Internet Engineering Task Force (IETF)
Request for Comments: 8162
Category: Experimental
ISSN: 2070-1721

P. Hoffman
ICANN
J. Schlyter
Kirei AB

May 2017

Using Secure DNS to Associate Certificates with Domain Names for S/MIME

Abstract

This document describes how to use secure DNS to associate an S/MIME user's certificate with the intended domain name, similar to the way that DNS-Based Authentication of Named Entities (DANE), RFC 6698, does for TLS.

Status of This Memo

This document is not an Internet Standards Track specification; it is published for examination, experimental implementation, and evaluation.

This document defines an Experimental Protocol for the Internet community. 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). Not all documents approved by the IESG are a candidate for any level of Internet Standard; see 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 http://www.rfc-editor.org/info/rfc8162.

Table of Contents

1. Introduction

S/MIME [RFC5751] messages often contain a certificate (some messages contain more than one certificate). These certificates assist in authenticating the sender of the message and can be used for encrypting messages that will be sent in reply. In order for the S/MIME receiver to authenticate that a message is from the sender identified in the message, the receiver's Mail User Agent (MUA) must validate that this certificate is associated with the purported sender. Currently, the MUA must trust a trust anchor upon which the sender's certificate is rooted and must successfully validate the certificate. There are other requirements on the MUA, such as associating the identity in the certificate with that of the message, that are out of scope for this document.

Some people want to authenticate the association of the sender's certificate with the sender without trusting a configured trust anchor. Others to want mitigate the difficulty of finding certificates from outside the enterprise. Given that the DNS administrator for a domain name is authorized to give identifying information about the zone, it makes sense to allow that administrator to also make an authoritative binding between email messages purporting to come from the domain name and a certificate that might be used by someone authorized to send mail from those servers. The easiest way to do this is to use the DNS.

This document describes a mechanism for associating a user's certificate with the domain that is similar to that described in DANE itself [RFC6698], as updated by [RFC7218] and [RFC7671]; it is also similar to the mechanism given in [RFC7929] for OpenPGP. Most of the operational and security considerations for using the mechanism in this document are described in RFC 6698 and are not described here at all. Only the major differences between this mechanism and those used in RFC 6698 are described here. Thus, the reader must be familiar with RFC 6698 before reading this document.

1.1. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

This document also makes use of standard PKIX, DNSSEC, and S/MIME terminology. See PKIX [RFC5280], DNSSEC [RFC4033] [RFC4034] [RFC4035], and S/MIME [RFC5751] for these terms.

1.2. Experiment Goal

This specification is one experiment in improving access to public keys for end-to-end email security. There are a range of ways in which this can reasonably be done for OpenPGP or S/MIME, for example, using the DNS, SMTP, or HTTP. Proposals for each of these have been made with various levels of support in terms of implementation and deployment. For each such experiment, specifications such as this will enable experiments to be carried out that may succeed or that may uncover technical or other impediments to large- or small-scale deployments. The IETF encourages those implementing and deploying such experiments to publicly document their experiences so that future specifications in this space can benefit.

This document defines an RRtype whose use is Experimental. The goal of the experiment is to see whether encrypted email usage will increase if an automated discovery method is available to Mail Transfer Agents (MTAs) and if MUAs help the end user with email encryption key management.

It is unclear if this RRtype will scale to some of the larger email service deployments. Concerns have been raised about the size of the SMIMEA record and the size of the resulting DNS zone files. This experiment hopefully will give the IETF some insight into whether or not this is a problem.

If the experiment is successful, it is expected that the findings of the experiment will result in an updated document for Standards Track approval.

2. The SMIMEA Resource Record

The SMIMEA DNS resource record (RR) is used to associate an end entity certificate or public key with the associated email address, thus forming a "SMIMEA certificate association". The semantics of how the SMIMEA resource record is interpreted are given later in this document. Note that the information returned in the SMIMEA record might be for the end entity certificate, or it might be for the trust anchor or an intermediate certificate. This mechanism is similar to the one given in [RFC7929] for OpenPGP.

The type value for the SMIMEA RRtype is defined in Section 8. The SMIMEA resource record is class independent.

The SMIMEA wire format and presentation format are the same as for the TLSA record as described in Section 2.1 of [RFC6698]. The certificate usage field, the selector field, and the matching type field have the same format; the semantics are also the same except where RFC 6698 talks about TLS as the target protocol for the certificate information.

3. Location of the SMIMEA Record

The DNS does not allow the use of all characters that are supported in the "local-part" of email addresses as defined in [RFC5322] and [RFC6530]. Therefore, email addresses are mapped into DNS using the following method:

1. The "left-hand side" of the email address, called the "local-part" in both the mail message format definition [RFC5322] and in the specification for internationalized email [RFC6530]) is encoded in UTF-8 (or its subset ASCII). If the local-part is written in another charset, it MUST be converted to UTF-8.

2. The local-part is first canonicalized using the following rules. If the local-part is unquoted, any comments and/or folding whitespace (CFWS) around dots (".") is removed. Any enclosing double quotes are removed. Any literal quoting is removed.

3. If the local-part contains any non-ASCII characters, it SHOULD be normalized using the Unicode Normalization Form C from [UNICODE]. Recommended normalization rules can be found in Section 10.1 of [RFC6530].

4. The local-part is hashed using the SHA2-256 [RFC5754] algorithm, with the hash truncated to 28 octets and represented in its hexadecimal representation, to become the left-most label in the prepared domain name.

5. The string "_smimecert" becomes the second left-most label in the prepared domain name.

6. The domain name (the "right-hand side" of the email address, called the "domain" in [RFC5322]) is appended to the result of step 5 to complete the prepared domain name.

For example, to request an SMIMEA resource record for a user whose email address is "hugh@example.com", an SMIMEA query would be placed for the following QNAME: "c93f1e400f26708f98cb19d936620da35eec8f72e57f9eec01c1afd6._smimecert.example.com".

4. Email Address Variants and Internationalization Considerations

Mail systems usually handle variant forms of local-parts. The most common variants are upper and lower case, often automatically corrected when a name is recognized as such. Other variants include systems that ignore "noise" characters such as dots, so that local-parts ’johnsmith’ and ’John.Smith’ would be equivalent. Many systems allow "extensions" such as ’john-ext’ or ’mary+ext’ where ’john’ or ’mary’ is treated as the effective local-part, and the ’ext’ is passed to the recipient for further handling. This can complicate finding the SMIMEA record associated with the dynamically created email address.

[RFC5321] and its predecessors have always made it clear that only the recipient MTA is allowed to interpret the local-part of an address. Therefore, sending MUAs and MTAs supporting this specification MUST NOT perform any kind of mapping rules based on the email address. In order to improve the chances of finding SMIMEA resource records for a particular local-part, domains that allow variant forms (such as treating local-parts as case-insensitive) might publish SMIMEA resource records for all variants of local-parts, might publish variants on first use (for example, a webmail provider that also controls DNS for a domain can publish variants as used by owner of a particular local-part), or might just publish SMIMEA resource records for the most common variants.

Section 3 above defines how the local-part is used to determine the location in which one looks for an SMIMEA resource record. Given the variety of local-parts seen in email, designing a good experiment for this is difficult as a) some current implementations are known to lowercase at least US-ASCII local-parts, b) we know from (many) other

situations that any strategy based on guessing and making multiple DNS queries is not going to achieve consensus for good reasons, and c) the underlying issues are just hard -- see Section 10.1 of [RFC6530] for discussion of just some of the issues that would need to be tackled to fully address this problem.

However, while this specification is not the place to try to address these issues with local-parts, doing so is also not required to determine the outcome of this experiment. If this experiment succeeds, then further work on email addresses with non-ASCII local-parts will be needed, and that would be better based on the findings from this experiment, rather than doing nothing or starting this experiment based on a speculative approach to what is a very complex topic.

5. Mandatory-to-Implement Features

S/MIME MUAs conforming to this specification MUST be able to correctly interpret SMIMEA records with certificate usages 0, 1, 2, and 3. S/MIME MUAs conforming to this specification MUST be able to compare a certificate association with a certificate offered by another S/MIME MUA using selector types 0 and 1, and matching type 0 (no hash used) and matching type 1 (SHA-256), and SHOULD be able to make such comparisons with matching type 2 (SHA-512).

S/MIME MUAs conforming to this specification MUST be able to interpret any S/MIME capabilities (defined in [RFC4262]) in any certificates that it receives through SMIMEA records.

6. Application Use of S/MIME Certificate Associations

The SMIMEA record allows an application or service to obtain an S/MIME certificate or public key and use it for verifying a digital signature or encrypting a message to the public key. The DNS answer MUST pass DNSSEC validation; if DNSSEC validation reaches any state other than "Secure" (as specified in [RFC4035]), the DNSSEC validation MUST be treated as a failure.

If no S/MIME certificates are known for an email address, an SMIMEA DNS lookup MAY be performed to seek the certificate or public key that corresponds to that email address. This can then be used to verify a received signed message or can be used to send out an encrypted email message. An application whose attempt fails to retrieve a DNSSEC-verified SMIMEA resource record from the DNS should remember that failed attempt and not retry it for some time. This will avoid sending out a DNS request for each email message the application is sending out; such DNS requests constitute a privacy leak.

7. Certificate Size and DNS

Due to the expected size of the SMIMEA record, applications SHOULD use TCP -- not UDP -- to perform queries for the SMIMEA resource record.

Although the reliability of the transport of large DNS resource records has improved in the last years, it is still recommended to keep the DNS records as small as possible without sacrificing the security properties of the public key. The algorithm type and key size of certificates should not be modified to accommodate this section.

8. IANA Considerations

This document uses a new DNS RRtype, SMIMEA, whose value (53) was allocated by IANA from the "Resource Record (RR) TYPEs" subregistry of the "Domain Name System (DNS) Parameters" registry.

9. Security Considerations

Client treatment of any information included in the trust anchor is a matter of local policy. This specification does not mandate that such information be inspected or validated by the domain name administrator.

DNSSEC does not protect the queries from pervasive monitoring as defined in [RFC7258]. Since DNS queries are currently mostly unencrypted, a query to look up a target SMIMEA record could reveal that a user using the (monitored) recursive DNS server is attempting to send encrypted email to a target.

Various components could be responsible for encrypting an email message to a target recipient. It could be done by the sender’s MUA, an MUA plugin, or the sender’s MTA. Each of these have their own characteristics. An MUA can ask the user to make a decision before continuing. The MUA can either accept or refuse a message. The MTA might deliver the message as is or encrypt the message before delivering. Each of these components should attempt to encrypt an unencrypted outgoing message whenever possible.

In theory, two different local-parts could hash to the same value. This document assumes that such a hash collision has a negligible chance of happening.

If an obtained S/MIME certificate is revoked or expired, that certificate MUST NOT be used, even if that would result in sending a message in plaintext.

Anyone who can obtain a DNSSEC private key of a domain name via coercion, theft, or brute-force calculations can replace any SMIMEA record in that zone and all of the delegated child zones. Any future messages encrypted with the malicious SMIMEA key could then be read. Therefore, a certificate or key obtained from a DNSSEC-validated SMIMEA record can only be trusted as much as the DNS domain can be trusted.

Organizations that are required to be able to read everyone's encrypted email should publish the escrow key as the SMIMEA record. Mail servers of such organizations MAY optionally re-encrypt the message to the individual's S/MIME key. This case can be considered a special case of the key-replacement attack described above.

9.1. Response Size

To prevent amplification attacks, an Authoritative DNS server MAY wish to prevent returning SMIMEA records over UDP unless the source IP address has been confirmed with DNS Cookies [RFC7873]. If a query is received via UDP without source IP address verification, the server MUST NOT return REFUSED but answer the query with an empty answer section and the truncation flag set ("TC=1").

9.2. Email Address Information Leak

The hashing of the local-part in this document is not a security feature. Publishing SMIMEA records will create a list of hashes of valid email addresses, which could simplify obtaining a list of valid email addresses for a particular domain. It is desirable to not ease the harvesting of email addresses where possible.

The domain name part of the email address is not used as part of the hash so that hashes can be used in multiple zones deployed using DNAME [RFC6672]. This makes it slightly easier and cheaper to brute-force the SHA2-256 hashes into common and short local-parts, as single rainbow tables [Rainbow] can be reused across domains. This can be somewhat countered by using NSEC3 [RFC5155].

DNS zones that are signed with DNSSEC using NSEC [RFC4033] for denial of existence are susceptible to zone walking, a mechanism that allows someone to enumerate all the SMIMEA hashes in a zone. This can be used in combination with previously hashed common or short local-parts (in rainbow tables) to deduce valid email addresses. DNSSEC-signed zones using NSEC3 for denial of existence instead of NSEC are significantly harder to brute-force after performing a zone walk.

10. References

10.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <http://www.rfc-editor.org/info/rfc2119>.

[RFC4033] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "DNS Security Introduction and Requirements", RFC 4033, DOI 10.17487/RFC4033, March 2005, <http://www.rfc-editor.org/info/rfc4033>.

[RFC4034] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "Resource Records for the DNS Security Extensions", RFC 4034, DOI 10.17487/RFC4034, March 2005, <http://www.rfc-editor.org/info/rfc4034>.

[RFC4035] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "Protocol Modifications for the DNS Security Extensions", RFC 4035, DOI 10.17487/RFC4035, March 2005, <http://www.rfc-editor.org/info/rfc4035>.

[RFC5280] Cooper, D., Santesson, S., Farrell, S., Boeyen, S., Housley, R., and W. Polk, "Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile", RFC 5280, DOI 10.17487/RFC5280, May 2008, <http://www.rfc-editor.org/info/rfc5280>.

[RFC5751] Ramsdell, B. and S. Turner, "Secure/Multipurpose Internet Mail Extensions (S/MIME) Version 3.2 Message Specification", RFC 5751, DOI 10.17487/RFC5751, January 2010, <http://www.rfc-editor.org/info/rfc5751>.

[RFC5754] Turner, S., "Using SHA2 Algorithms with Cryptographic Message Syntax", RFC 5754, DOI 10.17487/RFC5754, January 2010, <http://www.rfc-editor.org/info/rfc5754>.

[RFC6698] Hoffman, P. and J. Schlyter, "The DNS-Based Authentication of Named Entities (DANE) Transport Layer Security (TLS) Protocol: TLSA", RFC 6698, DOI 10.17487/RFC6698, August 2012, <http://www.rfc-editor.org/info/rfc6698>.

[RFC7671] Dukhovni, V. and W. Hardaker, "The DNS-Based Authentication of Named Entities (DANE) Protocol: Updates and Operational Guidance", RFC 7671, DOI 10.17487/RFC7671, October 2015, <http://www.rfc-editor.org/info/rfc7671>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <http://www.rfc-editor.org/info/rfc8174>.

10.2. Informative References

[Rainbow] Oechslin, P., "Making a Faster Cryptanalytic Time-Memory Trade-Off", DOI 10.1007/978-3-540-45146-4_36, 2003, <http://www.iacr.org/cryptodb/archive/2003/CRYPTO/1615/1615.ps>.

[RFC4262] Santesson, S., "X.509 Certificate Extension for Secure/Multipurpose Internet Mail Extensions (S/MIME) Capabilities", RFC 4262, DOI 10.17487/RFC4262, December 2005, <http://www.rfc-editor.org/info/rfc4262>.

[RFC5155] Laurie, B., Sisson, G., Arends, R., and D. Blacka, "DNS Security (DNSSEC) Hashed Authenticated Denial of Existence", RFC 5155, DOI 10.17487/RFC5155, March 2008, <http://www.rfc-editor.org/info/rfc5155>.

[RFC5321] Klensin, J., "Simple Mail Transfer Protocol", RFC 5321, DOI 10.17487/RFC5321, October 2008, <http://www.rfc-editor.org/info/rfc5321>.

[RFC5322] Resnick, P., Ed., "Internet Message Format", RFC 5322, DOI 10.17487/RFC5322, October 2008, <http://www.rfc-editor.org/info/rfc5322>.

[RFC6530] Klensin, J. and Y. Ko, "Overview and Framework for Internationalized Email", RFC 6530, DOI 10.17487/RFC6530, February 2012, <http://www.rfc-editor.org/info/rfc6530>.

[RFC6672] Rose, S. and W. Wijngaards, "DNAME Redirection in the DNS", RFC 6672, DOI 10.17487/RFC6672, June 2012, <http://www.rfc-editor.org/info/rfc6672>.

[RFC7218] Gudmundsson, O., "Adding Acronyms to Simplify Conversations about DNS-Based Authentication of Named Entities (DANE)", RFC 7218, DOI 10.17487/RFC7218, April 2014, <http://www.rfc-editor.org/info/rfc7218>.

[RFC7258] Farrell, S. and H. Tschofenig, "Pervasive Monitoring Is an Attack", BCP 188, RFC 7258, DOI 10.17487/RFC7258, May 2014, <http://www.rfc-editor.org/info/rfc7258>.

[RFC7873] Eastlake 3rd, D. and M. Andrews, "Domain Name System (DNS) Cookies", RFC 7873, DOI 10.17487/RFC7873, May 2016, <http://www.rfc-editor.org/info/rfc7873>.

[RFC7929] Wouters, P., "DNS-Based Authentication of Named Entities (DANE) Bindings for OpenPGP", RFC 7929, DOI 10.17487/RFC7929, August 2016, <http://www.rfc-editor.org/info/rfc7929>.

[UNICODE] The Unicode Consortium, "The Unicode Standard", <http://www.unicode.org/versions/latest/>.

Acknowledgements

A great deal of material in this document is copied from [RFC7929]. That material was created by Paul Wouters and other participants in the IETF DANE WG.

Brian Dickson, Stephen Farrell, Miek Gieben, Martin Pels, and Jim Schaad contributed technical ideas and support to this document.

Authors' Addresses

Paul Hoffman
ICANN

Email: paul.hoffman@icann.org

Jakob Schlyter
Kirei AB

Email: jakob@kirei.se