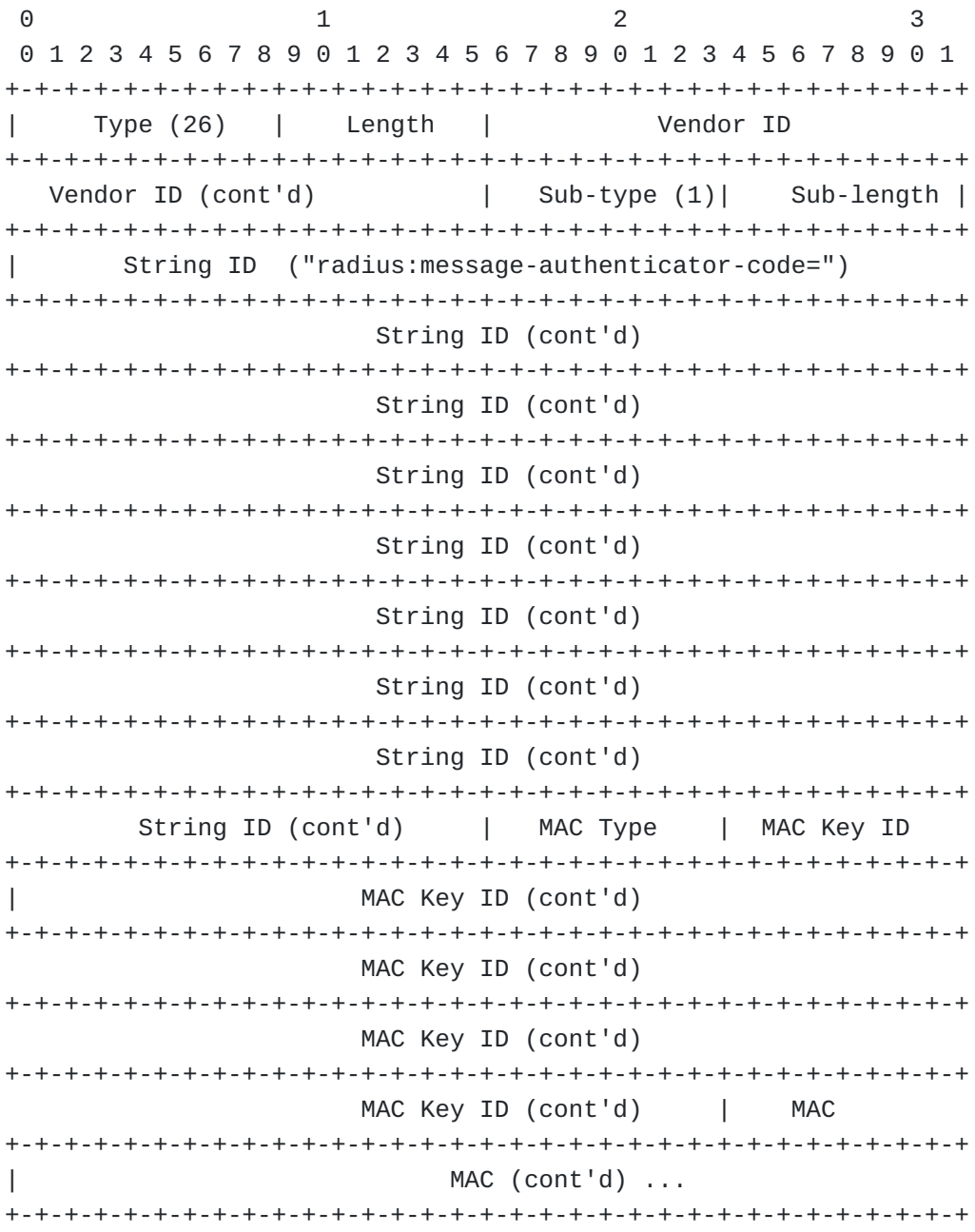
This Attribute MAY be used to "sign" messages to prevent spoofing. If it is present in a request, the receiver should take this a hint that the sender prefers the use of this Attribute for message authentication; the receiver is not obligated to do so, however.

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 field

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.180-2.2002] (National Institute of Standards and Technology, “Secure Hash Standard,” August 2002.) [RFC2104] (Krawczyk, H., Bellare, M., and R. Canetti, “HMAC: Keyed-Hashing for Message Authentication,” February 1997.)
>
> 1 HMAC-SHA-256 [FIPS.180-2.2002] (National Institute of Standards and Technology, “Secure Hash Standard,” August 2002.) [RFC4231] (Nystrom, M., “Identifiers and Test Vectors for HMAC-SHA-224, HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512,” December 2005.)
>
> 2 HMAC-SHA-512 [FIPS.180-2.2002] (National Institute of Standards and Technology, “Secure Hash Standard,” August 2002.) [RFC4231] (Nystrom, M., “Identifiers and Test Vectors for HMAC-SHA-224, HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512,” December 2005.)
>
> 3 CMAC-AES-128 [NIST.SP800-38B] (Dworkin, M., “Recommendation for Block Cipher Modes of Operation: The CMAC Mode for Authentication,” May 2005.)
>
> 4 CMAC-AES-192 [NIST.SP800-38B] (Dworkin, M., “Recommendation for Block Cipher Modes of Operation: The CMAC Mode for Authentication,” May 2005.)
>
> 5 CMAC-AES-256 [NIST.SP800-38B] (Dworkin, M., “Recommendation for Block Cipher Modes of Operation: The CMAC Mode for Authentication,” May 2005.)

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] (Chiba, M., Dommety, G., Eklund, M., Mitton, D., and B. Aboba, “Dynamic Authorization Extensions to Remote Authentication Dial In User Service (RADIUS),” January 2008.), Accounting-Request [RFC2866] (Rigney, C., “RADIUS Accounting,” June 2000.), 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] (Chiba, M., Dommety, G., Eklund, M., Mitton, D., and B. Aboba, "Dynamic Authorization Extensions to Remote Authentication Dial In User Service (RADIUS)," January 2008.), Accounting-Response [RFC2866] (Rigney, C., "RADIUS Accounting," June 2000.), 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.

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4. IANA Considerations

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This document does not define any actions for IANA.

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5. Security Considerations

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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] (Rigney, C., Willens, S., Rubens, A., and W. Simpson, "Remote Authentication Dial In User Service (RADIUS)," June 2000.), Request Authenticator [RFC2866] (Rigney, C., "RADIUS Accounting," June 2000.) [RFC5176] (Chiba, M., Dommety, G., Eklund, M., Mitton, D., and B. Aboba, "Dynamic Authorization Extensions to Remote Authentication Dial In User Service (RADIUS)," January 2008.) and Message-Authenticator Attribute [RFC3579] (Aboba, B. and P. Calhoun, "RADIUS (Remote Authentication Dial In User Service) Support For Extensible Authentication Protocol (EAP)," September 2003.); 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] (Zorn, G., "Microsoft Vendor-specific RADIUS Attributes," March 1999.)) encapsulating identical keying material, then breaking the weaker attribute might facilitate a known-plaintext attack against the KEK.

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6. Contributors

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

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7. Acknowledgements

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8. References

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8.1. Normative References

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[NIST.SP800-38B]	Dworkin, M., "Recommendation for Block Cipher Modes of Operation: The CMAC Mode for Authentication," May 2005.
[RFC2104]	Krawczyk, H., Bellare, M., and R. Canetti, "HMAC: Keyed-Hashing for Message Authentication," RFC 2104, February 1997 (TXT).
[RFC2119]	Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels," BCP 14, RFC 2119, March 1997 (TXT, HTML, XML).
[RFC2865]	Rigney, C., Willens, S., Rubens, A., and W. Simpson, "Remote Authentication Dial In User Service (RADIUS)," RFC 2865, June 2000 (TXT).
[RFC2866]	Rigney, C., "RADIUS Accounting," RFC 2866, June 2000 (TXT).
[RFC2868]	Zorn, G., Leifer, D., Rubens, A., Shriver, J., Holdrege, M., and I. Goyret, "RADIUS Attributes for Tunnel Protocol Support," RFC 2868, June 2000 (TXT).
[RFC3394]	Schaad, J. and R. Housley, "Advanced Encryption Standard (AES) Key Wrap Algorithm," RFC 3394, September 2002 (TXT).
[RFC3579]	Aboba, B. and P. Calhoun, "RADIUS (Remote Authentication Dial In User Service) Support For Extensible Authentication Protocol (EAP)," RFC 3579, September 2003 (TXT).
[RFC4086]	Eastlake, D., Schiller, J., and S. Crocker, "Randomness Requirements for Security," BCP 106, RFC 4086, June 2005 (TXT).
[RFC4231]	Nystrom, M., "Identifiers and Test Vectors for HMAC-SHA-224, HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512," RFC 4231, December 2005 (TXT).
[RFC5176]	Chiba, M., Dommety, G., Eklund, M., Mitton, D., and B. Aboba, "Dynamic Authorization Extensions to Remote Authentication Dial In User Service (RADIUS)," RFC 5176, January 2008 (TXT).

8.2. Informative References

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[RFC2548]	Zorn, G., "Microsoft Vendor-specific RADIUS Attributes," RFC 2548, March 1999 (TXT).
[RFC3748]	

Aboba, B., Blunk, L., Vollbrecht, J., Carlson, J., and H. Levkowetz, “Extensible Authentication Protocol (EAP),” RFC 3748, June 2004 (TXT).

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