RFC 9338
CBOR Object Signing and Encryption (COSE): Countersignatures

Abstract

Concise Binary Object Representation (CBOR) is a data format designed for small code size and small message size. CBOR Object Signing and Encryption (COSE) defines a set of security services for CBOR. This document defines a countersignature algorithm along with the needed header parameters and CBOR tags for COSE. This document updates RFC 9052.

Status of This Memo

This is an Internet Standards Track document.

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1. Introduction

There has been an increased focus on small, constrained devices that make up the Internet of Things (IoT). One of the standards that has come out of this process is "Concise Binary Object Representation (CBOR)" [RFC8949]. CBOR extended the data model of the JavaScript Object Notation (JSON) [STD90] by allowing for binary data, among other changes. CBOR has been adopted by several of the IETF working groups dealing with the IoT world as their method of encoding data structures. CBOR was designed specifically to be small in terms of both messages transported and implementation size and to have a schema-free decoder. A need exists to provide message security services for IoT, and using CBOR as the message-encoding format makes sense.

A countersignature is a second signature that confirms the primary signature. During the process of advancing CBOR Object Signing and Encryption (COSE) to Internet Standard, it was noticed that the description of the security properties of countersignatures was incorrect for the COSE_Sign1 structure mentioned in Section 4.5 of [RFC8152]. To remedy this situation, the COSE Working Group decided to remove all of the countersignature text from [RFC9052], which obsoletes [RFC8152]. This document defines a new countersignature with the desired security properties.

The problem with the previous countersignature algorithm was that the cryptographically computed value was not always included. The initial assumption that the cryptographic value was in the third slot of the array was known not to be true at the time, but in the case of the Message Authentication Code (MAC) structures this was not deemed to be an issue. The new algorithm defined in this document requires the inclusion of more values for the countersignature computation. The exception to this is the COSE_Signature structure where there is no cryptographically computed value.
The new algorithm defined in this document is designed to produce the same countersignature value in those cases where the computed cryptographic value was already included. This means that for those structures the only thing that would need to be done is to change the value of the header parameter.

With the publication of this document, implementers are encouraged to migrate uses of the previous countersignature algorithm to the one specified in this document. In particular, uses of "CounterSignature" will migrate to "CounterSignatureV2", and uses of "CounterSignature0" will migrate to "CounterSignature0V2". In addition, verification of "CounterSignature" must be supported by new implementations to remain compatible with senders that adhere to [RFC8152], which assumes that all implementations will understand "CounterSignature" as header parameter label 7. Likewise, verification of "CounterSignature0" may be supported for further compatibility.

1.1. Requirements 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.

1.2. CBOR Grammar

CBOR grammar in this document uses the Concise Data Definition Language (CDDL) [RFC8610]. The collected CDDL can be extracted from the XML version of this document via the XPath expression below. (Depending on the XPath evaluator one is using, it may be necessary to deal with &gt; as an entity.)

```
//sourcecode[@type='cddl']/text()
```

CDDL expects the initial non-terminal symbol to be the first symbol in the file. For this reason, the first fragment of CDDL is presented here.

```
start = COSE_Countersignature_Tagged / Internal_Types

; This is defined to make the tool quieter:
Internal_Types = Countersign_structure / COSE_Countersignature0
```

The non-terminal Internal_Types is defined for dealing with the automated validation tools used during the writing of this document. It references those non-terminals that are used for security computations but are not emitted for transport.

1.3. Document Terminology

In this document, we use the following terminology.
"Byte" is a synonym for "octet".

The Constrained Application Protocol (CoAP) is a specialized web transfer protocol for use in constrained systems. It is defined in [RFC7252].

"Context" is used throughout this document to represent information that is not part of the COSE message. Information that is part of the context can come from different sources, including protocol interactions, associated key structures, and application configuration. The context to use can be implicit, identified using either the "kid context" header parameter defined in [RFC8613] or a protocol-specific identifier. Context should generally be included in the cryptographic construction; for more details, see Section 4.4 of [RFC9052].

The term "byte string" is used for sequences of bytes, while the term "text string" is used for sequences of characters.

2. Countersignature Header Parameters

This section defines a set of common header parameters. A summary of these header parameters can be found in Table 1. This table should be consulted to determine the value of the label and the type of the value.

The set of header parameters defined in this section is:

V2 countersignature: This header parameter holds one or more countersignature values. Countersignatures provide a method of having a second party sign some data. The countersignature header parameter can occur as an unprotected attribute in any of the following structures that are defined in [RFC9052]: COSE_sign1, COSE_Signature, COSE_Encrypt, COSE_recipient, COSE_Encrypt0, COSE_Mac, and COSE_Mac0. Details of version 2 countersignatures are found in Section 3.

<table>
<thead>
<tr>
<th>Name</th>
<th>Label</th>
<th>Value Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countersignature</td>
<td>11</td>
<td>COSE_Countersignature / [+ COSE_Countersignature]</td>
<td>V2 countersignature attribute</td>
</tr>
<tr>
<td>version 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Countersignature0</td>
<td>12</td>
<td>COSE_Countersignature0</td>
<td>V2 Abbreviated Countersignature</td>
</tr>
<tr>
<td>version 2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 1: Common Header Parameters*

The CDDL fragment that represents the set of header parameters defined in this section is given below. Each of the header parameters is tagged as optional because they do not need to be in every map; however, the header parameters required in specific maps are discussed above.
3. Version 2 Countersignatures

A countersignature is normally defined as a second signature that confirms a primary signature. A normal example of a countersignature is the signature that a notary public places on a document as witnessing that you have signed the document. A notary typically includes a timestamp to indicate when notarization occurs; however, such a timestamp has not yet been defined for COSE. A timestamp, once defined in a future document, might be included as a protected header parameter. Thus, applying a countersignature to either the COSE_Signature or COSE_Sign1 objects matches this traditional definition. This document extends the context of a countersignature to allow it to be applied to all of the security structures defined. The countersignature needs to be treated as a separate operation from the initial operation even if it is applied by the same user, as is done in [GROUP-OSCORE].

COSE supports two different forms for countersignatures. Full countersignatures use the structure COSE_Countersignature, which has the same structure as COSE_Signature. Thus, full countersignatures can have protected and unprotected attributes, including chained countersignatures. Abbreviated countersignatures use the structure COSE_Countersignature0. This structure only contains the signature value and nothing else. The structures cannot be converted between each other; as the signature computation includes a parameter identifying which structure is being used, the converted structure will fail signature validation.

The version 2 countersignature changes the algorithm used for computing the signature from the original version that is specified in Section 4.5 of [RFC8152]. The new version now includes the cryptographic material generated for all of the structures rather than just for a subset.

COSE was designed for uniformity in how the data structures are specified. One result of this is that for COSE one can expand the concept of countersignatures beyond just the idea of signing a signature to being able to sign most of the structures without having to create a new signing layer. When creating a countersignature, one needs to be clear about the security properties that result. When done on a COSE_Signature or COSE_Sign1, the normal countersignature semantics are preserved. That is, the countersignature makes a statement about the existence of a signature and, when used with a yet-to-be-specified timestamp, a point in time at which the signature exists. When done on a COSE_Mac or COSE_Mac0, the payload is included as well as the MAC value. When done on a COSE_Encrypt or COSE_Encrypt0, the existence of the encrypted data is attested to. It should be noted that there is a distinction between attesting to the encrypted data as opposed to attesting to the unencrypted data. If the latter is what is desired, then one needs to apply a signature to the data and then encrypt that. It is always possible to construct cases where
the use of two different keys results in successful decryption, where the tag check succeeds, but two completely different plaintexts are produced. This situation is not detectable by a countersignature on the encrypted data.

3.1. Full Countersignatures

The COSE_Countersignature structure allows for the same set of capabilities as a COSE_Signature. This means that all of the capabilities of a signature are duplicated with this structure. Specifically, the countersigner does not need to be related to the producer of what is being countersigned, as key and algorithm identification can be placed in the countersignature attributes. This also means that the countersignature can itself be countersigned. This is a feature required by protocols such as long-term archiving services. More information on how countersignatures are used can be found in the evidence record syntax described in [RFC4998].

The full countersignature structure can be encoded as either tagged or untagged, depending on the context. A tagged COSE_Countersignature structure is identified by the CBOR tag 19. The countersignature structure is the same as that used for a signer on a signed object. The CDDL fragment for full countersignatures is:

```
COSE_Countersignature_Tagged = #6.19(COSE_Countersignature)
COSE_Countersignature = COSE_Signature
```

The details of the fields of a countersignature can be found in Section 4.1 of [RFC9052].

An example of a countersignature on a signature can be found in Appendix A.1.1. An example of a countersignature in an encryption object can be found in Appendix A.3.1.

It should be noted that only a signature algorithm with appendix (see Section 8.1 of [RFC9052]) can be used for countersignatures. This is because the body should be able to be processed without having to evaluate the countersignature, and this is not possible for signature schemes with message recovery.

3.2. Abbreviated Countersignatures

Abbreviated countersignatures support encrypted group messaging where identification of the message originator is required but there is a desire to keep the countersignature as small as possible. For abbreviated countersignatures, there is no provision for any protected attributes related to the signing operation. That is, the parameters for computing or verifying the abbreviated countersignatures are provided by the same context used to describe the encryption, signature, or MAC processing.

The CDDL fragment for the abbreviated countersignatures is:

```
COSE_Countersignature0 = bstr
```
The byte string representing the signature value is placed in the Countersignature0 attribute. This attribute is then encoded as an unprotected header parameter.

### 3.3. Signing and Verification Process

In order to create a signature, a well-defined byte string is needed. The Countersign_structure is used to create the canonical form. This signing and verification process takes in the countersignature target structure (COSE_Signature, COSE_Sign1, COSE_Sign, COSE_Mac, COSE_Mac0, COSE_Encrypt, or COSE_Encrypt0), the signer information (COSE_Signature), and the application data (external source). A Countersign_structure is a CBOR array. The target structure of the countersignature needs to have all of its cryptographic functions finalized before computing the signature. The fields of the Countersign_structure, in order, are:

- **context**: A context text string identifying the context of the signature. The context text string is one of the following:
  - "CounterSignature" for countersignatures using the COSE_Countersignature structure when other_fields is absent.
  - "CounterSignature0" for countersignatures using the COSE_Countersignature0 structure when other_fields is absent.
  - "CounterSignatureV2" for countersignatures using the COSE_Countersignature structure when other_fields is present.
  - "CounterSignature0V2" for countersignatures using the COSE_Countersignature0 structure when other_fields is present.

- **body_protected**: The serialized protected attributes from the target structure, encoded in a bstr type. If there are no protected attributes, a zero-length byte string is used.

- **sign_protected**: The serialized protected attributes from the signer structure, encoded in a bstr type. If there are no protected attributes, a zero-length byte string is used. This field is omitted for the Countersignature0V2 attribute.

- **external_aad**: The externally supplied additional authenticated data (AAD) from the application, encoded in a bstr type. If this field is not supplied, it defaults to a zero-length byte string. (See Section 4.4 of [RFC9052] for application guidance on constructing this field.)

- **payload**: The payload to be signed, encoded in a bstr type. The payload is placed here independently of how it is transported.

- **other_fields**: Omitted if there are only two bstr fields in the target structure. This field is an array of all bstr fields after the second. As an example, this would be an array of one element for the COSE_Sign1 structure containing the signature value.

The CDDL fragment that describes the above text is:
How to compute a countersignature:

1. Create a Countersign_structure and populate it with the appropriate fields.
2. Create the value ToBeSigned by encoding the Countersign_structure to a byte string, using the encoding described in Section 4.
3. Call the signature creation algorithm passing in K (the key to sign with), alg (the algorithm to sign with), and ToBeSigned (the value to sign).
4. Place the resulting signature value in the correct location. This is the "signature" field of the COSE_Countersignature structure for full countersignatures (see Section 3.1). This is the value of the Countersignature0 attribute for abbreviated countersignatures (see Section 3.2).

The steps for verifying a countersignature:

1. Create a Countersign_structure and populate it with the appropriate fields.
2. Create the value ToBeSigned by encoding the Countersign_structure to a byte string, using the encoding described in Section 4.
3. Call the signature verification algorithm passing in K (the key to verify with), alg (the algorithm used to sign with), ToBeSigned (the value to sign), and sig (the signature to be verified).

In addition to performing the signature verification, the application performs the appropriate checks to ensure that the key is correctly paired with the signing identity and that the signing identity is authorized before performing actions.

4. CBOR Encoding Restrictions

The deterministic encoding rules are defined in Section 4.2 of [RFC8949]. These rules are further narrowed in Section 9 of [RFC9052]. The narrowed deterministic encoding rules MUST be used to ensure that all implementations generate the same byte string for the "to be signed" value.

5. IANA Considerations

The registries and registrations listed below were created during the processing of [RFC152]. The majority of the actions are to update the references to point to this document.
5.1. CBOR Tags Registry
IANA created a registry titled "CBOR Tags" registry as part of processing RFC 7049, which was subsequently replaced by [RFC8949].

IANA has assigned a new tag for the CounterSignature type in the "CBOR Tags" registry.

Tag: 19  
Data Item: COSE_Countersignature  
Semantics: COSE standalone V2 countersignature  
Reference: RFC 9338

5.2. COSE Header Parameters Registry
IANA created a registry titled “COSE Header Parameters” as part of processing [RFC8152].

IANA has registered the Countersignature version 2 (label 11) and Countersignature0 version 2 (label 12) in the "COSE Header Parameters" registry. For these entries, the "Value Type" and "Description" are shown in Table 1, the "Value Registry" is blank, and the "Reference" is "RFC 9338".

<table>
<thead>
<tr>
<th>Name</th>
<th>Label</th>
<th>Value Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countersignature version 2</td>
<td>11</td>
<td>COSE_Countersignature / [+ COSE_Countersignature ]</td>
<td>V2 countersignature attribute</td>
</tr>
<tr>
<td>Countersignature0 version 2</td>
<td>12</td>
<td>COSE_Countersignature0</td>
<td>V2 Abbreviated Countersignature</td>
</tr>
</tbody>
</table>

Table 2: New Common Header Parameters
IANA has modified the existing "Description" field for "counter signature" (7) and "CounterSignature0" (9) to include the words "(Deprecated by RFC 9338)".

6. Security Considerations
Please review the Security Considerations section in [RFC9052]; these considerations apply to this document as well, especially the need for implementations to protect private key material.

When either COSE_Encrypt or COSE_Mac is used and more than two parties share the key, data origin authentication is not provided. Any party that knows the message-authentication key can compute a valid authentication tag; therefore, the contents could originate from any one of the parties that share the key.
Countersignatures of COSE_Encrypt and COSE_Mac with short authentication tags do not provide the security properties associated with the same algorithm used in COSE_Sign. To provide 128-bit security against collision attacks, the tag length **MUST** be at least 256 bits. A countersignature of a COSE_Mac with AES-MAC (using a 128-bit key or larger) provides at most 64 bits of integrity protection. Similarly, a countersignature of a COSE_Encrypt with AES-CCM-16-64-128 provides at most 32 bits of integrity protection.

7. References

7.1. Normative References


7.2. Informative References


Appendix A. Examples

This appendix includes a set of examples that show the different features and message types that have been defined in this document. To make the examples easier to read, they are presented using the extended CBOR diagnostic notation (defined in [RFC8610]) rather than as a binary dump.

The examples are presented using the CBOR diagnostic notation. A Ruby-based tool exists [CBORDIAG] that can convert between the diagnostic notation and binary. The referenced webpage includes installation instructions.

The diagnostic notation can be converted into binary files using the following command line:

```bash
diag2cbor.rb < inputfile > outputfile
```

The examples can be extracted from the XML version of this document via an XPath expression, as all of the sourcecode is tagged with the attribute 'type="cbor-diag"'. (Depending on the XPath evaluator one is using, it may be necessary to deal with &gt; as an entity.)

```xpath
//sourcecode[@type='cbor-diag']/text()
```

This appendix uses the following terms:

- AES-GCM: AES Galois/Counter Mode
- CEK: content-encryption key
- ECDH: Elliptic Curve Diffie-Hellman
- ECDH-ES: Elliptic Curve Diffie-Hellman Ephemeral Static
- ECDSA: Elliptic Curve Digital Signature Algorithm
- EdDSA: Edwards-curve Digital Signature Algorithm
HKDF: HMAC-based Key Derivation Function

HMAC: Hashed Message Authentication Code

A.1. Examples of Signed Messages

A.1.1. Countersignature

This example uses the following:

Signature Algorithm: ECDSA with SHA-256, Curve P-256

The same header parameters are used for both the signature and the countersignature.

The size of the binary file is 180 bytes.

```
98 {
  / protected / 'h'' ,
  / unprotected / {
    / countersign / 11 : [ 
      / protected / 'a10126' / << { 
        / alg / 1 : -7 / ECDSA 256 /
      } >> ,
      / unprotected / { 
        / kid / 4 : '11' 
      }, 
      / signature / '5ac05e289d5d0e1b0a7f048a5d2b643813ded50bc9e49220f4f7278f85f19d4a77d655c9d3b51e805a74b099e1e085aacc97fc29d72f828e802bb6630cccb2c' 
    ],
    / payload / 'This is the content.',
    / signatures / [ 
      / protected / 'a10126' / << { 
        / alg / 1 : -7 / ECDSA 256 /
      } >> ,
      / unprotected / { 
        / kid / 4 : '11' 
      },
      / signature / 'e2aeafd40d69d19dfe6e52077c5d7ff4e408282cbebfb5d06cf414af2e19d982ac45ac98b8544c908b4507de1e90b717c3d34816fe926a2b98f53af2fa0f30a' 
    ]
  }
}
```
A.2. Examples of Signed1 Messages

A.2.1. Countersignature

This example uses the following:

Signature Algorithm: ECDSA with SHA-256, Curve P-256

Countersignature Algorithm: ECDSA with SHA-512, Curve P-521

The size of the binary file is 275 bytes.

```plaintext
18( [
   / protected h'A201260300' / << {  
      / alg / 1:-7, / ECDSA 256 /  
      / ctyp / 3:0 
   } >>,  
   / unprotected / {  
      / kid / 4: '11',  
      / protected h'A1013823' / << {  
         / alg / 1:-36 / ECDSA 512 /  
      } >>,  
      / unprotected / {  
         / kid / 4: 'bilbo.baggins@hobbiton.example'  
      },  
      / signature / h'01B1291B0E60A79C459A4A9184A0D393E034B34AF069A1CCA345F5A913AFFFF698002295FA99F8FCBF6FDDF59132FC0C46E98754A98F1F8EB8C0309F548B856BC470170227206FA5BEE3C0431C56A66824E7AAAF6929B5925E31271434B2A2E47A335C658BE59954EB563CF2D0CDBD367D3E4CC8FFFD53B70D115BA9E86961FBD1A5CF'  
   },  
   / payload / 'This is the content.',  
   / signature / h'BB587D6B015F47BFD54D2CBFCECEF75451E92B08A514BD439FA3AA65C64AC92DF0D7328C4A47529B32ADD3DD1B4E940071C021E9A8F2641F1D8E3B053D0D65AE52'  
] )
```

A.3. Examples of Enveloped Messages

A.3.1. Countersignature on Encrypted Content

This example uses the following:

CEK: AES-GCM with 128-bit key

Recipient Class: ECDH Ephemeral-Static, Curve P-256
Countersignature Algorithm: ECDSA with SHA-512, Curve P-521

The size of the binary file is 326 bytes.

A.4. Examples of Encrypted Messages
A.4.1. Countersignature on Encrypted Content
This example uses the following:

```json
96{
   / protected h'a10101' / << {
      / alg / 1:1 / AES-GCM 128 / 
   } >>,
   / unprotected / {
      / iv / 5:h'c9cf4df2fe6c632bf7886413',
      / countersign / 11: {
         / protected h'a1013823' / << {
            / alg / 1:-36 / ES512 / 
         } >>,
         / unprotected / {
            / kid / 4: 'bilbo.baggins@hobbiton.example'
         }
      }
   }
}

},
/ciphertext / h'7adbe2709ca818fb415f1e5df66f4e1a51053ba6d65a1a0c52a357da7a644b8070a151b0',
/recipients / {
   / protected h'a1013818' / << {
      / alg / 1:-25 / ECDH-ES + HKDF-256 / 
   } >>,
   / unprotected / {
      / ephemeral / -1: {
         / kty / 1:2,
         / crv / -1:1,
         / x / -2:h'98f50a4ff6c05861c8860d13a638ea56c3f5ad7590bbf
bf054e1c7b4d91d6280',
      / y / -3:true
   },
   / kid / 4: 'meriadoc.brandybuck@buckland.example'
   },
   / ciphertext / h''
}
```
CEK: AES-GCM with 128-bit key

Countersignature Algorithm: EdDSA with Curve Ed25519

The size of the binary file is 136 bytes.

```
16(
    [  
        / protected h'A10101' / << { 
            / alg / 1:1 / AES-GCM 128 / 
        }>>, 
        / unprotected / { 
            / iv / 5: h'02D1F7E6F26C43D4868D87CE', 
            / countersign / 11: [ 
                / protected h'A10127' / << { 
                    / alg / 1:-8 / EdDSA with Ed25519 / 
                }>>, 
                / unprotected / { 
                    / kid / 4: '11' 
                }}, 
            / signature / h'E10439154CC75C7A3A5391491F88651E0292FD0FE0E0 
            2CF740547EAF6677B4A4040B8ECA16DB592881262F77B14C1A086C02268B17171CA1 
            6BE4B8595F8C0A08' 
        }], 
    / ciphertext / h'60973A94BB2898009EE52ECFD9AB1DD25867374B162E2C0 
    3568B41F57C3CC16F9166250A' 
}
```

A.5. Examples of MACed Messages

A.5.1. Countersignature on MAC Content

This example uses the following:

MAC Algorithm: HMAC/SHA-256 with 256-bit key

Countersignature Algorithm: EdDSA with Curve Ed25519

The size of the binary file is 159 bytes.
A.6. Examples of MAC0 Messages

A.6.1. Countersignature on MAC0 Content

This example uses the following:

MAC Algorithm: HMAC/SHA-256 with 256-bit key
Countersignature Algorithm: EdDSA with Curve Ed25519

The size of the binary file is 159 bytes.
Acknowledgments

This document is a product of the COSE Working Group of the IETF.

The initial draft version of the specification was based to some degree on the outputs of the JOSE and S/MIME Working Groups.

Jim Schaad passed on 3 October 2020. This document is primarily his work. Russ Housley served as the document editor after Jim’s untimely death, mostly helping with the approval and publication processes. Jim deserves all credit for the technical content.

Jim Schaad and Jonathan Hammell provided the examples in Appendix A.

The reviews by Carsten Bormann, Ben Kaduk, and Elwyn Davies greatly improved the clarity of the document.

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