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Using the AES-GMAC Algorithm with the Cryptographic Message Syntax (CMS)

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Abstract

This document specifies the conventions for using the AES-GMAC Message Authentication Code algorithms with the Cryptographic Message Syntax (CMS) as specified in RFC 5652.

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1. Introduction

This document specifies the conventions for using the AES-GMAC [AES][GCM] Message Authentication Code (MAC) algorithm with the Cryptographic Message Syntax (CMS) [RFC5652].

2. Terminology

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.

3. Message Authentication Code Algorithms

This section specifies the conventions employed by CMS [RFC5652] implementations that support the AES-GMAC [AES][GCM] Message Authentication Code (MAC) algorithm.

MAC algorithm identifiers are located in the AuthenticatedData macAlgorithm field.

MAC values are located in the AuthenticatedData mac field.

3.1. AES-GMAC

The AES-GMAC [AES][GCM] Message Authentication Code (MAC) algorithm uses one of the following algorithm identifiers in the AuthenticatedData macAlgorithm field; the choice depends on the size of the AES key, which is either 128 bits, 192 bits, or 256 bits:


```
aes OBJECT IDENTIFIER ::= { joint-iso-itu-t(2) country(16) us(840)
        organization(1) gov(101) csor(3) nistAlgorithm(4) 1 }

id-aes128-GMAC OBJECT IDENTIFIER ::= { aes 9 }

id-aes192-GMAC OBJECT IDENTIFIER ::= { aes 29 }

id-aes256-GMAC OBJECT IDENTIFIER ::= { aes 49 }
```

For all three of these algorithm identifier values, the AlgorithmIdentifier parameters field MUST be present, and the parameters MUST contain GMACParameters:

```
GMACParameters ::= SEQUENCE {
   nonce        OCTET STRING, -- recommended size is 12 octets
   length       MACLength DEFAULT 12 }

MACLength ::= INTEGER (12 | 13 | 14 | 15 | 16)
```

The GMACParameters nonce field is the GMAC initialization vector. The nonce may have any number of bits between 8 and (2^64)-1, but it MUST be a multiple of 8 bits. Within the scope of any content-authentication key, the nonce value MUST be unique. A nonce value of 12 octets can be processed more efficiently, so that length for the nonce value is RECOMMENDED.

The GMACParameters length field tells the size of the message authentication code. It MUST match the size in octets of the value in the AuthenticatedData mac field. A length of 12 octets is RECOMMENDED.

4. Implementation Considerations

An implementation of the Advanced Encryption Standard (AES) Galois/Counter Mode (GCM) authenticated encryption algorithm is specified in [GCM]. An implementation of AES-GCM can be used to compute the GMAC

message authentication code by providing the content-authentication key as the AES key, the nonce as the initialization vector, a zero-length plaintext content, and the content to be authenticated as the additional authenticated data (AAD). The result of the AES-GCM invocation is the AES-GMAC authentication code, which is called the authentication tag in some implementations. In AES-GCM, the encryption step is skipped when no input plaintext is provided, and therefore, no ciphertext is produced.

The DEFAULT and RECOMMENDED values in GMACParameters were selected to align with the parameters defined for AES-GCM in Section 3.2 of [RFC5084].

5. ASN.1 Module

The following ASN.1 module uses the definition for MAC-ALGORITHM from [RFC5912].

```
CryptographicMessageSyntaxGMACAlgorithms
    { iso(1) member-body(2) us(840) rsadsi(113549)
      pkcs(1) pkcs-9(9) smime(16) modules(0)
      id-mod-aes-gmac-alg-2020(TBD) }

DEFINITIONS IMPLICIT TAGS ::=
BEGIN

-- EXPORTS All

IMPORTS
  AlgorithmIdentifier{}, MAC-ALGORITHM
  FROM AlgorithmInformation-2009 -- from [RFC5912]
      { iso(1) identified-organization(3) dod(6) internet(1)
        security(5) mechanisms(5) pkix(7) id-mod(0)
        id-mod-algorithmInformation-02(58)} ;

-- Object Identifiers

aes OBJECT IDENTIFIER ::= { joint-iso-itu-t(2) country(16) us(840)
       organization(1) gov(101) csor(3) nistAlgorithm(4) 1 }

id-aes128-GMAC OBJECT IDENTIFIER ::= { aes 9 }
```

```
   id-aes192-GMAC OBJECT IDENTIFIER ::= { aes 29 }

   id-aes256-GMAC OBJECT IDENTIFIER ::= { aes 49 }

   -- GMAC Parameters

   GMACParameters ::= SEQUENCE {
      nonce        OCTET STRING, -- recommended size is 12 octets
      length       MACLength DEFAULT 12 }

   MACLength ::= INTEGER (12 | 13 | 14 | 15 | 16)

   -- Algorithm Identifiers

   maca-aes128-GMAC MAC-ALGORITHM ::= {
      IDENTIFIER id-aes128-GMAC
      PARAMS TYPE GMACParameters ARE required
      IS-KEYED-MAC TRUE }
```



```
   maca-aes192-GMAC MAC-ALGORITHM ::= {
      IDENTIFIER id-aes192-GMAC
      PARAMS TYPE GMACParameters ARE required
      IS-KEYED-MAC TRUE }

   maca-aes256-GMAC MAC-ALGORITHM ::= {
      IDENTIFIER id-aes256-GMAC
      PARAMS TYPE GMACParameters ARE required
      IS-KEYED-MAC TRUE }

   END -- of CryptographicMessageSyntaxGMACAlgorithms
```

6. IANA Considerations

IANA is asked to register object identifiers for one module identifier in the "SMI Security for S/MIME Module Identifier (1.2.840.113549.1.9.16.0)" registry for id-mod-aes-gmac-alg-2020.

7. Security Considerations

The CMS provides a method for authenticating data. This document identifies the conventions for using the AES-GMAC algorithm with the

CMS.

The key management technique employed to distribute message-authentication keys must itself provide authentication, otherwise the content is delivered with integrity from an unknown source.

When more than two parties share the same message-authentication key, data origin authentication is not provided. Any party that knows the message-authentication key can compute a valid MAC, therefore the content could originate from any one of the parties.

Within the scope of any content-authentication key, the AES-GMAC nonce value MUST be unique. Use of a nonce value more than once allows an attacker to generate valid AES-GMAC authentication codes for arbitrary messages, resulting in the loss of authentication as described in Appendix A of [GCM].

Within the scope of any content-authentication key, the authentication tag length (MACLength) MUST be fixed.

If AES-GMAC is used as a building block in another algorithm (e.g., as a pseudo-random function), AES-GMAC MUST be used only one time by that algorithm. For instance, AES-GMAC MUST NOT be used as the pseudo-random function for PBKDF2.

When IV lengths other than 96 bits are used, the GHASH function is used to process the provided IV, which introduces a potential of IV collisions. However, IV collisions are not a concern with CMS AuthenticatedData because a fresh content-authentication key is usually generated for each message.

The probability of a successful forgery is close to 2^(-t), where t is the number of bits in the authentication tag length (MACLength*8). This nearly ideal authentication protection is achieved for CMS AuthenticatedData when a fresh content-authentication key is generated for each message. However, the strength of GMAC degrades slightly as a function of the length of the message being authenticated [F2005][MV2005]. Implementations SHOULD use 16-octet authentication tags for messages over 2^64 octets.

Implementations must randomly generate message-authentication keys. The use of inadequate pseudo-random number generators (PRNGs) to generate keys can result in little or no security. An attacker may find it much easier to reproduce the PRNG environment that produced the keys, searching the resulting small set of possibilities, rather than brute force searching the whole key space. The generation of quality random numbers is difficult. [RFC4086] offers important guidance in this area.

Implementers should be aware that cryptographic algorithms become weaker with time. As new cryptanalysis techniques are developed and computing performance improves, the work factor to break a particular cryptographic algorithm will reduce. Therefore, cryptographic algorithm implementations should be modular allowing new algorithms to be readily inserted. That is, implementers should be prepared to regularly update the set of algorithms in their implementations. More information is available in BCP 201 [RFC7696].

8. Acknowledgements

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