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Using EdDSA in the Internet X.509 Public Key Infrastructure
draft-josefsson-pkix-eddsa-03

Abstract

This document specify algorithm identifiers and ASN.1 encoding formats for EdDSA digital signatures and subject public keys used in the Internet X.509 Public Key Infrastructure (PKIX) for Certificates and CRLs. Parameters for Ed25519 are defined.

Status of This Memo

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

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This Internet-Draft will expire on March 26, 2016.

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1. Introduction

In [Ed25519], an elliptic curve signature system EdDSA was introduced, and a recommended choice of curve Ed25519 is chosen. EdDSA and Ed25519 was designed with performance and security in mind. Specification, test vectors and a sample implementation is available in [I-D.josefsson-eddsa-ed25519].

This RFC defines ASN.1 object identifiers for EdDSA for use in the Internet X.509 PKI [RFC5280], and parameters for Ed25519. This document serves a similar role as [RFC3279] does for RSA (and more), [RFC4055] for RSA-OAEP/PSS, and [RFC5758] for SHA2-based (EC)DSA.

2. Requirements Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3. Subject Public Key Information Fields

In the X.509 certificate, the subjectPublicKeyInfo field has the

SubjectPublicKeyInfo type, which has the following ASN.1 syntax:


```
SubjectPublicKeyInfo  ::=  SEQUENCE  {
  algorithm         AlgorithmIdentifier,
  subjectPublicKey  BIT STRING
}
```

The fields in SubjectPublicKeyInfo have the following meanings:

- algorithm is the algorithm identifier and parameters for the public key (see below).

- subjectPublicKey is the EdDSA public key.

The AlgorithmIdentifier type, which is included for convenience, is defined as follows:

```
AlgorithmIdentifier  ::=  SEQUENCE  {
  algorithm   OBJECT IDENTIFIER,
  parameters  ANY DEFINED BY algorithm OPTIONAL
}
```

The fields in AlgorithmIdentifier have the following meanings:

- algorithm identifies the cryptographic algorithm with an object identifier. This is the EdDSA OID defined below.

- parameters, which are optional, are the associated parameters for the algorithm identifier in the algorithm field.

4. EdDSA Public Keys

Certificates conforming to [RFC5280] may convey a public key for any public key algorithm. The certificate indicates the algorithm through an algorithm identifier. This algorithm identifier is an OID and optionally associated parameters.

This section identify the OID and parameters for the EdDSA algorithm.

Conforming CAs MUST use the identified OIDs when issuing certificates containing EdDSA public keys. Conforming applications supporting EdDSA MUST, at a minimum, recognize the OID identified in this section.

The id-EdDSAPublicKey OID is used for identifying EdDSA public keys.

```
id-EdDSAPublicKey OBJECT IDENTIFIER ::= { 1.3.101.100 }
```

The id-EdDSAPublicKey OID is intended to be used in the algorithm field of a value of type AlgorithmIdentifier.

EdDSA public keys use the parameter field to specify the particular instantiation of EdDSA parameters. The parameters field have the ASN.1 type EdDSAParameters as follows.

```
EdDSAParameters ::= ENUMERATED { ed25519 (1),
                                 sha512-ed25519 (2) }
```

The EdDSAParameters enumeration may be extended in the future.

The value 'ed25519' means the set of "pure" EdDSA parameters associated with Ed25519, including internal hash function (SHA512) and curve. The value 'sha512-ed25519' means that the SHA512 algorithm will be used as the prehash parameter and the hash function for the signature. For the definitions see [EdDSA-prehash].

The raw binary EdDSA public key is encoded directly in the subjectPublicKey BIT STRING object. Note that unlike some other schemes, there is no additional OCTET STRING encoding step.

5. Key Usage Bits

The intended application for the key MAY be indicated in the keyUsage certificate extension.

If the keyUsage extension is present in an end-entity certificate that conveys an EdDSA public key with the id-EdDSAPublicKey object identifier, then the keyUsage extension MUST contain one or both of the following values:

nonRepudiation; and
digitalSignature.

If the keyUsage extension is present in a certification authority certificate that conveys an EdDSA public key with the id-EdDSAPublicKey object identifier, then the keyUsage extension MUST contain one or more of the following values:

nonRepudiation;
digitalSignature;
keyCertSign; and
cRLSign.

6. EdDSA Signatures

Certificates and CRLs conforming to [RFC5280] may be signed with any public key signature algorithm. The certificate or CRL indicates the algorithm through an algorithm identifier which appears in the signatureAlgorithm field within the Certificate or CertificateList.

This algorithm identifier is an OID and has optionally associated parameters. For illustration the Certificate structure is reproduced here:

```
   Certificate  ::=  SEQUENCE  {
        tbsCertificate       TBSCertificate,
        signatureAlgorithm   AlgorithmIdentifier,
        signatureValue       BIT STRING  }
```

Recall the definition of the AlgorithmIdentifier type:

```
      AlgorithmIdentifier  ::=  SEQUENCE  {
        algorithm   OBJECT IDENTIFIER,
        parameters  ANY DEFINED BY algorithm OPTIONAL
      }
```

This document identify an AlgorithmIdentifier OID for EdDSA signatures. No parameters are defined. The EdDSA parameters follow from the public-key parameters.

The data to be signed is prepared for EdDSA. Then, a private key operation is performed to generate the signature value. This value

is the opaque value ENC(R) || ENC'(S) described in section 4.3 of [I-D.josefsson-eddsa-ed25519]. This signature value is then ASN.1 encoded as a BIT STRING and included in the Certificate or CertificateList in the signatureValue field.

The id-EdDSASignature OID is used for identifying EdDSA signatures.

```
id-EdDSASignature OBJECT IDENTIFIER ::= { 1.3.101.101 }
```

The id-EdDSASignature OID is intended to be used in the algorithm field of a value of type AlgorithmIdentifier. The parameters field MUST be absent. To further clarify how to encode the parameters field, due to historical misunderstandings in this area, it MUST NOT have an ASN.1 type NULL.

7. Human Readable Algorithm Names

For the purpose of consistent cross-implementation naming this section establish human readable names for the algorithms specified in this document. Implementations SHOULD use these names when referring to the algorithms. If there is a strong reason to deviate from these names -- for example, if the implementation has a different naming convention and wants to maintain internal consistency -- it is encouraged to deviate as little as possible from the names given here. For example, if a naming convention is to not

use hyphen ("-") then instead of "SHA512-Ed25519" the string "SHA512Ed25519" could be used.

Use the string "EdDSA" when referring to a public key or signature when the parameter set is not known or relevant.

When the EdDSAParameters value is known, use a more specific string. For the ed25519(1) value use the string "Ed25519". For the sha512-ed25519(2) value use the string "SHA512-Ed25519".

8. Examples

This section contains illustrations of EdDSA public keys and certificates, illustrating parameter choices.

8.1. Example SHA512-Ed25519 Public Key

An example of a SHA512-Ed25519 public key:

```
Public Key Information:
    Public Key Algorithm: EdDSA
    Algorithm Security Level: High (256 bits)
    Parameters: SHA512-Ed25519

Public Key Usage:

Public Key ID: 9b1f5eeded043385e4f7bc623c5975b90bc8bb3b

-----BEGIN PUBLIC KEY-----
MC0wCAYDK2VkCgECAyEAGb9ECWmEzf6FQbrBZ9w7lshQhqowtrbLDFw4rXAxZuE=
-----END PUBLIC KEY-----
```

8.2. Example SHA512-Ed25519 Certificate

An example of a PKIX certificate using SHA512-Ed25519 would be:

```
X.509 Certificate Information:
    Version: 3
    Serial Number (hex): 5601474a2a8dc326
    Issuer: CN=Test Ed25519-SHA512 certificate
    Validity:
        Not Before: Tue Sep 22 12:19:24 UTC 2015
        Not After: Fri Dec 31 23:59:59 UTC 9999
    Subject: CN=Test Ed25519-SHA512 certificate
    Subject Public Key Algorithm: SHA512-EdDSA
    Algorithm Security Level: High (256 bits)
    Extensions:
        Basic Constraints (critical):
```



```
            Certificate Authority (CA): FALSE
        Key Usage (critical):
            Digital signature.
        Subject Key Identifier (not critical):
            9b1f5eeded043385e4f7bc623c5975b90bc8bb3b
    Signature Algorithm: SHA512-Ed25519
    Signature:
        be:9d:f8:b4:19:07:99:c9:04:12:21:e7:85:33:55:76
```

```
            b0:5f:29:70:77:bd:69:7a:a6:db:33:fe:c4:f5:3d:79
            d2:ba:77:6d:68:9b:a3:e9:53:bc:a6:56:54:3f:fa:f4
            1c:37:89:4e:c7:43:c0:3b:77:68:5d:98:f6:19:9d:05
    Other Information:
        SHA1 fingerprint:
            a3b75d83a56e127d0728ed8563233cadf943757e
        SHA256 fingerprint:
            cab1d7df29bdf82270d2192997c81f1b333dc37e670d7e88068fbe9dd747da3a
        Public Key ID:
            9b1f5eeded043385e4f7bc623c5975b90bc8bb3b
        Public key's random art:
            +-[SHA512Ed25519]-+
            |              .  |
            |             o ..|
            |              o.=|
            |          . .  +=|
            |        S  o .+oo|
            |         o  o.++o|
            |        o ...*.o.|
            |         o Eo.oo |
            |          ooo ..o|
            +-----------------+

    -----BEGIN CERTIFICATE-----
    MIIBUTCCAQKgAwIBAgIIVgFHSiqNwyYwBgYEK2VkATAqMSgwJgYDVQQDEx9UZXN0
    IEVkMjU1MTktU0hBNTEyIGNlcnRpZmljYXRlMCAXDTE1MDkyMjEyMTkyNFoYDzk5
    OTkxMjMxMjM1OTU5WjAqMSgwJgYDVQQDEx9UZXN0IEVkMjU1MTktU0hBNTEyIGNl
    cnRpZmljYXRlMC0wCAYDK2VkCgECAyEAGb9ECWmEzf6FQbrBZ9w7lshQhqowtrbL
    DFw4rXAxZuGjQDA+MAwGA1UdEwEB/wQCMAAwDwYDVR0PAQH/BAUDAweAADAdBgNV
    HQ4EFgQUmx9e7e0EM4Xk97xiPFl1uQvIuzswBgYEK2VkAQNBAL6d+LQZB5nJBBIh
    54UzVXawXylwd71peqbbM/7E9T150rp3bWibo+lTvKZWVD/69Bw3iU7HQ8A7d2hd
    mPYZnQU=
    -----END CERTIFICATE-----
```

8.3. Example SHA512-Ed25519 Private Key

An example of a SHA512-Ed25519 private key:


```
    Public Key Info:
```

```
        Public Key Algorithm: EdDSA
        Key Security Level: High (256 bits)

    parameters:    SHA512-Ed25519
    private key:
        d4:ee:72:db:f9:13:58:4a:d5:b6:d8:f1:f7:69:f8:ad
        3a:fe:7c:28:cb:f1:d4:fb:e0:97:a8:8f:44:75:58:42

    x:
        19:bf:44:09:69:84:cd:fe:85:41:ba:c1:67:dc:3b:96
        c8:50:86:aa:30:b6:b6:cb:0c:5c:38:ad:70:31:66:e1


    Public Key ID: 9B:1F:5E:ED:ED:04:33:85:E4:F7:BC:62:3C:59:75:B9:0B:C8:BB:3
    Public key's random art:
    +-[SHA512Ed25519]-+
    |               .  |
    |              o ..|
    |               o.=|
    |           . .  +=|
    |        S  o .+oo|
    |         o  o.++o|
    |        o ...*.o.|
    |         o Eo.oo |
    |          ooo ..o|
    +-----------------+

    -----BEGIN EDDSA PRIVATE KEY-----
    MCUKAQEEINTuctv5E1hK1bbY8fdp+K06/nwoy/HU++CXqI9EdVhC
    -----END EdDSA PRIVATE KEY-----
```

9. Acknowledgements

Text and/or inspiration were drawn from [RFC5280], [RFC3279], [RFC4055], [RFC5480], and [RFC5639].

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10. IANA Considerations

None.

11. Security Considerations

The security considerations of [RFC5280] and [I-D.josefsson-eddsa-ed25519] apply accordingly.

A common misconception may be that a Ed25519 public key can be used to create SHA512-Ed25519 signatures, or vice versa. This leads to cross-key attacks, and is not permitted.

12. References

12.1. Normative References

[I-D.josefsson-eddsa-ed25519]
Josefsson, S. and N. Moller, "EdDSA and Ed25519", draft-josefsson-eddsa-ed25519-02 (work in progress), February 2015.

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12.2. Informative References

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[RFC5480] Turner, S., Brown, D., Yiu, K., Housley, R., and T. Polk, "Elliptic Curve Cryptography Subject Public Key Information", RFC 5480, March 2009.

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