NIST Special Publication 800-49

Federal S/MIME V3 Client Profile

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Technology Administration
U.S. Department of Commerce

C O M P U T E R S E C U R I T Y

November 2002

NIST Special Publication 800-49

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Recommendations of the National Institute of Standards and Technology

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November 2002

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National Institute of Standards and Technology Special Publication 800-46
Natl. Inst. Stand. Technol. Spec. Publ. 800-31, 26 pages (November 2002)
CODEN: NSPUE2

Acknowledgments

NIST would like to thank the many people who assisted with the development of this profile. We are grateful for the support that we received from members of the Internet Engineering Task Force (IETF), IETF's Public-Key Infrastructure Group (X.509) (PKIX) and S/MIME Working Groups. Special thanks are due to John Pawling, Jim Schaad, Russ Housley, Blake Ramsdell, and Tim Polk.

Executive Summary to the Federal S/MIME V3 Client Profile

(For Procurement Officials, Implementers, Vendors and Others Interested in Specifying S/MIME Technology)

S/MIME (Secure / Multipurpose Internet Mail Extensions) is a set of specifications for securing electronic mail. S/MIME is based upon the widely used MIME standard [MIME] and describes a protocol for adding cryptographic security services through MIME encapsulation of digitally signed and encrypted objects. The basic security services offered by S/MIME are authentication, non-repudiation of origin, message integrity, and message privacy. Optional security services include signed receipts, security labels, secure mailing lists, and an extended method of identifying the signer's certificate(s).

To understand S/MIME it is useful to understand some of the history of Internet e-mail. In the past twenty-five years or so, Internet e-mail has evolved from a simple text-based (ASCII) transfer of messages designed for researchers into a more sophisticated messaging system capable of communicating a wealth of digital information (e.g., photographic images, computer files, sound clips, cinema) to many millions of people around the world.

Internet e-mail was designed for a small community of trusted researchers (primarily at university and government sites) for exchanging text-based messages, and thus security was not a goal in its design. Over the years many deficiencies in Internet e-mail have been overcome to a certain extent through the use of a technology called Multipurpose Internet Mail Extensions (MIME). Employing MIME for messaging allows the use of multiple-text effects (e.g., bold, italic, various font sizes, and colors) as well as the transfer of digital information. MIME by itself also does not address security issues. However, a set of security features has been developed and added to MIME to form what is known as S/MIME (Secure MIME).

S/MIME adds features to e-mail messaging including privacy (using encryption), authentication of sending party (using digital signatures), integrity (non-alteration of messages), etc. S/MIME V3 is the latest version of S/MIME and is supported in whole or part by several vendors with "Commercial-Off-The-Shelf" (COTS) products.

Because S/MIME still uses the same extant Internet e-mail technology that has been widely deployed for many years, it is not necessary to modify or replace e-mail "servers" to accommodate S/MIME. Rather S/MIME functionality may be added to e-mail "client" software. By not disturbing the underlying e-mail server/message transfer system, S/MIME allows gradual migration from non-secure to secure e-mail messaging, rather than requiring a large, possibly abrupt change in technology.

Like other services and protocols used by the Internet community, S/MIME has been under development for many years, with the main components specified by the Internet Engineering Task Force (IETF), a technical body that issues specifications that serve as standards for vendor

implementation. These specifications are known as "Request for Comments"[1] (RFCs). The IETF RFCs for S/MIME reference important standards issued by the International Organization for Standardization (ISO) and the International Telecommunication Union (ITU). In addition, the U.S. National Institute of Standards and Technology (NIST) has issued certain Federal Information Processing Standards (FIPS) that are used to specify requirements for cryptographic algorithms and related hardware/software modules used by S/MIME. Thus, implementers and users must adhere to a very large set of "standards."

Furthermore, because standards developers allow many options within communications systems, even if all standards are rigidly adhered to, interoperability may not be possible due to differing choices of options selected by different vendors. For example, if vendor A chooses to implement signed receipts and vendor B chooses not to, then the signed receipts requested by the user of vendor A's products will never be sent by vendor B's product although neither implementation violates the standards.

To help assure that S/MIME products can interoperate and meet the e-mail security needs of federal agencies both with respect to security features, and adequate cryptographic algorithms, NIST has developed this Federal S/MIME V3 Client Profile. This profile states requirements for implementing sets of cryptographic algorithm suites specified elsewhere by the standards development organizations. The profile specifies a set of e-mail security features (e.g., encrypted e-mail, signed receipts) that are mandatory to be implemented. In the definition of this Profile, NIST's intention is never to violate underlying S/MIME standards, but rather to provide additional specificity within the standards.

While NIST believes that use of this profile will help assure interoperability of the near term secure e-mail products, NIST anticipates that future revisions of the profile will be required to reflect new cryptographic algorithms and related attacks, new underlying S/MIME standards, and new e-mail security features required by federal agencies.

The use of S/MIME requires the establishment of a Public Key Infrastructure (PKI) to support each sender and recipient of S/MIME messages. While the details of PKI are out of scope for this document, it is important to note that PKI is used to provide mechanisms to establish the identity of S/MIME users (known as authentication) and to provide for digital signatures, confidentiality, non-repudiation of sender, etc. X.509 Certificates are used to bind an entity's identity and public key for secure operations for S/MIME and other PKI-enabled secure applications. For a further understanding of PKI, see [Kuhn01], [Housley01], or [Adams00] in the References clause.

[1] (Note: The RFC name is a misnomer, but is retained for historic purposes, and is well-known in the Internet development community.)

Summary of E-mail Security Features Mandated by the Federal S/MIME V3 Client Profile

Feature	Requirement
Signed Messages	Send and receive
Encrypted Messages	Send and receive
Signed and Encrypted Messages	Send and receive
Signed Receipt Processing	Request, send, and process signed receipts
Receipt of Messages from Secure Mail List Agents	Process messages from secure mail list agents (includes suppressing of receipts as required and non-disclosure of list recipients as required)
Cryptographic Modules	FIPS 140-1 or FIPS 140-2, Security Requirements for Cryptographic Modules[2]
Cryptographic Algorithm Suite 1 (ALS1)	RSA for digital signature [RFC2313] with SHA-1 hash algorithm [FIPS180-1], RSA for key transport [RFC2313], Triple-DES [FIPS46-3] for content encryption (RSA Key Sizes >= 1024 bits)
Cryptographic Algorithm Suite 2 (ALS2)	DSA for digital signature [FIPS186-2] with SHA-1 hash algorithm [FIPS180-1], RSA [RFC2313] for key transport, Triple-DES [FIPS46-3] for content encryption (DSA Key Size =1024 bits) (RSA Key Size >= 1024 bits)
Public Key Infrastructure (PKI)	Senders/receivers require valid X.509 certificates (Conformance to Federal PKI X.509 Certificate and CRL Extensions Profile required)

Note that compliant implementations can generate "clear" signed messages using RSA or DSA signature algorithms. ("Clear" signed messages can be read by non S/MIME-enabled clients, although signatures cannot be automatically processed and verified by such clients.) S/MIME signed messages may include the time that signatures were generated as well as the sender's PKI certificates. The sender's PKI certificates (also known as X.509 certificates) can be used to verify the sender's identity and help to enable other security services.

[2] FIPS-140 defines four levels of security. The appropriate security level is determined by the sensitivity of the data. Cryptographic module security levels are thus chosen on the basis of data sensitivity, and this selection is beyond the scope of this profile. See Clause 1 of [FIPS 140-2] for a description of security levels.

Compliant implementations process both “clear” and “opaque” signed messages. (“Opaque” signed messages are encoded such that the recipient requires an S/MIME-enabled e-mail client to automatically read the message.) Each implementation uses the Lightweight Directory Access Protocol (LDAP) to obtain certificates and certificate revocation lists (CRLs) and checks that the proper fields within each certificate match the sender’s name.

Compliant implementations must be able to encrypt messages for one or more recipients.

Optional Services

The profile identifies three optional cryptographic algorithm suites. These are desirable to implement but not mandatory. These suites are:

> ALS3: {RSA [RFC 2313] for digital signature with SHA-1 hash algorithm [FIPS180-1], RSA [RFC 2313] for key transport, AES [FIPS197] for content encryption}
>
> ALS4: {DSA for digital signature [FIPS186-2] with SHA-1 hash algorithm [FIPS180-1], Diffie-Hellman [RFC2631] for key agreement, Triple-DES for content encryption [FIPS46-3].}
>
> ALS5: {DSA for digital signature [FIPS186-2] with SHA-256 hash algorithm [FIPS180-2], Diffie-Hellman [RFC2631] for key agreement, AES [FIPS197] for content encryption}
> Note: Newer versions of DSA are anticipated with support for key sizes greater than 1024 bits. New standards for D-H and AES usage are anticipated to require the use of the SHA-256 hash algorithm. The SHA-256 algorithm is now available. [FIPS180-2]

Optional services in this profile include the ability to send and process e-mail with security labels (as defined in the S/MIME V3 standards [RFC2634]). Another optional service is the ability to securely bind sender’s certificates to their signatures through the signing certificate attribute (as defined in [RFC2634]).

Mail list agent processing (also defined in [RFC2634]) is out-of-scope (i.e., will not be tested for conformance) with respect to this protocol. However, S/MIME-enabled e-mail client software MUST be able to properly process messages from secure mail list agents.

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1 Introduction

S/MIME (Secure / Multipurpose Internet Mail Extensions) is a set of specifications for securing electronic mail. S/MIME is based upon the widely used MIME standard [MIME] and describes a protocol for adding cryptographic security services through MIME encapsulation of digitally signed and encrypted objects. The basic security services offered by S/MIME are authentication, non-repudiation of origin, message integrity, and message privacy. Optional security services include signed receipts, security labels, secure mailing lists, and an extended method of identifying the signer's certificate(s).

S/MIME Version 3 is the latest version of S/MIME. Version 3 is specified in IETF RFCs 2630 through 2634 ([RFC2630], [RFC2631], [RFC2632], [RFC2633], and [RFC2634]).

The S/MIME specifications were designed to promote interoperable secure electronic mail, such that two compliant implementations would be able to communicate securely with one another. However, implementations may support different optional services, and the specifications may unintentionally allow multiple interpretations. As a result, different implementations of S/MIME may not be fully interoperable or provide the desired level of security.

The S/MIME specifications rely on cryptographic mechanisms and public key infrastructures (PKI) to provide security services. If the cryptographic and PKI components that are used to support the S/MIME implementation are sufficiently robust, users can obtain additional assurance that sufficiently strong cryptographic algorithms are used, and that procedures are in place to protect sensitive information.

Conformance to this profile helps to assure that S/MIME implementations will be able to interoperate and provide reasonable assurance to users.

The National Institute of Standards and Technology (NIST), Information Technology Laboratory, Computer Security Division, has developed this S/MIME client profile as guidance in the development and procurement of commercial-off-the-shelf (COTS) S/MIME-compliant products. This profile document identifies requirements for a secure and interoperable S/MIME V3 client implementation. NIST is developing tests and testing tools to determine the level of conformance of an S/MIME V3 client implementation with this profile.

This profile does not address requirements for network infrastructure components that implement S/MIME V3, such as mail list agents (MLAs) and secure mail gateways (e.g., security guards). Such systems will have significant overlap but will have additional requirements specific to their function.

The remainder of this document is organized into four principal sections: (a) S/MIME Profile requirements; (b) Support for Enhanced Security Services (ESS); (c) Optional Features and Notes on Testing; and (d) References. In addition, there is a non-Normative Appendix on Cryptographic Algorithms. The profile requirements describe the minimum functionality required to support secure and interoperable S/MIME client implementations. The support for

ESS section discusses requirements for ESS conformance. The optional features and notes on testing section specifies desirable, but optional features for S/MIME client implementations as well as useful notes for testing. These features will be useful to "power" users, but fall outside the core services required to support mainstream S/MIME users. The references section provides current URL as well as document titles when documents are on-line. The non-normative appendix on cryptographic algorithms provides guidance on cryptographic algorithms.

2 S/MIME Profile Requirements

Important S/MIME interoperability and security features are identified in this section. First, underlying technologies are examined, including cryptography, public key infrastructure (PKI), and formatting of cryptographically protected data. The following subsection describes requirements in these areas. Using these technologies, S/MIME clients perform two fundamental operations: they generate electronic mail messages and process electronic mail messages. The second and third sections describe the minimum functionality for S/MIME message generation and reception, respectively.

Conformant implementations MUST be able to generate and process signed, encrypted, and signed and encrypted messages as detailed in the paragraphs that follow. Conformant implementations MUST be able to support all of the mandatory clauses of the IETF RFCs 2630, 2632, and 2633 with the exception that implementation of RFC 2631 Ephemeral-Static Diffie-Hellman Key Agreement [RFC2631] algorithm mandated in [RFC2630] is NOT required by this Profile. However, implementation of the Ephemeral-Static Diffie-Hellman Key Agreement algorithm in RFC 2631 is recommended. The terms "MUST," "SHOULD," and "MAY" are used as defined in RFC 2119 [MUSTSHOULD].

Conformance to this profile also assumes implementations of Federal Information Processing Standards (FIPS) approved cryptographic algorithms as specified in Clause 2.1.1.

2.1 Fundamental Technologies

S/MIME relies on four fundamental technologies to format and protect electronic mail messages. These fundamental technologies are cryptographic algorithms, public key infrastructure (PKI), the cryptographic message syntax (CMS) data format, and MIME. Correct implementation of these mechanisms is essential to the security and interoperability of every S/MIME client. While these technologies will not be tested in isolation, they will be tested indirectly.

However, not all features available through these technologies are required for S/MIME. To that end, we describe the features that are required by this profile.

2.1.1 Cryptographic Algorithm Suite Conformance

To help ensure that cryptographic functions are correctly implemented, software modules implementing cryptographic functions MUST conform to either FIPS 140-1, or FIPS 140-2, Security Requirements For Cryptographic Modules [FIPS140-1] [FIPS140-2][3].

2.1.1.1 Mandatory to Implement Algorithm Suites

Conforming Federal S/MIME Profile implementations MUST support the following suites of cryptographic algorithms:

> ALS1: {RSA for digital signature [RFC2313] with SHA-1 hash algorithm [FIPS180-1], RSA for key transport [RFC2313], Triple-DES [FIPS46-3] for content encryption} Conforming implementations MUST support a RSA key size of at least 1024 bits. For Triple-DES, when generating messages at least two independent keys MUST be supported using the Cipher Block Chaining (CBC) Mode. This algorithm is also known as DES EDE3 CBC.
>
> ALS2: {DSA for digital signature [FIPS186-2] with SHA-1 hash algorithm [FIPS180-1], RSA [RFC2313] for key transport, Triple-DES [FIPS46-3] for content encryption} Conforming implementations MUST support a DSA key size of 1024 bits.

This profile requires that implementations MUST be able to verify signatures on certificates and messages using either of the above algorithm suites. However for message generation only one of these algorithm suites MUST be supported. This implies that both the RSA digital signature and DSA algorithms MUST be supported for message verification, but only one of these algorithms MUST be supported for message generation. However, implementations SHOULD support both signature algorithms for message generation.

2.1.1.2 Recommended Algorithm Suites

In addition to supporting ALS1 or ALS2, conforming implementations SHOULD support the following additional algorithm suites:

> ALS3: {RSA [RFC 2313] for digital signature with SHA-1 hash algorithm [FIPS180-1], RSA [RFC 2313] for key transport, Advanced Encryption Standard [FIPS197] for content encryption}
>
> ALS4: {DSA for digital signature [FIPS186-2] with SHA-1 hash algorithm [FIPS180-1], Diffie-Hellman [RFC2631] for key agreement, Triple-DES for content encryption [FIPS46-3].}
>
> ALS5: {DSA for digital signature [FIPS186-2] with SHA-256 hash algorithm [FIPS180-2], Diffie-Hellman [RFC2631] for key agreement, AES [FIPS197] for content encryption}

[3] FIPS-140 defines four levels of security. The appropriate security level is determined by the sensitivity of the data. Cryptographic module security levels are thus chosen on the basis of data sensitivity, and this selection is beyond the scope of this profile. See Clause 1 of [FIPS 140-2] for a description of security levels.

Note: Newer versions of DSA will become available with support for key sizes greater than 1024 bits. New standards for D-H and AES usage are anticipated to require the use of the SHA-256 hash algorithm. The SHA-256 algorithm is now available in draft form.

Related recommendations on public key sizes:

- If an implementation supports AES in conjunction with RSA, the implementation SHOULD also support RSA public key sizes greater than 1024 bits.
- If an implementation supports AES in conjunction with D-H, the implementation SHOULD also support D-H public key sizes greater than 1024 bits.
- If an implementation supports public key sizes greater than 1024 bits when using either DSA or RSA for digital signature, the implementation SHOULD also support SHA-256.

Additional algorithm suites will be identified in the future.

Note: The current Digital Signature Algorithm (DSA) defined in [FIPS186-2] uses a key size of at least 1024 bits. Future versions of FIPS 186 will be defined to allow for key sizes of 1024 bits or longer.

Support of additional algorithm suites, especially using other FIPS approved algorithms (e.g., the Elliptical Curve Digital Signature Algorithm ECDSA [ANSIX9.62]) or other FIPS approved algorithms [FIPS140-1] or [FIPS140-2], is encouraged to promote interoperability and backward compatibility.

However, some older and weaker algorithm suites should be avoided and not trusted. For example, the MD2 message digest algorithm and 512 bit RSA are now considered to be weak by many cryptographers.

Further information on cryptographic algorithm suites is provided in Appendix A.

2.1.1.3 Key Wrap Specifications

In S/MIME V3, management of symmetric cryptographic keys often leads to situations where one symmetric key is used to encrypt (or wrap) another (e.g., sending enveloped data to several recipients). In situations where Triple-DES [FIPS46-3] is used for symmetric key encryption and key wrapping is required, the method for encoding the key wrap is as specified in [RFC3217] (or its successor document) MUST be used. In situations where AES [FIPS197] is used for symmetric key encryption and key wrapping is required, the method for encoding the key wrap as specified in [RFC3394] MUST be used.

2.1.2 PKI Profile Conformance

In order to help ensure that S/MIME V3 implementations interoperate securely, it is useful to adopt a profile of the X.509 standard. The most widely accepted PKI profile is the IETF Public Key Infrastructure using X.509 (PKIX) profile developed by the PKIX working group. The PKIX profile [RFC3280] identifies the format and semantics of certificates and CRLs for use on the Internet. Procedures are described for processing and validating certification paths in the Internet environment. The PKIX profile has also been adopted by the Federal PKI Technical

Working Group in the "Federal Public Key Infrastructure (PKI) X.509 Certificate and CRL Extensions Profile" [CERTCRL]. Conformance to this S/MIME V3 Profile requires conformance to [CERTCRL].

2.1.3 Cryptographic Messaging Systems (CMS) Content Types

Conforming implementations MUST be able to generate and receive the following CMS Content Types embedded in a ContentInfo object as defined in [RFC2630]:

- SignedData
- EnvelopedData
- Receipt

Conforming implementations MUST be able to generate and receive the following CMS content types as embedded content:

- Data

Note: The inclusion of Signed Receipts in Sections 2.2, 2.3, and 3.1 implies that implementations MUST include the Receipt content type from [RFC2634].

In S/MIME messages, the Data content type is only used within SignedData or EnvelopedData content types and always contains a MIME-encoded message.

Conforming implementations MUST be able to process nested S/MIME security layers such that signed data may appear within enveloped data and enveloped data may appear within signed data. Details of nesting of content types within MIME types are contained in [RFC2634] Clauses 1.1 and 1.2. Nesting beyond triple wrapping as defined in [RFC2634] Clauses 1.1 and 1.2 is not required.

2.1.4 MIME Encoding

S/MIME is used to secure MIME content. Traditionally S/MIME implementations have used Base64 MIME encoding for all information. (Base64 encoding is used to transfer binary information through Internet (SMTP) mail because Internet mail was originally designed to transfer ASCII information only. Therefore to ensure that binary information is passed through the Internet without modification, it is necessary to translate the information into an ASCII representation such as Base64.) Unfortunately Base64 encoding applied to binary information causes an increase of message size of at least 33 percent and thus represents a waste of network bandwidth, and possibly storage at either end.

S/MIME uses ASN.1 Basic Encoding Rules (BER) to represent data [X.208] [X.209]. There are multiple layers of BER encoded data in S/MIME messages, each usually "wrapped" in Base64 encoding. While it is necessary to have the outermost binary (BER) representation Base64 encoded for passage through the Internet, inner binary representations need not have Base64 encoding applied, although most implementations apply Base64 even to inner binary representations.

Conforming implementations MUST be able to receive messages where inner MIME encodings are not individually Base64 encoded. There is no requirement that S/MIME implementations generate messages with inner MIME encodings without Base64, although S/MIME implementations SHOULD be able to generate messages with Base64 encoding applied only to the outermost binary data.

2.1.5 Mail Access Protocols (POP/IMAP)

To send S/MIME messages over the Internet each end user (e.g., e-mail client) must have one or more e-mail accounts on an SMTP-enabled server (i.e., a standard Internet mail server). Normally, each client also needs a "mail access" protocol, (e.g., POP, IMAP) to support transfer of messages to/from the e-mail server and their local computer. With respect to this S/MIME V3 Client Profile, the "mail access" protocol is out-of-scope.

2.2 S/MIME Message Generation

S/MIME implementations MUST be able to generate S/MIME messages that are correctly formatted as per IETF S/MIME V3 specifications and include sufficient information for the recipient to verify the signature or decrypt the data. In addition, these messages MAY include information to allow the recipient to generate secure responses.

2.2.1 Sending Signed Messages

- S/MIME implementations MUST be able to generate SignerInfo including signed attributes.
- S/MIME implementations MUST be able to generate SMIMECapabilities and signingTime attributes.
- S/MIME implementations SHOULD be able to generate signingCertificate attributes.
- S/MIME implementations MUST be able to include user certificates and appropriate CRLs.
- S/MIME implementations MUST be able to generate multipart/signed (i.e., "clear") messages.
- S/MIME implementations MUST be able to request return signed receipt messages (as specified in [RFC 2634]) where the receipt goes to the message originator. (Requesting a return signed receipt where the receipt is directed to a third party is out of scope for this profile, and thus claims to conformance will not be tested. However, correctly responding to the reception of such a signed receipt request is required, as stated in Clause 2.3.2)

2.2.2 Sending Encrypted Messages

- S/MIME implementations MUST be able to generate symmetric keys, encrypt messages using these keys, and encrypt symmetric keys using PKCS#1 v1.5 RSA keys as defined in [RFC2313].
- S/MIME implementations SHOULD be able to generate Diffie-Hellman keys and derive pairwise symmetric key-encryption keys (KEK) as defined in [RFC2631], and then use the KEK to encrypt the content-encryption key as specified in [RFC2630].
- S/MIME implementations MUST be able to encrypt a message for multiple recipients.

- When the sender supports more than one method for key management, the implementation SHOULD automatically select an appropriate method based on the contents of each recipient's key management certificates (usually obtained from previously received messages).
- When the sender supports more than one method for symmetric encryption, the implementation SHOULD automatically select the appropriate encryption method based on each recipient's SMIMECapabilities attributes from previously received messages.
- S/MIME implementations MUST be able to construct a certification path for the receiver's key management certificate, including CRLs, using the Lightweight Directory Access Protocol (LDAP). This includes:
  - the ability to build the path.
  - the ability to fetch the recipient's certificate using LDAP.
  - the ability to fetch CRLs using LDAP.
  - the ability to fetch issuer certificates using LDAP.
- S/MIME implementations MUST validate the certification path where the end certificate is the receiver's key management certificate or reject the certificate.

2.2.3 Sending Signed and Encrypted Messages

- S/MIME implementations MUST be able to satisfy the requirements for sending signed messages as in Clause 2.2.1 above and MUST be able to satisfy the requirements for sending encrypted messages as in Clause 2.2.2 above.
- S/MIME implementations MUST be able to generate signed and then encrypted messages. This includes generating a symmetric key and encrypting the message.
- S/MIME implementations SHOULD be able to use the application/pkcs7-mime type to generate signed then encrypted messages.

2.2.4 Building MIME Header

- S/MIME implementations MUST be able to create properly formatted MIME headers as per [RFC2633] for each of the message types above.
- S/MIME implementations MUST be able to create the intermediate MIME wrappers.

2.3 S/MIME Message Reception and Processing

S/MIME implementations MUST be able to receive and process S/MIME messages that are correctly formatted. Recipients MUST be able to verify the signature or decrypt the data using the information provided by the sender. Where necessary, the recipient MUST be able to augment sender-provided information with certificates, CRLs, or other status information. (For example, the recipient may use LDAP for retrievals of CRLs.)

2.3.1 Parsing MIME Header

- S/MIME implementations MUST be able to process properly formatted MIME headers.

2.3.2 Receiving Signed Messages

- S/MIME implementations MUST be able to process SignerInfo including signed attributes.

- S/MIME implementations MUST be able to process both multipart/signed (i.e., "clear") and application/pkcs7-signature MIME Type (i.e., "opaque") signed messages.
- S/MIME implementations MUST be able to acquire certificates by extracting certificates from incoming signed messages.
- S/MIME implementations MUST handle unknown attributes gracefully by accepting the message and informing the user.
- S/MIME implementations MUST be able to construct a certification path for the sender's signature certificate, including CRLs, using LDAP. This is further described in Clause 2.4.4. below.
- S/MIME implementations MUST validate the certification path where the end certificate is the sender's signature certificate or reject the certificate.
- Whenever an S/MIME implementation indicates the signature on a message is valid, that implementation MUST display an authenticated name (e.g., the subject name or a subjectAltName) from the signer's certificate.
- S/MIME implementations MUST compare the SubjectAltName.rfc822Name or PKCS#9 emailAddress in the signer's certificate with the actual e-mail address used in the received message's "From" or "Sender" field (See [RFC3280] and [RFC2632].).
    1. If the addresses do not match or the certificate does not contain any e-mail addresses, the S/MIME implementation MUST display information to the user to allow the user to accept or reject the message. This information MUST be displayed the first time that an e-mail message arrives with a unique pair of "From" address and signer certificate.
    2. To avoid continual display of information in environments where certificates either do not contain e-mail address, or there are frequent mismatches between e-mail addresses used in the "From" field of RFC822 messages and those in the signer's certificate, the implementation SHOULD allow the user the option of suppressing further display of information on subsequent messages received with the same unique pair of "From" address and signer certificate.
    3. The implementation MUST clearly differentiate between authenticated names (from the signer's certificate) and unauthenticated names (e.g., the rfc822 "phrase" in "mailbox" in the address specification in the "From" field) when displaying signature validation information.
- S/MIME implementations MUST be able to generate return signed receipt messages as specified in [RFC2634]. Signed receipts SHOULD be sent to the entities named in the receiptsTo field of the receipt request according to the processing described in Section 2 of [RFC2634]. Note: As specified in [RFC2634], this processing may cause modification in determining if return signed receipts should be sent according to the value of the mlExpansionHistory attribute (if any) contained in received messages.

2.3.3 Receiving Encrypted Messages

- S/MIME implementations MUST be able to process encrypted messages. This includes recovering the symmetric key and using the key to decrypt the message.
- S/MIME implementations MUST be able to process messages for one or more recipients.
- Receiving agents SHOULD allow a transparent selection of the appropriate private key for decryption of an incoming message when the recipient has multiple certificates (each associated with a private key) used for key management.

2.3.4 Receiving Signed and Encrypted Messages

- S/MIME implementations MUST be able to receive and process messages that are signed and then encrypted. Implementations SHOULD be able to receive and process messages that are signed, encrypted, and then signed again. (Triple wrapping as defined in [RFC2634].) Implementations that can process arbitrary layers of wrapping are preferable.

2.3.5 Processing Return Receipts

- S/MIME implementations MUST be able to process return signed receipts as specified in [RFC2634] for messages that the implementation generated and are still retained on the client system. Receipts for messages generated by a third party are out of scope for this profile, and thus claims to conformance will not be tested.
- S/MIME implementations MUST be able to match receipts to messages automatically.
- When S/MIME implementations process return signed receipt messages, the requirements for receiving signed messages as in Clause 2.3.2 above MUST be satisfied.

2.4 Certificate Processing

S/MIME is a PKI-enabled secure application. Specifically, S/MIME V3 implementations MUST obtain and validate X.509 public key certificates to validate the signature on a message or exchange symmetric key material. If critical PKI features are not present or are weak, the security of S/MIME implementations will be adversely affected. PKI features are described in detail in [RFC3280], "Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile."

The PKI features may be divided into four basic categories. These categories are explained in detail below.

2.4.1 X.509 Certificate Processing

S/MIME implementations MUST be able to process all critical or optionally critical certificate extensions in the Federal Certificate and CRL Profile [CERTCRL]. S/MIME implementations MUST not reject certificates with unrecognized non-critical extensions. S/MIME agents MUST have the capability to support distinct certificates for digital signature and key management security services for both message origination and reception.

2.4.2 X.509 CRL Processing

S/MIME implementations MUST be able to process all critical or optionally critical CRL extensions in the Federal Certificate and CRL Profile [CERTCRL]. S/MIME implementations MUST not reject CRLs with unrecognized non-critical extensions.

2.4.3 Path Validation

S/MIME implementations MUST be able to validate a certification path according to [RFC3280], Section 6. S/MIME implementations MUST be able to use X.509 CRLs to

establish certificate status for path validation. At a minimum, the following aspects of path validation MUST be implemented:

- certificate policies, policy constraints, and policy mapping
- basic constraints
- name constraints for distinguished names and RFC822 names
- DSA parameter inheritance
- processing certification paths with multiple signature algorithms
- name chaining
- signature verification
- validity date checking
- revocation checking by processing CRLs
- key usage/extended key usage
- CRL distribution points
- CRL entry extensions: invalidity date, reason code.

2.4.4 Path Building

Although not described in [RFC3280], path building is an important aspect of PKI-enabled applications. S/MIME implementations MUST be able to construct certification paths between an accepted trust point and a sender's or a recipient's certificate(s). Path building algorithms are not specified in any standard or specification. However, a variety of resources are available to assist in path building using heuristic methods. These resources include standard directory attributes and a variety of supplementary information in certificate extensions. S/MIME implementations MUST be able to take advantage of this information to provide complete path building services. At a minimum, the following features MUST be supported:

- retrieve CRLs using LDAP from the following directory attributes:
  - certificate revocation list, and
  - authority revocation list.
- retrieve certificates using LDAP from the following directory attributes:
  - Cross certificate pair,
  - CA certificate, and
  - user certificate.
- locate certificates in directory entries through at least one of the following methods:
  - Authority Information Access (AIA) extension,
  - Subject Information Access (SIA) extension, or
  - retrieval from a well-known directory.
- locate CRLs in directory entries through both of the following methods:
  - CRL distribution point extension, and
  - retrieval from a well-known directory.

The use of the above features is intended to allow implementations to build certification paths in non-hierarchical PKIs (e.g., across bridge PKIs.)

3 Support for Enhanced Security Services for S/MIME (RFC 2634)

The IETF has defined a set of Enhanced Security Services (ESS) for S/MIME in [RFC2634]. The services defined include signed receipts, security labels, secure mailing lists, and an extended method of identifying the signer's certificate(s). This profile does not require conformance to [RFC2634] with the exception that signed receipt requesting, processing, and generation is required as specified in Clause 3.1 of this profile. However, mail agents that include support for any of these ESS services may optionally claim support for any or all of these services, either in origination of messages, receipt of messages, or both. Note that some optional services defined in [RFC2634] are out of scope for this profile as specified below, and thus claims to conformance will not be tested.

3.1 Signed Receipts

Support for signed receipts is one of the four optional security services defined in [RFC2634]. For the purposes of this Profile, e-mail agents MUST be able to request, generate, and process signed receipts as described in [RFC2634].

- S/MIME agents that originate messages MUST be able to generate signed receipt requests for signed messages as defined in [RFC2634]. (See Clause 2.2.1 above.)
- S/MIME agents that receive messages MUST be able to generate signed receipts for signed messages that they receive containing signed receipt requests as defined in [RFC2634]. (See Clause 2.3.2 above.)
- S/MIME agents that receive messages MUST be able to process signed receipts (including signature verification) as defined in [RFC2634]. (See Clause 2.3.5 above.)
- Mail list agent processing is beyond the scope of this profile. However, S/MIME agents MUST be able to process mlExpansionHistory attributes as defined in Section 2 of [RFC2634].

3.2 Security Labels

Support for security labels is one of the four optional security services defined in [RFC2634]. If an S/MIME implementation claims to conform to the security label service defined in Clause 3 of [RFC2634], then the following requirements are imposed on the implementation:

- S/MIME agents that originate messages MUST be able to generate security labels as defined in [RFC2634].
- S/MIME agents MUST be able to display security labels in received messages as defined in [RFC2634]. S/MIME agents MUST be able to examine the security label on a received message and determine whether the recipient is allowed to see the contents of the message. If the recipient is not allowed to see the message contents then the agent MUST not display the message contents.
- The generation and processing of Equivalent Security Labels is beyond the scope of this profile, but may be added to a future profile. However, as stated in [RFC2634], "[a]ll receiving agents SHOULD recognize equivalentLabels attributes even if they do not process them."

3.3 Secure Mailing Lists

Support for Secure Mailing Lists ("Mail List Management") is one of the four optional security services defined in [RFC2634]. Mail list agent processing is beyond the scope of this profile but may be added to a future profile. However, S/MIME implementations MUST be able to process received signed messages that contain the mlExpansionHistory attribute as described in Clause 3.1 above.

3.4 Signing Certificate Attribute

Support for Signing Certificate Attributes is one of the four optional security services defined in [RFC2634]. If an S/MIME implementation claims to conform to the Signing Certificate Attribute requirements defined in Clause 5 of [RFC2634], then the following requirements are imposed on the implementation:

- S/MIME agents that originate messages MUST be able to generate messages that contain a signing certificate attribute as defined in [RFC2634].
- S/MIME agents that receive messages MUST be able to properly process messages that contain a signing certificate attribute as defined in [RFC2634].

4 Optional Features and Notes on Testing

Since the functionality offered by these optional features may be achieved through other means, inclusion of these options in S/MIME implementations is recommended, but not required.

4.1 Generate Application/pkcs7-signature MIME Type (Opaque) Signed Messages

Sending agents SHOULD have the capability to generate application/pkcs7-signature MIME Type (i.e., "opaque") signed messages.

4.2 Self-Signed Certificates

Sending and receiving agents SHOULD have the capability to support self-signed certificates by accepting them as trust anchors.

4.3 Sending CRLs

Sending agents SHOULD have the capability to include appropriate CRLs with outgoing messages (i.e., CRLs which are associated with the sender's certificates).

4.4 Selective Trust of Certificates

S/MIME agents SHOULD provide the capability to configure the set of trust anchors, (i.e., set the root trust certificates).

4.5 Acquiring Certificates

S/MIME agents SHOULD have the capability to acquire certificates in either of the following ways:

1) Loading certificates (or chains of certificates) from *.p7c and *.p7m files (file extension types) and messages as defined in [RFC2633].

2) Loading certificates from commonly used (e.g., *.cer and *.crt (binary encoded certificates)) file extension types.

Note: Lookup of certificates (and chains of certificates) from a LDAP repository is required as stated in Clause 2.2.2.

4.6 Importing/Exporting PKCS #12 Credentials

S/MIME agents SHOULD have the capability to import PKCS #12 objects as defined in [PKCS#12].

4.7 Notes on Testing and Scope

- Some testing requires "human scoring" because a user interface is involved. For example, as stated in Clause 2.3.2:

  "S/MIME implementations MUST ensure that either the SubjectAltName.rfc822Name or PKCS#9 emailAddress in the signer's certificate matches the actual e-mail address used in the received message's "From" or "Sender" field (See [RFC3280] and [RFC2632].) If the addresses do not match, the S/MIME implementation MUST display information to the user to allow the user to accept or reject the message.

  There is no efficient method to automate verification that the S/MIME implementation actually displays the mismatch information. Thus, human scoring is required to evaluate the implementation's conformance to this requirement.

- Security of operating system and e-mail mechanisms are beyond the scope of this profile. For example, system operators must ensure that the operating system itself is secured, and that the e-mail system is secure. This profile addresses only the security aspects of IETF-developed S/MIME extensions.

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Note: All RFCs and Internet-Drafts are available from the IETF at http://www.ietf.org/rfc.html and http://www.ietf.org/ID.html, respectively.

A. Appendix A Cryptographic Algorithms (Non-Normative)

The availability and implementation of cryptographic algorithms affect both the security and interoperability of S/MIME implementations. If a message is hashed or signed with an algorithm not supported by the recipient, the recipient cannot verify the signature. If the symmetric key (for message encryption) is derived or transferred with a key management algorithm not supported by the recipient, the recipient will not be able to recover the symmetric key and decrypt the message. If a message is encrypted with a symmetric algorithm not supported by the recipient, the recipient will not be able to recover the clear text.

In addition, cryptographic algorithms offer different levels of protection [ORMAN]. Users of S/MIME products need to make their systems resistant to some predetermined level of attack. That level-of-attack resistance is the strength of the system. The one-way hash algorithm, digital signature algorithm, key management algorithm, and symmetric algorithm SHOULD be at least as strong as the system strength requirements.

Selecting and matching appropriate cryptographic algorithms is a complex task. This document identifies algorithms that offer currently viable levels of security and identifies suites of algorithms that may be used together.

To help ensure that cryptographic functions are correctly implemented, software modules implementing cryptographic functions MUST conform to either FIPS 140-1 or to FIPS 140-2, Security Requirements For Cryptographic Modules [FIPS140-1] [FIPS140-2] as specified in Clause 2.1.1 of this profile.

A.1 One-Way Hash Algorithms

Hash algorithms map arbitrarily long inputs into a fixed-size output such that it is very difficult (computationally infeasible) to find two different hash inputs that produce the same output. Such algorithms are an essential part of the process of producing fixed-size digital signatures that can both authenticate the signer and provide for data integrity checking (detection of input modification after signature) in a S/MIME message. For S/MIME V3, the following hash algorithms are identified:

SHA-1: S/MIME agents MUST support the Secure Hash Algorithm (SHA-1) as specified in [FIPS180-1] in agreement with Clause 2.1.1.1 of this profile.

SHA-256: This enhanced secure hash algorithm has been published. When it becomes widely available, S/MIME agents SHOULD be capable of using [FIPS180-2].

A.2 Symmetric Encryption Algorithms

Symmetric encryption algorithms use the same secret key for data encryption and decryption. The Data Encryption Standard (DES) [FIPS46-3] algorithm using 56-bit keys has been available since the late 1970s and is now considered weak. The much

stronger Advanced Encryption Standard (AES) [FIPS197] algorithm allowing up to 256-bit keys has recently been approved and implementations are expected to be widely available soon. In the interim, the triple DES algorithm, which uses multiple passes of the DES algorithm (significantly stronger than DES) is specified for use within S/MIME V3. Thus for S/MIME V3, the following symmetric encryption algorithms are identified:

3DES: The Triple DES algorithm [FIPS46-3] for encryption and decryption MUST be supported by sending and receiving agents as specified in Clause 2.1.1.1 of this profile. When generating messages, at least two independent keys MUST be supported. The Cipher Block Chaining Mode (CBC) MUST be supported. This algorithm is also known as DES EDE3 CBC.

AES: The Cipher Block Chaining (CBC) mode of the Advanced Encryption Standard [FIPS197] with 128-bit keys SHOULD be supported by sending and receiving agents when it becomes widely available. (See Clause 2.1.1.2.)

A.3 Digital Signature Algorithms

Digital signature algorithms are asymmetric (using public-private key pairs) algorithms that are used for digitally signing data. Use of signature algorithms in S/MIME V3 provides authentication, message integrity, and non-repudiation of origin. For S/MIME V3, the following digital signature algorithms are identified:

RSA: The RSA Public Key digital signature algorithm identified in [RFC2313] MUST be supported in combination with the SHA-1 hash algorithm as specified in Clause 2.1.1.1 of this profile.

DSA: The DSA algorithm defined in [FIPS186-2] MUST be supported in combination with the SHA-1 hash algorithm as specified in Clause 2.1.1.1 of this profile.

rDSA: Implementations MAY support digital signatures using reversible public key cryptography (rDSA) as defined in [ANSIX9.31]

ECDSA: Implementations MAY support elliptic curve digital signatures as defined in [ANSIX9.62]

Note: Currently no standard methods (e.g., appropriate algorithm identifying OIDs) are defined for using rDSA or ECDSA with S/MIME.

A.4 Key Management Algorithms

Key management algorithms are used for either key transport or for key agreement in a secure manner.

The following key management algorithms are identified:

RSA (RFC2313): The RSA key exchange algorithm identified in [RFC2313] MUST be supported as specified in Clause 2.1.1.1 of this profile.

Diffie-Hellman: Implementations SHOULD support the Diffie-Hellman Key Agreement method as defined in [RFC2631] as specified in Clause 2.1.1.2 of this profile.

RSA (X9.44): The RSA Key Exchange Algorithm identified in [ANSIX9.44] MAY be supported.

Elliptic Curve Diffie-Hellman (X9.63): The Elliptic Curve Diffie-Hellman Key Agreement Algorithm identified in X9.63 [ANSIX9.63] MAY be supported.

Note: Currently no standard methods are defined for using RSA (X9.44) or Elliptic Curve Diffie-Hellman (X9.63) with S/MIME.

A.5 Algorithm Suites

Secure Hash Algorithms (Message Digest Algorithms), Symmetric Encryption Algorithms, Digital Signature Algorithms, and Key Management Algorithms are used together in algorithm suites to provide a full set of cryptographic security services for S/MIME. Each algorithm suite contains one of each of the cryptographic algorithm types to provide the cryptographic services. It is important that all of the components of each suite provide comparable protection against cryptographic attack. The following list of algorithm suites is identified for use within S/MIME V3:

SHA-1 hash algorithm, RSA (RFC 2313) for digital signature, RSA (RFC 2313) for key transport, Triple-DES [FIPS46-3] for content encryption. Implementations of S/MIME V3 MUST support this suite of algorithms. (See Clause 2.1.1.1.)

SHA-1 hash algorithm, DSA for digital signature, RSA (RFC 2313) for key transport, Triple-DES for content encryption. Implementations of S/MIME V3 MUST support this suite of algorithms. (See Clause 2.1.1.1)

SHA-1 hash algorithm, DSA for digital signature, Diffie-Hellman (RFC2631) for key agreement, Triple-DES for content encryption. Implementations of S/MIME V3 SHOULD support this suite of algorithms. (See Clause 2.1.1.2.)

SHA-1 hash algorithm, rDSA for digital signature, RSA [ANSIX9.44] for key transport, Triple-DES for content encryption. Implementations of S/MIME V3 MAY support this suite of algorithms.

SHA-1 hash algorithm, ECDSA for digital signature, ECDH for key agreement, Triple-DES for content encryption. Implementations of S/MIME V3 MAY support this suite of algorithms.

Recommendations: (These recommendations also appear in Clause 2.1.1.2.)

- If an implementation supports AES, the implementation SHOULD also support RSA public key sizes greater than 1024 bits.
- If an implementation supports AES and D-H, the implementation SHOULD also support D-H public key sizes greater than 1024 bits.
- If an implementation supports RSA or DSA public key sizes greater than 1024 bits, the implementation SHOULD also support SHA-256.

Additional algorithm suites may be identified in the future as advanced algorithms including AES, SHA-256, and extended versions of DSA emerge.