Internet X.509 Public Key Infrastructure: Additional Algorithm Identifiers for RSASSA-PSS and ECDSA using SHAKEs
draft-ietf-lamps-pkix-shake-12

Abstract

Digital signatures are used to sign messages, X.509 certificates and CRLs. This document updates [RFC3279] and describes the conventions for using the SHAKE function family in Internet X.509 certificates and CRLs as one-way hash functions with the RSA Probabilistic signature and ECDSA signature algorithms. The conventions for the associated subject public keys are also described.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at https://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on January 1, 2020.

Copyright Notice

Copyright (c) 2019 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to BCP 78 and the IETF Trust’s Legal Provisions Relating to IETF Documents (https://trustee.ietf.org/license-info) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must
include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Table of Contents

1.  Change Log ................................. 2
2.  Introduction ............................... 4
3.  Terminology ................................. 5
4.  Identifiers ................................. 5
5.  Use in PKIX ................................. 6
   5.1.  Signatures ............................... 6
          5.1.1.  RSASSA-PSS Signatures ............... 7
          5.1.2.  ECDSA Signatures ................... 8
6.  IANA Considerations ....................... 9
7.  Security Considerations ................... 10
8.  Acknowledgements ............................ 10
9.  References ................................. 10
   9.1.  Normative References ................... 10
   9.2.  Informative References ................. 11
Appendix A.  ASN.1 module ....................... 12
Authors’ Addresses ............................. 16

1.  Change Log

[ EDNOTE: Remove this section before publication. ]

- draft-ietf-lamps-pkix-shake-12:
  * Nits identified by Roman, Eric V. Ben K., Barry L. in ballot position review.

- draft-ietf-lamps-pkix-shake-11:
  * Nits identified by Roman in AD Review.

- draft-ietf-lamps-pkix-shake-10:
  * Updated IANA considerations section to request for OID assignments.

- draft-ietf-lamps-pkix-shake-09:
  * Fixed minor text nits.
  * Added text name allocation for SHAKEs in IANA considerations.
* Updates in Sec Considerations section.

- **draft-ietf-lamps-pkix-shake-08:**
  * Small nits from Russ while in WGLC.

- **draft-ietf-lamps-pkix-shake-07:**
  * Incorporated Eric’s suggestion from WGLC.

- **draft-ietf-lamps-pkix-shake-06:**
  * Added informative references.
  * Updated ASN.1 so it compiles.
  * Updated IANA considerations.

- **draft-ietf-lamps-pkix-shake-05:**
  * Added RFC8174 reference and text.
  * Explicitly explained why RSASSA-PSS-params are omitted in section 5.1.1.
  * Simplified Public Keys section by removing redundant info from RFCs.

- **draft-ietf-lamps-pkix-shake-04:**
  * Removed paragraph suggesting KMAC to be used in generating k in Deterministic ECDSA. That should be RFC6979-bis.
  * Removed paragraph from Security Considerations that talks about randomness of k because we are using deterministic ECDSA.
  * Various ASN.1 fixes.
  * Text fixes.

- **draft-ietf-lamps-pkix-shake-03:**
  * Updates based on suggestions and clarifications by Jim.
  * Added ASN.1.

- **draft-ietf-lamps-pkix-shake-02:**
2. Introduction

This document defines cryptographic algorithm identifiers for several cryptographic algorithms that use variable length output SHAKE functions introduced in [SHA3] which can be used with the Internet X.509 Certificate and Certificate Revocation List (CRL) profile [RFC5280].

In the SHA-3 family, two extendable-output functions (SHAKEs), SHAKE128 and SHAKE256, are defined. Four other hash function instances, SHA3-224, SHA3-256, SHA3-384, and SHA3-512, are also defined but are out of scope for this document. A SHAKE is a variable length hash function defined as SHAKE(M, d) where the output is a d-bits-long digest of message M. The corresponding collision and second-preimage-resistance strengths for SHAKE128 are
min(d/2,128) and min(d,128) bits, respectively (Appendix A.1 [SHA3]).
And the corresponding collision and second-preimage-resistance strengths for SHAKE256 are min(d/2,256) and min(d,256) bits, respectively.

A SHAKE can be used as the message digest function (to hash the message to be signed) in RSASSA-PSS [RFC8017] and ECDSA [X9.62] and as the hash in the mask generation function (MGF) in RSASSA-PSS.

3. 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.

4. Identifiers

This section defines four new object identifiers (OIDs), for RSASSA-PSS and ECDSA with each of SHAKE128 and SHAKE256. The same algorithm identifiers can be used for identifying a public key in RSASSA-PSS.

The new identifiers for RSASSA-PSS signatures using SHAKEs are below.

\[
\text{id-RSASSA-PSS-SHAKE128} \quad \text{OBJECT IDENTIFIER} \ ::= \ { \text{iso}(1) \text{identified-organization}(3) \text{dod}(6) \text{internet}(1) \text{security}(5) \text{mechanisms}(5) \text{pkix}(7) \text{algorithms}(6) \text{TBD1} \}
\]

\[
\text{id-RSASSA-PSS-SHAKE256} \quad \text{OBJECT IDENTIFIER} \ ::= \ { \text{iso}(1) \text{identified-organization}(3) \text{dod}(6) \text{internet}(1) \text{security}(5) \text{mechanisms}(5) \text{pkix}(7) \text{algorithms}(6) \text{TBD2} \}
\]

The new algorithm identifiers of ECDSA signatures using SHAKEs are below.
The parameters for the four identifiers above MUST be absent. That is, the identifier SHALL be a SEQUENCE of one component, the OID.

Section 5.1.1 and Section 5.1.2 specify the required output length for each use of SHAKE128 or SHAKE256 in RSASSA-PSS and ECDSA. In summary, when hashing messages to be signed, output lengths of SHAKE128 and SHAKE256 are 256 and 512 bits respectively. When the SHAKEs are used as mask generation functions RSASSA-PSS, their output length is \((8 \cdot \text{ceil}((n-1)/8) - 264)\) or \((8 \cdot \text{ceil}((n-1)/8) - 520)\) bits, respectively, where \(n\) is the RSA modulus size in bits.

5. Use in PKIX

5.1. Signatures

Signatures are used in a number of different ASN.1 structures. As shown in the ASN.1 representation from [RFC5280] below, in an X.509 certificate, a signature is encoded with an algorithm identifier in the signatureAlgorithm attribute and a signatureValue attribute that contains the actual signature.

\[
\text{Certificate} ::= \text{SEQUENCE} \{
\text{tbsCertificate} \quad \text{TBSCertificate},
\text{signatureAlgorithm} \quad \text{AlgorithmIdentifier},
\text{signatureValue} \quad \text{BIT STRING} \}
\]

The identifiers defined in Section 4 can be used as the AlgorithmIdentifier in the signatureAlgorithm field in the sequence Certificate and the signature field in the sequence TBSCertificate in X.509 [RFC5280]. The parameters of these signature algorithms are absent as explained in Section 4.

Conforming CA implementations MUST specify the algorithms explicitly by using the OIDs specified in Section 4 when encoding RSASSA-PSS or ECDSA with SHAKE signatures in certificates and CRLs. Conforming client implementations that process certificates and CRLs using RSASSA-PSS or ECDSA with SHAKE MUST recognize the corresponding OIDs.
Encoding rules for RSASSA-PSS and ECDSA signature values are specified in [RFC4055] and [RFC5480], respectively.

When using RSASSA-PSS or ECDSA with SHAKEs, the RSA modulus and ECDSA curve order SHOULD be chosen in line with the SHAKE output length. In the context of this document SHAKE128 OIDs are RECOMMENDED for 2048 or 3072-bit RSA modulus or curves with group order of 256-bits. SHAKE256 OIDs are RECOMMENDED for 4096-bit RSA modulus and higher or curves with group order of 384-bits and higher.

5.1.1. RSASSA-PSS Signatures

The RSASSA-PSS algorithm is defined in [RFC8017]. When id-RSASSA-PSS-SHAKE128 or id-RSASSA-PSS-SHAKE256 specified in Section 4 is used, the encoding MUST omit the parameters field. That is, the AlgorithmIdentifier SHALL be a SEQUENCE of one component, id-RSASSA-PSS-SHAKE128 or id-RSASSA-PSS-SHAKE256. [RFC4055] defines RSASSA-PSS-params that are used to define the algorithms and inputs to the algorithm. This specification does not use parameters because the hash, mask generation algorithm, trailer and salt are embedded in the OID definition.

The hash algorithm to hash a message being signed and the hash algorithm used as the mask generation function in RSASSA-PSS MUST be the same: both SHAKE128 or both SHAKE256. The output length of the hash algorithm which hashes the message SHALL be 32 (for SHAKE128) or 64 bytes (for SHAKE256).

The mask generation function takes an octet string of variable length and a desired output length as input, and outputs an octet string of the desired length. In RSASSA-PSS with SHAKEs, the SHAKEs MUST be used natively as the MGF function, instead of the MG1 algorithm that uses the hash function in multiple iterations as specified in Section B.2.1 of [RFC8017]. In other words, the MGF is defined as the SHAKE128 or SHAKE256 output of the mgfSeed for id-RSASSA-PSS-SHAKE128 and id-RSASSA-PSS-SHAKE256, respectively. The mgfSeed is the seed from which mask is generated, an octet string [RFC8017]. As explained in Step 9 of section 9.1.1 of [RFC8017], the output length of the MGF is emLen - hLen - 1 bytes. emLen is the maximum message length ceil((n-1)/8), where n is the RSA modulus in bits. hLen is 32 and 64-bytes for id-RSASSA-PSS-SHAKE128 and id-RSASSA-PSS-SHAKE256, respectively. Thus when SHAKE is used as the MGF, the SHAKE output length maskLen is (8*emLen - 264) or (8*emLen - 520) bits, respectively. For example, when RSA modulus n is 2048, the output length of SHAKE128 or SHAKE256 as the MGF will be 1784 or 1528-bits when id-RSASSA-PSS-SHAKE128 or id-RSASSA-PSS-SHAKE256 is used, respectively.
The RSASSA-PSS saltLength MUST be 32 bytes for id-RSASSA-PSS-SHAKE128 or 64 bytes for id-RSASSA-PSS-SHAKE256. Finally, the trailerField MUST be 1, which represents the trailer field with hexadecimal value 0xBC [RFC8017].

5.1.2. ECDSA Signatures

The Elliptic Curve Digital Signature Algorithm (ECDSA) is defined in [X9.62]. When the id-ecdsa-with-shake128 or id-ecdsa-with-shake256 (specified in Section 4) algorithm identifier appears, the respective SHAKE function (SHAKE128 or SHAKE256) is used as the hash. The encoding MUST omit the parameters field. That is, the AlgorithmIdentifier SHALL be a SEQUENCE of one component, the OID id-ecdsa-with-shake128 or id-ecdsa-with-shake256.

For simplicity and compliance with the ECDSA standard specification, the output length of the hash function must be explicitly determined. The output length, d, for SHAKE128 or SHAKE256 used in ECDSA MUST be 256 or 512 bits, respectively.

Conforming CA implementations that generate ECDSA with SHAKE signatures in certificates or CRLs SHOULD generate such signatures with a deterministically generated, non-random k in accordance with all the requirements specified in [RFC6979]. They MAY also generate such signatures in accordance with all other recommendations in [X9.62] or [SEC1] if they have a stated policy that requires conformance to those standards. Those standards have not specified SHAKE128 and SHAKE256 as hash algorithm options. However, SHAKE128 and SHAKE256 with output length being 32 and 64 octets, respectively, can be used instead of 256 and 512-bit output hash algorithms such as SHA256 and SHA512.

5.2. Public Keys

Certificates conforming to [RFC5280] can convey a public key for any public key algorithm. The certificate indicates the public key algorithm through an algorithm identifier. This algorithm identifier is an OID and optionally associated parameters. The conventions and encoding for RSASSA-PSS and ECDSA public keys algorithm identifiers are as specified in Section 2.3.1 and 2.3.5 of [RFC3279], Section 3.1 of [RFC4055] and Section 2.1 of [RFC5480].

Traditionally, the rsaEncryption object identifier is used to identify RSA public keys. The rsaEncryption object identifier continues to identify the subject public key when the RSA private key owner does not wish to limit the use of the public key exclusively to RSASSA-PSS with SHAKEs. When the RSA private key owner wishes to limit the use of the public key exclusively to RSASSA-PSS with
SHAKEs, the AlgorithmIdentifiers for RSASSA-PSS defined in Section 4 SHOULD be used as the algorithm field in the SubjectPublicKeyInfo sequence [RFC5280]. Conforming client implementations that process RSASSA-PSS with SHAKE public keys when processing certificates and CRLs MUST recognize the corresponding OIDs.

Conforming CA implementations MUST specify the X.509 public key algorithm explicitly by using the OIDs specified in Section 4 when encoding ECDSA with SHAKE public keys in certificates and CRLs. Conforming client implementations that process ECDSA with SHAKE public keys when processing certificates and CRLs MUST recognize the corresponding OIDs.

The identifier parameters, as explained in Section 4, MUST be absent.

6. IANA Considerations

One object identifier for the ASN.1 module in Appendix A is requested for the SMI Security for PKIX Module Identifiers (1.3.6.1.5.5.7.0) registry:

+---------+--------------------------+--------------------+
| Decimal |       Description        |     References     |
+---------+--------------------------+--------------------+
| TBD     | id-mod-pkix1-shakes-2019 | [EDNOTE: THIS RFC] |
+---------+--------------------------+--------------------+

IANA is requested to update the SMI Security for PKIX Algorithms [SMI-PKIX] (1.3.6.1.5.5.7.6) registry with four additional entries:

+---------+------------------------+--------------------+
| Decimal |      Description       |     References     |
+---------+------------------------+--------------------+
| TBD1    | id-RSASSA-PSS-SHAKE128 | [EDNOTE: THIS RFC] |
| TBD2    | id-RSASSA-PSS-SHAKE256 | [EDNOTE: THIS RFC] |
| TBD3    | id-ecdsa-with-shake128 | [EDNOTE: THIS RFC] |
| TBD4    | id-ecdsa-with-shake256 | [EDNOTE: THIS RFC] |
+---------+------------------------+--------------------+

IANA is also requested to update the Hash Function Textual Names Registry [Hash-Texts] with two additional entries for SHAKE128 and SHAKE256:
### 7. Security Considerations

This document updates [RFC3279]. The security considerations section of that document applies to this specification as well.

NIST has defined appropriate use of the hash functions in terms of the algorithm strengths and expected time frames for secure use in Special Publications (SPs) [SP800-78-4] and [SP800-107]. These documents can be used as guides to choose appropriate key sizes for various security scenarios.

### 8. Acknowledgements

We would like to thank Sean Turner, Jim Schaad and Eric Rescorla for their valuable contributions to this document.

The authors would like to thank Russ Housley for his guidance and very valuable contributions with the ASN.1 module.

### 9. References

#### 9.1. Normative References


9.2. Informative References


This appendix includes the ASN.1 module for SHAKes in X.509. This module does not come from any existing RFC.

```
PKIXAlgsForSHAKE-2019 { iso(1) identified-organization(3) dod(6)
internet(1) security(5) mechanisms(5) pkix(7) id-mod(0)
id-mod-pkix1-shakes-2019(TBD) }

DEFINITIONS EXPLICIT TAGS ::= 
BEGIN
  -- EXPORTS ALL;
IMPORTS
  -- FROM [RFC5912]
PUBLIC-KEY, SIGNATURE-ALGORITHM, DIGEST-ALGORITHM, SMIME-CAPS
FROM AlgorithmInformation-2009
  { iso(1) identified-organization(3) dod(6) internet(1) security(5)
mechanisms(5) pkix(7) id-mod(0)
id-mod-algorithmInformation-02(58) }
```
-- FROM [RFC5912]

RSAPublicKey, rsaEncryption, pk-rsa, pk-ec, CURVE, id-ecPublicKey, ECPoint, ECPublicKey, ECParameters, ECDSA-Sig-Value FROM PKIXAlgs-2009 ( iso(1) identified-organization(3) dod(6) internet(1) security(5) mechanisms(5) pkix(7) id-mod(0) id-mod-pkix1-algorithms2008-02(56) )

-- Message Digest Algorithms (mda-)
--
DigestAlgorithms DIGEST-ALGORITHM ::= {
  -- This expands DigestAlgorithms from [RFC5912]
  mda-shake128 |
  mda-shake256,
  ...
}

-- One-Way Hash Functions
--
-- SHAKE128
mda-shake128 DIGEST-ALGORITHM ::= {
  IDENTIFIER id-shake128 -- with output length 32 bytes.
}
id-shake128 OBJECT IDENTIFIER ::= { joint-iso-itu-t(2) country(16) us(840) organization(1) gov(101) csor(3) nistAlgorithm(4) hashAlgs(2) 11 }

-- SHAKE256
mda-shake256 DIGEST-ALGORITHM ::= {
  IDENTIFIER id-shake256 -- with output length 64 bytes.
}
id-shake256 OBJECT IDENTIFIER ::= { joint-iso-itu-t(2) country(16) us(840) organization(1) gov(101) csor(3) nistAlgorithm(4) hashAlgs(2) 12 }

-- Public Key (pk-) Algorithms
--
PublicKeys PUBLIC-KEY ::= {
  -- This expands PublicKeys from [RFC5912]
  pk-rsaSSA-PSS-SHAKE128 |
  pk-rsaSSA-PSS-SHAKE256,
---

---

The hashAlgorithm is mda-shake128
-- The maskGenAlgorithm is id-shake128
-- Mask Gen Algorithm is SHAKE128 with output length
-- \((8*\text{ceil}(n-1)/8) - 264\) bits, where \(n\) is the RSA
-- modulus in bits.
-- The saltLength is 32. The trailerField is 1.

pk-rsaSSA-PSS-SHAKE128 PUBLIC-KEY ::= {
  IDENTIFIER id-RSASSA-PSS-SHAKE128
  KEY RSAPublickey
  PARAMS ARE absent
-- Private key format not in this module --
  CERT-KEY-USAGE { nonRepudiation, digitalSignature,
    keyCertSign, cRLSign }
}

-- The hashAlgorithm is mda-shake256
-- The maskGenAlgorithm is id-shake256
-- Mask Gen Algorithm is SHAKE256 with output length
-- \((8*\text{ceil}(n-1)/8) - 520\)-bits, where \(n\) is the RSA
-- modulus in bits.
-- The saltLength is 64. The trailerField is 1.

pk-rsaSSA-PSS-SHAKE256 PUBLIC-KEY ::= {
  IDENTIFIER id-RSASSA-PSS-SHAKE256
  KEY RSAPublickey
  PARAMS ARE absent
-- Private key format not in this module --
  CERT-KEY-USAGE { nonRepudiation, digitalSignature,
    keyCertSign, cRLSign }
}

--
-- Signature Algorithms (sa-)
--
SignatureAlgs SIGNATURE-ALGORITHM ::= {
  -- This expands SignatureAlgorithms from [RFC5912]
  sa-rsassapssWithSHAKE128 |
  sa-rsassapssWithSHAKE256 |
  sa-ecdsaWithSHAKE128 |
  sa-ecdsaWithSHAKE256,
  ...
}

--
-- SMIME Capabilities (sa-)
--
SMimeCaps SMIME-CAPS ::= {
    -- The expands SMimeCaps from [RFC5912]
    sa-rsassapssWithSHAKE128.&smimeCaps |
    sa-rsassapssWithSHAKE256.&smimeCaps |
    sa-ecdsaWithSHAKE128.&smimeCaps |
    sa-ecdsaWithSHAKE256.&smimeCaps,
    ...
}

-- RSASSA-PSS with SHAKE128
sa-rsassapssWithSHAKE128 SIGNATURE-ALGORITHM ::= {
    IDENTIFIER id-RSASSA-PSS-SHAKE128
    PARAMS ARE absent
    -- The hashAlgorithm is mda-shake128
    -- The maskGenAlgorithm is id-shake128
    -- Mask Gen Algorithm is SHAKE128 with output length
    -- (8*ceil((n-1)/8) - 264) bits, where n is the RSA
    -- modulus in bits.
    -- The saltLength is 32. The trailerField is 1
    HASHES { mda-shake128 }
    PUBLIC-KEYS { pk-rsa | pk-rsaSSA-PSS-SHAKE128 }
    SMIME-CAPS { IDENTIFIED BY id-RSASSA-PSS-SHAKE128 }
}

id-RSASSA-PSS-SHAKE128  OBJECT IDENTIFIER  ::=  { iso(1)
    identified-organization(3) dod(6) internet(1)
    security(5) mechanisms(5) pkix(7) algorithms(6)
    TBD1 }

-- RSASSA-PSS with SHAKE256
sa-rsassapssWithSHAKE256 SIGNATURE-ALGORITHM ::= {
    IDENTIFIER id-RSASSA-PSS-SHAKE256
    PARAMS ARE absent
    -- The hashAlgorithm is mda-shake256
    -- The maskGenAlgorithm is id-shake256
    -- Mask Gen Algorithm is SHAKE256 with output length
    -- (8*ceil((n-1)/8) - 520)-bits, where n is the RSA modulus in bits.
    -- The saltLength is 64. The trailerField is 1.
    HASHES { mda-shake256 }
    PUBLIC-KEYS { pk-rsa | pk-rsaSSA-PSS-SHAKE256 }
    SMIME-CAPS { IDENTIFIED BY id-RSASSA-PSS-SHAKE256 }
}

id-RSASSA-PSS-SHAKE256  OBJECT IDENTIFIER  ::=  { iso(1)
    identified-organization(3) dod(6) internet(1)
    security(5) mechanisms(5) pkix(7) algorithms(6)
    TBD2 }

-- ECDSA with SHAKE128
sa-ecdsaWithSHAKE128 SIGNATURE-ALGORITHM ::= {
  IDENTIFIER id-ecdsa-with-shake128
  VALUE ECDSA-Sig-Value
  PARAMS ARE absent
  HASHES { mda-shake128 }
  PUBLIC-KEYS { pk-ec }
  SMIME-CAPS { IDENTIFIED BY id-ecdsa-with-shake128 }
}

id-ecdsa-with-shake128 OBJECT IDENTIFIER ::= { iso(1)
  identified-organization(3) dod(6) internet(1)
  security(5) mechanisms(5) pkix(7) algorithms(6)
  TBD3 }

-- ECDSA with SHAKE256
sa-ecdsaWithSHAKE256 SIGNATURE-ALGORITHM ::= {
  IDENTIFIER id-ecdsa-with-shake256
  VALUE ECDSA-Sig-Value
  PARAMS ARE absent
  HASHES { mda-shake256 }
  PUBLIC-KEYS { pk-ec }
  SMIME-CAPS { IDENTIFIED BY id-ecdsa-with-shake256 }
}

id-ecdsa-with-shake256 OBJECT IDENTIFIER ::= { iso(1)
  identified-organization(3) dod(6) internet(1)
  security(5) mechanisms(5) pkix(7) algorithms(6)
  TBD4 }

END

Authors’ Addresses

Panos Kampanakis
Cisco Systems

Email: pkampana@cisco.com

Quynh Dang
NIST
100 Bureau Drive, Stop 8930
Gaithersburg, MD 20899-8930
USA

Email: quynh.dang@nist.gov