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CBOR Encoding of X.509 Certificates (CBOR Certificates)
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Abstract

This document specifies a CBOR encoding of PKIX profiled X.509 Certificates. The resulting certificates are called "CBOR certificates". The CBOR encoding supports a large subset of RFC 5280, while at the same time producing very small sizes for certificates compatible with RFC 7925. The CBOR encoding can be used to compress DER encoded X.509 certificates and to encode natively signed certificates. When uses to compress DER encoded X.509 certificates, the CBOR encoding can in many cases compress RFC 7925 profiled certificates with over 50%. The document also specifies COSE headers for CBOR certificates as well as a TLS certificate type for CBOR certificates.

Internet-DraftCBOR Encoding of X.509 Certificates (CBOR CerNovember 2020

Table of Contents

1. Introduction 3
2. Notational Conventions 4
3. CBOR Encoding 4
3.1. Message Fields 5
3.2. Encoding of Extensions 8
4. Compliance Requirements for Constrained IoT 10
5. Deployment settings 10
6. Expected Certificate Sizes 11
7. Natively Signed CBOR Certificates 11
8. Security Considerations 12
9. IANA Considerations 12
9.1. CBOR Certificate Types Registry 12
9.2. CBOR Attribute Type Registry 12
9.3. CBOR Extension Type Registry 13
9.4. CBOR Extended Key Usage Registry 14
9.5. CBOR Subject Alternative Name Registry 15
9.6. CBOR Certificate Signature Algorithms Registry 15
9.7. CBOR Certificate Public Key Algorithms Registry 16
9.8. COSE Header Parameters Registry 17
9.9. TLS Certificate Types Registry 18
10. References 18
10.1. Normative References 18
10.2. Informative References 19
Appendix A. Example CBOR Certificates 20
A.1. Example RFC 7925 profiled X.509 Certificate 20
A.2. Example HTPPS X.509 Certificate 23

Appendix B. X.509 Certificate Profile, ASN.1 26
Acknowledgments 28
Authors' Addresses 28

1. Introduction

One of the challenges with deploying a Public Key Infrastructure (PKI) for the Internet of Things (IoT) is the size and encoding of X.509 public key certificates [RFC5280], since those are not optimized for constrained environments [RFC7228]. More compact certificate representations are desirable. Due to the current PKI usage of DER encoded X.509 certificates, keeping compatibility with DER encoded X.509 is necessary at least for a transition period. However, the use of a more compact encoding with the Concise Binary Object Representation (CBOR) [RFC7049] reduces the certificate size significantly which has known performance benefits in terms of decreased communication overhead, power consumption, latency, storage, etc.

CBOR is a data format designed for small code size and small message size. CBOR builds on the JSON data model but extends it by e.g. encoding binary data directly without base64 conversion. In addition to the binary CBOR encoding, CBOR also has a diagnostic notation that is readable and editable by humans. The Concise Data Definition Language (CDDL) [RFC8610] provides a way to express structures for protocol messages and APIs that use CBOR. [RFC8610] also extends the diagnostic notation.

CBOR data items are encoded to or decoded from byte strings using a type-length-value encoding scheme, where the three highest order bits of the initial byte contain information about the major type. CBOR supports several different types of data items, in addition to integers (int, uint), simple values (e.g. null), byte strings (bstr), and text strings (tstr), CBOR also supports arrays [] of data items, maps {} of pairs of data items, and sequences of data items. For a complete specification and examples, see [RFC7049], [RFC8610], and [RFC8742].

RFC 7925 [RFC7925] specifies a certificate profile for Internet of Things deployments which can be applied for lightweight certificate

based authentication with e.g. TLS [RFC8446], DTLS [I-D.ietf-tls-dtls13], COSE [RFC8152], or EDHOC [I-D.ietf-lake-edhoc]. This document specifies a CBOR encoding which can support large parts of [RFC5280] based on [X.509-IoT]. The encoding support all [RFC7925] profiled X.509 certificates. Two variants are defined using the same CBOR encoding and differing only in what is being signed:

- CBOR compression of DER encoded X.509 certificates [RFC5280], which can be decompressed into the original DER encoded X.509 certificate.

- Natively signed CBOR certificates, which further optimizes the performance in constrained environments but is not backwards compatible with [RFC5280], see Section 7.

This document specifies COSE headers for use of the CBOR certificates with COSE, see Section 9.8. The document also specifies a TLS certificate type for use of the CBOR certificates with TLS (with or without additional TLS certificate compression), see Section 9.9.

2. Notational Conventions

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 specification makes use of the terminology in [RFC5280], [RFC7049], [RFC7228], and [RFC8610].

3. CBOR Encoding

This section specifies the content and encoding for CBOR certificates, with the overall objective to produce a very compact representation supporting large parts of [RFC5280] and everything in [RFC7925]. In the CBOR encoding, static fields are elided, elliptic curve points are compressed, OID are replaced with short integers, time values are compressed, and redundant encoding is removed. Combining these different components reduces the certificate size

significantly, which is not possible with general purpose compressions algorithms, see Figure 1.

The CBOR certificate can be either a CBOR compressed X.509 certificate, in which case the signature is calculated on the DER encoded ASN.1 data in the X.509 certificate, or a natively signed CBOR certificate, in which case the signature is calculated directly on the CBOR encoded data (see Section 7). In both cases the certificate content is adhering to the restrictions given by [RFC5280]. When used as for compression of an existing X.509 certificate, the encoding only works on canonical encoded certificates. The encoding is known to work with DER but might work with other canonical encodings. The compression does not work for BER encoded certificates.

In the encoding described below the order of elements in arrays are always encoded in the same order as the elements or the corresponding SEQUENCE or SET in the DER encoding.

3.1. Message Fields

The X.509 fields and their CBOR encodings are listed below.

CBOR certificates are defined in terms of DER encoded [RFC5280] X.509 certificates:

- version. The 'version' field is known (fixed to v3) and is omitted in the CBOR encoding.

- serialNumber. The 'serialNumber' INTEGER value field is encoded as the unwrapped CBOR positive bignum (~biguint) 'certificateSerialNumber'. Any leading 0x00 byte (to indicate that the number is not negative) is therefore omitted.

- signatureAlgorithm. The 'signatureAlgorithm' field is encoded as a CBOR int 'issuerSignatureAlgorithm' (see Section 9.6) or a CBOR OID tag [I-D.ietf-cbor-tags-oid]. Algorithms with parameters are not supported except RSA algorithms that use parameters = NULL.

- signature. The 'signature' field is always the same as the 'signatureAlgorithm' field and always omitted from the CBOR

encoding.

- issuer. In the general case, the sequence of 'RelativeDistinguishedName' is encoded as CBOR array of CBOR arrays of Attributes, where each Attribute type and value is encoded as a (CBOR int, CBOR text string) pair. Each AttributeType is encoded as a CBOR int (see Figure 3), where the sign is used to represent the character string type; positive for printableString, negative for utf8String. The string types teletexString, universalString, and bmpString are not supported. If Name contains a single Attribute containing an utf8String encoded 'common name' it is encoded as a CBOR text string. If the text string contains an EUI-64 of the form "HH-HH-HH-HH-HH-HH-HH-HH" where 'H' is one of the symbol '0'-'9' or 'A'-'F' it is encoded as a CBOR byte string of length 8 instead. EUI-64 mapped from a 48-bit MAC address (i.e. of the form "HH-HH-HH-FF-FE-HH-HH-HH) is encoded as a CBOR byte string of length 6.

- validity. The 'notBefore' and 'notAfter' fields are ASCII string of the form "yymmddHHMMSSZ" for UTCTime and "yyyymmddHHMMSSZ" for GeneralizedTime. They ASCII strings are converted to integers using the following invertible encoding (Horner's method with different bases).

  n = SS + 61 * (MM + 60 * (HH + 24 * (dd + 32 * (mm + 13 * (yy)yy))))

The integer n is encoded as the unwrapped CBOR positive bignum (~biguint). GeneralizedTime before the year 100 AD is not supported. Decoding can be done by a succession of modulo and subtraction operations. I.e. SS = n mod 61, MM = ((n - SS) / 61) mod 60, etc.

- subject. The 'subject' is encoded exactly like issuer.

- subjectPublicKeyInfo. The 'algorithm' field is encoded as the CBOR int 'subjectPublicKeyAlgorithm' (see Section 9.7) or a CBOR OID tag [I-D.ietf-cbor-tags-oid] . Algorithms with parameters are not supported except id-ecPublicKey with named curves and the RSA algorithms that use parameters = NULL. For id-ecPublicKey the namedCurve parameter is encoded in the CBOR int. The 'subjectPublicKey' BIT STRING value field is encoded as a CBOR

byte string. This specification assumes the BIT STRING has zero unused bits and the unused bits byte is omitted. Uncompressed public keys of type id-ecPublicKey are point compressed as defined in Section 2.3.3 of [SECG]. If a DER encoded certificate with a point compressed public key of type id-ecPublicKey is CBOR encoded, the octets 0xfe and 0xfd are used instead of 0x02 and 0x03 in the CBOR encoding to represent an even and odd y-coordinate respectively.

- extensions. The 'extensions' field is encoded as a CBOR array where each extension is encoded as either a CBOR int (see Section 9.3) followed by an optional CBOR item of any type or a CBOR OID tag [I-D.ietf-cbor-tags-oid] followed by a CBOR bool encoding 'critical' and the DER encoded value of the 'extnValue' encoded as a CBOR byte string. If the array contains exactly two ints and the absolute value of the first int is 2, the array is omitted and the extensions is encoded as a single CBOR int with the absolute value of the second int and the sign of the first int. Extensions are encoded as specified in Section 3.2. The extensions mandated to be supported by [RFC7925] are given special treatment.

- signatureValue. The 'signatureValue' BIT STRING value field is encoded as the CBOR byte string issuerSignatureValue. This specification assumes the BIT STRING has zero unused bits and the unused bits byte is omitted. ECDSA signatures are given special treatment. For ECDSA signatures the SEQUENCE and INTEGER type and length fields are omitted and the two INTEGER value fields are padded to the fixed length L = ceil(log2(n) / 8), where n is the size of the largest prime-order subgroup. For secp256r1, secp384r1, and secp521r1, L is 32, 48, and 66 respectively. For natively signed CBOR certificates the signatureValue is calculated over the CBOR sequence TBSCertificate.

In addition to the above fields present in X.509, the CBOR encoding introduces an additional field:

- cborCertificateType. A CBOR int used to indicate the type of CBOR certificate. Currently, type can be a natively signed CBOR certificate (cborCertificateType = 0) or a CBOR compressed X.509 v3 certificate (cborCertificateType = 1), see Section 9.1.

The following Concise Data Definition Language (CDDL) defines CBORCertificate and TBSCertificate, which are encoded as CBOR Sequences [RFC8742]. The member names therefore only have documentary value.

Internet-DraftCBOR Encoding of X.509 Certificates (CBOR CerNovember 2020

```
; This defines an array, the elements of which are to be used in a CBOR Sequenc
```

```
CBORCertificate = [
   TBSCertificate,
   issuerSignatureValue : bytes,
]

TBSCertificate = (
   cborCertificateType : int,
   certificateSerialNumber : ~biguint,
   issuerSignatureAlgorithm : Algorithm,
   issuer : Name,
   validityNotBefore : ~biguint,
   validityNotAfter : ~biguint,
   subject : Name,
   subjectPublicKeyAlgorithm : Algorithm,
   subjectPublicKey : bytes,
   extensions : Extensions,
)

Algorithm = int / OID

OID = #6.6(bstr) ; tag number 6 is used here, but tag number is TBD

Name = [ * [ + Attribute ] ] / text / bytes

Attribute = (
   attributeType : int,
   attributeValue : text,
)

Extensions =   [ * Extension ] / int,

Extension = (
   extensionID : int / OID,
   ? critical : bool,        ; present if and only if extensionID is an OID
   extensionValue : any,     ; type known from extensionType
)
```

3.2. Encoding of Extensions

EDITOR'S NOTE: The current specification encodes many common extensions with a DER encoded byte string. It should be discussed if more or all commonly active extensions should be natively encoded with CBOR. Would a specific CBOR encoding have to be specified for each extension or can a general CBOR encoding that apply to all remaining extensions be specified?

This section details the encoding of the 'extensions' field. The 'extensions' field is encoded as a CBOR array where each extensionID is encoded as either a CBOR int or a CBOR OID tag. If 'extensionID' is encoded an int (see Section 9.3),the sign is used to encode if the extension is critical and the 'critical' field is omitted. Critical extensions are encoded with a positive sign and non-critical extensions are encoded with a negative sign.

The 'extnValue' OCTET STREAM value field is encoded as the CBOR byte string 'extensionValue' except for the extensions specified below. The 'extensionValue' for the extensions mandated to be supported by [RFC7925] are encoded as follows:

- basicConstraints. If 'cA' = false then extensionValue = -2, if 'cA' = true and 'pathLenConstraint' is not present then extensionValue = -1, and if 'cA' = true and 'pathLenConstraint' is present then extensionValue = pathLenConstraint.

- keyUsage. The 'KeyUsage' BIT STRING is interpreted as an unsigned integer n in network byte order and encoded as a CBOR int.

- extKeyUsage. extensionValue is encoded as an array of CBOR ints (see Section 9.4) or CBOR OID tags [I-D.ietf-cbor-tags-oid] where each ints or OID tag encodes a key usage purpose. If the array contains a single int, the array is omitted.

  extensionValue = [* int / OID] / int

- subjectAltName. extensionValue is encoded as an [* (int, any)] array where each (int, any) pair encodes a general name (see Section 9.5). If subjectAltName contains exactly one dNSName, the array and the int are omitted and extensionValue is the dNSName encoded as a CBOR text string.

3.2.1. Example Encoding of Extensions

The examples below use values from Section 9.3, Section 9.4, and Section 9.5:

- A critical basicConstraints ('cA' = true) without pathLenConstraint is encoded as the two CBOR ints -1, -1.

- A non-critical keyUsage with digitalSignature and keyAgreement asserted is encoded as the two CBOR ints 2, 17 (2^0 + 2^4 = 17).

- A non-critical extKeyUsage containing id-kp-codeSigning and id-kp-

OCSPSigning is encoded as the CBOR int 3 followed by the CBOR array [3, 6].

- A non-critical subjectAltName containing only the dNSName example.com is encoded as the CBOR int 4 followed by the CBOR text string "example.com".

Thus, the extension field of a certificate containing all of the above extensions in the given order would be encoded as the CBOR array [-1, -1, 2, 17, 3, [3, 6], 4, "example.com"].

4. Compliance Requirements for Constrained IoT

For general purpose applications, the normative requirements of [RFC5280] applies. This section describes the mandatory to implement algorithms and OIDs for constrained IoT application; the values of the OIDs including certificate fields and extensions, time format, attributes in distinguished names, etc.

TODO: Write this section

5. Deployment settings

CBOR certificates can be deployed with legacy X.509 certificates and CA infrastructure. In order to verify the signature, the CBOR certificate is used to recreate the original X.509 data structure to be able to verify the signature.

For protocols like TLS/DTLS 1.2, where the handshake is sent unencrypted, the actual encoding and compression can be done at different locations depending on the deployment setting. For example, the mapping between CBOR certificate and standard X.509 certificate can take place in a 6LoWPAN border gateway which allows the server side to stay unmodified. This case gives the advantage of the low overhead of a CBOR certificate over a constrained wireless links. The conversion to X.509 within an IoT device will incur a computational overhead, however, measured in energy this is negligible compared to the reduced communication overhead.

For the setting with constrained server and server-only authentication, the server only needs to be provisioned with the CBOR certificate and does not perform the conversion to X.509. This

option is viable when client authentication can be asserted by other means.

For protocols like IKEv2, TLS/DTLS 1.3, and EDHOC, where certificates are encrypted, the proposed encoding needs to be done fully end-to-end, through adding the encoding/decoding functionality to the server.

6. Expected Certificate Sizes

The CBOR encoding of the sample certificate given in Appendix A results in the numbers shown in Figure 1. After [RFC7925] profiling, most duplicated information has been removed, and the remaining text strings are minimal in size. Therefore, the further size reduction reached with general compression mechanisms will be small, mainly corresponding to making the ASN.1 encoding more compact. The zlib number was calculated with zlib-flate.

```
zlib-flate -compress < cert.der > cert.compressed
```

	RFC 7925	zlib	CBOR Certificate
Certificate Size	314	295	138

Figure 1: Comparing Sizes of Certificates (bytes)

7. Natively Signed CBOR Certificates

The difference between CBOR compressed X.509 certificate and natively signed CBOR certificate is that the signature is calculated over the CBOR encoding of the CBOR sequence TBSCertficate rather than the DER encoded ASN.1 data. This removes entirely the need for ASN.1 DER and base64 encoding which reduces the processing in the authenticating devices and avoids known complexities with these encoding.

Natively signed CBOR certificates can be applied in devices that are only required to authenticate to natively signed CBOR certificate compatible servers. This is not a major restriction for many IoT

deployments, where the parties issuing and verifying certificates can be a restricted ecosystem which not necessarily involves public CAs.

CBOR compressed X.509 certificates provides an intermediate step between [RFC7925] profiled X.509 certificates and natively signed CBOR certificates: An implementation of CBOR compressed X.509 certificates contains both the CBOR encoding of the X.509 certificate and the signature operations sufficient for natively signed CBOR certificates.

The natively signed approach based on DER encoded X.509 certificates described in this document has a lot of benefits. A CA can use existing ASN.1 machinery to create a DER encoded certificate, the DER encoded certificate can then be transformed to CBOR before signing.

8. Security Considerations

The CBOR profiling of X.509 certificates does not change the security assumptions needed when deploying standard X.509 certificates but decreases the number of fields transmitted, which reduces the risk for implementation errors.

Conversion between the certificate formats can be made in constant time to reduce risk of information leakage through side channels.

The mechanism in this draft does not reveal any additional information compared to X.509. Because of difference in size, it will be possible to detect that this profile is used. The gateway solution described in Section 5 requires unencrypted certificates and is not recommended.

9. IANA Considerations

For all items, the 'Reference' field points to this document.

9.1. CBOR Certificate Types Registry

IANA has created a new registry titled "CBOR Certificate Types" under the new heading "CBOR Certificate". For values in the interval [-24, 23] the registration procedure is "IETF Review". For all other

values the registration procedure is "Expert Review". The columns of the registry are Value, Description, and Reference, where Value is an integer, and the other columns are text strings. The initial contents of the registry are:

Value	Description
0	Natively Signed CBOR Certificate
1	CBOR Compressed X.509 v3 Certificate

Figure 2: CBOR Certificate Types

9.2. CBOR Attribute Type Registry

IANA has created a new registry titled "CBOR Attribute Type Registry" under the new heading "CBOR Certificate". The columns of the registry are Value, X.509 Attribute Type, and Reference, where Value is an integer, and the other columns are text strings. Only positive values can be registered. For values in the interval [1, 23] the registration procedure is "IETF Review". For all other values the

registration procedure is "Expert Review". The initial contents of the registry are:

Value	X.509 Attribute Type
1	id-at-commonName
2	id-at-surname
3	id-at-serialNumber
4	id-at-countryName
5	id-at-localityName
6	id-at-stateOrProvinceName
7	id-at-organizationName
8	id-at-organizationalUnitName
9	id-at-title
10	id-at-givenName
11	id-at-initials
12	id-at-generationQualifier

	13	id-at-dnQualifier
	14	id-at-pseudonym
	15	id-at-organizationIdentifier

Figure 3: CBOR Attribute Type Registry

9.3. CBOR Extension Type Registry

IANA has created a new registry titled "CBOR Extension Type Registry" under the new heading "CBOR Certificate". The columns of the registry are Value, X.509 Extension Type, and Reference, where Value is an integer, and the other columns are text strings. Only positive values can be registered. For values in the interval [1, 23] the registration procedure is "IETF Review". For all other values the registration procedure is "Expert Review". The initial contents of the registry are:

Value	X.509 Extension Type	extensionValue
1	id-ce-basicConstraints	int
2	id-ce-keyUsage	int
3	id-ce-extKeyUsage	[] / int
4	id-ce-subjectAltName	[] / text
5	id-ce-authorityKeyIdentifier	bytes
6	id-ce-subjectKeyIdentifier	bytes
7	id-ce-certificatePolicies	bytes
8	id-ce-cRLDistributionPoints	bytes

	9	id-pe-authorityInfoAccess	bytes
	10	SCT List (1.3.6.1.4.1.11129.2.4.2)	bytes
	248	id-ce-nameConstraints	bytes
	249	id-ce-policyConstraints	bytes
	250	id-ce-inhibitAnyPolicy	bytes
	251	id-ce-authorityKeyIdentifier	bytes
	252	id-ce-policyMappings	bytes
	253	id-ce-issuerAltName	bytes
	254	id-ce-subjectDirectoryAttributes	bytes
	255	id-ce-freshestCRL	bytes
	256	id-pe-subjectInfoAccess	bytes

Figure 4: CBOR Extension Type Registry

9.4. CBOR Extended Key Usage Registry

IANA has created a new registry titled "CBOR Extended Key Usage Registry" under the new heading "CBOR Certificate". The columns of the registry are Value, Extended Key Usage Purpose, and Reference, where Value is an integer, and the other columns are text strings. For values in the interval [-24, 23] the registration procedure is "IETF Review". For all other values the registration procedure is "Expert Review". The initial contents of the registry are:

Value	Extended Key Usage
0	anyExtendedKeyUsage

	1	id-kp-serverAuth
	2	id-kp-clientAuth
	3	id-kp-codeSigning
	4	id-kp-emailProtection
	5	id-kp-timeStamping
	6	id-kp-OCSPSigning

Figure 5: CBOR Extended Key Usage Registry

9.5. CBOR Subject Alternative Name Registry

IANA has created a new registry titled "CBOR Subject Alternative Name Registry" under the new heading "CBOR Certificate". The columns of the registry are Value, Extended Key Usage Purpose, and Reference, where Value is an integer, and the other columns are text strings. For values in the interval [-24, 23] the registration procedure is "IETF Review". For all other values the registration procedure is "Expert Review". The initial contents of the registry are:

Value	Subject Alternative Name	
0	otherName	[OID, bytes]
1	rfc822Name	text
2	dNSName	text
3	directoryName	Name
4	uniformResourceIdentifier	text
5	iPAddress	bytes

Figure 6: CBOR Subject Alternative Name Registry

9.6. CBOR Certificate Signature Algorithms Registry

IANA has created a new registry titled "CBOR Certificate Signature Algorithms" under the new heading "CBOR Certificate". For values in the interval [-24, 23] the registration procedure is "IETF Review". For all other values the registration procedure is "Expert Review". The columns of the registry are Value, X.509 Algorithm, and Reference, where Value is an integer, and the other columns are text strings. The initial contents of the registry are:

Value	X.509 Signature Algorithm
0	sha1WithRSAEncryption
1	sha256WithRSAEncryption
2	sha384WithRSAEncryption
3	sha512WithRSAEncryption
4	id-RSASSA-PSS-SHAKE128
5	id-RSASSA-PSS-SHAKE256
6	ecdsa-with-SHA256
7	ecdsa-with-SHA384
8	ecdsa-with-SHA512
9	id-ecdsa-with-shake128
10	id-ecdsa-with-shake256
11	id-Ed25519
12	id-Ed448
13	id-alg-hss-lms-hashsig
14	id-alg-xmss
15	id-alg-xmssmt
245	sha224WithRSAEncryption
246	id-rsassa-pkcs1-v1_5-with-sha3-224
247	id-rsassa-pkcs1-v1_5-with-sha3-256
248	id-rsassa-pkcs1-v1_5-with-sha3-384
249	id-rsassa-pkcs1-v1_5-with-sha3-512
250	ecdsa-with-SHA1
251	ecdsa-with-SHA224
252	id-ecdsa-with-sha3-224
253	id-ecdsa-with-sha3-256
254	id-ecdsa-with-sha3-384
255	id-ecdsa-with-sha3-512

Figure 7: CBOR Certificate Signature Algorithms

9.7. CBOR Certificate Public Key Algorithms Registry

IANA has created a new registry titled "CBOR Certificate Public Key Algorithms" under the new heading "CBOR Certificate". For values in the interval [-24, 23] the registration procedure is "IETF Review". For all other values the registration procedure is "Expert Review". The columns of the registry are Value, X.509 Algorithm, and Reference, where Value is an integer, and the other columns are text strings. The initial contents of the registry are:

Value	X.509 Public Key Algorithm
0	rsaEncryption
1	id-ecPublicKey + secp256r1
2	id-ecPublicKey + secp384r1
3	id-ecPublicKey + secp521r1
4	id-X25519
5	id-X448
6	id-Ed25519
7	id-Ed448
8	id-alg-hss-lms-hashsig
9	id-alg-xmss
10	id-alg-xmssmt

Figure 8: CBOR Certificate Public Key Algorithms

9.8. COSE Header Parameters Registry

This document registers the following entries in the "COSE Header Parameters" registry under the "CBOR Object Signing and Encryption (COSE)" heading. The formatting and processing are the same as the corresponding x5bag, x5chain, x5t, and x5u defined in [I-D.ietf-cose-x509] except that the certificates are CBOR encoded instead of DER encoded. Note that certificates can also be identified with a 'kid' header parameter by storing 'kid' and the associated bag or chain in a dictionary.

Name	Label	Value Type	Description
c5bag	TBD1	COSE_X509	An unordered bag of CBOR certificates
c5chain	TBD2	COSE_X509	An ordered chain of CBOR certificates
c5t	TBD3	COSE_CertHash	Hash of an CBOR certificate

c5u	TBD4	uri	URI pointing to a CBOR certificate

9.9. TLS Certificate Types Registry

This document registers the following entry in the "TLS Certificate Types" registry under the "Transport Layer Security (TLS) Extensions" heading. The new certificate type can be used with addtional TLS certificate compression [I-D.ietf-tls-certificate-compression].

EDITOR'S NOTE: The TLS registrations should be discussed and approved by the TLS WG at a later stage. When COSE WG has adopted work on CBOR certificates, it could perhaps be presented in the TLS WG. The TLS WG might e.g. want a separate draft in the TLS WG.

Value	Name	Recommended	Comment
TBD5	CBOR Certificate	Y	

10. References

10.1. Normative References

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Appendix A. Example CBOR Certificates

A.1. Example RFC 7925 profiled X.509 Certificate

Example of [RFC7925] profiled X.509 certificate parsed with OpenSSL.


```
   Certificate:
       Data:
           Version: 3 (0x2)
           Serial Number: 128269 (0x1f50d)
           Signature Algorithm: ecdsa-with-SHA256
           Issuer: CN=RFC test CA
           Validity
               Not Before: Jan  1 00:00:00 2020 GMT
               Not After : Feb  2 00:00:00 2021 GMT
           Subject: CN=01-23-45-FF-FE-67-89-AB
           Subject Public Key Info:
               Public Key Algorithm: id-ecPublicKey
```

```
                    Public-Key: (256 bit)
                    pub:
                        04:ae:4c:db:01:f6:14:de:fc:71:21:28:5f:dc:7f:
                        5c:6d:1d:42:c9:56:47:f0:61:ba:00:80:df:67:88:
                        67:84:5e:e9:a6:9f:d4:89:31:49:da:e3:d3:b1:54:
                        16:d7:53:2c:38:71:52:b8:0b:0d:f3:e1:af:40:8a:
                        95:d3:07:1e:58
                    ASN1 OID: prime256v1
                    NIST CURVE: P-256
            X509v3 extensions:
                X509v3 Key Usage:
                    Digital Signature
        Signature Algorithm: ecdsa-with-SHA256
             30:44:02:20:37:38:73:ef:87:81:b8:82:97:ef:23:5c:1f:ac:
             cf:62:da:4e:44:74:0d:c2:a2:e6:a3:c6:c8:82:a3:23:8d:9c:
             02:20:3a:d9:35:3b:a7:88:68:3b:06:bb:48:fe:ca:16:ea:71:
             17:17:34:c6:75:c5:33:2b:2a:f1:cb:73:38:10:a1:fc
```

The DER encoding of the above certificate is 314 bytes.

```
30 82 01 36 30 81 DE A0 03 02 01 02 02 03 01 F5 0D 30 0A 06 08 2A 86 48
CE 3D 04 03 02 30 16 31 14 30 12 06 03 55 04 03 0C 0B 52 46 43 20 74 65
73 74 20 43 41 30 1E 17 0D 32 30 30 31 30 31 30 30 30 30 30 30 5A 17 0D
32 31 30 32 30 32 30 30 30 30 30 30 5A 30 22 31 20 30 1E 06 03 55 04 03
0C 17 30 31 2D 32 33 2D 34 35 2D 46 46 2D 46 45 2D 36 37 2D 38 39 2D 41
42 30 59 30 13 06 07 2A 86 48 CE 3D 02 01 06 08 2A 86 48 CE 3D 03 01 07
03 42 00 04 AE 4C DB 01 F6 14 DE FC 71 21 28 5F DC 7F 5C 6D 1D 42 C9 56
47 F0 61 BA 00 80 DF 67 88 67 84 5E E9 A6 9F D4 89 31 49 DA E3 D3 B1 54
16 D7 53 2C 38 71 52 B8 0B 0D F3 E1 AF 40 8A 95 D3 07 1E 58 A3 0F 30 0D
30 0B 06 03 55 1D 0F 04 04 03 02 07 80 30 0A 06 08 2A 86 48 CE 3D 04 03
02 03 47 00 30 44 02 20 37 38 73 EF 87 81 B8 82 97 EF 23 5C 1F AC CF 62
DA 4E 44 74 0D C2 A2 E6 A3 C6 C8 82 A3 23 8D 9C 02 20 3A D9 35 3B A7 88
68 3B 06 BB 48 FE CA 16 EA 71 17 17 34 C6 75 C5 33 2B 2A F1 CB 73 38 10
A1 FC
```


A.1.1. Example CBOR Certificate Compression

The CBOR certificate compression of the X.509 in CBOR diagnostic format is:

```
/This defines a CBOR Sequence (RFC 8742):/

  1,
  h'01f50d',
  6,
  "RFC test CA",
  h'2B044180',
  h'2D543300',
  h'0123456789AB',
  1,
  h'02ae4cdb01f614defc7121285fdc7f5c6d1d42c95647f061ba
    0080df678867845e',
  1,
  h'373873EF8781B88297EF235C1FACCF62DA4E44740DC2A2E6A3
    C6C882A3238D9C3AD9353BA788683B06BB48FECA16EA711717
    34C675C5332B2AF1CB733810A1FC'
```

The CBOR encoding (CBOR sequence) of the CBOR certificate is 138 bytes.

```
01
43 01 F5 0D
06
6B 52 46 43 20 74 65 73 74 20 43 41
44 2B 04 41 80
44 2D 54 33 00
46 01 23 45 67 89 AB
01
58 21 02 AE 4C DB 01 F6 14 DE FC 71 21 28 5F DC 7F 5C 6D 1D 42 C9 56 47
F0 61 BA 00 80 DF 67 88 67 84 5E
01
58 40 37 38 73 EF 87 81 B8 82 97 EF 23 5C 1F AC CF 62 DA 4E 44 74 0D C2
A2 E6 A3 C6 C8 82 A3 23 8D 9C 3A D9 35 3B A7 88 68 3B 06 BB 48 FE CA 16
EA 71 17 17 34 C6 75 C5 33 2B 2A F1 CB 73 38 10 A1 FC
```

A.1.2. Example: Natively Signed CBOR Certificate

The corresponding natively signed CBOR certificate in CBOR diagnostic format is identical except for type and signatureValue.

```
  /This defines a CBOR Sequence (RFC 8742):/

    0,
    h'01f50d',
    6,
    "RFC test CA",
    h'2B044180',
    h'2D543300',
    h'0123456789AB',
    1,
    h'02ae4cdb01f614defc7121285fdc7f5c6d1d42c95647f061
      ba0080df678867845e',
    1,
    h'7F10A063DA8DB2FD49414440CDF85070AC22A266C7F1DFB1
      577D9A35A295A8742E794258B76968C097F85542322A0796
      0199C13CC0220A9BC729EF2ECA638CFE'
```

The CBOR encoding (CBOR sequence) of the CBOR certificate is 138 bytes.

```
00
43 01 F5 0D
06
6B 52 46 43 20 74 65 73 74 20 43 41
44 2B 04 41 80
44 2D 54 33 00
46 01 23 45 67 89 AB
01
58 21 02 AE 4C DB 01 F6 14 DE FC 71 21 28 5F DC 7F 5C 6D 1D 42 C9 56 47
F0 61 BA 00 80 DF 67 88 67 84 5E
01
58 40 7F 10 A0 63 DA 8D B2 FD 49 41 44 40 CD F8 50 70 AC 22 A2 66 C7 F1
DF B1 57 7D 9A 35 A2 95 A8 74 2E 79 42 58 B7 69 68 C0 97 F8 55 42 32 2A
07 96 01 99 C1 3C C0 22 0A 9B C7 29 EF 2E CA 63 8C FE
```

A.2. Example HTPPS X.509 Certificate

The DER encoding of the tools.ietf.org certificate is 1647 bytes.

```
30 82 06 6b 30 82 05 53 a0 03 02 01 02 02 09 00 a6 a5 5c 87 0e 39 b4 0e
30 0d 06 09 2a 86 48 86 f7 0d 01 01 0b 05 00 30 81 c6 31 0b 30 09 06 03
55 04 06 13 02 55 53 31 10 30 0e 06 03 55 04 08 13 07 41 72 69 7a 6f 6e
61 31 13 30 11 06 03 55 04 07 13 0a 53 63 6f 74 74 73 64 61 6c 65 31 25
30 23 06 03 55 04 0a 13 1c 53 74 61 72 66 69 65 6c 64 20 54 65 63 68 6e
6f 6c 6f 67 69 65 73 2c 20 49 6e 63 2e 31 33 30 31 06 03 55 04 0b 13 2a
68 74 74 70 3a 2f 2f 63 65 72 74 73 2e 73 74 61 72 66 69 65 6c 64 74 65
63 68 2e 63 6f 6d 2f 72 65 70 6f 73 69 74 6f 72 79 2f 31 34 30 32 06 03
```

```
 55 04 03 13 2b 53 74 61 72 66 69 65 6c 64 20 53 65 63 75 72 65 20 43 65
 72 74 69 66 69 63 61 74 65 20 41 75 74 68 6f 72 69 74 79 20 2d 20 47 32
 30 1e 17 0d 32 30 31 30 30 31 31 39 33 38 33 36 5a 17 0d 32 31 31 31 30
 32 31 39 33 38 33 36 5a 30 3e 31 21 30 1f 06 03 55 04 0b 13 18 44 6f 6d
 61 69 6e 20 43 6f 6e 74 72 6f 6c 20 56 61 6c 69 64 61 74 65 64 31 19 30
 17 06 03 55 04 03 0c 10 2a 2e 74 6f 6f 6c 73 2e 69 65 74 66 2e 6f 72 67
 30 82 01 22 30 0d 06 09 2a 86 48 86 f7 0d 01 01 01 05 00 03 82 01 0f 00
 30 82 01 0a 02 82 01 01 00 b1 e1 37 e8 eb 82 d6 89 fa db f5 c2 4b 77 f0
 2c 4a de 72 6e 3e 13 60 d1 a8 66 1e c4 ad 3d 32 60 e5 f0 99 b5 f4 7a 7a
 48 55 21 ee 0e 39 12 f9 ce 0d ca f5 69 61 c7 04 ed 6e 0f 1d 3b 1e 50 88
 79 3a 0e 31 41 16 f1 b1 02 64 68 a5 cd f5 4a 0a ca 99 96 35 08 c3 7e 27
 5d d0 a9 cf f3 e7 28 af 37 d8 b6 7b dd f3 7e ae 6e 97 7f f7 ca 69 4e cc
 d0 06 df 5d 27 9b 3b 12 e7 e6 fe 08 6b 52 7b 82 11 7c 72 b3 46 eb c1 e8
 78 b8 0f cb e1 eb bd 06 44 58 dc 83 50 b2 a0 62 5b dc 81 b8 36 e3 9e 7c
 79 b2 a9 53 8a e0 0b c9 4a 2a 13 39 31 13 bd 2c cf a8 70 cf 8c 8d 3d 01
 a3 88 ae 12 00 36 1d 1e 24 2b dd 79 d8 53 01 26 ed 28 4f c9 86 94 83 4e
 c8 e1 14 2e 85 b3 af d4 6e dd 69 46 af 41 25 0e 7a ad 8b f2 92 ca 79 d9
 7b 32 4f f7 77 e8 f9 b4 4f 23 5c d4 5c 03 ae d8 ab 3a ca 13 5f 5d 5d 5d
 a1 02 03 01 00 01 a3 82 02 e1 30 82 02 dd 30 0c 06 03 55 1d 13 01 01 ff
 04 02 30 00 30 1d 06 03 55 1d 25 04 16 30 14 06 08 2b 06 01 05 05 07 03
 01 06 08 2b 06 01 05 05 07 03 02 30 0e 06 03 55 1d 0f 01 01 ff 04 04 03
 02 05 a0 30 3d 06 03 55 1d 1f 04 36 30 34 30 32 a0 30 a0 2e 86 2c 68 74
 74 70 3a 2f 2f 63 72 6c 2e 73 74 61 72 66 69 65 6c 64 74 65 63 68 2e 63
 6f 6d 2f 73 66 69 67 32 73 31 2d 32 34 32 2e 63 72 6c 30 63 06 03 55 1d
 20 04 5c 30 5a 30 4e 06 0b 60 86 48 01 86 fd 6e 01 07 17 01 30 3f 30 3d
 06 08 2b 06 01 05 05 07 02 01 16 31 68 74 74 70 3a 2f 2f 63 65 72 74 69
 66 69 63 61 74 65 73 2e 73 74 61 72 66 69 65 6c 64 74 65 63 68 2e 63 6f
 6d 2f 72 65 70 6f 73 69 74 6f 72 79 2f 30 08 06 06 67 81 0c 01 02 01 30
 81 82 06 08 2b 06 01 05 05 07 01 01 04 76 30 74 30 2a 06 08 2b 06 01 05
 05 07 30 01 86 1e 68 74 74 70 3a 2f 2f 6f 63 73 70 2e 73 74 61 72 66 69
 65 6c 64 74 65 63 68 2e 63 6f 6d 2f 30 46 06 08 2b 06 01 05 05 07 30 02
 86 3a 68 74 74 70 3a 2f 2f 63 65 72 74 69 66 69 63 61 74 65 73 2e 73 74
 61 72 66 69 65 6c 64 74 65 63 68 2e 63 6f 6d 2f 72 65 70 6f 73 69 74 6f
 72 79 2f 73 66 69 67 32 2e 63 72 74 30 1f 06 03 55 1d 23 04 18 30 16 80
 14 25 45 81 68 50 26 38 3d 3b 2d 2c be cd 6a d9 b6 3d b3 66 63 30 2b 06
 03 55 1d 11 04 24 30 22 82 10 2a 2e 74 6f 6f 6c 73 2e 69 65 74 66 2e 6f
 72 67 82 0e 74 6f 6f 6c 73 2e 69 65 74 66 2e 6f 72 67 30 1d 06 03 55 1d
 0e 04 16 04 14 ad 8a b4 1c 07 51 d7 92 89 07 b0 b7 84 62 2f 36 55 7a 5f
 4d 30 82 01 06 06 0a 2b 06 01 04 01 d6 79 02 04 02 04 81 f7 04 81 f4 00
 f2 00 77 00 f6 5c 94 2f d1 77 30 22 14 54 18 08 30 94 56 8e e3 4d 13 19
 33 bf df 0c 2f 20 0b cc 4e f1 64 e3 00 00 01 74 e5 ac 71 13 00 00 04 03
 00 48 30 46 02 21 00 8c f5 48 52 ce 56 35 43 39 11 cf 10 cd b9 1f 52 b3
```

```
36 39 22 3a d1 38 a4 1d ec a6 fe de 1f e9 0f 02 21 00 bc a2 25 43 66 c1
9a 26 91 c4 7a 00 b5 b6 53 ab bd 44 c2 f8 ba ae f4 d2 da f2 52 7c e6 45
49 95 00 77 00 5c dc 43 92 fe e6 ab 45 44 b1 5e 9a d4 56 e6 10 37 fb d5
fa 47 dc a1 73 94 b2 5e e6 f6 c7 0e ca 00 00 01 74 e5 ac 72 3c 00 00 04
03 00 48 30 46 02 21 00 a5 e0 90 6e 63 e9 1d 4f dd ef ff 03 52 b9 1e 50
89 60 07 56 4b 44 8a 38 28 f5 96 dc 6b 28 72 6d 02 21 00 fc 91 ea ed 02
```



```
16 88 66 05 4e e1 8a 2e 53 46 c4 cc 51 fe b3 fa 10 a9 1d 2e db f9 91 25
f8 6c e6 30 0d 06 09 2a 86 48 86 f7 0d 01 01 0b 05 00 03 82 01 01 00 14
04 3f a0 be d2 ee 3f a8 6e 3a 1f 78 8e a0 4c 35 53 0f 11 06 1f ff 60 a1
6d 0b 83 e9 d9 2a db b3 3f 9d b3 d7 e0 59 4c 19 a8 e4 19 a5 0c a7 70 72
77 63 d5 fe 64 51 0a d2 7a d6 50 a5 8a 92 38 ec cb 2f 0f 5a c0 64 58 4d
5c 06 b9 73 63 68 27 8b 89 34 dc 79 c7 1d 3a fd 34 5f 83 14 41 58 49 80
68 29 80 39 8a 86 72 69 cc 79 37 ce e3 97 f7 dc f3 95 88 ed 81 03 29 00
d2 a2 c7 ba ab d6 3a 8e ca 09 0b d9 fb 39 26 4b ff 03 d8 8e 2d 3f 6b 21
ca 8a 7d d8 5f fb 94 ba 83 de 9c fc 15 8d 61 fa 67 2d b0 c7 db 3d 25 0a
41 4a 85 d3 7f 49 46 37 3c f4 b1 75 d0 52 f3 dd c7 66 f1 4b fd aa 00 ed
bf e4 7e ed 01 ec 7b e4 f6 46 fc 31 fd 72 fe 03 d2 f2 65 af 4d 7e e2 81
9b 7a fd 30 3c f5 52 f4 05 34 a0 8a 3e 19 41 58 c8 a8 e0 51 71 84 09 15
ae ec a5 77 75 fa 18 f7 d5 77 d5 31 cc c7 2d
```

A.2.1. Example CBOR Certificate Compression

The CBOR certificate compression of the X.509 in CBOR diagnostic format is:

Internet-DraftCBOR Encoding of X.509 Certificates (CBOR CerNovember 2020

/This defines a CBOR Sequence (RFC 8742):/

```
  1,
  h'A6A55C870E39B40E',
  0,
  [
    [4, "US"],
    [6, "Arizona"],
    [5, "Scottsdale"],
    [7, "Starfield Technologies, Inc."],
    [8, "http://certs.starfieldtech.com/repository/"],
    [1, "Starfield Secure Certificate Authority - G2"]
  ],
  h'2D3EE7F6',
  h'2F98B716',
  [
    [8, "Domain Control Validated"],
    [-1, "*.tools.ietf.org"]
  ],
  0,
  h'3082010A0282010100B1E137E8EB82D689FADBF5C24B77F02C4ADE726E3E1360D1A8661EC4A
  [
    -1, -2,
     3, [ 1, 2 ],
    -2, 5,
     8, h'30343032a030a02e862c687474703a2f2f63726c2e737461726669656c64746563682
     7, h'305A304E060B6086480186FD6E01071701303F303D06082B0601050507020116316870
     9, h'3074302A06082B0601050507300186E687474703A2F2F6F6373702E7374617266696
```

```
    5, h'30168014254581685026383D3B2D2CBECD6AD9B63DB36663',
    4, [ 2, "*.tools.ietf.org", 2, "tools.ietf.org" ],
    6, h'0414AD8AB41C0751D7928907B0B784622F36557A5F4D',
   10, h'0481F400F2007700F65C942FD1773022145418083094568EE34D131933BFDF0C2F200
],
h'14043FA0BED2EE3FA86E3A1F788EA04C35530F11061FFF60A16D0B83E9D92ADBB33F9DB3D7E
```

The CBOR encoding (CBOR sequence) of the CBOR certificate is 1374 bytes.

Appendix B. X.509 Certificate Profile, ASN.1

EDITOR'S NOTE: The ASN.1 below is not up to date with the rest of the specification. The below ASN.1 for RFC 7925 profile should be in draft-ietf-uta-tls13-iot-profile instead. If CBOR Certificates support a large subset of RFC 5280, we should probably not duplicate all the ASN.1 in that document. Should be discussed what kind and how much (if any) ASN.1 this document needs. If possible, one option would be to have ASN.1 for the restrictions compared to RFC 5280.


```
IOTCertificate DEFINITIONS EXPLICIT TAGS ::= BEGIN

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

TBSCertificate  ::= SEQUENCE {
  version           [0] INTEGER {v3(2)},
  serialNumber          INTEGER (1..MAX),
  signature             AlgorithmIdentifier,
  issuer                Name,
  validity              Validity,
  subject               Name,
  subjectPublicKeyInfo  SubjectPublicKeyInfo,
  extensions        [3] Extensions OPTIONAL
}

Name  ::= SEQUENCE SIZE (1) OF DistinguishedName
```

```
   DistinguishedName  ::= SET SIZE (1) OF CommonName

   CommonName  ::= SEQUENCE {
     type              OBJECT IDENTIFIER (id-at-commonName),
     value             UTF8String
   }

   Validity  ::= SEQUENCE {
     notBefore         UTCTime,
     notAfter          UTCTime
   }

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

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

   Extensions  ::= SEQUENCE SIZE (1..MAX) OF Extension

   Extension  ::= SEQUENCE {
     extnId            OBJECT IDENTIFIER,
     critical          BOOLEAN DEFAULT FALSE,
```



```
     extnValue         OCTET STRING
    }

   id-at-commonName    OBJECT IDENTIFIER   ::=
            {joint-iso-itu-t(2) ds(5) attributeType(4) 3}

   END
```

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