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RFC 9921
CBOR Object Signing and Encryption (COSE) Header Parameter for Timestamp Tokens as Defined in RFC 3161

Abstract

This document defines two CBOR Object Signing and Encryption (COSE) header parameters for incorporating timestamping based on RFC 3161 into COSE message structures (`COSE_Sign` and `COSE_Sign1`). This enables the use of established timestamping infrastructure per RFC 3161 in COSE-based protocols.

Status of This Memo

This is an Internet Standards Track document.

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1. Introduction

RFC 3161 [RFC3161] provides a method for timestamping a message digest to prove that it was created before a given time.

This document defines two new CBOR Object Signing and Encryption (COSE) [RFC9052] header parameters that carry the `TimeStampToken` (TST) output [RFC3161], thus allowing existing and widely deployed trust infrastructure to be used with COSE structures used for signing (`COSE_Sign` and `COSE_Sign1`).

1.1. Use Cases

This section discusses two use cases, each representing one of the two modes of use defined in Section 2. As the security characteristics of the two cases differ, care must be taken when choosing the appropriate mode for a given application. See Section 5.1 for a discussion on the security of the implementations.

The primary use case is that of "long-term signatures", i.e., signatures that can still be verified even after the signing certificate has expired. This can address situations where it is important to prevent subsequent denial by the signer or to verify signatures made using (very) short-term certificates. To achieve this, the document signer acquires a fresh TST for the document's signature from a trusted Time Stamping Authority (TSA) [RFC3161] and concatenates it with the document. Later, when a relying party verifies the signed document and its associated TST, they can be certain that the document was signed *at least* at the time specified by the TSA and that the signing certificate was valid at the time the signature was made.

This primary usage scenario motivates the "COSE, Then Timestamp" mode described in Section 2.1.

The second use case is new. It is the notarization of a signed document by registering it with a transparency service. This is common practice for ensuring the accountability and auditability of issued documents, which are typically referred to as "statements" in this context. It is also common practice to only register the signed parts of a statement (the "signed statement" portion) with a transparency service, in order to reduce the complexity of consistency checks at a later stage and to avoid the need to retrieve or reconstruct unsigned parts. Once the signed parts of a document have been registered in the append-only log at a transparency service, the log entry cannot be changed. In order to avoid losing the TST during the registration process, the TST must be included in the signed statement. To achieve this, the issuer acquires a TST from a TSA, includes it in the to-be-signed part of the statement so that the resulting signed statement includes the TST, and then registers the signed parts (rendering it a "transparent statement"). Later on, a relying party consuming the transparent statement including the TST can be certain that the statement was signed by the issuer *at least* at the time specified by the TSA. If the issuer's signing key has expired (or has been compromised), the authenticity of the statement can be ascertained by ensuring that no revocation information was made public before the time asserted by the issuer and registered at the transparency service.

This new usage scenario motivates the "Timestamp, Then COSE" mode defined in Section 2.2.

1.2. Requirements Notation

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.

2. Modes of Use

There are two different modes of composing COSE protection and timestamping, motivated by the usage scenarios discussed above.

The diagrams in this section illustrate the processing flow of the specified modes. For simplicity, only the `COSE_Sign1` processing is shown. Similar diagrams for `COSE_Sign` can be derived by allowing multiple `private-key` parallelogram boxes and replacing the label `[signature]` with `[signatures]`.

2.1. COSE, Then Timestamp (CTT)

Figure 1 shows the case where the signature(s) field of the COSE Signed Message is digested and submitted to a TSA to be timestamped. The obtained timestamp token is then added back as an unprotected header into the same COSE object.

This mode is utilized when a record of the timing of the signature operation is desired.
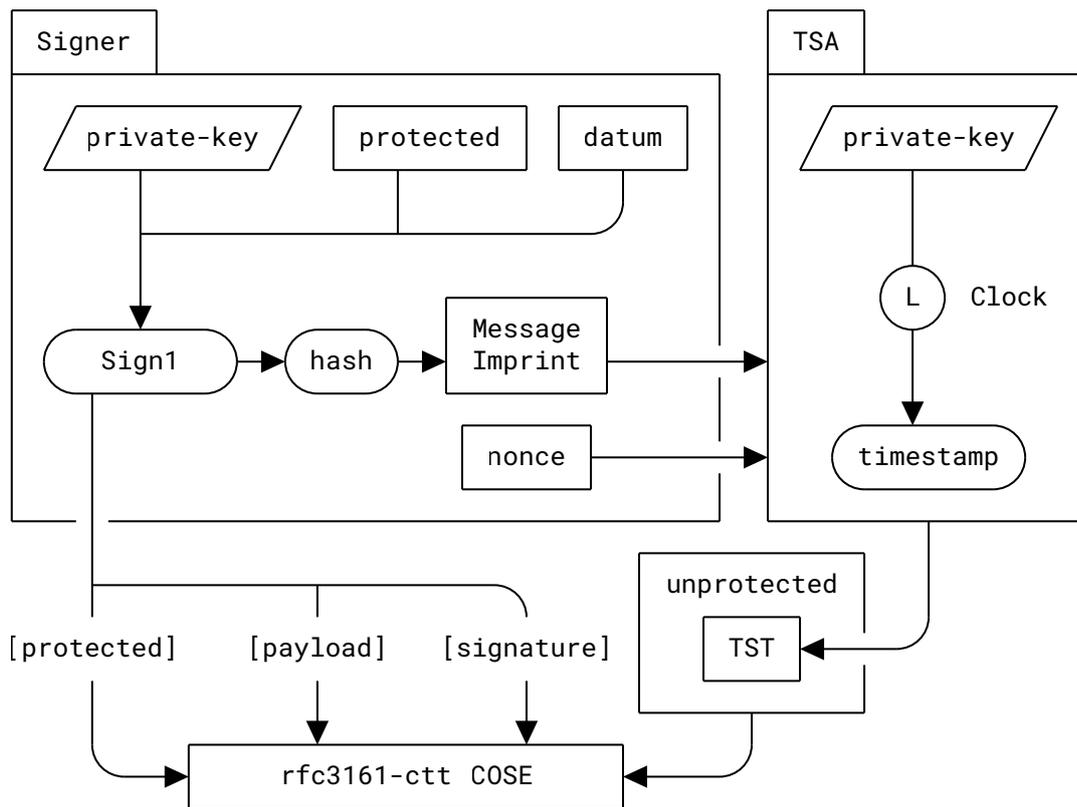
Figure 1: COSE, Then Timestamp (CTT)

In this context, timestamp tokens are similar to a countersignature made by the TSA.

2.2. Timestamp, Then COSE (TTC)

Figure 2 shows the case where a datum is first digested and submitted to a TSA to be timestamped.

This mode is used to wrap the signed document and its timestamp together in an immutable payload.

A COSE Signed Message is then built as follows:

• The obtained timestamp token is added to the protected headers.
• The original datum becomes the payload of the COSE Signed Message.
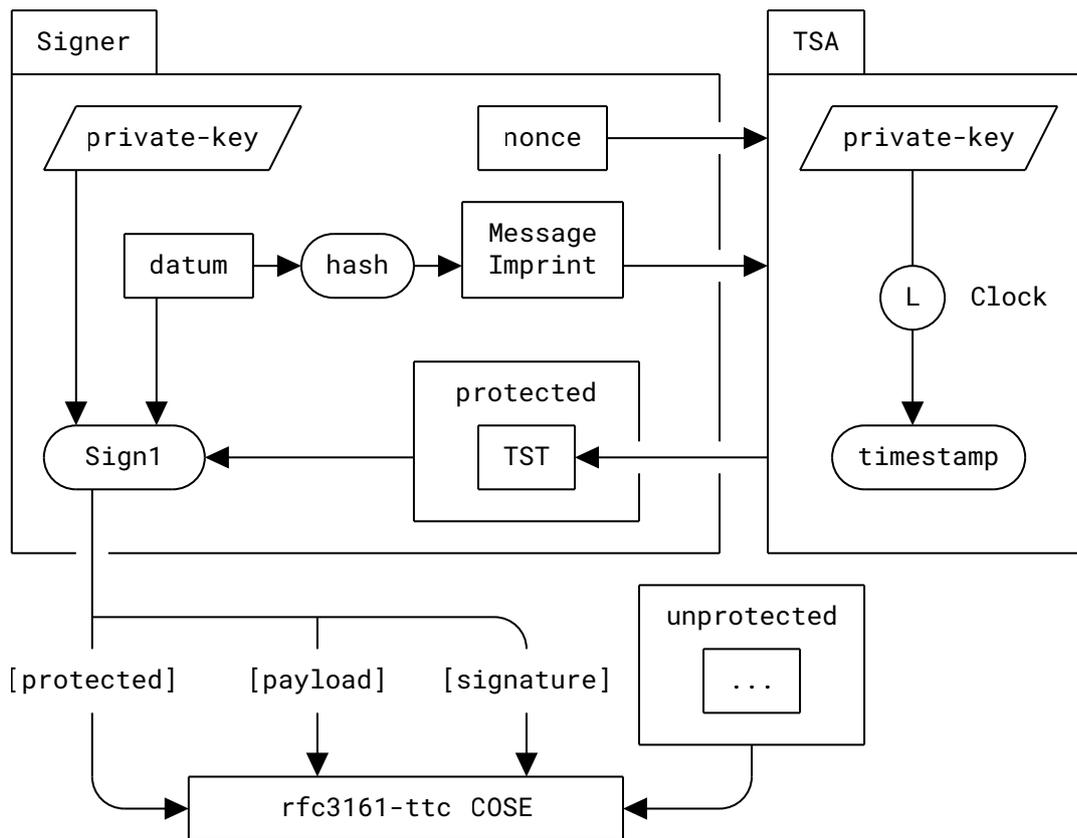
Figure 2: Timestamp, Then COSE (TTC)

3. Timestamp Tokens per RFC 3161: COSE Header Parameters

The two modes described in Sections 2.2 and 2.1 use different inputs into the timestamping machinery and consequently create different kinds of bindings between COSE and TST. To clearly separate their semantics, two different COSE header parameters are defined as described in the following subsections.

3.1. 3161-ctt

The `3161-ctt` COSE *unprotected* header parameter **MUST** be used for the mode described in Section 2.1.

The `3161-ctt` unprotected header parameter contains a DER-encoded TST [RFC3161] wrapped in a CBOR byte string (Major type 2).

The `MessageImprint` sent in the request to the TSA **MUST** be

  • the hash of the CBOR-encoded signature field of the `COSE_Sign1` message, or

  • the hash of the CBOR-encoded signatures field of the `COSE_Sign` message.

In either case, to minimize dependencies, the hash algorithm **SHOULD** be the same as the algorithm used for signing the COSE message. This may not be possible if the timestamp token has been obtained outside the processing context in which the COSE object is assembled.

Refer to Sections 3.1.1 and 3.1.2 for concrete examples of `MessageImprint` computation.

3.1.1. `MessageImprint` Computation for `COSE_Sign1`

The following illustrates how `MessageImprint` is computed using a sample `COSE_Sign1` message.

Given the `COSE_Sign1` message

```
18(
  [
    / protected h'a10126' / << {
        / alg / 1:-7 / ECDSA 256 /
      } >>,
    / unprotected / {
      / kid / 4:'11'
    },
    / payload / 'This is the content.',
    / signature / h'8eb33e4ca31d1c465ab05aac34cc6b23d58fef5c083106c4
d25a91aef0b0117e2af9a291aa32e14ab834dc56ed2a223444547e01f11d3b0916e5
a4c345cacb36'
  ]
)
```

the `bstr`-wrapped `signature`

```
58 40                                      # bytes(64)
   8eb33e4ca31d1c465ab05aac34cc6b23
   d58fef5c083106c4d25a91aef0b0117e
   2af9a291aa32e14ab834dc56ed2a2234
   44547e01f11d3b0916e5a4c345cacb36
```

(including the heading bytes `0x5840`) is used as input for computing the `MessageImprint`.

When using SHA-256, the resulting `MessageImprint` is

```
SEQUENCE {
  SEQUENCE {
    OBJECT IDENTIFIER sha-256 (2 16 840 1 101 3 4 2 1)
    NULL
    }
  OCTET STRING
    44 C2 41 9D 13 1D 53 D5 55 84 B5 DD 33 B7 88 C2
    4E 55 1C 6D 44 B1 AF C8 B2 B8 5E 69 54 76 3B 4E
  }
```

3.1.2. `MessageImprint` Computation for `COSE_Sign`

The following illustrates how `MessageImprint` is computed using a sample `COSE_Sign` message.

Given the `COSE_Sign` message

```
98(
  [
    / protected / h'',
    / unprotected / {},
    / payload / 'This is the content.',
    / signatures / [
      [
        / protected h'a10126' / << {
            / alg / 1:-7 / ECDSA 256 /
          } >>,
        / unprotected / {
          / kid / 4:'11'
        },
        / signature / h'e2aeafd40d69d19dfe6e52077c5d7ff4e408282cbefb
5d06cbf414af2e19d982ac45ac98b8544c908b4507de1e90b717c3d34816fe926a2b
98f53afd2fa0f30a'
      ]
    ]
  ]
)
```

the `signatures` array

```
81                                                   # array(1)
   83                                                # array(3)
     43                                              # bytes(3)
       a10126
     a1                                              # map(1)
       04                                            # unsigned(4)
       42                                            # bytes(2)
          3131                                       # "11"
     58 40                                           # bytes(64)
       e2aeafd40d69d19dfe6e52077c5d7ff4
       e408282cbefb5d06cbf414af2e19d982
       ac45ac98b8544c908b4507de1e90b717
       c3d34816fe926a2b98f53afd2fa0f30a
```

is used as input for computing the `MessageImprint`.

When using SHA-256, the resulting `MessageImprint` is

```
SEQUENCE {
  SEQUENCE {
    OBJECT IDENTIFIER sha-256 (2 16 840 1 101 3 4 2 1)
    NULL
    }
  OCTET STRING
    80 3F AD A2 91 2D 6B 7A 83 3A 27 BD 96 1C C0 5B
    C1 CC 16 47 59 B1 C5 6F 7A A7 71 E4 E2 15 26 F7
  }
```

3.2. `3161-ttc`

The `3161-ttc` COSE *protected* header parameter **MUST** be used for the mode described in Section 2.2.

The `3161-ttc` protected header parameter contains a DER-encoded TST [RFC3161] wrapped in a CBOR byte string (Major type 2).

The `MessageImprint` sent to the TSA (Section 2.4 of [RFC3161]) **MUST** be the hash of the payload of the COSE Signed Message. This does not include the `bstr` wrapping -- only the payload bytes. (For an example, see Appendix A.1.)

To minimize dependencies, the hash algorithm used for signing the COSE message **SHOULD** be the same as the algorithm used in the `MessageImprint` [RFC3161]. However, this may not be possible if the timestamp requester and the COSE message signer are different entities.

4. Timestamp Processing

Timestamp tokens [RFC3161] use Cryptographic Message Syntax (CMS) as the signature envelope format. [RFC5652] provides details about signature verification, and [RFC3161] provides details specific to timestamp token validation. The payload of the signed timestamp token is the `TSTInfo` structure defined in [RFC3161], which contains the `MessageImprint` that was sent to the TSA. The hash algorithm is contained in the `MessageImprint` structure, together with the hash itself.

As part of the signature verification, the receiver **MUST** make sure that the `MessageImprint` in the embedded timestamp token matches a hash of either the payload, signature, or signature fields, depending on the mode of use and type of COSE structure.

Appendix B of [RFC3161] provides an example that illustrates how timestamp tokens can be used to verify signatures of a timestamped message when utilizing X.509 certificates.

5. Security Considerations

Please review the Security Considerations section in [RFC3161]; these considerations apply to this document as well.

Also review the Security Considerations section in [RFC9052]. These considerations apply to this document as well, particularly with regard to the need for implementations to protect private key material. Additionally, solutions based on the COSE header parameters defined in this document must be able to report compromised keys promptly.

The following scenario assumes that an attacker can manipulate the clocks on the COSE signer and its relying parties, but not the TSA. It is also assumed that the TSA is a trusted third party, so the attacker cannot impersonate the TSA and create valid timestamp tokens. In such a setting, any tampering with the COSE signer's clock does not have an impact, because once the timestamp is obtained from the TSA, it becomes the only reliable source of time. However, in both CTT mode and TTC mode, a denial of service can occur if the attacker can adjust the relying party's clock so that the CMS validation fails. This could disrupt the timestamp validation.

In CTT mode, an attacker could manipulate the unprotected header by removing or replacing the timestamp. To avoid that, the COSE Signed Message should be integrity protected during transit and at rest.

In TTC mode, the TSA is given an opaque identifier (a cryptographic hash value) for the payload. While this means that the content of the payload is not directly revealed, to prevent comparison with known payloads or disclosure of identical payloads being used over time, the payload would need to be armored, e.g., with a nonce that is shared with the recipient of the header parameter but not the TSA. Such a mechanism is out of scope for this document.

The resolution, accuracy, and precision of the TSA clock, as well as the expected latency introduced by round trips to and from the TSA, must be taken into account when implementing solutions based on the COSE header parameters defined in this document.

5.1. Avoiding Semantic Confusion

CTT mode and TTC mode have different semantic meanings. An implementation must ensure that the contents of the CTT and TTC headers are interpreted according to their specific semantics. In particular, symmetric to the signature and assembly mechanics, each mode has its own separate verification algorithm.

Implementers **MUST** clearly differentiate between TSA timestamps [RFC3161] proving the existence of payload data at an earlier point in time (TTC) and timestamps explicitly providing evidence of the existence of the cryptographic signature (CTT). Failure to clearly distinguish between these timestamp semantics can result in vulnerabilities, such as incorrectly accepting signatures created after key revocation based on older payload-only timestamps. Validators must not interpret protected-header payload timestamps as proof of signature creation time and should rely exclusively on TSA timestamps [RFC3161] explicitly covering signature data for determining signature validity timing.

6. IANA Considerations

IANA has allocated the COSE header parameters defined in Table 1 in the "COSE Header Parameters" registry [IANA.cose_header-parameters] as follows:

Name	Label	Value Type	Value Registry	Description	Reference
3161-ttc	269	bstr	-	Timestamp Token per [RFC3161]: Timestamp, Then COSE	RFC 9921, Section 3.2
3161-ctt	270	bstr	-	Timestamp Token per [RFC3161]: COSE, Then Timestamp	RFC 9921, Section 3.1

Table 1: New COSE Header Parameters

7. Normative References

[IANA.cose_header-parameters]   IANA, "COSE Header Parameters", <https://www.iana.org/assignments/cose>.

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

[RFC3161]   Adams, C., Cain, P., Pinkas, D., and R. Zuccherato, "Internet X.509 Public Key Infrastructure Time-Stamp Protocol (TSP)", RFC 3161, DOI 10.17487/RFC3161, August 2001, <https://www.rfc-editor.org/info/rfc3161>.

[RFC5652]   Housley, R., "Cryptographic Message Syntax (CMS)", STD 70, RFC 5652, DOI 10.17487/RFC5652, September 2009, <https://www.rfc-editor.org/info/rfc5652>.

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

[RFC9052]   Schaad, J., "CBOR Object Signing and Encryption (COSE): Structures and Process", STD 96, RFC 9052, DOI 10.17487/RFC9052, August 2022, <https://www.rfc-editor.org/info/rfc9052>.

Appendix A. Examples

A.1. TTC

The payload

```
'This is the content.'
```

is hashed using SHA-256 to create the following `TimeStampReq` object

```
SEQUENCE {
  INTEGER 1
  SEQUENCE {
    SEQUENCE {
      OBJECT IDENTIFIER sha-256 (2 16 840 1 101 3 4 2 1)
      NULL
      }
    OCTET STRING
      09 E6 38 D4 AA 95 FD 72 71 86 62 03 59 53 03 BC
      E2 32 F4 62 A9 4D 38 E3 93 77 3C D3 AA E3 F6 B0
    }
  BOOLEAN TRUE
  }
```

which is sent to the TSA.

A `TimeStampResp` containing the following TST is returned:

```
SEQUENCE {
  OBJECT IDENTIFIER signedData (1 2 840 113549 1 7 2)
  [0] {
    SEQUENCE {
      INTEGER 3
      SET {
        SEQUENCE {
          OBJECT IDENTIFIER sha-512 (2 16 840 1 101 3 4 2 3)
          NULL
          }
        }
      SEQUENCE {
        OBJECT IDENTIFIER tSTInfo (1 2 840 113549 1 9 16 1 4)
        [0] {
          OCTET STRING, encapsulates {
            SEQUENCE {
              INTEGER 1
              OBJECT IDENTIFIER '1 2 3 4 1'
              SEQUENCE {
                SEQUENCE {
                  OBJECT IDENTIFIER sha-256 (2 16 840 1 101 3 4 2 1)
                  NULL
                  }
                OCTET STRING
                  09 E6 38 D4 AA 95 FD 72 71 86 62 03 59 53 03 BC
                  E2 32 F4 62 A9 4D 38 E3 93 77 3C D3 AA E3 F6 B0
                }
              INTEGER 12096870
              GeneralizedTime 29/08/2025 07:45:46 GMT
              BOOLEAN TRUE
  [...]
```

The contents of the TST are `bstr`-wrapped and added to the protected headers bucket, which is then signed alongside the original payload to obtain the `COSE_Sign1` object.

```
18([
        <<{1: -7, 269: h'3082154906092a864886f70d010702a082153a308215
36020103310f300d06096086480165030402030500308201084060b2a864886f70d010
9100104a08201730482016f3082016b02010106042a0304013031300d060960864801
650304020105000042009e638d4aa95fd7271866203595303bce232f462a94d38e3937
73cd3aae3f6b0020400b89566180f3230323530383239303734353436350101ffa082
0111a482010d308201093111300f060355040a13084672656520545341310c300a060
355040b1303545341317630740603550d136d546869732063657274696669636174
6520469676974616c6c79207369676e20646f63756d656e7473206e6420746f6696
d65207374616d7020726571756573747320d61646520777369696e6720746865206672
65657473612e6f7267206f6e6c696e6520736572766963657331183016060355040431
30f7777772e667265657473612e6f726731223020006092a864886f70d010901116136
27573696c657a617340676d61696c2e636f6d311230100603550407130957775727a6
2757267310b3009060355040613024445310f300d060355040813064261796572650a0
8210083082080130820.5e9a00302010202090c1e986160da8e982300d06092a86488
6f70d01010d05003081953111300f060355040a130846726565205453413110300e06
0355040b1307526f6f74204341311183016060355040313f7777772e6672656574473
12e6f72673122302006092a864886f70d0109011613627573696c657a617340676d61
696c2e636f6d311230100603550407130957775727a62757267310f300d0603550401
08130642617965726e310b300906035504061302444531e170d313630333133033135
3733395a170d3236303331313031353733395a308201093111300f060355040a13084
67265652054534131f0c300a060355040b130354534131317630740603550d136d5468
697320636572746966696361746520646967697461616c6c79207369676e20646f637
56d656e747320616e642074696d65207374616d702072657175657374732073206d616465
207573696e672074686520667265657473612e6f7267206f6e6c696e65207365727661766
963657331183016060355040413f7777772e667265657473612e6f7267312230200
6092a864886f70d0109011613627573696c657a617340676d61696c2e636f6d311230
100603550407130957775727a62757267310b3009060355040613024445310f300d06
0355040813064261796572656e30820222300d06092a864886f70d010101050003820
f003082020a0282020100b591048c4e486f34e9dc08627fc2375162236984b82cb130
beff517cfc38f84bce5c65a874dab2621ae0bce7e33563e0ede934fd5f8823159f078
48808227460c1ed88261706f4281334359dfbb81bd1353fc179610af1a8c8c865dc00
ea23b3a89be6bd03ba85a9ec827d60565905e22d6a584ed1380ae150280cee397e98a
012f380464007862443bc077cb95f421af31712d9683cdb6dffbaf3c8ba5ba566ae52
3d459d6177346d4d840e27886b7c01c5b890d78a2e27bba8dd2f9a2812e157d62f921
c65962548069dcdb7d06de181de0e9570d66f87220ce28b628ab55906f3ee0c210f70
51e8f4858af8b9a92d09e46af2d9cba5bfcfad168cdf604491a4b06603b114caf7031
f065e7eeefa53c575f3490c059d2e32ddc76ac4d4c4c710683b97fd1be591bc610551
86d88f9a0391b307b6f91ed954daa36f9acd6a1e14aa2e4adf17464b54db18dbb6ffe
30080246547370436ce4e77bae5de6fe0f3f9d6e7ffbeb461e794e92fb0951f8aae61
a412cce9b21074635c8be327ae1a0f6b4a646eb0f8463bc63bf845530435d19e80251
1ec9f66c3496952d8becb69b0aa4d4c41f60515fe7dcbb89319cdda59ba6aea4be3ce
ae718e6fcb6ccd7db9fc50bb15b12f3665b0aa307289c2e6dd4b111ce48ba2d9efdb5
a6b9a506069334fb34f6fc7ae330f0b34208aac80df3266fdd90465876ba2cb898d95
05315b6e7b0203010001a38201db308201d730090603551d1304023000301d0603551
d0e041604146e760b7b4e4f9ce160ca6d2ce927a2a294b37737301f0603551d230418
30168014fa550d8c346651434cf7e7b3a76c95af7ae6a497300b0603551d0f0404030
206c030160603551d250101ff040c300a06082b06010505070308306306082b060105
05070101045730553602a06082b060105050730028261e687474703a2f2f7777772e667
265657473612e6f72672f7473612e637274302706082b06010505073001861b687474
703a2f2f7777772e667265657473612e6f72673a323533630307060603551d1f043030
2e302ca02aa0288626687474703a2f2f7777772e667265657473612e6f72672f63726c
2f726f6f745f63612e63726c3081c60603551d200481be3081bb3081b80601003081b
2303306082b060105050702011627687474703a2f2f7777772e667265657473612e6f
72672f667265657473615f6370732e68746d6c303206082b06010505070201162668747
4703a2f2f7777772e667265657473612e6f72672f667265657473615f6370732e70
64663047060082b060105050702023b1a3946726565545341207472757374656420207
```

```
4696d657374616d70696e6720536f6674776172652061732061205365727769636520
285361615329300d06092a864886f70d01010d05000382020100a5c944e2c6fac0a14
d930a7fd0a0b172b41fc1483c3e957c68a2bcd9b9764f1a950161fd72472d41a5eed2
77786203b5422240fb3a26cde176087b6fb1011df4cc19e2571aa4a051109665e94c4
6f50bd2adee6ac4137e251b25a39dabda451515d8ff9e07209e8ec20b7874f7e1a0ed
e7c00937fe84a334f8b3265ced2d8ed9df61396583677feb382c1ee3b23e6ea5f05df
30de7b9f89005d25266f612f39c8b4f6daba6d7bfbac19632b90637329f52a6f066a1
0e43eaa81f849a6c5fe3fe8b5ea23275f687f2052e502ea6c30762a668cce07871dd8
e97e315bba929e25589977a0a312ce96c5106b1437c779f2b361b182888f3ee8a2343
74fa063e956192627f7c431073965d1260928eba009e803429ae324cf96f042354f37
bca5afddc79f79346ab388bfc79f01dc9861254ea6cc129941076b83d20556f3be513
26837f2876f7833b370e7c3d410523827d4f53400c72218d75229ff10c6f8893a9a3a
1c0c42bb4c898c13df41c7f6573b4fc56515971a610a7b0d2857c8225a9fb204eacec
a2e8971aa1af87886a2ae3c72fe0a0aae842980a77bef16b92115458090d982b59466
03764e75a0ad3d11454b9986f678b9ab6afe8497033ae3abfd4eb43b7bc9dee688159
49e6481582a82e785277f2282107efe390200e0508acb8ea82ea2505276f3c9da2a3d
3b4ad38bbf8842bda36fc2448291f558dc02dd1e0308207ff308205e7a00302010202
0900c1e986160da8e980300d06092a864886f70d01010d05003081953111300f06035
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0603550403130f7777772e667265657473612e6f72673122302006092a864886f70d0
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9577565727a62757267310f300d06035504081306426172796572e310b3009060355040
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1335a3081953111300f060355040a13084672656520545341311300e060355040b130
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0382020f003082020a0282020100b6028e0e3032f11110d964cda94b9d0278e1942a
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dcabc94138056dfcf017e7eb8572fd52f70144f188da05f5823f58dd06297e7387bed
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0403130f7777772e667265657473612e6f72673122302006092a864886f70d0109011
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7473615f6370732e68746d6c303206082b0601050507020116266687474703a2f2f777
7772e667265657473612e6f72672f667265657473615f6370732e706466304706082b
06010505070202303b1a394672656554534120747275737465642074696d657374616
```

```
d70696e6720536f6667477617265520617320612053656572766963652028536161532930
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d7328e07396e60b4f3bb803ad4a555c80fefb53f85e7764a0a9fb4afc399f4cd2f5fb
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c04a0cc1ec4f8d185e2da55dfb7bc2a2036c6219246a4f99ddbb6f1f829398f3b803d
c0ad90dcb59bef4c27c77404b99043b78271867991152c399f12cbfc4c625adc09635
5ae44e342100ec517a502e2f06f940b8d43599bbc1154f8ae761a0b0d555fb4a1391d
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e5e48004d5e166a83c82ec6fd54fb385ebaf7133a85b52de46db5244e1c34ae8d36e7
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c023630b76adaa8d91433825ecc41c49a5b98b181c7da30e997ab954c73c2cd805afd
a993182038a308203860201013081a33081953111300f060355040a13084672656520
5453413110300e060355040b1307526f6f7420434131183016060355040313074f7777
72e667265657473612e6f726773122302006092a864886f70d010901161362757369c
657a617340676d61696c2e636f6d311230100603550407130957565727a6275726273
10f300d0603550408130642617965726e310b3009060355040613024445020900c1e9
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0904314204408831bbe259ac6314847a26804e155a6d04c485b43aa55d2dd4c6dd7f5
943b5bd5a3dd24f05a17a2658ef65759ce4e0001f2b8ff99e38718044ab3784b3f174
b6300d06092a864886f70d0101010500048202000b1536e5491e8e941364fa7f2640d
30bfc8543dd8d472dad2db6df0c0483633d2dd4b9455f05d6e65a48ad9382e03741fc
be1e0c8f7f607bae33979f9f4f71a07d852db0869518733fafe60779867781f584fc5
221a4fbdfd0736e976543ff5170b5520a65ea8b0b04f8f92b39808b4e3ed74d66d63b
a0d1db353baa829db1d1905e4e833fb8f3824acff1a18a4735e5381b89c5e0df92d16
ec0a9a552298c52027e7bde806c153c1161d466d706455c0ae32d0cb108ca86209f57
edc3a7f4b36215170994d9ecb9e69d31bab52567b84a3a1568540469984d9b5b6bf63
4f9d022999cbd6519516d53065f919bee0f520b6b539e2f8fca66f2590c1ce032cb5b
fdb170ad32125372e651ca4fa7a05ac72f7d5814ea324f99ad2c8110c06853fcf7d2a
f1f28543b0f9ceba2a0f1536faabb07587ebe1d1dddd59fc804697928276613f8d146
f966812da7f25748cfcd298891acdfe041632b760677dfd53865d04d186ce7735d119
0aee0b2cddc0c55e6c48acfda749ec20af4dc0739430d10388bc83efed192c22917f2
f4a67474ac5f36e6608bb71631803fd5fb1a78d7973dd2a01c84dda46f9befccebfcb
300ab73628716b8151acf94e58af15de27c141c8d5ef4f82a51bbebc54cb2e1d4ac2f
0c05be7d3db16b9687f5a2fd28fb110f78f82a0ad0370a16cd9cbb59dc0814cba99e1
11e33482e45c9b4f948bff15eba70'}>>,
        {4: '11'},
        'This is the content.',
        h'f5f0f27964f178dcb2254b30fdfdc48abc4499beaea7cb80f4004f30403
f13a44bcca24fc61c5d71d3823bac04b923011dc7d31de35df1aefcd5a8ec5fe0fe6e
'
    ])
```

A.2. CTT

Starting with the following `COSE_Sign1` object,

```
18(
  [
    / protected h'a10126' / << {
        / alg / 1:-7 / ECDSA 256 /
      } >>,
    / unprotected / {
      / kid / 4:'11'
    },
    / payload / 'This is the content.',
    / signature / h'8eb33e4ca31d1c465ab05aac34cc6b23d58fef5c083106c4d
25a91aef0b0117e2af9a291aa32e14ab834dc56ed2a223444547e01f11d3b0916e5a4
c345cacb36'
  ]
)
```

the CBOR-encoded signature field is hashed using SHA-256 to create the following `TimeStampReq` object

```
SEQUENCE {
  INTEGER 1
  SEQUENCE {
    SEQUENCE {
      OBJECT IDENTIFIER sha-256 (2 16 840 1 101 3 4 2 1)
      NULL
      }
    OCTET STRING
      DD 94 71 EF E7 43 C4 05 13 35 DF 8F 6D 28 82 F3
      BA DC 38 77 00 F7 ED 3F 70 91 67 2A 3E EA F7 C8
    }
  BOOLEAN TRUE
  }
```

which is sent to the TSA.

A `TimeStampResp` containing the following TST is returned:

```
SEQUENCE {
  OBJECT IDENTIFIER signedData (1 2 840 113549 1 7 2)
  [0] {
    SEQUENCE {
      INTEGER 3
      SET {
        SEQUENCE {
          OBJECT IDENTIFIER sha-512 (2 16 840 1 101 3 4 2 3)
          NULL
        }
      }
    }
    SEQUENCE {
      OBJECT IDENTIFIER tSTInfo (1 2 840 113549 1 9 16 1 4)
      [0] {
        OCTET STRING, encapsulates {
          SEQUENCE {
            INTEGER 1
            OBJECT IDENTIFIER '1 2 3 4 1'
            SEQUENCE {
              SEQUENCE {
                OBJECT IDENTIFIER sha-256 (2 16 840 1 101 3 4 2 1)
                NULL
              }
              OCTET STRING
                DD 94 71 EF E7 43 C4 05 13 35 DF 8F 6D 28 82 F3
                BA DC 38 77 00 F7 ED 3F 70 91 67 2A 3E EA F7 C8
            }
            INTEGER 12100074
            GeneralizedTime 29/08/2025 07:53:00 GMT
            BOOLEAN TRUE
[...]
```

The contents of the TST are `bstr`-wrapped and added to the unprotected headers bucket in the original `COSE_Sign1` object to obtain the following:

```
18(
  [
    / protected h'a10126' / << {
        / alg / 1:-7 / ECDSA 256 /
    } >>,
    / unprotected / {
    / 3161-ctt / 270 : h'3082154906092a864886f70d010702a082153a3082
1536020103310f300d0609608648016503040203050030820184060b2a864886f70d0
109100104a08201730482016f3082016b02010106042a0304013031300d0609608648
0165030402010500042 0dd9471efe743c4051335df8f6d2882f3badc387700f7ed3f7
091672a3eeaf7c8020400b8a1ea180f3230323530383239303735333030305a0101ffa0
820111a482010d308201093111300f060355040a1308467265652053414131 0c300a0
60355040b130354534131176307406035504 0d136d5468697320636572746966696361
7465206469676974616c6c79207369676e7320646f63756d656e7473 20616e6420746
96d65207374616d702072657175657374732 06d6164652 07573696e67207468652066
7265657473612e6f7267206f6e6c696e6520736572766963653311 3016 060355040
3130f7777772e667265657473612e6f72673122302006092a864886f70d0109011613
627573696c657a617340676d61696c2e636f6d3112301006035504071309577565727
a6275726731 0b30090603550406130244453 10f300d06035504081306426179657 26e
a082100830820801308205e9a0030201020209 00c1e986160da8e982300d06092a864
```

886f70d01010d05003081953111300f060355040a13084672656520545341311 0300e
060355040b1307526f6f74204341311830160603550403130f7777772e6672 65657547
3612e6f726731223020006092a864886f70d0109011613627573696c657a6 17340676d
61696c2e636f6d3112301006035504071309577565727a62757267310f300 d0603550
408130642617965726e310b3009060355040613024445301e170d31363033 31333031
353733395a170d3236303331313031353733395a308201093111300f06035 5040a130
84672656520545341310c300a060355040b13035453413131763074060355 040d136d54
686973206365727469666966696361746520696469676974616c6c7920736 96e20646f
3756d656e747320616e642074696d65207374616d7020726571756573747 3206d6164
65207573696e672074686852206672656573612e6f7267206f6e6c696e655 2073657
77696365733311830160603550403130f7777772e6672656557473612e6f 7267312302
06092a864886f70d0109011613627573696c657a617340676d61696c2e636 f6d31123
01006035504071309577565727a62757267310b30090603550406130244453 10f300d
0603550408130642617965726e30820222300d06092a864886f70d0101010 5000382
20f003082020a0282020100b591048c4e486f34e9dc08627fc23751622369 84b82cb1
30beff517cfc38f84bce5c65a874dab2621ae0bce7e33563e0ede934fd5f882 3159f0
7848808227460c1ed88261706f4281334359dfbb81bd1353fc179610af1a8c8c 865dc
00ea23b3a89be6bd03ba85a9ec827d60565905e22d6a584ed1380ae150280cee397e9
8a012f380464007862443bc077cb95f421af31712d9683cdb6dffbaf3c8ba5ba566ae
523d459d6177346d4d840e27886b7c01c5b890d78a2e27bba8dd2f9a2812e157d62f9
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7051e8f4858af8b9a92d09e46af2d9cba5bfcfad168cdf604491a4b06603b114caf70
31f065e7eeefa53c575f3490c059d2e32ddc76ac4d4c4c710683b97fd1be591bc6105
5186d88f9a0391b307b6f91ed954daa36f9acd6a1e14aa2e4adf17464b54db18dbb6f
fe30080246547370436ce4e77bae5de6fe0f3f9d6e7ffbeb461e794e92fb0951f8aae
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b5a6b9a506069334fb34f6fc7ae330f0b34208aac80df3266fdd90465876ba2cb898d
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51d0e041604146e760b7b4e4f9ce160ca6d2ce927a2a294b37737301f0603551d2304
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050507010104573055302a06082b06010505073002861e687474703a2f2f777 72e6
672656657473612e6f72672f7473612e63727430270606082b06010505073001 861b687
474703a2f2f7777772e6672656657473612e6f7267a3235363030370603551d1f04303
02e302ca02aa0288626687474703a2f2f7777772e6672656657473612e6f72672f637 2
6c2f726f6f745f63612e63726c3081c60603551d200481be3081bb3081b8060100308
1b2303306082b0601050507020116276874703a2f2f7777772e66726565574736127 2e
6f72672f667265657574736157f6370732e68746d6c303206082b06010505070201 6266
87474703a2f2f7777772e6672656657473612e6f72672f667265657574736157f6370732 e
706466304706082b060105050702023b1a394672656555453412074727573746564 2
074696d65737461607696e6720536f6674776172652061732053657276696365
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a10e43eaa81f849a6c5fe3fe8b5ea23275f687f2052e502ea6c30762a668cce07871d
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4374fa063e956192627f7c431073965d1260928eba009e803429ae324cf96f042354f
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```
3d3b4ad38bbf8842bda36fc2448291f558dc02dd1e0308207ff308205e7a003020102
020900c1e986160da8e980300d06092a864886f70d01010d05003081953111300f060
355040a13084672656520545341311030100e060355040b1307526f6f74204341311830
160603550403130f7777772e667265657473612e6f72673122302006092a864886f70
d01090111613627573696c657a617340676d61696c2e636f6d31123010060355040713
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