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# AES-GCM Cipher Suites for TLS
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## Status of this Memo



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## Abstract

This memo describes the use of the Advanced Encryption Standard (AES) in Galois/Counter Mode (GCM) as a Transport Layer Security (TLS) authenticated encryption operation. GCM provides both confidentiality and data origin authentication, can be efficiently implemented in hardware for speeds of 10 gigabits per second and above, and is also well-suited to software implementations. This memo defines TLS ciphersuites that use AES-GCM with RSA, DSS and

Diffie-Hellman based key exchange mechanisms.

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## 1. Introduction

This document describes the use of AES [AES]in Galois Counter Mode (GCM) [GCM] (AES-GCM) with various key exchange mechanisms as a ciphersuite for TLS. AES-GCM is not only efficient and secure, but hardware implementations can achieve high speeds with low cost and low latency, because the mode can be pipelined. Applications like CAPWAP, which uses DTLS, can benefit from the high-speed implementations when wireless termination points (WTPs) and controllers (ACs) have to meet requirements to support higher throughputs in the future. AES-GCM has been specified as a mode that can be used with IPsec ESP [RFC4106] and 802.1AE MAC Security [IEEE8021AE]. This document defines ciphersutes based on RSA, DSS and Diffie-Hellman key exchanges; ECC based ciphersuites are defined in a separate document [I-D.ietf-tls-ecc-new-mac]. AES-GCM is an authenticated encryption with associated data (AEAD) cipher, as defined in TLS 1.2 [I-D.ietf-tls-rfc4346-bis]. The ciphersuites defined in this draft may be used with Datagram TLS defined in [RFC4347]. This memo uses GCM in a way similar to [I-D.ietf-tls-ecc-new-mac].

## 2. Conventions Used In This Document

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. AES-GCM Cipher Suites

The following ciphersuites use the new authenticated encryption modes defined in TLS 1.2 with AES in Galois Counter Mode (GCM) [GCM]:

```
CipherSuite TLS_RSA_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_RSA_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
```

```
CipherSuite TLS_DHE_RSA_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_DHE_RSA_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
CipherSuite TLS_DH_RSA_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_DH_RSA_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
CipherSuite TLS_DHE_DSS_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_DHE_DSS_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
CipherSuite TLS_DH_DSS_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_DH_DSS_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
CipherSuite TLS_DH_anon_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_DH_anon_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
```

These ciphersuites use the AES-GCM authenticated encryption with





associated data (AEAD) algorithms AEAD_AES_128_GCM and AEAD_AES_256_GCM described in [RFC5116]. Note that each of these AEAD algorithms uses a 128-bit authentication tag with GCM. The "nonce" SHALL be 12 bytes long and it is "partially implicit" (see section 3.2.1 in [RFC5116]). Part of the nonce is generated as part of the handshake process and is static for the entire session and the other part is carried in each packet.

```
Struct{
   opaque salt[4];
   opaque explicit_nonce_part[8];
} GCMNonce
```

The salt is the "implicit" part of the nonce and is not sent in the packet. It is either the client_write_IV if the client is sending or the server_write_IV if the server is sending. These IVs SHALL be 4 bytes long, therefore, for all the algorithms defined in this section, SecurityParameters.fixed_iv_length=4.

The explicit_nonce_part is chosen by the sender and included in the packet. Each value of the explicit_nonce_part MUST be distinct for each distinct invocation of GCM encrypt function for any fixed key. Failure to meet this uniqueness requirement can significantly degrade security. The explicit_nonce_part is carried in the IV field of the GenericAEADCipher structure. For all the algorithms defined in this section, SecurityParameters.record_iv_length=8.

In the case of TLS the explicit_nonce_part MAY be the 64-bit sequence number. In the case of Datagram TLS [RFC4347] the explicit_nonce_part MAY be formed from the concatenation of the 16-bit epoch with the 48-bit DTLS seq_num.

The RSA, DHE_RSA, DH_RSA, DHE_DSS, DH_DSS, and DH_anon key exchanges are performed as defined in [I-D.ietf-tls-rfc4346-bis].

The PRF algorithms SHALL be as follows:

For ciphersuites ending in _SHA256 the hash function is SHA256.

For ciphersuites ending in _SHA384 the hash function is SHA384.

## 4. TLS Versions

These ciphersuites make use of the authenticated encryption with additional data defined in TLS 1.2 [I-D.ietf-tls-rfc4346-bis]. They MUST NOT be negotiated in older versions of TLS. Clients MUST NOT offer these cipher suites if they do not offer TLS 1.2 or later.





Servers which select an earlier version of TLS MUST NOT select one of these cipher suites. Because TLS has no way for the client to indicate that it supports TLS 1.2 but not earlier, a non-compliant server might potentially negotiate TLS 1.1 or earlier and select one of the cipher suites in this document. Clients MUST check the TLS version and generate a fatal "illegal_parameter" alert if they detect an incorrect version.

## 5. IANA Considerations

IANA has assigned the following values for the ciphersuites defined in this draft:

```
CipherSuite TLS_RSA_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_RSA_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
CipherSuite TLS_DHE_RSA_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_DHE_RSA_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
CipherSuite TLS_DH_RSA_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_DH_RSA_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
CipherSuite TLS_DHE_DSS_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_DHE_DSS_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
```

```
CipherSuite TLS_DH_DSS_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_DH_DSS_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
CipherSuite TLS_DH_anon_WITH_AES_128_GCM_SHA256 = {TBD,TBD}
CipherSuite TLS_DH_anon_WITH_AES_256_GCM_SHA384 = {TBD,TBD}
```

## 6. Security Considerations

The security considerations in [I-D.ietf-tls-rfc4346-bis] apply to this document as well. The remainder of this section describes security considerations specific to the cipher suites described in this document.

### 6.1. Counter Reuse

AES-GCM security requires that the counter is never reused. The IV construction in Section 3 is designed to prevent counter reuse.

### 6.2. Recommendations for Multiple Encryption Processors

If multiple cryptographic processors are in use by the sender, then the sender MUST ensure that, for a particular key, each value of the explicit_nonce_part used with that key is distinct. In this case each encryption processor SHOULD include in the explicit_nonce_part a fixed value that is distinct for each processor. The recommended format is





```
explicit_nonce_part = FixedDistinct || Variable
```

where the FixedDistinct field is distinct for each encryption processor, but is fixed for a given processor, and the Variable field is distinct for each distinct nonce used by a particular encryption processor. When this method is used, the FixedDistinct fields used by the different processors MUST have the same length.

In the terms of Figure 2 in [RFC5116], the Salt is the Fixed-Common part of the nonce (it is fixed, and it is common across all encryption processors), the FixedDistinct field exactly corresponds to the Fixed-Distinct field, and the Variable field corresponds to the Counter field, and the explicit part exactly corresponds to the explicit_nonce_part.

For clarity, we provide an example for TLS in which there are two distinct encryption processors, each of which uses a one-byte FixedDistinct field:

```
Salt          = eedc68dc
FixedDistinct = 01       (for the first encryption processor)
FixedDistinct = 02       (for the second encryption processor)
```

The GCMnonces generated by the first encryption processor, and their corresponding explicit_nonce_parts, are:

```
GCMNonce                    explicit_nonce_part
------------------------    ----------------------------
eedc68dc0100000000000000    0100000000000000
eedc68dc0100000000000001    0100000000000001
eedc68dc0100000000000002    0100000000000002
...
```

The GCMnonces generated by the second encryption processor, and their corresponding explicit_nonce_parts, are

```
GCMNonce                    explicit_nonce_part
------------------------    ----------------------------
eedc68dc0200000000000000    0200000000000000
eedc68dc0200000000000001    0200000000000001
eedc68dc0200000000000002    0200000000000002
...
```





## 7. Acknowledgements

This draft borrows heavily from [I-D.ietf-tls-ecc-new-mac]. The authors would like to thank Alex Lam and Pasi Eronen for providing useful comments during the review of this draft.

## 8. References

### 8.1. Normative References

[AES] National Institute of Standards and Technology, "Specification for the Advanced Encryption Standard (AES)", FIPS 197, November 2001.

[GCM] National Institute of Standards and Technology, "Recommendation for Block Cipher Modes of Operation: Galois Counter Mode (GCM) for Confidentiality and Authentication", SP 800-38D, April 2006.

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[RFC4347] Rescorla, E. and N. Modadugu, "Datagram Transport Layer Security", RFC 4347, April 2006.

[RFC5116] McGrew, D., "An Interface and Algorithms for Authenticated Encryption", RFC 5116, January 2008.

### 8.2. Informative References

[I-D.ietf-tls-ecc-new-mac] Rescorla, E., "TLS Elliptic Curve Cipher Suites with SHA-256/384 and AES Galois Counter Mode", draft-ietf-tls-ecc-new-mac-02 (work in progress), December 2007.

[IEEE8021AE] Institute of Electrical and Electronics Engineers, "Media Access Control Security", IEEE Standard 802.1AE, August 2006.

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(GCM) in IPsec Encapsulating Security Payload (ESP)", RFC 4106, June 2005.

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