

LAMPS Working Group
Internet-Draft
Intended status: Standards Track
Expires: 8 January 2026

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7 July 2025

Nonce-based Freshness for Remote Attestation in Certificate Signing
Requests (CSRs) for the Certification Management Protocol (CMP) and for
Enrollment over Secure Transport (EST)
draft-ietf-lamps-attestation-freshness-04

Abstract

When an end entity includes attestation Evidence in a Certificate Signing Request (CSR), it may be necessary to demonstrate the freshness of the provided Evidence. Current attestation technology commonly achieves this using nonces.

This document outlines the process through which nonces are supplied to the end entity by an RA/CA for inclusion in Evidence, leveraging the Certificate Management Protocol (CMP) and Enrollment over Secure Transport (EST)

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1. Introduction

The management of certificates, encompassing issuance, CA certificate provisioning, renewal, and revocation, has been streamlined through standardized protocols.

The Certificate Management Protocol (CMP) [I-D.ietf-lamps-rfc4210bis] defines messages for X.509v3 certificate creation and management. CMP facilitates interactions between end entities and PKI management entities, such as Registration Authorities (RAs) and Certification Authorities (CAs). For Certificate Signing Requests (CSRs), CMP primarily utilizes the Certificate Request Message Format (CRMF) [RFC4211] but also supports PKCS#10 [RFC2986].

Enrollment over Secure Transport (EST) ([RFC7030], [RFC8295]) is another certificate management protocol that provides a subset of CMP's features, primarily using PKCS#10 for CSRs.

When an end entity requests a certificate from a Certification Authority (CA), it may need to assert credible claims about the protections of the corresponding private key, such as the use of a hardware security module or the protective capabilities provided by the hardware, as well as claims about the platform itself.

To include these claims as Evidence in remote attestation, the remote attestation extension [I-D.ietf-lamps-csr-attestation] has been defined. It specifies how Evidence produced by an Attester is encoded for inclusion in CRMF or PKCS#10, along with any necessary certificates for its validation.

For a Verifier or Relying Party to ensure the freshness of the Evidence, knowing the exact time of its production is crucial. Current attestation technologies, like [TPM20] and [RFC9783], often employ nonces to ensure the freshness of Evidence. Further details on ensuring Evidence freshness can be found in Section 10 of [RFC9334].

Section 4 of [I-D.ietf-lamps-csr-attestation] provides examples where a CSR contains one or more Evidence statements. For each Evidence statement the end entity may wish to request a separate nonce.

Since an end entity requires one or more nonces from one or more Verifier via the RA/CA, an additional roundtrip is necessary. However, a CSR is a one-shot message. Therefore, CMP and EST enable the end entity to request information from the RA/CA before submitting a certification request conveniently.

Once a nonce is obtained, the end entity invokes the API on an Attester, providing the nonce as an input parameter. The Attester then returns an Evidence, which is embedded into a CSR and potentially together with further Evidence statements, submitted back to the RA/CA in a certification request message.

Figure 1 illustrates this interaction:

- * One or more nonces are requested in step (0) and obtained in step (1) using the extension to CMP/EST defined in this document.
- * The CSR extension [I-D.ietf-lamps-csr-attestation] conveys one or more Evidence statements to the RA/CA in step (2).
- * One or more Verifier process the received Evidence and return the Attestation Result(s) to the Relying Party. The CA uses the Attestation Result(s) with the Appraisal Policy and other information to create the requested certificate. The certificate is returned to the End Entity in step (3).

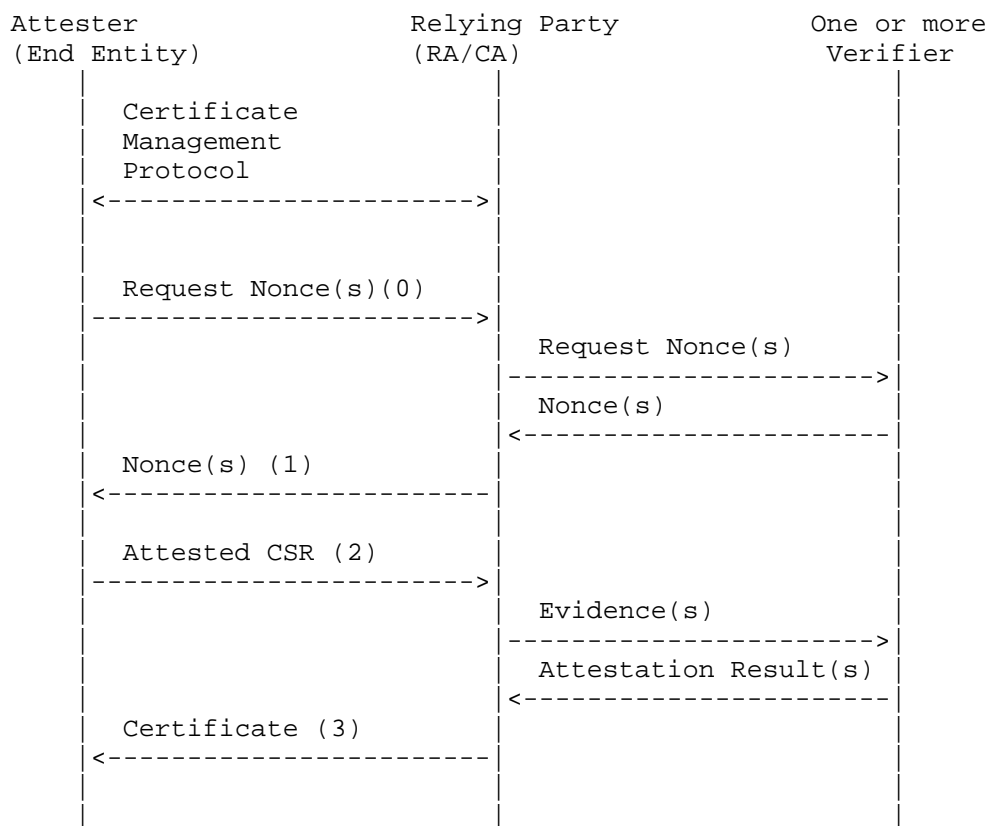


Figure 1: Architecture with Background Check Model.

The functionality described in this document is divided into two sections:

- * Section 3 describes how to convey the nonce using CMP.
- * Section 4 describes the equivalent functionality for EST.

2. Terminology and Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

The terms Attester, Relying Party, Verifier and Evidence are defined in [RFC9334]. The terms end entity, certification authority (CA), and registration authority (RA) are defined in [RFC5280].

We use the terms Certificate Signing Request (CSR) and certification request interchangeably.

3. Conveying a Nonce in CMP

Section 5.3.19 of [I-D.ietf-lamps-rfc4210bis] defines the general request message (genm) and general response (genp). The NonceRequest payload of the genm message, sent by the end entity to request a nonce, optionally includes details on the required length of the nonce from the Attester. The NonceResponse payload of the genp message, sent by the CA/RA in response to the request, contains the nonce itself.

```
GenMsg:      {id-it TBD1}, NonceRequestValue
GenRep:      {id-it TBD2}, NonceResponseValue | < absent >
```

```
id-it-nonceRequest OBJECT IDENTIFIER ::= { id-it TBD1 }
NonceRequestValue ::= SEQUENCE SIZE (1..MAX) OF NonceRequest
NonceRequest ::= SEQUENCE {
    len INTEGER OPTIONAL,
    -- indicates the required length of the requested nonce
    type EVIDENCE-STATEMENT.&id({EvidenceStatementSet}) OPTIONAL,
    -- indicates which Evidence type to request a nonce for
    hint UTF8String OPTIONAL
    -- indicates which Verifier to request a nonce from
}
```

```
id-it-nonceResponse OBJECT IDENTIFIER ::= { id-it TBD2 }
NonceResponseValue ::= SEQUENCE SIZE (1..MAX) OF NonceResponse
NonceResponse ::= SEQUENCE {
    nonce OCTET STRING,
    -- contains the nonce of length len
    -- provided by the Verifier indicated with hint
    expiry INTEGER OPTIONAL,
    -- indicates how long in seconds the Verifier considers
    -- the nonce valid
    type EVIDENCE-STATEMENT.&id({EvidenceStatementSet}) OPTIONAL,
    -- indicates which Evidence type to request a nonce for
    hint UTF8String OPTIONAL
    -- indicates which Verifier to request a nonce from
}
```

The end entity may request one or more nonces for different Verifier. The EVIDENCE-STATEMENT type is defined in [I-D.ietf-lamps-csr-attestation]. They allow the Attester to specify to the Relying Party which Verifier should be contacted to obtain a nonce. If a NonceRequest structure does not contain type or hint, the RA/CA should respond with a nonce it MAY generated by itself.

The use of the general request/response message exchange introduces an additional roundtrip for transmitting nonce(s) from the CA/RA to the end entity (and subsequently to the Attester within the end entity).

The end entity MUST construct a `id-it-nonceRequest` message to prompt the RA/CA to send a nonce(s) in response. The message may contain one or more `NonceRequest` structures, at a maximum one per Evidence statement the end entity wishes to provide in a CSR. If a `NonceRequest` structure does neither contain a type nor a hint, the RA/CA MAY generate a nonce itself and provide it in the respective `NonceResponse` structure. If an RA/CA is not able to provide a requested nonce, it MUST provide an empty OCTET STRING in the respective `NonceResponse` structure.

`NonceRequest`, `NonceResponse`, and `EvidenceStatement` structures can contain a type field and a hint field. In terms of type and hint content, the order in which the `NonceRequest` structures were sent in the request message MUST match the order of the `NonceResponse` structures in the response message and the `EvidenceStatements` in the CSR later. This is important so that the RA/CA can send the Evidence statement to the Verifier who generated the nonce used by the Attester who generated it.

When receiving nonces from the RA/CA in a `id-it-nonceResponse` message, the end entity MUST use them to request Evidence Statements from the respective Attester optionally indicated by type and hint. If a nonce is provided in a `NonceResponse` structure without indicating any type or hint, it can be used for all Evidence statements requiring a nonce.

An Evidence statement generated using a nonce provided with an expiry value will be accepted by the Verifier as valid until the respective expiry time elapsed. It is expected that the respective messages are delivered in a timely manner.

The interaction is illustrated in Figure 2.

End Entity =====	RA/CA =====
<pre> -->>--- id-it-NonceRequest --->>-- </pre>	<pre> Verify request Generate nonce(s)* Create response </pre>
<pre> --<<--- id-it-NonceResponse ---<<-- (nonce(s), expiry) </pre>	
<pre> Generate key pair Generate Evidence(s)* Generate certification request message -->>--- certification request --->>-- +Evidence(s) including nonce) </pre>	
	<pre> Verify request Verify Evidence(s)* Check for replay* Issue certificate Create response </pre>
<pre> --<<--- certification response ---<<-- Handle response Store certificate </pre>	
<p>*: These steps require interactions with the Attester (on the EE side) and with the Verifier (on the RA/CA side).</p>	

Figure 2: CMP Exchange with Nonce and Evidence.

If HTTP is used to transfer the NonceRequest and NonceResponse messages, the OPTIONAL <operation> path segment defined in Section 3.6 of [I-D.ietf-lamps-rfc4210bis] MAY be used.

Operation	Operation path	Details
Get Attestation	getnonce	{{CMP}}
Freshness Nonce		

If CoAP is used for transferring NonceRequest and NonceResponse messages, the OPTIONAL <operation> path segment defined in Section 2.1 of [RFC9482] MAY be used.

Operation	Operation path	Details
Get Attestation Freshness Nonce	nonce	{{CMP}}

4. Conveying a Nonce in EST

The EST client requests one or more nonces for its Attester from the EST server. This function typically follows the request for CA certificates and precedes other EST operations.

The EST server MUST support the path-prefix of `"/.well-known/"` as defined in [RFC5785] and the registered name of `"est"`. Therefore, a valid EST server URI path begins with `"https://www.example.com/.well-known/est"`. Each EST operation is indicated by a path-suffix that specifies the intended operation.

The following operation is defined by this specification:

Operation	Operation path	Details
Retrieval of a nonce	/nonce	{{EST}}

The operation path is appended to the path-prefix to form the URI used with HTTP GET or POST to perform the desired EST operation. An example of a valid URI absolute path for the `"/nonce"` operation is `"/.well-known/est/nonce"`.

4.1. Request Methods

An EST client uses either a GET or a POST method, depending on whether additional parameters need to be conveyed:

- * A GET request MUST be used when the EST client does not want to convey extra parameters.
- * A POST request MUST be used when parameters, such as nonce length or a hint about the verification service, are included in the request.

Message type (per operation)	Media type(s)	Reference
Nonce Request	N/A (for GET) or application/json (for POST)	This section
Nonce Response	application/json	This section

4.2. Example Requests

To retrieve one nonce without providing length, type, or hint using a GET request:

```
GET /.well-known/est/nonce HTTP/1.1
```

To retrieve one or more nonces while specifying the length, type, and/or hint using a POST request:

```
POST /.well-known/est/nonce HTTP/1.1
Content-Type: application/json
```

```
[
  {
    "len": 8,
    "type": "<OID>",
    "hint": "https://example.com"
  },
  ...
]
```

< ToDo: Fix the json structure regarding the sequence of len, type, and hint and how the OID for type shall be encoded. >

The payload in a POST request MUST be of content-type "application/json" and MUST contain an array of JSON objects [RFC7159] containing "len", "type", and "hint" members. The optional member "len" indicating the length of the requested nonce value in bytes. The optional "type" (containing an EvidenceStatement OID as defined in [I-D.ietf-lamps-csr-attestation]) and "hint" members (containing an FQDN based on the definition in the EvidenceHint structure as defined in [I-D.ietf-lamps-csr-attestation]) indicate the Verifier to use.

4.3. Server Response

If successful, the EST server MUST respond with an HTTP 200 status code and a content-type of "application/json", containing an array of JSON objects [RFC7159] with the "nonce" member. The "expiry" member is optional and indicates the validity period of the nonce. The optional "type" and "hint" members are copied from the request.

The EST server MAY request HTTP-based client authentication, as explained in Section 3.2.3 of [RFC7030].

Below is an example response:

```
HTTP/1.1 200 OK
Content-Type: application/json
[
  {
    "nonce": "MTIzNDU2Nzg5MDEyMzQ1Njc4OTAxMjM0NTY3ODkwMTI=",
    "expiry": "2031-10-12T07:20:50.52Z"
    "type": "<OID>",
    "hint": "https://example.com"
  },
  ...
]
```

< ToDo: Fix the json structure regarding the sequence of len, type, and hint and how the OID for type shall be encoded. >

Open Issue: Should a specific content type be registered for use with EST over CoAP, where the nonce and expiry fields are encoded in a CBOR structure?

5. Nonce Processing Guidelines

When the RA/CA is requested to provide a nonce to an end entity, it interacts with the Verifier. According to the IETF RATS architecture [RFC9334], the Verifier is responsible for validating Evidence about an Attester and generating Attestation Results for use by a Relying Party. The Verifier also acts as the source of the nonce to prevent replay attacks.

The nonce value MUST contain a random byte sequence whereby the length depends on the used remote attestation technology as specific nonce length may be required by the end entity. This specification assumes that the RA/CA possesses knowledge, either out-of-band or through the len field in the NonceRequest, regarding the required nonce length for the attestation technology. Nonces of incorrect length will cause the remote attestation protocol to fail.

For instance, the PSA attestation token [RFC9783] supports nonce lengths of 32, 48, and 64 bytes. Other attestation technologies employ nonces of similar lengths.

If a specific length was requested, the RA/CA must provide a nonce of that size. The end entity MUST use the received nonce if the remote attestation supports the requested length. If necessary, the end entity MAY adjust the length of the nonce by truncating or padding it accordingly.

While this specification does not address the semantics of the attestation API or the underlying software/hardware architecture, the API returns Evidence from the Attester in a format specific to the attestation technology used and specified by the type and hint. The returned Evidence is encapsulated within the CSR, as defined in [I-D.ietf-lamps-csr-attestation]. The software generating the CSR treats the Evidence as an opaque blob and does not interpret its format. It's crucial to note that the nonce is included in the Evidence, either implicitly or explicitly, and MUST NOT be conveyed in CSR structures outside of the Evidence payload.

The processing of CSRs containing Evidence is detailed in [I-D.ietf-lamps-csr-attestation]. Importantly, certificates issued based on this process do not contain the nonce, as specified in [I-D.ietf-lamps-csr-attestation].

6. IANA Considerations

This document adds new entries to the "CMP Well-Known URI Path Segments" registry defined in [RFC8615].

Path Segment	Description	Reference
getnonce	Get Attestation Freshness Nonce over HTTP	{{cmp}}
nonce	Get Attestation Freshness Nonce over CoAP	{{cmp}}

[Open Issue: Register path segments for EST]

IANA is also requested to register the following ASN.1 [X.680] module OID in the "SMI Security for PKIX Module Identifier" registry (1.3.6.1.5.5.7.0). This OID is defined in Appendix A.

Decimal	Description	References
TBDMOD	id-mod-att-fresh-req	This-RFC

Table 1

7. Security Considerations

This specification details the process of obtaining a nonce via CMP and EST, assuming that the nonce does not require confidentiality protection while maintaining the security properties of the remote attestation protocol. [RFC9334] defines the IETF remote attestation architecture and extensively discusses nonce-based freshness.

Section 8.4 of [RFC9711] specifies requirements for the randomness and privacy of nonce generation when used with the Entity Attestation Token (EAT). These requirements, which are also adopted by attestation technologies like the PSA attestation token [RFC9783], provide general utility:

- * The nonce MUST have at least 64 bits of entropy.
- * To prevent disclosure of privacy-sensitive information, it should be derived using a salt from a genuinely random number generator or another reliable source of randomness.

Each attestation technology specification offers guidance on replay protection using nonces and other techniques. Specific recommendations are deferred to these individual specifications in this document.

Regarding the use of Evidence in a CSR, the security considerations outlined in [I-D.ietf-lamps-csr-attestation] are pertinent to this specification.

8. Acknowledgments

We would like to thank Russ Housley, Thomas Fossati, Watson Ladd, Ionut Mihalcea, Carl Wallace, and Michael StJohns for their review comments.

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9.1. Normative References

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Appendix A. ASN.1 Module

The following module adheres to ASN.1 specifications [X.680] and [X.690].

<CODE BEGINS>

```
att-fres-req
{ iso(1) identified-organization(3) dod(6) internet(1)
  security(5) mechanisms(5) pkix(7) id-mod(0)
  id-mod-att-fresh-req (TBDMOD) }

DEFINITIONS IMPLICIT TAGS ::=
BEGIN
EXPORTS ALL;
IMPORTS

id-it, InfoTypeAndValue{
  FROM PKIXCMP-2023
    { iso(1) identified-organization(3) dod(6) internet(1)
      security(5) mechanisms(5) pkix(7) id-mod(0)
      id-mod-cmp2023-02(TBD-PKIXCMP-23) }
  -- RFC Editor: The value for id-mod-cmp2023-02 must be set as soon
  -- as it is assigned by I-D.ietf-lamps-rfc4210bis

EVIDENCE-STATEMENT, EvidenceStatementSet
  FROM CSR-ATTESTATION-2023
    { iso(1) identified-organization(3) dod(6) internet(1) security(5)
      mechanisms(5) pkix(7) id-mod(0) id-mod-pkix-attest-01(TBD-CSR-ATTESTATION-2023)
}
-- RFC Editor: The value for id-mod-pkix-attest-01 must be set as soon
-- as it is assigned by I-D.ietf-lamps-csr-attestation

;

-- NonceRequest and NonceResponse messages

id-it-nonceRequest OBJECT IDENTIFIER ::= { id-it TBD1 }
NonceRequestValue ::= SEQUENCE SIZE (1..MAX) OF NonceRequest
NonceRequest ::= SEQUENCE {
  len      INTEGER OPTIONAL,
  -- indicates the required length of the requested nonce
  type     EVIDENCE-STATEMENT.&id({EvidenceStatementSet}) OPTIONAL,
  -- indicates which Evidence type to request a nonce for
  hint     UTF8String OPTIONAL
  -- indicates which Verifier to request a nonce from
}

id-it-nonceResponse OBJECT IDENTIFIER ::= { id-it TBD2 }
```

```
NonceResponseValue ::= SEQUENCE SIZE (1..MAX) OF NonceResponse
NonceResponse ::= SEQUENCE {
    nonce  OCTET STRING,
    -- contains the nonce of length len
    -- provided by the Verifier indicated with hint
    expiry INTEGER OPTIONAL,
    -- indicates how long in seconds the Verifier considers
    -- the nonce valid
    type   EVIDENCE-STATEMENT.&id({EvidenceStatementSet}) OPTIONAL,
    -- indicates which Evidence type to request a nonce for
    hint   UTF8String OPTIONAL
    -- indicates which Verifier to request a nonce from
}

END
```

<CODE ENDS>

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