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**Use of Elliptic Curve Cryptography (ECC) Algorithms
in Cryptographic Message Syntax (CMS)
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Abstract

This document describes how to use Elliptic Curve Cryptography (ECC) public-key algorithms in the Cryptographic Message Syntax (CMS). The ECC algorithms support the creation of digital signatures and the exchange of keys to encrypt or authenticate content. The definition of the algorithm processing is based on the NIST FIPS 186-3 for digital signature, NIST SP800-56A and SEC1 for key agreement, [RFC 3370](#) and [RFC 3565](#) for key wrap and content encryption, NIST FIPS 180-3 for message digest, SEC1 for key derivation, and [RFC 2104](#) and [RFC 4231](#) for message authentication code standards. This document obsoletes [RFC 3278](#).

Discussion

This draft is being discussed on the 'ietf-smime' mailing list. To subscribe, send a message to ietf-smime-request@imc.org with the single word subscribe in the body of the message. There is a Web site for the mailing list at <http://www.imc.org/ietf-smime/>.

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[1. Introduction](#)

The Cryptographic Message Syntax (CMS) is cryptographic algorithm independent. This specification defines a profile for the use of Elliptic Curve Cryptography (ECC) public key algorithms in the CMS. The ECC algorithms are incorporated into the following CMS content types:

- 'SignedData' to support ECC-based digital signature methods (ECDSA) to sign content;
- 'EnvelopedData' to support ECC-based public-key agreement methods (ECDH and ECMQV) to generate pairwise key-encryption keys to encrypt content-encryption keys used for content encryption;
- 'AuthenticatedData' to support ECC-based public-key agreement methods (ECMQV) to generate pairwise key-encryption keys to encrypt message-authentication keys used for content authentication and integrity; and,
- 'AuthEnvelopedData' to support ECC-based public-key agreement methods (ECMQV) to generate pairwise key-encryption keys to encrypt message-authentication and content-encryption keys used for content authentication, integrity, and encryption.

Certification of EC public keys is also described to provide public-key distribution in support of the specified techniques.

The document will obsolete [\[CMS-ECC\]](#). The technical changes performed since [RFC 3278](#) are detailed in [Appendix B](#).

1.1. Requirements Terminology

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 [[MUST](#)].

2. SignedData using ECC

This section describes how to use ECC algorithms with the CMS SignedData format to sign data.

2.1. SignedData using ECDSA

This section describes how to use the Elliptic Curve Digital Signature Algorithm (ECDSA) with SignedData. ECDSA is specified in [[FIPS186-3](#)]. The method is the elliptic curve analog of the Digital Signature Algorithm (DSA) [[FIPS186-3](#)]. ECDSA is used with the Secure Hash Algorithm (SHA) [[FIPS180-3](#)].

In an implementation that uses ECDSA with CMS SignedData, the following techniques and formats MUST be used.

2.1.1. Fields of the SignedData

When using ECDSA with SignedData, the fields of SignerInfo are as in [[CMS](#)], but with the following restrictions:

- digestAlgorithm MUST contain the algorithm identifier of the hash algorithm (see [Section 7.1.1](#)) which MUST be one of the following: id-sha1, id-sha224, id-sha256, id-sha384, or id-sha512.
- signatureAlgorithm contains the signature algorithm identifier (see [Section 7.1.3](#)): ecdsa-with-SHA1, ecdsa-with-SHA224, ecdsa-with-SHA256, ecdsa-with-SHA384, or ecdsa-with-SHA512. The hash algorithm identified in the name of the signature algorithm MUST be the same as the digestAlgorithm (e.g., digestAlgorithm is id-sha256 therefore signatureAlgorithm is ecdsa-with-SHA256).
- signature MUST contain the DER encoding (as an octet string) of a value of the ASN.1 type ECDSA-Sig-Value (see [Section 7.2](#)).

When using ECDSA, the SignedData certificates field MAY include the certificate(s) for the EC public key(s) used in the generation of the ECDSA signatures in SignedData. ECC certificates are discussed in [Section 5](#).

2.1.2. Actions of the sending agent

When using ECDSA with SignedData, the sending agent uses the message digest calculation process and signature generation process for SignedData that are specified in [CMS]. To sign data, the sending agent uses the signature method specified in [FIPS186-3].

The sending agent encodes the resulting signature using the ECDSA-Sig-Value syntax (see [Section 7.2](#)) and places it in the SignerInfo signature field.

2.1.3. Actions of the receiving agent

When using ECDSA with SignedData, the receiving agent uses the message digest calculation process and signature verification process for SignedData that are specified in [CMS]. To verify SignedData, the receiving agent uses the signature verification method specified in [FIPS186-3].

In order to verify the signature, the receiving agent retrieves the integers r and s from the SignerInfo signature field of the received message.

3. EnvelopedData using ECC Algorithms

This section describes how to use ECC algorithms with the CMS EnvelopedData format.

This document does not specify the static-static ECDH, method C(0,2, ECC CDH) from [SP800-56A]. Static-static ECDH is analogous to static-static DH, which is specified in [CMS-ALG]. Ephemeral-static ECDH and 1-Pass ECMQV were specified because they provide better security due to the originator's ephemeral contribution to the key agreement scheme.

3.1. EnvelopedData using (ephemeral-static) ECDH

This section describes how to use the ephemeral-static Elliptic Curve Diffie-Hellman (ECDH) key agreement algorithm with EnvelopedData, method C(1, 1, ECC CDH) from [SP800-56A] and ECDH with the standard primitive from Section 3.3.1 of [SEC1]. Ephemeral-static ECDH is the elliptic curve analog of the ephemeral-static Diffie-Hellman key agreement algorithm specified jointly in the documents [CMS-ALG] and [CMS-DH].

If an implementation uses ECDH with CMS EnvelopedData, then the following techniques and formats MUST be used.

The fields of EnvelopedData are as in [CMS]; as ECDH is a key agreement algorithm, the RecipientInfo kari choice is used.

3.1.1. Fields of KeyAgreeRecipientInfo

When using ephemeral-static ECDH with EnvelopedData, the fields of KeyAgreeRecipientInfo are as follows:

- version MUST be 3.
- originator MUST be the alternative originatorKey. The originatorKey algorithm field MUST contain the id-ecPublicKey object identifier (see [Section 7.1.2](#)). The parameters associated with id-ecPublicKey MUST be absent, ECPParameters, or NULL. The parameters associated with id-ecPublicKey SHOULD be absent or ECPParameters, and NULL is allowed to support legacy implementations. The previous version of this document required NULL to be present. If the parameters are ECPParameters, then they MUST be namedCurve. The originatorKey publicKey field MUST contain the value of the ASN.1 type ECPoint (see [Section 7.2](#)), which represents the sending agent's ephemeral EC public key. The ECPoint in uncompressed form MUST be supported.
- ukm MAY be present or absent. However, message originators SHOULD include the ukm. As specified in [RFC 3852](#) [CMS], implementations MUST support ukm message recipient processing, so interoperability is not a concern if the ukm is present or absent. The ukm is placed in the entityUInfo field of the ECC-CMS-SharedInfo structure. When present, the ukm is used to ensure that a different key-encryption key is generated, even when the ephemeral private key is improperly used more than once, by using the ECC-CMS-SharedInfo as an input to the key derivation function (see [Section 7.2](#)).
- keyEncryptionAlgorithm MUST contain the object identifier of the key encryption algorithm, which in this case is a key agreement algorithm (see [Section 7.1.4](#)). The parameters field contains KeyWrapAlgorithm. The KeyWrapAlgorithm is the algorithm identifier that indicates the symmetric encryption algorithm used to encrypt the content-encryption key (CEK) with the key-encryption key (KEK) and any associated parameters (see [Section 7.1.5](#)). Algorithm requirements are found in [Section 8](#).
- recipientEncryptedKeys contains an identifier and an encrypted key for each recipient. The RecipientEncryptedKey KeyAgreeRecipientIdentifier MUST contain either the issuerAndSerialNumber identifying the recipient's certificate or

the RecipientKeyIdentifier containing the subject key identifier from the recipient's certificate. In both cases, the recipient's certificate contains the recipient's static ECDH public key. RecipientEncryptedKey EncryptedKey MUST contain the content-encryption key encrypted with the ephemeral-static, ECDH-generated pairwise key-encryption key using the algorithm specified by the KeyWrapAlgorithm.

3.1.2. Actions of the sending agent

When using ephemeral-static ECDH with EnvelopedData, the sending agent first obtains the recipient's EC public key and domain parameters (e.g. from the recipient's certificate). The sending agent then determines an integer "keydatalen", which is the KeyWrapAlgorithm symmetric key-size in bits, and also a bit string "SharedInfo", which is the DER encoding of ECC-CMS-SharedInfo (see [Section 7.2](#)). The sending agent then performs the key deployment and the key agreement operation of the Elliptic Curve Diffie-Hellman Scheme specified in [SP800-56A] or [SEC1]; in either case, use the KDF defined in Section 3.6.1 of [SEC1] with the hash algorithm identified in the key agreement algorithm. As a result the sending agent obtains:

- an ephemeral public key, which is represented as a value of the type ECPoint (see [Section 7.2](#)), encapsulated in a bit string and placed in the KeyAgreeRecipientInfo originator originatorKey publicKey field, and
- a shared secret bit string "K", which is used as the pairwise key-encryption key for that recipient, as specified in [CMS].

In a single message, if there are multiple layers for a recipient, then the ephemeral public key can be reused by the originator for that recipient in each of the different layers.

3.1.3. Actions of the receiving agent

When using ephemeral-static ECDH with EnvelopedData, the receiving agent determines the bit string "SharedInfo", which is the DER encoding of ECC-CMS-SharedInfo (see [Section 7.2](#)), and the integer "keydatalen" from the key-size, in bits, of the KeyWrapAlgorithm. The receiving agent retrieves the ephemeral EC public key from the bit string KeyAgreeRecipientInfo originator, with a value of the type ECPoint (see [Section 7.2](#)) encapsulated as a bit string, and if present, originally supplied additional user key material from the ukm field. The receiving agent performs the key agreement operation of the Elliptic Curve Diffie-Hellman Scheme specified in [SP800-56A]

or [\[SEC1\]](#); in either case, use the KDF defined in Section 3.6.1 of [\[SEC1\]](#). As a result, the receiving agent obtains a shared secret bit string "K", which is used as the pairwise key-encryption key to unwrap the CEK.

[3.2.](#) EnvelopedData using 1-Pass ECMQV

This section describes how to use the 1-Pass elliptic curve MQV (ECMQV) key agreement algorithm with EnvelopedData, method C(1, 2, ECC MQV) from [\[SP800-56A\]](#). Like the KEA algorithm [\[CMS-KEA\]](#), 1-Pass ECMQV uses three key pairs: an ephemeral key pair, a static key pair of the sending agent, and a static key pair of the receiving agent. Using an algorithm with the sender static key pair allows for knowledge of the message creator, this means that authentication can, in some circumstances, be obtained for AuthEnvelopedData and AuthenticatedData. This means that 1-Pass ECMQV can be a common algorithm for EnvelopedData, AuthenticatedData and AuthEnvelopedData, while ECDH can only be used in EnvelopedData.

If an implementation uses 1-Pass ECMQV with CMS EnvelopedData, then the following techniques and formats MUST be used.

The fields of EnvelopedData are as in [\[CMS\]](#); as 1-Pass ECMQV is a key agreement algorithm, the RecipientInfo kari choice is used. When using 1-Pass ECMQV, the EnvelopedData originatorInfo field MAY include the certificate(s) for the EC public key(s) used in the formation of the pairwise key. ECC certificates are discussed in [Section 5](#).

[3.2.1.](#) Fields of KeyAgreeRecipientInfo

When using 1-Pass ECMQV with EnvelopedData, the fields of KeyAgreeRecipientInfo are:

- version MUST be 3.
- originator identifies the static EC public key of the sender. It SHOULD be one of the alternatives, issuerAndSerialNumber or subjectKeyIdentifier, and point to one of the sending agent's certificates.
- ukm MUST be present. The ukm field is an octet string which MUST contain the DER encoding of the type MQVuserKeyingMaterial (see [Section 7.2](#)). The MQVuserKeyingMaterial ephemeralPublicKey algorithm field MUST contain the id-ecPublicKey object identifier (see [Section 7.1.2](#)). The parameters associated with id-ecPublicKey MUST be absent, ECPParameters, or NULL. The

parameters associated with `id-ecPublicKey` SHOULD be absent or `ECPParameters`, as NULL is allowed to support legacy implementations. The previous version of this document required NULL to be present. If the parameters are `ECPParameters`, then they MUST be named `Curve`. The `MQVUserKeyingMaterial` `ephemeralPublicKey` `publicKey` field MUST contain the DER-encoding of the ASN.1 type `ECPoint` (see [Section 7.2](#)) representing the sending agent's ephemeral EC public key. The `MQVUserKeyingMaterial` `addedukm` field, if present, contains additional user keying material from the sending agent.

- `keyEncryptionAlgorithm` MUST contain the object identifier of the key encryption algorithm, which in this case is a key agreement algorithm (see [Section 7.1.4](#)). The `parameters` field contains `KeyWrapAlgorithm`. The `KeyWrapAlgorithm` indicates the symmetric encryption algorithm used to encrypt the CEK with the KEK generated using the 1-Pass ECMQV algorithm and any associated parameters (see [Section 7.1.5](#)). Algorithm requirements are found in [Section 8](#).
- `recipientEncryptedKeys` contains an identifier and an encrypted key for each recipient. The `RecipientEncryptedKey` `KeyAgreeRecipientIdentifier` MUST contain either the `issuerAndSerialNumber` identifying the recipient's certificate or the `RecipientKeyIdentifier` containing the subject key identifier from the recipient's certificate. In both cases, the recipient's certificate contains the recipient's static ECMQV public key. `RecipientEncryptedKey` `EncryptedKey` MUST contain the content-encryption key encrypted with the 1-Pass ECMQV-generated pairwise key-encryption key using the algorithm specified by the `KeyWrapAlgorithm`.

3.2.2. Actions of the sending agent

When using 1-Pass ECMQV with EnvelopedData, the sending agent first obtains the recipient's EC public key and domain parameters (e.g. from the recipient's certificate), and checks that the domain parameters are the same as the sender's domain parameters. The sending agent then determines an integer "keydatalen", which is the KeyWrapAlgorithm symmetric key-size in bits, and also a bit string "SharedInfo", which is the DER encoding of ECC-CMS-SharedInfo (see [Section 7.2](#)). The sending agent then performs the key deployment and key agreement operations of the Elliptic Curve MQV Scheme specified in [SP800-56A], but uses the KDF defined in Section 3.6.1 of [SEC1]. As a result, the sending agent obtains:

- an ephemeral public key, which is represented as a value of type ECPoint (see [Section 7.2](#)), encapsulated in a bit string, placed in an MQVuserKeyingMaterial ephemeralPublicKey publicKey field (see [Section 7.2](#)), and
- a shared secret bit string "K", which is used as the pairwise key-encryption key for that recipient, as specified in [CMS].

In a single message, if there are multiple layers for a recipient, then the ephemeral public key can be reused by the originator for that recipient in each of the different layers.

3.2.3. Actions of the receiving agent

When using 1-Pass ECMQV with EnvelopedData, the receiving agent determines the bit string "SharedInfo", which is the DER encoding of ECC-CMS-SharedInfo (see [Section 7.2](#)), and the integer "keydatalen" from the key-size, in bits, of the KeyWrapAlgorithm. The receiving agent then retrieves the static and ephemeral EC public keys of the originator, from the originator and ukm fields as described in [Section 3.2.1](#), and its static EC public key identified in the rid field and checks that the originator's domain parameters are the same as the recipient's domain parameters. The receiving agent then performs the key agreement operation of the Elliptic Curve MQV Scheme [SP800-56A], but uses the KDF defined in Section 3.6.1 of [SEC1]. As a result, the receiving agent obtains a shared secret bit string "K", which is used as the pairwise key-encryption key to unwrap the CEK.

4. AuthenticatedData and AuthEnvelopedData using ECC

This section describes how to use ECC algorithms with the CMS AuthenticatedData format. AuthenticatedData lacks non-repudiation, and so in some instances is preferable to SignedData. (For example,

the sending agent might not want the message to be authenticated when forwarded.)

This section also describes how to use ECC algorithms with the CMS AuthEnvelopedData format [[CMS-AUTHENV](#)]. AuthEnvelopedData supports authentication and encryption, and in some instances is preferable to signing and then encrypting data.

For both AuthenticatedData and AuthEnvelopedData, data origin authentication with 1-Pass ECMQV can only be provided when there is one and only one recipient. When there are multiple recipients, an attack is possible where one recipient modifies the content without other recipients noticing [[BON](#)]. A sending agent who is concerned with such an attack SHOULD use a separate AuthenticatedData or AuthEnvelopedData for each recipient.

Using an algorithm with the sender static key pair allows for knowledge of the message creator; this means that authentication can, in some circumstances, be obtained for AuthEnvelopedData and AuthenticatedData. This means that 1-Pass ECMQV can be a common algorithm for EnvelopedData, AuthenticatedData, and AuthEnvelopedData while ECDH can only be used in EnvelopedData.

[4.1](#). AuthenticatedData using 1-pass ECMQV

This section describes how to use the 1-Pass elliptic curve MQV (ECMQV) key agreement algorithm with AuthenticatedData. ECMQV is method C(1, 2, ECC MQV) from [[SP800-56A](#)].

When using ECMQV with AuthenticatedData, the fields of AuthenticatedData are as in [[CMS](#)], but with the following restrictions:

- macAlgorithm MUST contain the algorithm identifier of the message authentication code (MAC) algorithm (see [Section 7.1.7](#)) which MUST be one of the following: hmac-SHA1, id-hmacWITHSHA224, id-hmacWITHSHA256, id-hmacWITHSHA384, or id-hmacWITHSHA512.
- digestAlgorithm MUST contain the algorithm identifier of the hash algorithm (see [Section 7.1.1](#)) which MUST be one of the following: id-sha1, id-sha224, id-sha256, id-sha384, and id-sha512.

As 1-Pass ECMQV is a key agreement algorithm, the RecipientInfo kari choice is used in the AuthenticatedData. When using 1-Pass ECMQV, the AuthenticatedData originatorInfo field MAY include the

certificate(s) for the EC public key(s) used in the formation of the pairwise key. ECC certificates are discussed in [Section 5](#).

[4.1.1](#). Fields of the KeyAgreeRecipientInfo

The AuthenticatedData KeyAgreeRecipientInfo fields are used in the same manner as the fields for the corresponding EnvelopedData KeyAgreeRecipientInfo fields of [Section 3.2.1](#) of this document.

[4.1.2](#). Actions of the sending agent

The sending agent uses the same actions as for EnvelopedData with 1-Pass ECMQV, as specified in [Section 3.2.2](#) of this document.

In a single message, if there are multiple layers for a recipient, then the ephemeral public key can be reused by the originator for that recipient in each of the different layers.

[4.1.3](#). Actions of the receiving agent

The receiving agent uses the same actions as for EnvelopedData with 1-Pass ECMQV, as specified in [Section 3.2.3](#) of this document.

[4.2](#). AuthEnvelopedData using 1-pass ECMQV

This section describes how to use the 1-Pass elliptic curve MQV (ECMQV) key agreement algorithm with AuthEnvelopedData. ECMQV is method C(1, 2, ECC MQV) from [\[SP800-56A\]](#).

When using ECMQV with AuthEnvelopedData, the fields of AuthEnvelopedData are as in [\[CMS-AUTHENV\]](#).

As 1-Pass ECMQV is a key agreement algorithm, the RecipientInfo kari choice is used. When using 1-Pass ECMQV, the AuthEnvelopedData originatorInfo field MAY include the certificate(s) for the EC public key used in the formation of the pairwise key. ECC certificates are discussed in [Section 5](#).

[4.2.1](#). Fields of the KeyAgreeRecipientInfo

The AuthEnvelopedData KeyAgreeRecipientInfo fields are used in the same manner as the fields for the corresponding EnvelopedData KeyAgreeRecipientInfo fields of [Section 3.2.1](#) of this document.

4.2.2. Actions of the sending agent

The sending agent uses the same actions as for EnvelopedData with 1-Pass ECMQV, as specified in [Section 3.2.2](#) of this document.

In a single message, if there are multiple layers for a recipient, then the ephemeral public key can be reused by the originator for that recipient in each of the different layers.

4.2.3. Actions of the receiving agent

The receiving agent uses the same actions as for EnvelopedData with 1-Pass ECMQV, as specified in [Section 3.2.3](#) of this document.

5. Certificates using ECC

Internet X.509 certificates [[PKI](#)] can be used in conjunction with this specification to distribute agents' public keys. The use of ECC algorithms and keys within X.509 certificates is specified in [PKI-ALG].

6. SMIMECapabilities Attribute and ECC

A sending agent MAY announce to receiving agents that it supports one or more of the ECC algorithms specified in this document by using the SMIMECapabilities signed attribute [[MSG](#)] in either a signed message or a certificate [[CERTCAP](#)].

The SMIMECapabilities attribute value indicates support for one of the ECDSA signature algorithms in a SEQUENCE with the capabilityID field containing the object identifier ecdsa-with-SHA1 with NULL parameters and ecdsa-with-SHA* (where * is 224, 256, 384, or 512) with absent parameters. The DER encodings are:

ecdsa-with-SHA1: 30 0b 06 07 2a 86 48 ce 3d 04 01 05 00

ecdsa-with-SHA224: 30 0a 06 08 2a 86 48 ce 3d 04 03 01

ecdsa-with-SHA256: 30 0a 06 08 2a 86 48 ce 3d 04 03 02

ecdsa-with-SHA384: 30 0a 06 08 2a 86 48 ce 3d 04 03 03

ecdsa-with-SHA512: 30 0a 06 08 2a 86 48 ce 3d 04 03 04

NOTE: The SMIMECapabilities attribute indicates that parameters for ECDSA with SHA-1 are NULL; however, the parameters are absent when used to generate a digital signature.

The SMIMECapabilities attribute value indicates support for

- a) the standard ECDH key agreement algorithm,
- b) the cofactor ECDH key agreement algorithm, or
- c) the 1-Pass ECMQV key agreement algorithm and

is a SEQUENCE with the capabilityID field containing the object identifier

- a) dhSinglePass-stdDH-sha*kdf-scheme,
- b) dhSinglePass-cofactorDH-sha*kdf-scheme, or
- c) mqvSinglePass-sha*kdf-scheme

respectively (where * is 1, 224, 256, 384, or 512) with the parameters present. The parameters indicate the supported key-encryption algorithm with the KeyWrapAlgorithm algorithm identifier.

The DER encodings that indicate capabilities are as follows (KA is key agreement, KDF is key derivation function, and Wrap is key wrap algorithm):

KA=ECDH standard KDF=SHA-1 Wrap=Triple-DES

```
30 1c 06 09 2b 81 05 10 86 48 3f 00 02 30 0f 06 0b 2a 86 48 86
f7 0d 01 09 10 03 06 05 00
```

KA=ECDH standard KDF=SHA-224 Wrap=Triple-DES

```
30 17 06 06 2b 81 04 01 0B 00 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06
```

KA=ECDH standard KDF=SHA-256 Wrap=Triple-DES

```
30 17 06 06 2b 81 04 01 0B 01 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06
```

KA=ECDH standard KDF=SHA-384 Wrap=Triple-DES

```
30 17 06 06 2b 81 04 01 0B 02 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06
```

KA=ECDH standard KDF=SHA-512 Wrap=Triple-DES

```
30 17 06 06 2b 81 04 01 0B 03 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06
```


KA=ECDH standard KDF=SHA-1 Wrap=AES-128

30 18 06 09 2b 81 05 10 86 48 3f 00 02 30 0b 06 09 60 86 48 01
65 03 04 01 05

KA=ECDH standard KDF=SHA-224 Wrap=AES-128

30 15 06 06 2b 81 04 01 0B 00 30 0b 06 09 60 86 48 01 65 03 04
01 05

KA=ECDH standard KDF=SHA-256 Wrap=AES-128

30 15 06 06 2b 81 04 01 0B 01 30 0b 06 09 60 86 48 01 65 03 04
01 05

KA=ECDH standard KDF=SHA-384 Wrap=AES-128

30 15 06 06 2b 81 04 01 0B 02 30 0b 06 09 60 86 48 01 65 03 04
01 05

KA=ECDH standard KDF=SHA-512 Wrap=AES-128

30 15 06 06 2b 81 04 01 0B 03 30 0b 06 09 60 86 48 01 65 03 04
01 05

KA=ECDH standard KDF=SHA-1 Wrap=AES-192

30 18 06 09 2b 81 05 10 86 48 3f 00 02 30 0b 06 09 60 86 48 01
65 03 04 01 19

KA=ECDH standard KDF=SHA-224 Wrap=AES-192

30 15 06 06 2b 81 04 01 0B 00 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECDH standard KDF=SHA-256 Wrap=AES-192

30 15 06 06 2b 81 04 01 0B 01 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECDH standard KDF=SHA-384 Wrap=AES-192

30 15 06 06 2b 81 04 01 0B 02 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECDH standard KDF=SHA-512 Wrap=AES-192

30 15 06 06 2b 81 04 01 0B 03 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECDH standard KDF=SHA-1 Wrap=AES-256

30 18 06 09 2b 81 05 10 86 48 3f 00 02 30 0b 06 09 60 86 48 01
65 03 04 01 2D

KA=ECDH standard KDF=SHA-224 Wrap=AES-256

30 15 06 06 2b 81 04 01 0B 00 30 0b 06 09 60 86 48 01 65 03 04
01 2D

KA=ECDH standard KDF=SHA-256 Wrap=AES-256

30 15 06 06 2b 81 04 01 0B 01 30 0b 06 09 60 86 48 01 65 03 04
01 2D

KA=ECDH standard KDF=SHA-384 Wrap=AES-256

30 15 06 06 2b 81 04 01 0B 02 30 0b 06 09 60 86 48 01 65 03 04
01 2D 05 00

KA=ECDH standard KDF=SHA-512 Wrap=AES-256

30 15 06 06 2b 81 04 01 0B 03 30 0b 06 09 60 86 48 01 65 03 04
01 2D

KA=ECDH cofactor KDF=SHA-1 Wrap=Triple-DES

30 1c 06 09 2b 81 05 10 86 48 3f 00 03 30 0f 06 0b 2a 86 48 86
f7 0d 01 09 10 03 06 05 00

KA=ECDH cofactor KDF=SHA-224 Wrap=Triple-DES

30 17 06 06 2b 81 04 01 0E 00 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06

KA=ECDH cofactor KDF=SHA-256 Wrap=Triple-DES

30 17 06 06 2b 81 04 01 0E 01 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06

KA=ECDH cofactor KDF=SHA-384 Wrap=Triple-DES

30 17 06 06 2b 81 04 01 0E 02 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06

KA=ECDH cofactor KDF=SHA-512 Wrap=Triple-DES

30 17 06 06 2b 81 04 01 0E 03 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06

KA=ECDH cofactor KDF=SHA-1 Wrap=AES-128

30 18 06 09 2b 81 05 10 86 48 3f 00 03 30 0b 06 09 60 86 48 01
65 03 04 01 05

KA=ECDH cofactor KDF=SHA-224 Wrap=AES-128

30 15 06 06 2b 81 04 01 0E 00 30 0b 06 09 60 86 48 01 65 03 04
01 05

KA=ECDH cofactor KDF=SHA-256 Wrap=AES-128

30 15 06 06 2b 81 04 01 0E 01 30 0b 06 09 60 86 48 01 65 03 04
01 05

KA=ECDH cofactor KDF=SHA-384 Wrap=AES-128

30 15 06 06 2b 81 04 01 0E 02 30 0b 06 09 60 86 48 01 65 03 04
01 05

KA=ECDH cofactor KDF=SHA-512 Wrap=AES-128

30 17 06 06 2b 81 04 01 0E 03 30 0b 06 09 60 86 48 01 65 03 04
01 05

KA=ECDH cofactor KDF=SHA-1 Wrap=AES-192

30 18 06 09 2b 81 05 10 86 48 3f 00 03 30 0b 06 09 60 86 48 01
65 03 04 01 19

KA=ECDH cofactor KDF=SHA-224 Wrap=AES-192

30 15 06 06 2b 81 04 01 0E 00 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECDH cofactor KDF=SHA-256 Wrap=AES-192

30 15 06 06 2b 81 04 01 0E 01 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECDH cofactor KDF=SHA-384 Wrap=AES-192

30 15 06 06 2b 81 04 01 0E 02 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECDH cofactor KDF=SHA-512 Wrap=AES-192

30 15 06 06 2b 81 04 01 0E 03 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECDH cofactor KDF=SHA-1 Wrap=AES-256

30 15 06 09 2b 81 05 10 86 48 3f 00 03 30 0b 06 09 60 86 48 01
65 03 04 01 2D

KA=ECDH cofactor KDF=SHA-224 Wrap=AES-256

30 15 06 06 2b 81 04 01 0E 00 30 0b 06 09 60 86 48 01 65 03 04
01 2D

KA=ECDH cofactor KDF=SHA-256 Wrap=AES-256

30 15 06 06 2b 81 04 01 0E 01 30 0b 06 09 60 86 48 01 65 03 04
01 2D

KA=ECDH cofactor KDF=SHA-384 Wrap=AES-256

30 15 06 06 2b 81 04 01 0E 02 30 0b 06 09 60 86 48 01 65 03 04
01 2D

KA=ECDH cofactor KDF=SHA-512 Wrap=AES-256

30 15 06 06 2b 81 04 01 0E 03 30 0b 06 09 60 86 48 01 65 03 04
01 2D

KA=ECMQV 1-Pass KDF=SHA-1 Wrap=Triple-DES

30 1c 06 09 2b 81 05 10 86 48 3f 00 10 30 0f 06 0b 2a 86 48 86
f7 0d 01 09 10 03 06 05 00

KA=ECMQV 1-Pass KDF=SHA-224 Wrap=Triple-DES

30 17 06 06 2b 81 04 01 0F 00 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06

KA=ECMQV 1-Pass KDF=SHA-256 Wrap=Triple-DES

30 17 06 06 2b 81 04 01 0F 01 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06

KA=ECMQV 1-Pass KDF=SHA-384 Wrap=Triple-DES

30 17 06 06 2b 81 04 01 0F 02 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06

KA=ECMQV 1-Pass KDF=SHA-512 Wrap=Triple-DES

30 17 06 06 2b 81 04 01 0F 03 30 0d 06 0b 2a 86 48 86 f7 0d 01
09 10 03 06

KA=ECMQV 1-Pass KDF=SHA-1 Wrap=AES-128

30 18 06 09 2b 81 05 10 86 48 3f 00 10 30 0b 06 09 60 86 48 01
65 03 04 01 05

KA=ECMQV 1-Pass KDF=SHA-224 Wrap=AES-128

30 15 06 06 2b 81 04 01 0F 00 30 0b 06 09 60 86 48 01 65 03 04
01 05

KA=ECMQV 1-Pass KDF=SHA-256 Wrap=AES-128

30 15 06 06 2b 81 04 01 0F 01 30 0b 06 09 60 86 48 01 65 03 04
01 05

KA=ECMQV 1-Pass KDF=SHA-384 Wrap=AES-128

30 15 06 06 2b 81 04 01 0F 02 30 0b 06 09 60 86 48 01 65 03 04
01 05

KA=ECMQV 1-Pass KDF=SHA-512 Wrap=AES-128

30 15 06 06 2b 81 04 01 0F 03 30 0d 06 09 60 86 48 01 65 03 04
01 05

KA=ECMQV 1-Pass KDF=SHA-1 Wrap=AES-192

30 18 06 09 2b 81 05 10 86 48 3f 00 10 30 0b 06 09 60 86 48 01
65 03 04 01 19

KA=ECMQV 1-Pass KDF=SHA-224 Wrap=AES-192

30 15 06 06 2b 81 04 01 0f 00 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECMQV 1-Pass KDF=SHA-256 Wrap=AES-192

30 15 06 06 2b 81 04 01 0f 01 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECMQV 1-Pass KDF=SHA-384 Wrap=AES-192

30 15 06 06 2b 81 04 01 0f 02 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECMQV 1-Pass KDF=SHA-512 Wrap=AES-192

30 15 06 06 2b 81 04 01 0f 03 30 0b 06 09 60 86 48 01 65 03 04
01 19

KA=ECMQV 1-Pass KDF=SHA-1 Wrap=AES-256

30 18 06 09 2b 81 05 10 86 48 3f 00 10 30 0b 06 09 60 86 48 01
65 03 04 01 2D

KA=ECMQV 1-Pass KDF=SHA-224 Wrap=AES-256

30 15 06 06 2b 81 04 01 0f 00 30 0b 06 09 60 86 48 01 65 03 04
01 2D

KA=ECMQV 1-Pass KDF=SHA-256 Wrap=AES-256

30 15 06 06 2b 81 04 01 0f 01 30 0b 06 09 60 86 48 01 65 03 04
01 2D

KA=ECMQV 1-Pass KDF=SHA-384 Wrap=AES-256

30 15 06 06 2b 81 04 01 0f 02 30 0b 06 09 60 86 48 01 65 03 04
01 2D

KA=ECMQV 1-Pass KDF=SHA-512 Wrap=AES-256

30 15 06 06 2b 81 04 01 0f 03 30 0b 06 09 60 86 48 01 65 03 04
01 2D

NOTE: The S/MIME Capabilities indicate that parameters for the key wrap algorithm AES-* (where * is 128, 192, or 256) are NULL; however, the parameters are absent when used to encrypt/decrypt a content encryption key.

NOTE: The S/MIME Capabilities for the supported AES content encryption key sizes are defined in [[CMS-AES](#)].

NOTE: The S/MIME Capabilities for the supported MAC algorithms are defined in [[CMS-ASN](#)].

[7. ASN.1 Syntax](#)

The ASN.1 syntax used in this document is gathered in this section for reference purposes.

[7.1. Algorithm Identifiers](#)

This section provides the object identifiers for the algorithms used in this document along with any associated parameters.

[7.1.1. Digest Algorithms](#)

Digest algorithm object identifiers are used in the SignedData digestAlgorithms and digestAlgorithm fields and the AuthenticatedData digestAlgorithm field. The digest algorithms used in this document are: SHA-1, SHA-224, SHA-256, SHA-384, and SHA-512. The object identifiers and parameters associated with these algorithms are found in [[CMS-ALG](#)] and [[CMS-SHA2](#)].

[7.1.2. Originator Public Key](#)

The KeyAgreeRecipientInfo originator field uses the following object identifier to indicate an elliptic curve public key:

```
id-ecPublicKey OBJECT IDENTIFIER ::= {  
    ansi-x9-62 keyType(2) 1 }
```

where

```
ansi-x9-62 OBJECT IDENTIFIER ::= {  
    iso(1) member-body(2) us(840) 10045 }
```


When the object identifier `id-ecPublicKey` is used here with an algorithm identifier, the associated parameters **MUST** be either absent or `ECPParameters`. Implementations **MUST** accept `id-ecPublicKey` with absent and `ECPParameters` parameters. If `ECPParameters` is present, its value **MUST** match the recipient's `ECPParameters`. Implementations **SHOULD** generate absent parameters for the `id-ecPublicKey` object identifier in the `KeyAgreeRecipientInfo` originator field.

NOTE: [\[CMS-ECC\]](#) indicated the parameters were NULL. Support for this legacy form is OPTIONAL.

7.1.3. Signature Algorithms

Signature algorithm identifiers are used in the `SignedData` `signatureAlgorithm` and `signature` fields. The signature algorithms used in this document are ECDSA with SHA-1, ECDSA with SHA-224, ECDSA with SHA-256, ECDSA with SHA-384, and ECDSA with SHA-512. The object identifiers and parameters associated with these algorithms are found in [\[PKI-ALG\]](#).

NOTE: [\[CMS-ECC\]](#) indicated the parameters were NULL. Support for this legacy form is OPTIONAL.

7.1.4. Key Agreement Algorithms

Key agreement algorithms are used in `EnvelopedData`, `AuthenticatedData`, and `AuthEnvelopedData` in the `KeyAgreeRecipientInfo` `keyEncryptionAlgorithm` field. The following object identifiers indicate the key agreement algorithms used in this document:

```
dhSinglePass-stdDH-sha1kdf-scheme OBJECT IDENTIFIER ::= {  
    x9-63-scheme 2 }
```

```
dhSinglePass-stdDH-sha224kdf-scheme OBJECT IDENTIFIER ::= {  
    secg-scheme 11 0 }
```

```
dhSinglePass-stdDH-sha256kdf-scheme OBJECT IDENTIFIER ::= {  
    secg-scheme 11 1 }
```

```
dhSinglePass-stdDH-sha384kdf-scheme OBJECT IDENTIFIER ::= {  
    secg-scheme 11 2 }
```

```
dhSinglePass-stdDH-sha512kdf-scheme OBJECT IDENTIFIER ::= {  
    secg-scheme 11 3 }
```

```
dhSinglePass-cofactorDH-sha1kdf-scheme OBJECT IDENTIFIER ::= {  
    x9-63-scheme 3 }
```



```
dhSinglePass-cofactorDH-sha224kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 14 0 }

dhSinglePass-cofactorDH-sha256kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 14 1 }

dhSinglePass-cofactorDH-sha384kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 14 2 }

dhSinglePass-cofactorDH-sha512kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 14 3 }

mqvSinglePass-sha1kdf-scheme OBJECT IDENTIFIER ::= {
    x9-63-scheme 16 }

mqvSinglePass-sha224kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 0 }

mqvSinglePass-sha256kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 1 }

mqvSinglePass-sha384kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 2 }

mqvSinglePass-sha512kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 3 }
```

where

```
x9-63-scheme OBJECT IDENTIFIER ::= {
    iso(1) identified-organization(3) tc68(133) country(16)
    x9(840) x9-63(63) schemes(0) }
```

and

```
secg-scheme OBJECT IDENTIFIER ::= {
    iso(1) identified-organization(3) certicom(132) schemes(1) }
```

When the object identifiers are used here within an algorithm identifier, the associated parameters field contains KeyWrapAlgorithm to indicate the key wrap algorithm and any associated parameters.

7.1.5. Key Wrap Algorithms

Key wrap algorithms are used as part of the parameters in the key agreement algorithm. The key wrap algorithms used in this document are Triple-DES, AES-128, AES-192, and AES-256. The object

identifiers and parameters for these algorithms are found in [CMS-ALG] and [CMS-AES].

7.1.6. Content Encryption Algorithms

Content encryption algorithms are used in EnvelopedData and AuthEnvelopedData in the EncryptedContentInfo contentEncryptionAlgorithm field. The content encryption algorithms used with EnvelopedData in this document are 3-Key Triple DES in CBC mode, AES-128 in CBC mode, AES-192 in CBC mode, and AES-256 in CBC mode. The object identifiers and parameters associated with these algorithms are found in [CMS-ALG] and [CMS-AES]. The content encryption algorithms used with AuthEnvelopedData in this document are AES-128 in CCM mode, AES-192 in CCM mode, AES-256 in CCM mode, AES-128 in GCM mode, AES-192 in GCM mode, and AES-256 in GCM mode. The object identifiers and parameters associated with these algorithms are found in [CMS-AESCG].

7.1.7. Message Authentication Code Algorithms

Message authentication code algorithms are used in AuthenticatedData in the macAlgorithm field. The message authentication code algorithms used in this document are HMAC with SHA-1, HMAC with SHA-224, HMAC with SHA-256, HMAC with SHA-384, and HMAC with SHA-512. The object identifiers and parameters associated with these algorithms are found in [CMS-ALG] and [HMAC-SHA2].

7.1.8. Key Derivation Algorithm

The KDF used in this document is as specified in 3.6.1 of [SEC1]. The hash algorithm is identified in key agreement algorithm. For example, dhSinglePass-stdDH-sha256kdf-scheme uses the KDF from [SEC1] but uses SHA-256 instead of SHA-1.

7.2. Other Syntax

The following additional syntax is used here.

When using ECDSA with SignedData, ECDSA signatures are encoded using the type:

```
ECDSA-Sig-Value ::= SEQUENCE {  
    r INTEGER,  
    s INTEGER }
```


ECDSA-Sig-Value is specified in [[PKI-ALG](#)]. Within CMS, ECDSA-Sig-Value is DER-encoded and placed within a signature field of SignedData.

When using ECDH and ECMQV with EnvelopedData, AuthenticatedData, and AuthEnvelopedData, ephemeral and static public keys are encoded using the type ECPoint. Implementations MUST support uncompressed keys, MAY support compressed keys, and MUST NOT support hybrid keys.

```
ECPoint ::= OCTET STRING
```

When using ECMQV with EnvelopedData, AuthenticatedData, and AuthEnvelopedData, the sending agent's ephemeral public key and additional keying material are encoded using the type:

```
MQVuserKeyingMaterial ::= SEQUENCE {  
    ephemeralPublicKey      OriginatorPublicKey,  
    addedukm                [0] EXPLICIT UserKeyingMaterial OPTIONAL }
```

The ECPoint syntax is used to represent the ephemeral public key and is placed in the ephemeralPublicKey publicKey field. The additional user keying material is placed in the addedukm field. Then the MQVuserKeyingMaterial value is DER-encoded and placed within the ukm field of EnvelopedData, AuthenticatedData, or AuthEnvelopedData.

When using ECDH or ECMQV with EnvelopedData, AuthenticatedData, or AuthEnvelopedData, the key-encryption keys are derived by using the type:

```
ECC-CMS-SharedInfo ::= SEQUENCE {  
    keyInfo      AlgorithmIdentifier,  
    entityUInfo [0] EXPLICIT OCTET STRING OPTIONAL,  
    suppPubInfo [2] EXPLICIT OCTET STRING }
```

The fields of ECC-CMS-SharedInfo are as follows:

keyInfo contains the object identifier of the key-encryption algorithm (used to wrap the CEK) and associated parameters. In this specification, 3DES wrap has NULL parameters while the AES wraps have absent parameters.

entityUInfo optionally contains additional keying material supplied by the sending agent. When used with ECDH and CMS, the entityUInfo field contains the octet string ukm. When used with ECMQV and CMS, the entityUInfo contains the octet string addedukm (encoded in MQVuserKeyingMaterial).

suppPubInfo contains the length of the generated KEK, in bits, represented as a 32 bit number, as in [CMS-DH] and [CMS-AES]. (E.g. for AES-256 it would be 00 00 01 00.)

Within CMS, ECC-CMS-SharedInfo is DER-encoded and used as input to the key derivation function, as specified in Section 3.6.1 of [SEC1].

NOTE: ECC-CMS-SharedInfo differs from the OtherInfo specified in [CMS-DH]. Here, a counter value is not included in the keyInfo field because the key derivation function specified in Section 3.6.1 of [SEC1] ensures that sufficient keying data is provided.

8. Recommended Algorithms and Elliptic Curves

It is RECOMMENDED that implementations of this specification support SignedData and EnvelopedData. Support for AuthenticatedData and AuthEnvelopedData is OPTIONAL.

In order to encourage interoperability, implementations SHOULD use the elliptic curve domain parameters specified by [PKI-ALG].

Implementations that support SignedData with ECDSA:

- MUST support ECDSA with SHA-256; and,
- MAY support ECDSA with SHA-1, ECDSA with SHA-224, ECDSA with SHA-384, and ECDSA with SHA-512; other digital signature algorithms MAY also be supported.

When using ECDSA, to promote interoperability it is RECOMMENDED that the P-192, P-224, and the P-256 curves be used with SHA-256, the P-384 curve be used with SHA-384, and the P-521 curve be used with SHA-512.

If EnvelopedData is supported, then ephemeral-static ECDH standard primitive MUST be supported. Support for ephemeral-static ECDH co-factor is OPTIONAL and support for 1-Pass ECMQV is also OPTIONAL.

Implementations that support EnvelopedData with the ephemeral-static ECDH standard primitive:

- MUST support the dhSinglePass-stdDH-sha256kdf-scheme key agreement algorithm, the id-aes128-wrap key wrap algorithm, and the id-aes128-cbc content encryption algorithm; and,
- MAY support the dhSinglePass-stdDH-sha1kdf-scheme, dhSinglePass-stdDH-sha224kdf-scheme, dhSinglePass-stdDH-sha384kdf-scheme and

dhSinglePass-stdDH-sha512kdf-scheme key agreement algorithms, the id-alg-CMS3DESwrap, id-aes192-wrap, and id-aes256-wrap key wrap algorithms and the des-ede3-cbc, id-aes192-cbc, and id-aes256-cbc content encryption algorithms; other algorithms MAY also be supported.

Implementations that support EnvelopedData with the ephemeral-static ECDH cofactor primitive:

- MUST support the dhSinglePass-cofactorDH-sha256kdf-scheme key agreement algorithm, the id-aes128-wrap key wrap algorithm, and the id-aes128-cbc content encryption algorithm; and,
- MAY support the dhSinglePass-cofactorDH-sha1kdf-scheme, dhSinglePass-cofactorDH-sha224kdf-scheme, dhSinglePass-cofactorDH-sha384kdf-scheme, and dhSinglePass-cofactorDH-sha512kdf-scheme key agreement, the id-alg-CMS3DESwrap, id-aes192-wrap, and id-aes256-wrap key wrap algorithms and the des-ede3-cbc, id-aes192-cbc, and id-aes256-cbc content encryption algorithms; other algorithms MAY also be supported.

Implementations that support EnvelopedData with 1-Pass ECMQV:

- MUST support the mqvSinglePass-sha256kdf-scheme key agreement algorithm, the id-aes128-wrap key wrap algorithm, and the id-aes128-cbc content encryption algorithm; and,
- MAY support mqvSinglePass-sha1kdf-scheme, mqvSinglePass-sha224kdf-scheme, mqvSinglePass-sha384kdf-scheme, and mqvSinglePass-sha512kdf-scheme key agreement algorithms, the id-alg-CMS3DESwrap, id-aes192-wrap, and id-aes256-wrap key wrap algorithms and the des-ede3-cbc, id-aes192-cbc, and id-aes256-cbc content encryption algorithms; other algorithms MAY also be supported.

Implementations that support AuthenticatedData with 1-Pass ECMQV:

- MUST support the mqvSinglePass-sha256kdf-scheme key agreement, the id-aes128-wrap key wrap, the id-sha256 message digest, and id-hmacWithSHA256 message authentication code algorithms; and,
- MAY support the mqvSinglePass-sha1kdf-scheme, mqvSinglePass-sha224kdf-scheme, mqvSinglePass-sha384kdf-scheme, mqvSinglePass-sha512kdf-scheme key agreement algorithms, the id-alg-CMS3DESwrap, id-aes192-wrap, and id-aes256-wrap key wrap algorithms, the id-sha1, id-sha224, id-sha384, and id-sha512, message digest algorithms, and the hmac-SHA1, id-hmacWithSHA224,

id-hmacWithSHA384, and id-hmacWithSHA512 message authentication code algorithms; other algorithms MAY also be supported.

Implementations that support AuthEnvelopedData with 1-Pass ECMQV:

- MUST support the mqvSinglePass-sha256kdf-scheme key agreement, the id-aes128-wrap key wrap, and the id-aes128-ccm authenticated-content encryption; and,
- MAY support the mqvSinglePass-sha1kdf-scheme, mqvSinglePass-sha224kdf-scheme, mqvSinglePass-sha384kdf-scheme, and mqvSinglePass-sha512kdf-scheme key agreement algorithms, the id-alg-CMS3DESwrap, id-aes192-wrap, and id-aes256-wrap key wrap algorithms, the id-aes192-ccm, id-aes256-ccm, id-aes128-gcm, id-aes192-gcm, and id-aes256-ccm authenticated-content encryption algorithms; other algorithms MAY also be supported.

9. Security Considerations

Cryptographic algorithms will be broken or weakened over time. Implementers and users need to check that the cryptographic algorithms listed in this document continue to provide the expected level of security. The IETF from time to time may issue documents dealing with the current state of the art.

Cryptographic algorithms rely on random numbers. See [[RANDOM](#)] for guidance on generation of random numbers.

Receiving agents that validate signatures and sending agents that encrypt messages need to be cautious of cryptographic processing usage when validating signatures and encrypting messages using keys larger than those mandated in this specification. An attacker could send keys and/or certificates with keys which would result in excessive cryptographic processing, for example keys larger than those mandated in this specification, which could swamp the processing element. Agents which use such keys without first validating the certificate to a trust anchor are advised to have some sort of cryptographic resource management system to prevent such attacks.

Using secret keys of an appropriate size is crucial to the security of a Diffie-Hellman exchange. For elliptic curve groups, the size of the secret key must be equal to the size of n (the order of the group generated by the point g). Using larger secret keys provides absolutely no additional security, and using smaller secret keys is likely to result in dramatically less security. (See [[SP800-56A](#)] for more information on selecting secret keys.)

This specification is based on [\[CMS\]](#), [\[CMS-AES\]](#), [\[CMS-AESCG\]](#), [\[CMS-ALG\]](#), [\[CMS-AUTHENV\]](#), [\[CMS-DH\]](#), [\[CMS-SHA2\]](#), [\[FIPS180-3\]](#), [\[FIPS186-3\]](#), and [\[HMAC-SHA2\]](#), and the appropriate security considerations of those documents apply.

In addition, implementers of `AuthenticatedData` and `AuthEnvelopedData` should be aware of the concerns expressed in [\[BON\]](#) when using `AuthenticatedData` and `AuthEnvelopedData` to send messages to more than one recipient. Also, users of MQV should be aware of the vulnerability described in [\[K\]](#).

When implementing `EnvelopedData`, `AuthenticatedData`, and `AuthEnvelopedData`, there are five algorithm related choices that need to be made:

- 1) What is the public key size?
- 2) What is the KDF?
- 3) What is the key wrap algorithm?
- 4) What is the content encryption algorithm?
- 5) What is the curve?

Consideration must be given to the strength of the security provided by each of these choices. Security is measured in bits, where a strong symmetric cipher with a key of X bits is said to provide X bits of security. It is recommended that the bits of security provided by each are roughly equivalent. The following table provides comparable minimum bits of security [\[SP800-57\]](#) for the ECDH/ECMQV key sizes, KDFs, key wrapping algorithms, and content encryption algorithms. It also lists curves [\[PKI-ALG\]](#) for the key sizes.

Minimum Bits of Security	ECDH or ECQMV Key Size	Key Derivation Function	Key Wrap Alg.	Content Encryption Alg.	Curves
80	160-223	SHA-1	3DES	3DES CBC	sect163k1
		SHA-224	AES-128	AES-128 CBC	secp163r2
		SHA-256	AES-192	AES-192 CBC	secp192r1
		SHA-384	AES-256	AES-256 CBC	
		SHA-512			
112	224-255	SHA-1	3DES	3DES CBC	secp224r1
		SHA-224	AES-128	AES-128 CBC	sect233k1
		SHA-256	AES-192	AES-192 CBC	sect233r1
		SHA-384	AES-256	AES-256 CBC	
		SHA-512			
128	256-383	SHA-1	AES-128	AES-128 CBC	secp256r1
		SHA-224	AES-192	AES-192 CBC	sect283k1
		SHA-256	AES-256	AES-256 CBC	sect283r1
		SHA-384			
		SHA-512			
192	384-511	SHA-224	AES-192	AES-192 CBC	secp384r1
		SHA-256	AES-256	AES-256 CBC	sect409k1
		SHA-384			sect409r1
		SHA-512			
256	512+	SHA-256	AES-256	AES-256 CBC	secp521r1
		SHA-384			sect571k1
		SHA-512			sect571r1

To promote interoperability, the following choices are RECOMMENDED:

Minimum Bits of Security	ECDH or ECQMV Key Size	Key Derivation Function	Key Wrap Alg.	Content Encryption Alg.	Curve
80	192	SHA-256	3DES	3DES CBC	secp192r1
112	224	SHA-256	3DES	3DES CBC	secp224r1
128	256	SHA-256	AES-128	AES-128 CBC	secp256r1
192	384	SHA-384	AES-256	AES-256 CBC	secp384r1
256	512+	SHA-512	AES-256	AES-256 CBC	secp521r1

When implementing SignedData, there are three algorithm related choices that need to be made:

- 1) What is the public key size?
- 2) What is the hash algorithm?
- 3) What is the curve?

Consideration must be given to the bits of security provided by each of these choices. Security is measured in bits, where a strong symmetric cipher with a key of X bits is said to provide X bits of security. It is recommended that the bits of security provided by each choice are roughly equivalent. The following table provides comparable minimum bits of security [[SP800-57](#)] for the ECDSA key sizes and message digest algorithms. It also lists curves [[PKI-ALG](#)] for the key sizes.

Minimum Bits of Security	ECDSA Key Size	Message Digest Algorithm	Curve
80	160-223	SHA-1	sect163k1
		SHA-224	secp163r2
		SHA-256	secp192r1
		SHA-384	
		SHA-512	
112	224-255	SHA-224	secp224r1
		SHA-256	sect233k1
		SHA-384	sect233r1
		SHA-512	
128	256-383	SHA-256	secp256r1
		SHA-384	sect283k1
		SHA-512	sect283r1
192	384-511	SHA-384	secp384r1
		SHA-512	sect409k1
			sect409r1
256	512+	SHA-512	secp521r1
			sect571k1
			sect571r1

To promote interoperability, the following choices are RECOMMENDED:

Minimum Bits of Security	ECDSA Key Size	Message Digest Algorithm	Curve
80	192	SHA-256	sect192r1
112	224	SHA-256	secp224r1
128	256	SHA-256	secp256r1
192	384	SHA-384	secp384r1
256	512+	SHA-512	secp521r1

10. IANA Considerations

This document makes extensive use of object identifiers to register originator public key types and algorithms. The algorithm object identifiers are registered in the ANSI X9.62, ANSI X9.63, NIST, RSA, and SECG arcs. Additionally, object identifiers are used to identify the ASN.1 modules found in [Appendix A](#). These are defined in an arc delegated by IANA to the SMIME Working Group. No further action by IANA is necessary for this document or any anticipated updates.

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Appendix A ASN.1 Modules

[Appendix A.1](#) provides the normative ASN.1 definitions for the structures described in this specification using ASN.1 as defined in [\[X.680\]](#) for compilers that support the 1988 ASN.1.

[Appendix A.2](#) provides an informative ASN.1 definitions for the structures described in this specification using ASN.1 as defined in [\[X.680\]](#), [\[X.681\]](#), [\[X.682\]](#), and [\[X.683\]](#) for compilers that support the 2002 ASN.1. This appendix contains the same information as [Appendix A.1](#) in a more recent (and precise) ASN.1 notation, however [Appendix A.1](#) takes precedence in case of conflict.

NOTE: The values for the TBAs will be included during AUTH48.

/** RFC Editor: Remove this note prior to publication **/

[Appendix A.1](#) 1988 ASN.1 Module

SMIMEECCAlgs-1988

```
{ iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)
  smime(16) modules(0) TBA1 }
```

DEFINITIONS IMPLICIT TAGS ::=

BEGIN

-- EXPORTS ALL

IMPORTS

-- From [\[PKI\]](#)

AlgorithmIdentifier

FROM PKIX1Explicit88

```
{ iso(1) identified-organization(3) dod(6)
  internet(1) security(5) mechanisms(5) pkix(7) mod(0)
  pkix1-explicit(18) }
```

-- From [\[RSAOAEF\]](#)

id-sha224, id-sha256, id-sha384, id-sha512

FROM PKIX1-PSS-OAEP-Algorithms

```
{ iso(1) identified-organization(3) dod(6) internet(1)
  security(5) mechanisms(5) pkix(7) id-mod(0)
  id-mod-pkix1-rsa-pkalgs(33) }
```


-- From [[PKI-ALG](#)]

```
id-sha1, ecdsa-with-SHA1, ecdsa-with-SHA224,  
ecdsa-with-SHA256, ecdsa-with-SHA384, ecdsa-with-SHA512,  
id-ecPublicKey, ECDSA-Sig-Value, ECPPoint, ECPParameters  
FROM PKIXAlgIDs-2008  
  { iso(1) identified-organization(3) dod(6) internet(1)  
    security(5) mechanisms(5) pkix(7) id-mod(0) TBA1 }
```

-- From [[CMS](#)]

```
OriginatorPublicKey, UserKeyingMaterial  
FROM CryptographicMessageSyntax2004  
  { iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)  
    smime(16) modules(0) cms-2004(24) }
```

-- From [[CMS-ALG](#)]

```
hMAC-SHA1, id-hmacWithSHA224, id-hmacWithSHA256, id-hmacWithSHA384,  
id-hmacWithSHA512, des-ede3-cbc, id-alg-CMS3DESwrap, CBCParameter  
FROM CryptographicMessageSyntaxAlgorithms  
  { iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)  
    smime(16) modules(0) cmsalg-2008(TBD) }
```

-- From [[CMS-AES](#)]

```
id-aes128-CBC, id-aes192-CBC, id-aes256-CBC, AES-IV,  
id-aes128-wrap, id-aes192-wrap, id-aes256-wrap  
FROM CMSAesRsaesOaep  
  { iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)  
    smime(16) modules(0) id-mod-cms-aes(19) }
```

-- From [[CMS-AESCG](#)]

```
id-aes128-CCM, id-aes192-CCM, id-aes256-CCM, CCMPParameters  
id-aes128-GCM, id-aes192-GCM, id-aes256-GCM, GCMPParameters  
FROM CMS-AES-CCM-and-AES-GCM  
  { iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)  
    smime(16) modules(0) id-mod-cms-aes(32) }
```

;


```
--
-- Message Digest Algorithms
--

-- id-sha1 Parameters are preferred absent
-- id-sha224 Parameters are preferred absent
-- id-sha256 Parameters are preferred absent
-- id-sha384 Parameters are preferred absent
-- id-sha512 Parameters are preferred absent

--
-- Signature Algorithms
--

-- ecdsa-with-SHA1 Parameters are NULL
-- ecdsa-with-SHA224 Parameters are absent
-- ecdsa-with-SHA256 Parameters are absent
-- ecdsa-with-SHA384 Parameters are absent
-- ecdsa-with-SHA512 Parameters are absent

-- ECDSA Signature Value
-- Contents of SignatureValue OCTET STRING

-- ECDSA-Sig-Value ::= SEQUENCE {
--   r  INTEGER,
--   s  INTEGER
-- }

--
-- Key Agreement Algorithms
--

x9-63-scheme OBJECT IDENTIFIER ::= {
  iso(1) identified-organization(3) tc68(133) country(16) x9(840)
  x9-63(63) schemes(0) }

secg-scheme OBJECT IDENTIFIER ::= {
  iso(1) identified-organization(3) certicom(132) schemes(1) }
```

```
--
-- Diffie-Hellman Single Pass, Standard, with KDFs
--

-- Parameters are always present and indicate the key wrap algorithm
-- with KeyWrapAlgorithm.

dhSinglePass-stdDH-sha1kdf-scheme OBJECT IDENTIFIER ::= {
    x9-63-scheme 2 }

dhSinglePass-stdDH-sha224kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 11 0 }

dhSinglePass-stdDH-sha256kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 11 1 }

dhSinglePass-stdDH-sha384kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 11 2 }

dhSinglePass-stdDH-sha512kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 11 3 }

--
-- Diffie-Hellman Single Pass, Cofactor, with KDFs
--

dhSinglePass-cofactorDH-sha1kdf-scheme OBJECT IDENTIFIER ::= {
    x9-63-scheme 3 }

dhSinglePass-cofactorDH-sha224kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 14 0 }

dhSinglePass-cofactorDH-sha256kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 14 1 }

dhSinglePass-cofactorDH-sha384kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 14 2 }

dhSinglePass-cofactorDH-sha512kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 14 3 }

--
-- MQV Single Pass, Cofactor, with KDFs
--

mqvSinglePass-sha1kdf-scheme OBJECT IDENTIFIER ::= {
    x9-63-scheme 16 }
```



```
mqvSinglePass-sha224kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 0 }
```

```
mqvSinglePass-sha256kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 1 }
```

```
mqvSinglePass-sha384kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 2 }
```

```
mqvSinglePass-sha512kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 3 }
```

```
--
```

```
-- Key Wrap Algorithms
```

```
--
```

```
KeyWrapAlgorithm ::= AlgorithmIdentifier
```

```
-- id-alg-CMS3DESwrap Parameters are NULL
```

```
-- id-aes128-wrap Parameters are absent
```

```
-- id-aes192-wrap Parameters are absent
```

```
-- id-aes256-wrap Parameters are absent
```

```
--
```

```
-- Content Encryption Algorithms
```

```
--
```

```
-- des-ede3-cbc Parameters are CBCParameter
```

```
-- id-aes128-CBC Parameters are AES-IV
```

```
-- id-aes192-CBC Parameters are AES-IV
```

```
-- id-aes256-CBC Parameters are AES-IV
```

```
-- id-aes128-CCM Parameters are CCMPParameters
```

```
-- id-aes192-CCM Parameters are CCMPParameters
```

```
-- id-aes256-CCM Parameters are CCMPParameters
```

```
-- id-aes128-GCM Parameters are GCMPParameters
```

```
-- id-aes192-GCM Parameters are GCMPParameters
```

```
-- id-aes256-GCM Parameters are GCMPParameters
```

```
--
```

```
-- Message Authentication Code Algorithms
```

```
--
```

```
-- HMAC-SHA1 Parameters are preferred absent
```

```
-- id-hmacWithSHA224 Parameters are absent
```

```
-- id-hmacWithSHA256 Parameters are absent
```

```
-- id-hmacWithSHA384 Parameters are absent
```

```
-- id-hmacWithSHA512 Parameters are absent
```



```
--
-- Originator Public Key Algorithms
--

-- id-ecPublicKey Parameters are absent, NULL, or ECPParameters

-- Format for both ephemeral and static public keys

-- ECPoint ::= OCTET STRING

-- ECPParameters ::= CHOICE {
--   namedCurve      OBJECT IDENTIFIER
--   commented out in [PKI-ALG] implicitCurve  NULL
--   commented out in [PKI-ALG] specifiedCurve SpecifiedECDomain
--   commented out in [PKI-ALG] Extensible
-- }
--   implicitCurve and specifiedCurve MUST NOT be used in PKIX.
--   Details for SpecifiedECDomain can be found in [X9.62].
--   Any future additions to this CHOICE should be coordinated
--   with ANSI X9.

-- Format of KeyAgreeRecipientInfo ukm field when used with
-- ECMQV

MQVUserKeyingMaterial ::= SEQUENCE {
    ephemeralPublicKey      OriginatorPublicKey,
    addedukm                [0] EXPLICIT UserKeyingMaterial OPTIONAL
}

-- 'SharedInfo' for input to KDF when using ECDH and ECMQV with
-- EnvelopedData, AuthenticatedData, or AuthEnvelopedData

ECC-CMS-SharedInfo ::= SEQUENCE {
    keyInfo      AlgorithmIdentifier,
    entityUInfo [0] EXPLICIT OCTET STRING OPTIONAL,
    suppPubInfo [2] EXPLICIT OCTET STRING
}
```

```
--
-- S/MIME Capabilities
-- An identifier followed by type.
--

--
-- S/MIME Capabilities: Message Digest Algorithms
--

-- Found in [CMS-SHA2].

--
-- S/MIME Capabilities: Signature Algorithms
--

-- ecdsa-with-SHA1 Type NULL
-- ecdsa-with-SHA224 Type absent
-- ecdsa-with-SHA256 Type absent
-- ecdsa-with-SHA384 Type absent
-- ecdsa-with-SHA512 Type absent

--
-- S/MIME Capabilities: ECDH, Single Pass, Standard
--

-- dhSinglePass-stdDH-sha1kdf Type is the KeyWrapAlgorithm
-- dhSinglePass-stdDH-sha224kdf Type is the KeyWrapAlgorithm
-- dhSinglePass-stdDH-sha256kdf Type is the KeyWrapAlgorithm
-- dhSinglePass-stdDH-sha384kdf Type is the KeyWrapAlgorithm
-- dhSinglePass-stdDH-sha512kdf Type is the KeyWrapAlgorithm

--
-- S/MIME Capabilities: ECDH, Single Pass, Cofactor
--

-- dhSinglePass-cofactorDH-sha1kdf Type is the KeyWrapAlgorithm
-- dhSinglePass-cofactorDH-sha224kdf Type is the KeyWrapAlgorithm
-- dhSinglePass-cofactorDH-sha256kdf Type is the KeyWrapAlgorithm
-- dhSinglePass-cofactorDH-sha384kdf Type is the KeyWrapAlgorithm
-- dhSinglePass-cofactorDH-sha512kdf Type is the KeyWrapAlgorithm
```



```
--
-- S/MIME Capabilities: ECMQV, Single Pass, Standard
--

-- mqvSinglePass-sha1kdf Type is the KeyWrapAlgorithm
-- mqvSinglePass-sha224kdf Type is the KeyWrapAlgorithm
-- mqvSinglePass-sha256kdf Type is the KeyWrapAlgorithm
-- mqvSinglePass-sha384kdf Type is the KeyWrapAlgorithm
-- mqvSinglePass-sha512kdf Type is the KeyWrapAlgorithm

END
```

[Appendix A.2](#) 2004 ASN.1 Module

```
SMIMEECCAlgs-2008
{ iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)
  smime(16) modules(0) TBA2 }

DEFINITIONS IMPLICIT TAGS ::=

BEGIN

-- EXPORTS ALL

IMPORTS

-- From [PKI-ALG]

mda-sha1, sa-ecdsaWithSHA1, sa-ecdsaWithSHA224, sa-ecdsaWithSHA256,
sa-ecdsaWithSHA384, sa-ecdsaWithSHA512, id-ecPublicKey,
ECDSA-Sig-Value, ECPPoint, ECPParameters
FROM PKIXAlgIDs-2008
{ iso(1) identified-organization(3) dod(6) internet(1)
  security(5) mechanisms(5) pkix(7) id-mod(0) TBA2 }

-- FROM [PKI-ASN]

KEY-WRAP, SIGNATURE-ALGORITHM, DIGEST-ALGORITHM, ALGORITHM,
PUBLIC-KEY, MAC-ALGORITHM, CONTENT-ENCRYPTION, KEY-AGREE
FROM AlgorithmInformation
{ iso(1) identified-organization(3) dod(6) internet(1)
  security(5) mechanisms(5) pkix(7) id-mod(0)
  id-mod-algorithmInformation(TBA5) }
```


-- From [[PKI-ASN](#)]

```
mda-sha224, mda-sha256, mda-sha384, mda-sha512
  FROM PKIX1-PSS-OAEP-Algorithms
    { iso(1) identified-organization(3) dod(6) internet(1)
      security(5) mechanisms(5) pkix(7) id-mod(0) TBA7 }
```

-- From [[CMS](#)]

```
OriginatorPublicKey, UserKeyingMaterial
  FROM CryptographicMessageSyntax2004
    { iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)
      smime(16) modules(0) cms-2004(24) }
```

-- From [[CMS-ASN](#)]

```
maca-hMAC-SHA1, maca-hMAC-SHA224, maca-hMAC-SHA256, maca-hMAC-SHA384,
maca-hMAC-SHA512, cea-des-edec3-cbc, kwa-3DESWrap, CBCParameter
  FROM CryptographicMessageSyntaxAlgorithms
    { iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)
      smime(16) modules(0) cmsalg-2001(16) }
```

-- From [[CMS-ASN](#)]

```
cea-aes128-CBC, cea-aes192-CBC, cea-aes256-CBC, kwa-aes128-wrap,
kwa-aes192-wrap, kwa-aes256-wrap
  FROM CMSAesRsaesOaep
    { iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)
      smime(16) modules(0) id-mod-cms-aes(19) }
```

-- From [[CMS-ASN](#)]

```
cea-aes128-ccm, cea-aes192-ccm, cea-aes256-ccm, cea-aes128-gcm,
cea-aes192-gcm, cea-aes256-gcm
  FROM CMS-AES-CCM-and-AES-GCM
    { iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)
      smime(16) modules(0) cms-aes-ccm-and-gcm(32) }
```

;

```
-- Constrains the SignedData digestAlgorithms field
-- Constrains the SignedData SignerInfo digestAlgorithm field
-- Constrains the AuthenticatedData digestAlgorithm field

-- MessageDigestAlgs DIGEST-ALGORITHM ::= {
--   mda-sha1      |
--   mda-sha224    |
--   mda-sha256    |
--   mda-sha384    |
--   mda-sha512,
--   ... -- Extensible
-- }

-- Constrains the SignedData SignerInfo signatureAlgorithm field

-- SignatureAlgs SIGNATURE-ALGORITHM ::= {
--   sa-ecdsaWithSHA1      |
--   sa-ecdsaWithSHA224    |
--   sa-ecdsaWithSHA256    |
--   sa-ecdsaWithSHA384    |
--   sa-ecdsaWithSHA512,
--   ... -- Extensible
-- }

-- ECDSA Signature Value
-- Contents of SignatureValue OCTET STRING

-- ECDSA-Sig-Value ::= SEQUENCE {
--   r  INTEGER,
--   s  INTEGER
-- }

--
-- Key Agreement Algorithms
--

-- Constrains the EnvelopedData RecipientInfo KeyAgreeRecipientInfo
--   keyEncryption Algorithm field
-- Constrains the AuthenticatedData RecipientInfo
--   KeyAgreeRecipientInfo keyEncryption Algorithm field
-- Constrains the AuthEnvelopedData RecipientInfo
--   KeyAgreeRecipientInfo keyEncryption Algorithm field

-- DH variants are not used with AuthenticatedData or
-- AuthEnvelopedData
```



```

KeyAgreementAlgs KEY-AGREE ::= {
  kaa-dhSinglePass-stdDH-sha1kdf-scheme      |
  kaa-dhSinglePass-stdDH-sha224kdf-scheme    |
  kaa-dhSinglePass-stdDH-sha256kdf-scheme    |
  kaa-dhSinglePass-stdDH-sha384kdf-scheme    |
  kaa-dhSinglePass-stdDH-sha512kdf-scheme    |
  kaa-dhSinglePass-cofactorDH-sha1kdf-scheme |
  kaa-dhSinglePass-cofactorDH-sha224kdf-scheme |
  kaa-dhSinglePass-cofactorDH-sha256kdf-scheme |
  kaa-dhSinglePass-cofactorDH-sha384kdf-scheme |
  kaa-dhSinglePass-cofactorDH-sha512kdf-scheme |
  kaa-mqvSinglePass-sha1kdf-scheme           |
  kaa-mqvSinglePass-sha224kdf-scheme         |
  kaa-mqvSinglePass-sha256kdf-scheme         |
  kaa-mqvSinglePass-sha384kdf-scheme         |
  kaa-mqvSinglePass-sha512kdf-scheme,
  ... -- Extensible
}

x9-63-scheme OBJECT IDENTIFIER ::= {
  iso(1) identified-organization(3) tc68(133) country(16) x9(840)
  x9-63(63) schemes(0) }

secg-scheme OBJECT IDENTIFIER ::= {
  iso(1) identified-organization(3) certicom(132) schemes(1) }

--
-- Diffie-Hellman Single Pass, Standard, with KDFs
--

-- Parameters are always present and indicate the Key Wrap Algorithm

kaa-dhSinglePass-stdDH-sha1kdf-scheme KEY-AGREE ::= {
  IDENTIFIER dhSinglePass-stdDH-sha1kdf-scheme
  PARAMS TYPE KeyWrapAlgorithm ARE required
  UKM TYPE -- unencoded data -- IS preferredPresent
  SMIME CAPS { TYPE KeyWrapAlgorithm
    IDENTIFIED BY dhSinglePass-stdDH-sha1kdf-scheme }
}

dhSinglePass-stdDH-sha1kdf-scheme OBJECT IDENTIFIER ::= {
  x9-63-scheme 2 }

```



```
kaa-dhSinglePass-stdDH-sha224kdf-scheme KEY-AGREE ::= {
  IDENTIFIER dhSinglePass-stdDH-sha224kdf-scheme
  PARAMS TYPE KeyWrapAlgorithm ARE required
  UKM TYPE -- unencoded data -- IS preferredPresent
  SMIME CAPS { TYPE KeyWrapAlgorithm
               IDENTIFIED BY dhSinglePass-stdDH-sha224kdf-scheme }
}

dhSinglePass-stdDH-sha224kdf-scheme OBJECT IDENTIFIER ::= {
  secg-scheme 11 0 }

kaa-dhSinglePass-stdDH-sha256kdf-scheme KEY-AGREE ::= {
  IDENTIFIER dhSinglePass-stdDH-sha256kdf-scheme
  PARAMS TYPE KeyWrapAlgorithm ARE required
  UKM TYPE -- unencoded data -- IS preferredPresent
  SMIME CAPS { TYPE KeyWrapAlgorithm
               IDENTIFIED BY dhSinglePass-stdDH-sha256kdf-scheme }
}

dhSinglePass-stdDH-sha256kdf-scheme OBJECT IDENTIFIER ::= {
  secg-scheme 11 1 }

kaa-dhSinglePass-stdDH-sha384kdf-scheme KEY-AGREE ::= {
  IDENTIFIER dhSinglePass-stdDH-sha384kdf-scheme
  PARAMS TYPE KeyWrapAlgorithm ARE required
  UKM TYPE -- unencoded data -- IS preferredPresent
  SMIME CAPS { TYPE KeyWrapAlgorithm
               IDENTIFIED BY dhSinglePass-stdDH-sha384kdf-scheme }
}

dhSinglePass-stdDH-sha384kdf-scheme OBJECT IDENTIFIER ::= {
  secg-scheme 11 2 }

kaa-dhSinglePass-stdDH-sha512kdf-scheme KEY-AGREE ::= {
  IDENTIFIER dhSinglePass-stdDH-sha512kdf-scheme
  PARAMS TYPE KeyWrapAlgorithm ARE required
  UKM TYPE -- unencoded data -- IS preferredPresent
  SMIME CAPS { TYPE KeyWrapAlgorithm
               IDENTIFIED BY dhSinglePass-stdDH-sha512kdf-scheme }
}

dhSinglePass-stdDH-sha512kdf-scheme OBJECT IDENTIFIER ::= {
  secg-scheme 11 3 }
```



```
--
-- Diffie-Hellman Single Pass, Cofactor, with KDFs
--

kaa-dhSinglePass-cofactorDH-sha1kdf-scheme KEY-AGREE ::= {
  IDENTIFIER dhSinglePass-cofactorDH-sha1kdf-scheme
  PARAMS TYPE KeyWrapAlgorithm ARE required
  UKM TYPE -- unencoded data -- IS preferredPresent
  SMIME CAPS { TYPE KeyWrapAlgorithm
                IDENTIFIED BY
                  dhSinglePass-cofactorDH-sha1kdf-scheme }
}

dhSinglePass-cofactorDH-sha1kdf-scheme OBJECT IDENTIFIER ::= {
  x9-63-scheme 3 }

kaa-dhSinglePass-cofactorDH-sha224kdf-scheme KEY-AGREE ::= {
  IDENTIFIER dhSinglePass-cofactorDH-sha224kdf-scheme
  PARAMS TYPE KeyWrapAlgorithm ARE required
  UKM TYPE -- unencoded data -- IS preferredPresent
  SMIME CAPS { TYPE KeyWrapAlgorithm
                IDENTIFIED BY
                  dhSinglePass-cofactorDH-sha224kdf-scheme }
}

dhSinglePass-cofactorDH-sha224kdf-scheme OBJECT IDENTIFIER ::= {
  secg-scheme 14 0 }

kaa-dhSinglePass-cofactorDH-sha256kdf-scheme KEY-AGREE ::= {
  IDENTIFIER dhSinglePass-cofactorDH-sha256kdf-scheme
  PARAMS TYPE KeyWrapAlgorithm ARE required
  UKM TYPE -- unencoded data -- IS preferredPresent
  SMIME CAPS { TYPE KeyWrapAlgorithm
                IDENTIFIED BY
                  dhSinglePass-cofactorDH-sha256kdf-scheme }
}

dhSinglePass-cofactorDH-sha256kdf-scheme OBJECT IDENTIFIER ::= {
  secg-scheme 14 1 }
```



```
kaa-dhSinglePass-cofactorDH-sha384kdf-scheme KEY-AGREE ::= {  
  IDENTIFIER dhSinglePass-cofactorDH-sha384kdf-scheme  
  PARAMS TYPE KeyWrapAlgorithm ARE required  
  UKM TYPE -- unencoded data -- IS preferredPresent  
  SMIME CAPS { TYPE KeyWrapAlgorithm  
    IDENTIFIED BY  
      dhSinglePass-cofactorDH-sha384kdf-scheme }  
}
```

```
dhSinglePass-cofactorDH-sha384kdf-scheme OBJECT IDENTIFIER ::= {  
  secg-scheme 14 2 }
```

```
kaa-dhSinglePass-cofactorDH-sha512kdf-scheme KEY-AGREE ::= {  
  IDENTIFIER dhSinglePass-cofactorDH-sha512kdf-scheme  
  PARAMS TYPE KeyWrapAlgorithm ARE required  
  UKM TYPE -- unencoded data -- IS preferredPresent  
  SMIME CAPS { TYPE KeyWrapAlgorithm  
    IDENTIFIED BY  
      dhSinglePass-cofactorDH-sha512kdf-scheme }  
}
```

```
dhSinglePass-cofactorDH-sha512kdf-scheme OBJECT IDENTIFIER ::= {  
  secg-scheme 14 3 }
```

```
--  
-- MQV Single Pass, Cofactor, with KDFs  
--
```

```
kaa-mqvSinglePass-sha1kdf-scheme KEY-AGREE ::= {  
  IDENTIFIER mvSinglePass-sha1kdf-scheme  
  PARAMS TYPE KeyWrapAlgorithm ARE required  
  UKM TYPE -- unencoded data -- IS preferredPresent  
  SMIME CAPS { TYPE KeyWrapAlgorithm  
    IDENTIFIED BY mvSinglePass-sha1kdf-scheme }  
}
```

```
mqvSinglePass-sha1kdf-scheme OBJECT IDENTIFIER ::= {  
  x9-63-scheme 16 }
```

```
kaa-mqvSinglePass-sha224kdf-scheme KEY-AGREE ::= {  
  IDENTIFIER mvSinglePass-sha224kdf-scheme  
  PARAMS TYPE KeyWrapAlgorithm ARE required  
  UKM TYPE -- unencoded data -- IS preferredPresent  
  SMIME CAPS { TYPE KeyWrapAlgorithm  
    IDENTIFIED BY mvSinglePass-sha224kdf-scheme }  
}
```



```
mqvSinglePass-sha224kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 0 }

kaa-mqvSinglePass-sha256kdf-scheme KEY-AGREE ::= {
    IDENTIFIER mqvSinglePass-sha256kdf-scheme
    PARAMS TYPE KeyWrapAlgorithm ARE required
    UKM TYPE -- unencoded data -- IS preferredPresent
    SMIME CAPS { TYPE KeyWrapAlgorithm
        IDENTIFIED BY mqvSinglePass-sha256kdf-scheme }
}

mqvSinglePass-sha256kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 1 }

kaa-mqvSinglePass-sha384kdf-scheme KEY-AGREE ::= {
    IDENTIFIER mqvSinglePass-sha384kdf-scheme
    PARAMS TYPE KeyWrapAlgorithm ARE required
    UKM TYPE -- unencoded data -- IS preferredPresent
    SMIME CAPS { TYPE KeyWrapAlgorithm
        IDENTIFIED BY mqvSinglePass-sha384kdf-scheme }
}

mqvSinglePass-sha384kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 2 }

kaa-mqvSinglePass-sha512kdf-scheme KEY-AGREE ::= {
    IDENTIFIER mqvSinglePass-sha512kdf-scheme
    PARAMS TYPE KeyWrapAlgorithm ARE required
    UKM TYPE -- unencoded data -- IS preferredPresent
    SMIME CAPS { TYPE KeyWrapAlgorithm
        IDENTIFIED BY mqvSinglePass-sha512kdf-scheme }
}

mqvSinglePass-sha512kdf-scheme OBJECT IDENTIFIER ::= {
    secg-scheme 15 3 }

--
-- Key Wrap Algorithms
--

KeyWrapAlgorithm ::= KeyWrapAlgs
```



```
KeyWrapAlgs KEY-WRAP ::= {
  kwa-3des      |
  kwa-aes128    |
  kwa-aes192    |
  kwa-aes256,
  ... -- Extensible
}

--
-- Content Encryption Algorithms
--

-- Constrains the EnvelopedData EncryptedContentInfo encryptedContent
-- field and the AuthEnvelopedData EncryptedContentInfo
-- contentEncryptionAlgorithm field

-- ContentEncryptionAlgorithms CONTENT-ENCRYPTION ::= {
--   cea-des-edec3-cbc |
--   cea-aes128-cbc    |
--   cea-aes192-cbc    |
--   cea-aes256-cbc    |
--   cea-aes128-ccm    |
--   cea-aes192-ccm    |
--   cea-aes256-ccm    |
--   cea-aes128-gcm    |
--   cea-aes192-gcm    |
--   cea-aes256-gcm,
--   ... -- Extensible
-- }

-- des-edec3-cbc and aes*-cbc are used with EnvelopedData and
-- EncryptedData
-- aes*-ccm are used with AuthEnvelopedData
-- aes*-gcm are used with AuthEnvelopedData
-- (where * is 128, 192, and 256)
```



```
--
-- Message Authentication Code Algorithms
--

-- Constrains the AuthenticatedData
-- MessageAuthenticationCodeAlgorithm field
--

-- MessageAuthenticationCodeAlgorithms MAC-ALGORITHM ::= {
--   maca-hMAC-SHA1      |
--   maca-hMAC-SHA224    |
--   maca-hMAC-SHA256    |
--   maca-hMAC-SHA384    |
--   maca-hMAC-SHA512,
--   ... -- Extensible
-- }

--

-- Originator Public Key Algorithms
--

-- Constraints on KeyAgreeRecipientInfo OriginatorIdentifierOrKey
-- OriginatorPublicKey algorithm field

-- PARAMS are NULL

OriginatorPKAlgorithms PUBLIC-KEY ::= {
  opka-ec,
  ... -- Extensible
}

opka-ec PUBLIC-KEY ::= {
  IDENTIFIER id-ecPublicKey
  KEY ECPublicKey
  PARAMS TYPE CHOICE { n NULL, p ECPParameters } ARE preferredAbsent
}

-- Format for both ephemeral and static public keys

-- ECPublicKey ::= OCTET STRING
```



```
-- ECPParameters ::= CHOICE {
--   namedCurve      CURVE.&id({NamedCurve})
--   commented out in [PKI-ALG] implicitCurve  NULL
--   commented out in [PKI-ALG] specifiedCurve SpecifiedECDomain
--   commented out in [PKI-ALG] ... Extensible
-- }
-- implicitCurve and specifiedCurve MUST NOT be used in PKIX.
-- Details for SpecifiedECDomain can be found in [X9.62].
-- Any future additions to this CHOICE should be coordinated
-- with ANSI X.9.

-- Format of KeyAgreeRecipientInfo ukm field when used with
-- ECMQV

MQVUserKeyingMaterial ::= SEQUENCE {
    ephemeralPublicKey      OriginatorPublicKey,
    addedukm                [0] EXPLICIT UserKeyingMaterial OPTIONAL
}

-- 'SharedInfo' for input to KDF when using ECDH and ECMQV with
-- EnvelopedData, AuthenticatedData, or AuthEnvelopedData

ECC-CMS-SharedInfo ::= SEQUENCE {
    keyInfo      AlgorithmIdentifier { KeyWrapAlgorithm },
    entityUIInfo [0] EXPLICIT OCTET STRING OPTIONAL,
    suppPubInfo  [2] EXPLICIT OCTET STRING
}

END
```

Appendix B Changes since [RFC 3278](#)

The following summarizes the changes:

- Abstract: The basis of the document was changed to refer to NIST FIPS 186-3 and SP800-56A. However, to maintain backwards compatibility the Key Derivation Function from ANSI/SEC1 is retained.
- [Section 1](#): A bullet was added to address AuthEnvelopedData.
- [Section 2.1](#): A sentence was added to indicate FIPS180-3 is used with ECDSA. Replaced reference to ANSI X9.62 with FIPS186-3.
- [Section 2.1.1](#): The permitted digest algorithms were expanded from SHA-1 to SHA-1, SHA-224, SHA-256, SHA-384, and SHA-512.

- [Section 2.1.2](#) and 2.1.3: The bullet addressing integer "e" was deleted.
- [Section 3](#): Added explanation of why static-static ECDH is not included.
- [Section 3.1](#): The reference for DH was changed from [RFC 3852](#) to [RFC 3370](#). Provided text to indicate fields of EnvelopedData are as in CMS.
- [Section 3.1.1](#): The text was updated to include description of all KeyAgreeRecipientInfo fields. Parameters for id-ecPublicKey field changed from NULL to absent or ECPParameter. Additional information about ukm was added.
- [Section 3.2](#): The sentence describing the advantages of 1-Pass ECMQV was rewritten.
- [Section 3.2.1](#): The text was updated to include description of all fields. Parameters for id-ecPublicKey field changed from NULL to absent or ECPoint.
- Sections [3.2.2](#) and [4.1.2](#): The re-use of ephemeral keys paragraph was reworded.
- [Section 4.1](#): The sentences describing the advantages of 1-Pass ECMQV was moved to [Section 4](#).
- [Section 4.1.2](#): The note about the attack was moved to [Section 4](#).
- [Section 4.2](#): This section was added to address AuthEnvelopedData with ECMQV.
- [Section 5](#): This section was moved to [Section 8](#). The 1st paragraph was modified to recommend both SignedData and EnvelopedData. The requirements were updated for hash algorithms and recommendations for matching curves and hash algorithms. Also the requirements were expanded to indicate which ECDH and ECMQV variants, key wrap algorithms, and content encryption algorithms are required for each of the content types used in this document. The permitted digest algorithms used in key derivations functions (KDFs) were expanded from SHA-1 to SHA-1, SHA-224, SHA-256, SHA-384, and SHA-512.
- [Section 6](#) (formerly 7): This section was updated to allow for SMIMECapabilities to be present in certificates. The S/MIME capabilities for ECDSA with SHA-224, SHA-256, SHA-384, and SHA-

512 were added to the list of S/MIME Capabilities. Also updated to include S/MIME capabilities for ECDH and ECMQV using the SHA-224, SHA-256, SHA-384, and SHA-512 algorithms as the KDF.

- [Section 7.1](#) (formerly 8.1): Added sub-sections for digest, signature, originator public key, key agreement, content encryption, key wrap, and message authentication code algorithms. Pointed to algorithms and parameters in appropriate documents for: SHA-224, SHA-256, SHA-384, and SHA-512 as well as SHA-224, SHA-256, SHA-384, and SHA-512 with ECDSA. Also added algorithm identifiers for ECDH std, ECDH cofactor, and ECMQV with SHA-224, SHA-256, SHA-384, and SHA-512 algorithms as the KDF. Changed id-ecPublicKey parameters to be absent, NULL, or ECPParameters, and if present the originator's ECPParameters must match the recipient's ECPParameters.
- [Section 7.2](#) (formerly 8.2): Updated to include AuthEnvelopedData. Also, added text to address support requirement for compressed, uncompressed, and hybrid keys, changed pointers from ANSI X9.61 to PKIX (where ECDSA-Sig-Value is imported), changed pointers from SECG to NIST specs, and updated example of suppPubInfo to be AES-256. keyInfo's parameters changed from NULL to any associated parameters (AES wraps have absent parameters).
- [Section 9](#): Replaced text, which was a summary paragraph, with an updated security considerations section. Paragraph referring to definitions of SHA-224, SHA-256, SHA-384, and SHA-512 is deleted.
- Updated references.
- Added ASN.1 modules.
- Updated acknowledgements section.

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