              Secure/Multipurpose Internet Mail Extensions (S/MIME) Version 4.0
                          Certificate Handling

Abstract

   This document specifies conventions for X.509 certificate usage by
   Secure/Multipurpose Internet Mail Extensions (S/MIME) v4.0 agents.
   S/MIME provides a method to send and receive secure MIME messages,
   and certificates are an integral part of S/MIME agent processing.
   S/MIME agents validate certificates as described in RFC 5280
   ("Internet X.509 Public Key Infrastructure Certificate and
   Certificate Revocation List (CRL) Profile"). S/MIME agents must meet
   the certificate-processing requirements in this document as well as
   those in RFC 5280. This document obsoletes RFC 5750.

Status of This Memo

   This is an Internet Standards Track document.

   This document is a product of the Internet Engineering Task Force
   (IETF). It represents the consensus of the IETF community. It has
   received public review and has been approved for publication by the
   Internet Engineering Steering Group (IESG). Further information on
   Internet Standards is available in Section 2 of RFC 7841.

   Information about the current status of this document, any errata,
   and how to provide feedback on it may be obtained at
   https://www.rfc-editor.org/info/rfc8550.

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1. Introduction

   S/MIME (Secure/Multipurpose Internet Mail Extensions) v4.0, described
   in [RFC8551], provides a method to send and receive secure MIME
   messages. Before using a public key to provide security services,
   the S/MIME agent MUST verify that the public key is valid. S/MIME
   agents MUST use PKIX certificates to validate public keys as
   described in [RFC5280] ("Internet X.509 Public Key Infrastructure
   Certificate and Certificate Revocation List (CRL) Profile"). S/MIME
   agents MUST meet the certificate-processing requirements specified in
   this document in addition to those stated in [RFC5280].

   This specification is compatible with the Cryptographic Message
   Syntax (CMS) [RFC5652] in that it uses the data types defined by CMS.
   It also inherits all the varieties of architectures for certificate-
   based key management supported by CMS.

   This document obsoletes [RFC5750]. The most significant changes
   revolve around changes in recommendations around the cryptographic
   algorithms used by the specification. More details can be found in
   Section 1.6.

   This specification contains a number of references to documents that
   have been obsoleted or replaced. This is intentional, as the updated
   documents often do not have the same information or protocol
   requirements in them.

1.1. Definitions

   For the purposes of this document, the following definitions apply.

   ASN.1:
      Abstract Syntax Notation One, as defined in ITU-T X.680 [X.680].

   Attribute certificate (AC):
      An X.509 AC is a separate structure from a subject's public key
      X.509 certificate. A subject may have multiple X.509 ACs
      associated with each of its public key X.509 certificates. Each
      X.509 AC binds one or more attributes with one of the subject's
      public key X.509 certificates. The X.509 AC syntax is defined in
      [RFC5755].

Certificate:
   A type that binds an entity's name to a public key with a digital
   signature. This type is defined in [RFC5280]. This type also
   contains the distinguished name of the certificate issuer (the
   signer), an issuer-specific serial number, the issuer's signature
   algorithm identifier, a validity period, and extensions also
   defined in that document.

Certificate Revocation List (CRL):
   A type that contains information about certificates whose validity
   an issuer has revoked. The information consists of an issuer
   name, the time of issue, the next scheduled time of issue, a list
   of certificate serial numbers and their associated revocation
   times, and extensions as defined in [RFC5280]. The CRL is signed
   by the issuer. The type intended by this specification is the one
   defined in [RFC5280].

Receiving agent:
   Software that interprets and processes S/MIME CMS objects, MIME
   body parts that contain CMS objects, or both.

Sending agent:
   Software that creates S/MIME CMS objects, MIME body parts that
   contain CMS objects, or both.

S/MIME agent:
   User software that is a receiving agent, a sending agent, or both.

1.2. Conventions Used in This Document

   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.

   We define the additional requirement levels:

   SHOULD+   This term means the same as SHOULD. However, the authors
             expect that a requirement marked as SHOULD+ will be
             promoted at some future time to be a MUST.

   SHOULD-   This term means the same as SHOULD. However, the authors
             expect that a requirement marked as SHOULD- will be demoted
             to a MAY in a future version of this document.

MUST-   This term means the same as MUST. However, the authors
           expect that this requirement will no longer be a MUST in a
           future document. Although its status will be determined at
           a later time, it is reasonable to expect that if a future
           revision of a document alters the status of a MUST-
           requirement, it will remain at least a SHOULD or a SHOULD-.

The term "RSA" in this document almost always refers to the
PKCS #1 v1.5 RSA signature algorithm even when not qualified as such.
There are a couple of places where it refers to the general RSA
cryptographic operation; these can be determined from the context
where it is used.

1.3. Compatibility with Prior Practice of S/MIME

S/MIME version 4.0 agents ought to attempt to have the greatest
interoperability possible with agents for prior versions of S/MIME.

   - S/MIME version 2 is described in RFC 2311 through RFC 2315
      inclusive [SMIMEv2].

   - S/MIME version 3 is described in RFC 2630 through RFC 2634
      inclusive and RFC 5035 [SMIMEv3].

   - S/MIME version 3.1 is described in RFC 2634, RFC 3850, RFC 3851,
      RFC 3852, and RFC 5035 [SMIMEv3.1].

   - S/MIME version 3.2 is described in RFC 2634, RFC 5035, RFC 5652,
      RFC 5750, and RFC 5751 [SMIMEv3.2].

   - RFC 2311 also has historical information about the development of
      S/MIME.

Appendix A contains information about algorithms that were used for
prior versions of S/MIME but are no longer considered to meet modern
security standards. Support of these algorithms may be needed to
support historic S/MIME artifacts such as messages or files but
SHOULD NOT be used for new artifacts.

1.4. Changes from S/MIME v3 to S/MIME v3.1

This section reflects the changes that were made when S/MIME v3.1 was
released. The language of RFC 2119 ("MUST", "SHOULD", etc.) used for
S/MIME v3 may have been superseded in later versions.

   - Version 1 and version 2 CRLs MUST be supported.

   - Multiple certification authority (CA) certificates with the same
      subject and public key, but with overlapping validity periods,
      MUST be supported.

   - Version 2 ACs SHOULD be supported, and version 1 ACs MUST NOT be
      used.

   - The use of the MD2 digest algorithm for certificate signatures is
      discouraged, and security language was added.

   - Clarified email address use in certificates. Certificates that do
      not contain an email address have no requirements for verifying
      the email address associated with the certificate.

   - Receiving agents SHOULD display certificate information when
      displaying the results of signature verification.

   - Receiving agents MUST NOT accept a signature made with a
      certificate that does not have at least one of the
      digitalSignature or nonRepudiation bits set.

   - Added clarifications for the interpretation of the key usage and
      extended key usage extensions.

1.5. Changes from S/MIME v3.1 to S/MIME v3.2

   This section reflects the changes that were made when S/MIME v3.2 was
   released. The language of RFC 2119 ("MUST", "SHOULD", etc.) used for
   S/MIME v3.1 may have been superseded in later versions.

   Note that the section numbers listed here (e.g., "Section 6") are
   from [RFC5750].

   - Moved "Conventions Used in This Document" to Section 1.2. Added
      definitions for SHOULD+, SHOULD-, and MUST-.

   - Section 1.1: Updated ASN.1 definition and reference.

   - Section 1.3: Added text about v3.1 RFCs.

   - Section 3: Aligned email address text with RFC 5280. Updated note
      to indicate that the emailAddress IA5String upper bound is
      255 characters. Added text about matching email addresses.

   - Section 4.2: Added text to indicate how S/MIME agents locate the
      correct user certificate.

   - Section 4.3: RSA with SHA-256 (PKCS #1 v1.5) added as MUST; DSA
      with SHA-256 added as SHOULD+; RSA with SHA-1, DSA with SHA-1, and
      RSA with MD5 changed to SHOULD-; and RSASSA-PSS with SHA-256 added
      as SHOULD+. Updated key sizes and changed pointer to PKIX RFCs.

   - Section 4.4.1: Aligned with PKIX on the use of a basicConstraints
      extension in CA certificates. Clarified which extension is used
      to constrain end entities from using their keys to perform
      issuing-authority operations.

   - Section 5: Updated security considerations.

   - Section 6: Moved references from Appendix A of RFC 3850 to this
      section. Updated the references.

   - Appendix A: Added Appendix A to move S/MIME v2 Certificate
      Handling to Historic status.

1.6. Changes since S/MIME 3.2

   This section reflects the changes that were made when S/MIME v4.0 was
   released. The language of RFC 2119 ("MUST", "SHOULD", etc.) used for
   S/MIME v3.2 may have been superseded by S/MIME v4.0 and may be
   superseded by future versions.

   - Section 3: Support for internationalized email addresses is
      required.

   - Section 4.3: Mandated support for the Elliptic Curve Digital
      Signature Algorithm (ECDSA) with P-256 and the Edwards-curve
      Digital Signature Algorithm (EdDSA) with curve25519 [RFC8410].
      SHA-1 and MD5 algorithms are marked as historical, as they are no
      longer considered secure. As the Digital Signature Algorithm
      (DSA) has been replaced by elliptic curve versions, support for
      DSA is now considered historical. Increased lower bounds on RSA
      key sizes.

   - Appendix A: Added Appendix A for algorithms that are now
      considered to be historical.

2. CMS Options

   The CMS message format allows for a wide variety of options in
   content and algorithm support. This section puts forth a number of
   support requirements and recommendations in order to achieve a base
   level of interoperability among all S/MIME implementations. Most of
   the CMS format for S/MIME messages is defined in [RFC8551].

2.1. Certificate Revocation Lists

   Receiving agents MUST support the CRL format defined in [RFC5280].
   If sending agents include CRLs in outgoing messages, the CRL format
   defined in [RFC5280] MUST be used. Receiving agents MUST support
   both v1 and v2 CRLs.

   All agents MUST be capable of performing revocation checks using CRLs
   as specified in [RFC5280]. All agents MUST perform revocation status
   checking in accordance with [RFC5280]. Receiving agents MUST
   recognize CRLs in received S/MIME messages.

   Agents SHOULD store CRLs received in messages for use in processing
   later messages.

2.2. Certificate Choices

   Receiving agents MUST support v1 X.509 and v3 X.509 certificates as
   profiled in [RFC5280]. End-entity certificates MAY include an
   Internet mail address, as described in Section 3.

   Receiving agents SHOULD support X.509 version 2 ACs. See [RFC5755]
   for details about the profile for ACs.

2.2.1. Historical Note about CMS Certificates

   The CMS message format supports a choice of certificate formats for
   public key content types: PKIX, PKCS #6 extended certificates
   [PKCS6], and PKIX ACs.

   The PKCS #6 format is not in widespread use. In addition, PKIX
   certificate extensions address much of the same functionality and
   flexibility as was intended in the PKCS #6 certificate extensions.
   Thus, sending and receiving agents MUST NOT use PKCS #6 extended
   certificates. Receiving agents MUST be able to parse and process a
   message containing PKCS #6 extended certificates, although ignoring
   those certificates is expected behavior.

   X.509 version 1 ACs are also not widely implemented and have
   been superseded by version 2 ACs. Sending agents MUST NOT send
   version 1 ACs.

2.3. Included Certificates

   Receiving agents MUST be able to handle an arbitrary number of
   certificates of arbitrary relationship to the message sender and to
   each other in arbitrary order. In many cases, the certificates
   included in a signed message may represent a chain of certification
   from the sender to a particular root. There may be, however,
   situations where the certificates in a signed message may be
   unrelated and included for convenience.

   Sending agents SHOULD include any certificates for the user's public
   key(s) and associated issuer certificates. This increases the
   likelihood that the intended recipient can establish trust in the
   originator's public key(s). This is especially important when
   sending a message to recipients that may not have access to the
   sender's public key through any other means or when sending a signed
   message to a new recipient. The inclusion of certificates in
   outgoing messages can be omitted if S/MIME objects are sent within a
   group of correspondents that have established access to each other's
   certificates by some other means such as a shared directory or manual
   certificate distribution. Receiving S/MIME agents SHOULD be able to
   handle messages without certificates by using a database or directory
   lookup scheme to find them.

   A sending agent SHOULD include at least one chain of certificates up
   to, but not including, a CA that it believes that the recipient may
   trust as authoritative. A receiving agent MUST be able to handle an
   arbitrarily large number of certificates and chains.

   Agents MAY send CA certificates -- that is, cross-certificates,
   self-issued certificates, and self-signed certificates. Note that
   receiving agents SHOULD NOT simply trust any self-signed certificates
   as valid CAs but SHOULD use some other mechanism to determine if this
   is a CA that should be trusted. Also note that when certificates
   contain DSA public keys the parameters may be located in the root
   certificate. This would require that the recipient possess both the
   end-entity certificate and the root certificate to perform a
   signature verification, and is a valid example of a case where
   transmitting the root certificate may be required.

   Receiving agents MUST support chaining based on the distinguished
   name fields. Other methods of building certificate chains MAY be
   supported.

   Receiving agents SHOULD support the decoding of X.509 ACs included in
   CMS objects. All other issues regarding the generation and use of
   X.509 ACs are outside the scope of this specification. One
   specification that addresses AC use is defined in [RFC3114].

3. Using Distinguished Names for Internet Mail

   End-entity certificates MAY contain an Internet mail address.
   Email addresses restricted to 7-bit ASCII characters use the
   pkcs-9-at-emailAddress object identifier (OID) (see below) and are
   encoded as described in Section 4.2.1.6 of [RFC5280].
   Internationalized email address names use the OID defined in
   [RFC8398] and are encoded as described therein. The email address
   SHOULD be in the subjectAltName extension and SHOULD NOT be in the
   subject distinguished name.

   Receiving agents MUST recognize and accept certificates that contain
   no email address. Agents are allowed to provide an alternative
   mechanism for associating an email address with a certificate that
   does not contain an email address, such as through the use of the
   agent's address book, if available. Receiving agents MUST recognize
   both ASCII and internationalized email addresses in the
   subjectAltName extension. Receiving agents MUST recognize email
   addresses in the distinguished name field in the PKCS #9 [RFC2985]
   emailAddress attribute:

   pkcs-9-at-emailAddress OBJECT IDENTIFIER ::=
     { iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9) 1 }

   Note that this attribute MUST be encoded as IA5String and has an
   upper bound of 255 characters. The comparing of email addresses is
   fraught with peril. [RFC8398] defines the procedure for doing the
   comparison of internationalized email addresses. For ASCII email
   addresses, the domain component (right-hand side of the '@') MUST be
   compared using a case-insensitive function. The local name
   component (left-hand side of the '@') SHOULD be compared using a
   case-insensitive function. Some localities may perform other
   transformations on the local name component before doing the
   comparison; however, an S/MIME client cannot know what specific
   localities do.

   Sending agents SHOULD make the address in the From or Sender header
   in a mail message match an Internet mail address in the signer's
   certificate. Receiving agents MUST check that the address in the
   From or Sender header of a mail message matches an Internet mail
   address in the signer's certificate, if mail addresses are present in
   the certificate. A receiving agent SHOULD provide some explicit
   alternate processing of the message if this comparison fails; this
   might be done by displaying or logging a message that shows the
   recipient the mail addresses in the certificate or other certificate
   details.

A receiving agent SHOULD display a subject name or other certificate
details when displaying an indication of successful or unsuccessful
signature verification.

All subject and issuer names MUST be populated (i.e., not an empty
SEQUENCE) in S/MIME-compliant X.509 certificates, except that the
subject distinguished name in a user's (i.e., an end entity's)
certificate MAY be an empty SEQUENCE, in which case the
subjectAltName extension will include the subject's identifier and
MUST be marked as critical.

4. Certificate Processing

S/MIME agents need to provide some certificate retrieval mechanism in
order to gain access to certificates for recipients of digital
envelopes. There are many ways to implement certificate retrieval
mechanisms. [X.500] directory service is an excellent example of a
certificate retrieval-only mechanism that is compatible with classic
X.500 distinguished names. The IETF has published [RFC8162], which
describes an experimental protocol to retrieve certificates from the
Domain Name System (DNS). Until such mechanisms are widely used,
their utility may be limited by the small number of the
correspondent's certificates that can be retrieved. At a minimum,
for initial S/MIME deployment, a user agent could automatically
generate a message to an intended recipient requesting the
recipient's certificate in a signed return message.

Receiving and sending agents SHOULD also provide a mechanism to allow
a user to "store and protect" certificates for correspondents in such
a way as to guarantee their later retrieval. In many environments,
it may be desirable to link the certificate retrieval/storage
mechanisms together in some sort of certificate database. In its
simplest form, a certificate database would be local to a particular
user and would function in a way similar to an "address book" that
stores a user's frequent correspondents. In this way, the
certificate retrieval mechanism would be limited to the certificates
that a user has stored (presumably from incoming messages). A
comprehensive certificate retrieval/storage solution might combine
two or more mechanisms to allow the greatest flexibility and utility
to the user. For instance, a secure Internet mail agent might resort
to checking a centralized certificate retrieval mechanism for a
certificate if it cannot be found in a user's local certificate
storage/retrieval database.

Receiving and sending agents SHOULD provide a mechanism for the
import and export of certificates, using a CMS certs-only message.
This allows for import and export of full certificate chains as
opposed to just a single certificate. This is described in
[RFC8551].

Agents MUST handle multiple valid CA certificates containing the same
subject name and the same public keys but with overlapping validity
intervals.

4.1. Certificate Revocation Lists

In general, it is always better to get the latest CRL information
from a CA than to get information stored in an incoming message. A
receiving agent SHOULD have access to some CRL retrieval mechanism in
order to gain access to certificate revocation information when
validating certification paths. A receiving or sending agent SHOULD
also provide a mechanism to allow a user to store incoming
certificate revocation information for correspondents in such a way
as to guarantee its later retrieval.

Receiving and sending agents SHOULD retrieve and utilize CRL
information every time a certificate is verified as part of a
certification path validation even if the certificate was already
verified in the past. However, in many instances (such as off-line
verification), access to the latest CRL information may be difficult
or impossible. The use of CRL information, therefore, may be
dictated by the value of the information that is protected. The
value of the CRL information in a particular context is beyond the
scope of this specification but may be governed by the policies
associated with particular certification paths.

All agents MUST be capable of performing revocation checks using CRLs
as specified in [RFC5280]. All agents MUST perform revocation status
checking in accordance with [RFC5280]. Receiving agents MUST
recognize CRLs in received S/MIME messages.

4.2. Certificate Path Validation

In creating a user agent for secure messaging, certificate, CRL, and
certification path validation should be highly automated while still
acting in the best interests of the user. Certificate, CRL, and path
validation MUST be performed as per [RFC5280] when validating a
correspondent's public key. This is necessary before using a public
key to provide security services such as verifying a signature,
encrypting a content-encryption key (e.g., RSA), or forming a
pairwise symmetric key (e.g., Diffie-Hellman) to be used to encrypt
or decrypt a content-encryption key.

Certificates and CRLs are made available to the path validation
procedure in two ways: a) incoming messages and b) certificate and
CRL retrieval mechanisms. Certificates and CRLs in incoming messages
are not required to be in any particular order, nor are they required
to be in any way related to the sender or recipient of the message
(although in most cases they will be related to the sender).
Incoming certificates and CRLs SHOULD be cached for use in path
validation and optionally stored for later use. This temporary
certificate and CRL cache SHOULD be used to augment any other
certificate and CRL retrieval mechanisms for path validation on
incoming signed messages.

When verifying a signature and the certificates that are included in
the message, if a signingCertificate attribute from RFC 2634 [ESS] or
a signingCertificateV2 attribute from RFC 5035 [ESS] is found in an
S/MIME message, it SHALL be used to identify the signer's
certificate. Otherwise, the certificate is identified in an S/MIME
message, using either (1) the issuerAndSerialNumber, which identifies
the signer's certificate by the issuer's distinguished name and the
certificate serial number or (2) the subjectKeyIdentifier, which
identifies the signer's certificate by a key identifier.

When decrypting an encrypted message, if an
SMIMEEncryptionKeyPreference attribute is found in an encapsulating
SignedData, it SHALL be used to identify the originator's certificate
found in OriginatorInfo. See [RFC5652] for the CMS fields that
reference the originator's and recipient's certificates.

4.3. Certificate and CRL Signing Algorithms, and Key Sizes

   Certificates and CRLs are signed by the certificate issuer.
   Receiving agents:

   - MUST support ECDSA with curve P-256 with SHA-256.

   - MUST support EdDSA with curve25519 using PureEdDSA mode.

   - MUST- support RSA PKCS #1 v1.5 with SHA-256.

   - SHOULD support the RSA Probabilistic Signature Scheme (RSASSA-PSS)
      with SHA-256.

   Implementations SHOULD use deterministic generation for the parameter
   'k' for ECDSA as outlined in [RFC6979]. EdDSA is defined to generate
   this parameter deterministically.

The following are the RSA and RSASSA-PSS key size requirements for
S/MIME receiving agents during certificate and CRL signature
verification:

```
        key size <= 2047 : SHOULD NOT (see Appendix A)
2048 <= key size <= 4096 : MUST (see Security Considerations)
4096 <  key size         : MAY  (see Security Considerations)
```

The signature algorithm OIDs for RSA PKCS #1 v1.5 and RSASSA-PSS with
SHA-256 using 1024-bit through 3072-bit public keys are specified in
[RFC4055], and the signature algorithm definition is found in
[FIPS186-2] with Change Notice 1.

The signature algorithm OIDs for RSA PKCS #1 v1.5 and RSASSA-PSS with
SHA-256 using 4096-bit public keys are specified in [RFC4055], and
the signature algorithm definition is found in [RFC3447].

For RSASSA-PSS with SHA-256, see [RFC4056].

For ECDSA, see [RFC5758] and [RFC6090]. The first reference provides
the signature algorithm's OID, and the second provides the signature
algorithm's definition. Curves other than curve P-256 MAY be used as
well.

For EdDSA, see [RFC8032] and [RFC8410]. The first reference provides
the signature algorithm's OID, and the second provides the signature
algorithm's definition. Curves other than curve25519 MAY be used as
well.

4.4. PKIX Certificate Extensions

PKIX describes an extensible framework in which the basic certificate
information can be extended and describes how such extensions can be
used to control the process of issuing and validating certificates.
The LAMPS Working Group has ongoing efforts to identify and create
extensions that have value in particular certification environments.
Further, there are active efforts underway to issue PKIX certificates
for business purposes. This document identifies the minimum required
set of certificate extensions that have the greatest value in the
S/MIME environment. The syntax and semantics of all the identified
extensions are defined in [RFC5280].

Sending and receiving agents MUST correctly handle the basic
constraints, key usage, authority key identifier, subject key
identifier, and subject alternative name certificate extensions when
they appear in end-entity and CA certificates. Some mechanism SHOULD
exist to gracefully handle other certificate extensions when they
appear in end-entity or CA certificates.

Certificates issued for the S/MIME environment SHOULD NOT contain any
critical extensions (extensions that have the critical field set to
TRUE) other than those listed here. These extensions SHOULD be
marked as non-critical, unless the proper handling of the extension
is deemed critical to the correct interpretation of the associated
certificate. Other extensions may be included, but those extensions
SHOULD NOT be marked as critical.

Interpretation and syntax for all extensions MUST follow [RFC5280],
unless otherwise specified here.

4.4.1. Basic Constraints

The basicConstraints extension serves to delimit the role and
position that an issuing-authority or end-entity certificate plays in
a certification path.

For example, certificates issued to CAs and subordinate CAs contain a
basicConstraints extension that identifies them as issuing-authority
certificates. End-entity certificates contain the key usage
extension, which restrains end entities from using the key when
performing issuing-authority operations (see Section 4.4.2).

As per [RFC5280], certificates MUST contain a basicConstraints
extension in CA certificates and SHOULD NOT contain that extension in
end-entity certificates.

4.4.2. Key Usage Extension

The key usage extension serves to limit the technical purposes for
which a public key listed in a valid certificate may be used.
Issuing-authority certificates may contain a key usage extension that
restricts the key to signing certificates, CRLs, and other data.

For example, a CA may create subordinate issuer certificates that
contain a key usage extension that specifies that the corresponding
public key can be used to sign end-user certificates and CRLs.

If a key usage extension is included in a PKIX certificate, then it
MUST be marked as critical.

S/MIME receiving agents MUST NOT accept the signature of a message if
it was verified using a certificate that contains a key usage
extension without at least one of the digitalSignature or
nonRepudiation bits set. Sometimes S/MIME is used as a secure
message transport for applications beyond interpersonal messaging; in

such cases, the S/MIME-enabled application can specify additional
requirements concerning the digitalSignature or nonRepudiation bits
within this extension.

If the key usage extension is not specified, receiving clients MUST
presume that both the digitalSignature and nonRepudiation bits
are set.

4.4.3. Subject Alternative Name

The subject alternative name extension is used in S/MIME as the
preferred means to convey the email address or addresses that
correspond to the entity for this certificate. If the local portion
of the email address is ASCII, it MUST be encoded using the
rfc822Name CHOICE of the GeneralName type as described in [RFC5280],
Section 4.2.1.6. If the local portion of the email address is not
ASCII, it MUST be encoded using the otherName CHOICE of the
GeneralName type as described in [RFC8398], Section 3. Since the
SubjectAltName type is a SEQUENCE OF GeneralName, multiple email
addresses MAY be present.

4.4.4. Extended Key Usage Extension

The extended key usage extension also serves to limit the technical
purposes for which a public key listed in a valid certificate may be
used. The set of technical purposes for the certificate therefore
are the intersection of the uses indicated in the key usage and
extended key usage extensions.

For example, if the certificate contains a key usage extension
indicating a digital signature and an extended key usage extension
that includes the id-kp-emailProtection OID, then the certificate may
be used for signing but not encrypting S/MIME messages. If the
certificate contains a key usage extension indicating a digital
signature but no extended key usage extension, then the certificate
may also be used to sign but not encrypt S/MIME messages.

If the extended key usage extension is present in the certificate,
then interpersonal-message S/MIME receiving agents MUST check that it
contains either the id-kp-emailProtection OID or the
anyExtendedKeyUsage OID as defined in [RFC5280]. S/MIME uses other
than interpersonal messaging MAY require the explicit presence of the
extended key usage extension, the presence of other OIDs in the
extension, or both.

5. IANA Considerations

   This document has no IANA actions.

6. Security Considerations

   All of the security issues faced by any cryptographic application
   must be faced by an S/MIME agent. Among these issues are protecting
   the user's private key, preventing various attacks, and helping the
   user avoid mistakes such as inadvertently encrypting a message for
   the wrong recipient. The entire list of security considerations is
   beyond the scope of this document, but some significant concerns are
   listed here.

   When processing certificates, there are many situations where the
   processing might fail. Because the processing may be done by a user
   agent, a security gateway, or some other program, there is no single
   way to handle such failures. Just because the methods to handle the
   failures have not been listed, however, the reader should not assume
   that they are not important. The opposite is true: if a certificate
   is not provably valid and associated with the message, the processing
   software should take immediate and noticeable steps to inform the end
   user about it.

   Some of the many places where signature and certificate checking
   might fail include the following:

   - no Internet mail addresses in a certificate match the sender of a
      message, if the certificate contains at least one mail address

   - no certificate chain leads to a trusted CA

   - no ability to check the CRL for a certificate is implemented

   - an invalid CRL was received

   - the CRL being checked is expired

   - the certificate is expired

   - the certificate has been revoked

   There are certainly other instances where a certificate may be
   invalid, and it is the responsibility of the processing software to
   check them all thoroughly and decide what to do if the check fails.

It is possible for there to be multiple unexpired CRLs for a CA. If
an agent is consulting CRLs for certificate validation, it SHOULD
make sure that the most recently issued CRL for that CA is consulted,
since an S/MIME message sender could deliberately include an older
unexpired CRL in an S/MIME message. This older CRL might not include
recently revoked certificates; this scenario might lead an agent to
accept a certificate that has been revoked in a subsequent CRL.

When determining the time for a certificate validity check, agents
have to be careful to use a reliable time. In most cases, the time
used SHOULD be the current time. Some exceptions to this would be as
follows:

- The time the message was received is stored in a secure manner and
   is used at a later time to validate the message.

- The time in a SigningTime attribute is found in a countersignature
   attribute [RFC5652] that has been successfully validated.

The signingTime attribute could be deliberately set to a time where
the receiving agent would (1) use a CRL that does not contain a
revocation for the signing certificate or (2) use a certificate that
has expired or is not yet valid. This could be done by either
(1) the sender of the message or (2) an attacker that has compromised
the key of the sender.

In addition to the security considerations identified in [RFC5280],
caution should be taken when processing certificates that have not
first been validated to a trust anchor. Certificates could be
manufactured by untrusted sources for the purpose of mounting denial-
of-service attacks or other attacks. For example, keys selected to
require excessive cryptographic processing, or extensive lists of CRL
Distribution Point (CDP) and/or Authority Information Access (AIA)
addresses in the certificate, could be used to mount denial-of-
service attacks. Similarly, attacker-specified CDP and/or AIA
addresses could be included in fake certificates to allow the
originator to detect receipt of the message even if signature
verification fails.

RSA keys of less than 2048 bits are now considered by many experts to
be cryptographically insecure (due to advances in computing power)
and SHOULD no longer be used to sign certificates or CRLs. Such keys
were previously considered secure, so processing previously received
signed and encrypted mail may require processing certificates or CRLs
signed with weak keys. Implementations that wish to support previous
versions of S/MIME or process old messages need to consider the
security risks that result from accepting certificates and CRLs with
smaller key sizes (e.g., spoofed certificates) versus the costs of

denial of service. If an implementation supports verification of
certificates or CRLs generated with RSA and DSA keys of less than
2048 bits, it MUST warn the user. Implementers should consider
providing a stronger warning for weak signatures on certificates and
CRLs associated with newly received messages than the one provided
for certificates and CRLs associated with previously stored messages.
Server implementations (e.g., secure mail list servers) where user
warnings are not appropriate SHOULD reject messages with weak
cryptography.

If an implementation is concerned about compliance with National
Institute of Standards and Technology (NIST) key size
recommendations, then see [SP800-57].

7. References

7.1. Reference Conventions

   [ESS] refers to [RFC2634] and [RFC5035].

   [SMIMEv2] refers to [RFC2311], [RFC2312], [RFC2313], [RFC2314], and
   [RFC2315].

   [SMIMEv3] refers to [RFC2630], [RFC2631], [RFC2632], [RFC2633],
   [RFC2634], and [RFC5035].

   [SMIMEv3.1] refers to [RFC2634], [RFC3850], [RFC3851], [RFC3852],
   and [RFC5035].

   [SMIMEv3.2] refers to [RFC2634], [RFC5035], [RFC5652], [RFC5750],
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   [SMIMEv4] refers to [RFC2634], [RFC5035], [RFC5652], [RFC8551], and
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Appendix A. Historic Considerations

A.1. Signature Algorithms and Key Sizes

   There are a number of problems with validating certificates on
   sufficiently historic messages. For this reason, it is strongly
   suggested that user agents treat these certificates differently from
   those on current messages. These problems include the following:

   - CAs are not required to keep certificates on a CRL beyond one
      update after a certificate has expired. This means that unless
      CRLs are cached as part of the message it is not always possible
      to check to see if a certificate has been revoked. The same
      problems exist with Online Certificate Status Protocol (OCSP)
      responses, as they may be based on a CRL rather than on the
      certificate database.

   - RSA and DSA keys of less than 2048 bits are now considered by many
      experts to be cryptographically insecure (due to advances in
      computing power). Such keys were previously considered secure, so
      the processing of historic certificates will often result in the
      use of weak keys. Implementations that wish to support previous
      versions of S/MIME or process old messages need to consider the
      security risks that result from smaller key sizes (e.g., spoofed
      messages) versus the costs of denial of service.

      [SMIMEv3.2] set the lower limit on suggested key sizes for
      creating and validation at 1024 bits. [SMIMEv3.1] set the lower
      limit at 768 bits. Prior to that, the lower bound on key sizes
      was 512 bits.

   - Hash functions used to validate signatures on historic messages
      may no longer be considered to be secure (see below). While there
      are not currently any known practical pre-image or second
      pre-image attacks against MD5 or SHA-1, the fact that they are no
      longer considered to be collision resistant implies that the
      security level of any signature that is created with these hash
      algorithms should also be considered as suspect.

   The following algorithms have been called out for some level of
   support by previous S/MIME specifications:

   - RSA with MD5 was dropped in [SMIMEv4]. MD5 is no longer
      considered to be secure, as it is no longer collision resistant.
      Details can be found in [RFC6151].

- RSA and DSA with SHA-1 were dropped in [SMIMEv4]. SHA-1 is no
  longer considered to be secure, as it is no longer collision
  resistant. The IETF statement on SHA-1 can be found in [RFC6194],
  but it is out of date relative to the most recent advances.

- DSA with SHA-256 support was dropped in [SMIMEv4]. DSA was
  dropped as part of a general movement from finite fields to
  elliptic curves. Issues related to dealing with non-deterministic
  generation of the parameter 'k' have come up (see [RFC6979]).

For 512-bit RSA with SHA-1, see [RFC3279] and [FIPS186-2] without
Change Notice 1; for 512-bit RSA with SHA-256, see [RFC4055] and
[FIPS186-2] without Change Notice 1. The first reference provides
the signature algorithm's OID, and the second provides the signature
algorithm's definition.

For 512-bit DSA with SHA-1, see [RFC3279] and [FIPS186-2] without
Change Notice 1; for 512-bit DSA with SHA-256, see [RFC5758] and
[FIPS186-2] without Change Notice 1; for 1024-bit DSA with SHA-1, see
[RFC3279] and [FIPS186-2] with Change Notice 1; and for 1024-bit
through 3072-bit DSA with SHA-256, see [RFC5758] and [FIPS186-3].
The first reference provides the signature algorithm's OID, and the
second provides the signature algorithm's definition.

Appendix B. Moving S/MIME v2 Certificate Handling to Historic Status

The S/MIME v3 [SMIMEv3], v3.1 [SMIMEv3.1], v3.2 [SMIMEv3.2], and v4.0
(this document) specifications are backward compatible with the
S/MIME v2 Certificate Handling Specification [SMIMEv2], with the
exception of the algorithms (dropped RC2/40 requirement, and added
DSA and RSASSA-PSS requirements). Therefore, RFC 2312 [SMIMEv2] was
moved to Historic status.

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