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Certificate Management Protocol (CMP) Updates

Abstract

This document contains a set of updates to the syntax and transfer of Certificate Management Protocol (CMP) version 2. This document updates RFC 4210, RFC 5912, and RFC 6712.

The aspects of CMP updated in this document are using EnvelopedData instead of EncryptedValue, clarifying the handling of p10cr messages, improving the crypto agility, as well as adding new general message types, extended key usages to identify certificates for use with CMP, and well-known URI path segments.

To properly differentiate the support of EnvelopedData instead of EncryptedValue, the CMP version 3 is introduced in case a transaction is supposed to use EnvelopedData.

CMP version 3 is introduced to enable signaling support of EnvelopedData instead of EncryptedValue and signaling the use of an explicit hash AlgorithmIdentifier in certConf messages, as far as needed.

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1. Introduction

While using CMP [RFC4210] in industrial and IoT environments and developing the Lightweight CMP Profile [I-D.ietf-lamps-lightweight-cmp-profile] some limitations were identified in the original CMP specification. This document updates RFC 4210 [RFC4210] and RFC 6712 [RFC6712] to overcome these limitations.

Among others, this document improves the crypto agility of CMP, which means to be flexible to react on future advances in cryptography.

This document also introduces new extended key usages to identify CMP endpoints on registration and certification authorities.

As the main content of RFC 4210 [RFC4210] and RFC 6712 [RFC6712] stays unchanged, this document lists all sections that are updated, replaced, or added to the current text of the respective RFCs.

1.1. Convention and 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.

Technical terminology is used in conformance with RFC 4210 [RFC4210], RFC 4211 [RFC4211], and RFC 5280 [RFC5280]. The following key words are used:

CA: Certification authority, which issues certificates.

RA: Registration authority, an optional system component to which a CA delegates certificate management functions such as authorization checks.

KGA: Key generation authority, which generates key pairs on behalf of an EE. The KGA could be co-located with an RA or a CA.

EE: End entity, a user, device, or service that holds a PKI certificate. An identifier for the EE is given as its subject of the certificate.

2. Updates to RFC 4210 - Certificate Management Protocol (CMP)

2.1. New Section 1.1. - Changes Since RFC 4210

The following subsection describes feature updates to RFC 4210 [RFC4210]. They are always related to the base specification. Hence references to the original sections in RFC 4210 [RFC4210] are used whenever possible.

Insert this section at the end of the current Section 1:

1.1. Changes Since RFC 4210

The following updates are made in [thisRFC]:

*Add new extended key usages for various CMP server types, e.g., registration authority and certification authority, to express the authorization of the entity identified in the certificate containing the respective extended key usage extension to act as the indicated PKI management entity.

*Extend the description of multiple protection to cover additional use cases, e.g., batch processing of messages.

*Offering EnvelopedData as the preferred choice next to EncryptedValue to better support crypto agility in CMP. Note that according to RFC 4211 [RFC4211] section 2.1. point 9 the use of the EncryptedValue structure has been deprecated in favor of the EnvelopedData structure. RFC 4211 [RFC4211] offers the

EncryptedKey structure, a choice of EncryptedValue and EnvelopedData for migration to EnvelopedData. For reasons of completeness and consistency the type EncryptedValue has been exchanged in all occurrences in RFC 4210 [RFC4210]. This includes the protection of centrally generated private keys, encryption of certificates, and protection of revocation passphrases. To properly differentiate the support of EnvelopedData instead of EncryptedValue, the CMP version 3 is introduced in case a transaction is supposed to use EnvelopedData.

*Offering an optional hashAlg field in CertStatus supporting confirmation of certificates signed with signature algorithms, e.g., EdDSA, not directly indicating a specific hash algorithm to use to compute the certHash.

*Adding new general message types to request CA certificates, a root CA update, a certificate request template, or a CRL update.

*Extend the usage of polling to p10cr, certConf, rr, genm, and error messages.

*Delete the mandatory algorithm profile in RFC 4210 Appendix D.2 [RFC4210] and refer to CMP Algorithms Section 7 [I-D.ietf-lamps-cmp-algorithms].

2.2. New Section 4.5 - Extended Key Usage

The following subsection introduces a new extended key usage for CMP servers authorized to centrally generate key pairs on behalf of end entities.

Insert this section at the end of the current Section 4:

4.5. Extended Key Usage

The Extended Key Usage (EKU) extension indicates the purposes for which the certified key pair may be used. It therefore restricts the use of a certificate to specific applications.

A CA may want to delegate parts of its duties to other PKI management entities. This section provides a mechanism to both prove this delegation and enable an automated means for checking the authorization of this delegation. Such delegation MAY also be expressed by other means, e.g., explicit configuration.

To offer automatic validation for the delegation of a role by a CA to another entity, the certificates used for CMP message protection or signed data for central key generation MUST be issued by the delegating CA and MUST contain the respective EKUs. This proves the

authorization of this entity by the delegating CA to act in the given role as described below.

The OIDs to be used for these EKUs are:

```
id-kp-cmcCA OBJECT IDENTIFIER ::= {
   iso(1) identified-organization(3) dod(6) internet(1)
   security(5) mechanisms(5) pkix(7) kp(3) 27 }

id-kp-cmcRA OBJECT IDENTIFIER ::= {
   iso(1) identified-organization(3) dod(6) internet(1)
   security(5) mechanisms(5) pkix(7) kp(3) 28 }

id-kp-cmKGA OBJECT IDENTIFIER ::= {
   iso(1) identified-organization(3) dod(6) internet(1)
   security(5) mechanisms(5) pkix(7) kp(3) 32 }
```

Note: RFC 6402 section 2.10 [RFC6402] specifies OIDs for a CMC CA and a CMC RA. As the functionality of a CA and RA is not specific to using CMC or CMP as the certificate management protocol, these OIDs MAY be re-used.

The meaning of the id-kp-cmKGA EKU is as follows:

CMP KGA: CMP Key Generation Authorities are identified by the id-kp-cmKGA extended key usage. The CMP KGA knows the private key it generated on behalf of the end entity. This is a very sensitive service and therefore needs specific authorization. This authorization is with the CA certificate itself. Alternatively, the CA MAY delegate the authorization by placing the id-kp-cmKGA extended key usage in the certificate used to authenticate the origin of the generated private key or the delegation MAY be determined through local configuration of the end entity.

Note: In device PKIs, especially those issuing IDevID certificates IEEE 802.1AR Section 8.5 [IEEE.802.1AR_2018], CA certificates may have very long validity (including the GeneralizedTime value 99991231235959Z to indicate a not well-defined expiration date as specified in IEEE 802.1AR Section 8.5 [IEEE.802.1AR_2018] and RFC 5280 Section 4.1.2.5 [RFC5280]). Such validity periods SHOULD NOT be used for protection of CMP messages and key generation. Certificates containing one of the above EKUs SHOULD NOT use indefinite expiration date.

2.3. Update Section 5.1.1. - PKI Message Header

Section 5.1.1 of RFC 4210 [RFC4210] describes the PKI message header. This document introduces the new version 3 indicating support of EnvelopedData as specified in Section 2.7.

Replace the ASN.1 Syntax of PKIHeader and the subsequent description of pvno with the following text:

```
PKIHeader ::= SEQUENCE {
   pvno                INTEGER     { cmp1999(1), cmp2000(2),
                                     cmp2021(3) },
   sender              GeneralName,
   recipient           GeneralName,
   messageTime     [0] GeneralizedTime         OPTIONAL,
   protectionAlg   [1] AlgorithmIdentifier{ALGORITHM, {...}}
                       OPTIONAL,
   senderKID       [2] KeyIdentifier           OPTIONAL,
   recipKID        [3] KeyIdentifier           OPTIONAL,
   transactionID   [4] OCTET STRING            OPTIONAL,
   senderNonce     [5] OCTET STRING            OPTIONAL,
   recipNonce      [6] OCTET STRING            OPTIONAL,
   freeText        [7] PKIFreeText             OPTIONAL,
   generalInfo     [8] SEQUENCE SIZE (1..MAX) OF
                       InfoTypeAndValue     OPTIONAL
}

PKIFreeText ::= SEQUENCE SIZE (1..MAX) OF UTF8String
```

The usage of pvno values is described in Section 7.

2.4. New Section 5.1.1.3. - CertProfile

Section 5.1.1 of RFC 4210 [RFC4210] defines the PKIHeader and id-it OIDs to be used in the generalInfo field. This section introduces id-it-certProfile.

Insert this section after Section 5.1.1.2:

5.1.1.3. CertProfile

This is used by the EE to indicate specific certificate profiles, e.g., when requesting a new certificate or a certificate request template, see Section 5.3.19.16.

```
id-it-certProfile  OBJECT IDENTIFIER ::= {id-it 21}
CertProfileValue ::= SEQUENCE SIZE (1..MAX) OF UTF8String
```

When used in an ir/cr/kur/genm, the value MUST NOT contain more elements than the number of CertReqMsg or InfoTypeAndValue elements and the certificate profile names refer to the elements in the given order.

When used in a p10cr, the value MUST NOT contain multiple certificate profile names.

2.5. Update Section 5.1.3.1. - Shared Secret Information

Section 5.1.3.1 of RFC 4210 [RFC4210] describes the MAC based protection of a PKIMessage using the algorithm id-PasswordBasedMac.

Replace the first paragraph with the following text:

In this case, the sender and recipient share secret information with sufficient entropy (established via out-of-band means or from a previous PKI management operation). PKIProtection will contain a MAC value and the protectionAlg MAY be one of the options described in CMP Algorithms [I-D.ietf-lamps-cmp-algorithms]. The PasswordBasedMac is specified as follows (see also [RFC4211] and [RFC9045]):

Replace the last paragraph with the following text (Note: This fixes Errata ID 2616):

Note: It is RECOMMENDED that the fields of PBMParameter remain constant throughout the messages of a single transaction (e.g., ir/ip/certConf/pkiConf) to reduce the overhead associated with PasswordBasedMac computation.

2.6. Replace Section 5.1.3.4 - Multiple Protection

Section 5.1.3.4 of RFC 4210 [RFC4210] describes the nested message. This document enables using nested messages also for batch-delivery transport of PKI messages between PKI management entities and with mixed body types.

Replace the text of the section with the following text:

5.1.3.4. Multiple Protection

When receiving a protected PKI message, a PKI management entity such as an RA MAY forward that message adding its own protection (which MAY be a MAC or a signature, depending on the information and certificates shared between the RA and the CA). Moreover, multiple

PKI messages MAY be aggregated. There are several use cases for such messages.

*The RA confirms having validated and authorized a message and forwards the original message unchanged.

*The RA modifies the message(s) in some way (e.g., adds or modifies particular field values or adds new extensions) before forwarding them, then it MAY create its own desired PKIBody. If the changes made by the RA to PKIMessage break the POP of a certificate request, the RA MUST set the popo field to RAVerified. It MAY include the original PKIMessage from the EE in the generalInfo field of PKIHeader of a nested message (to accommodate, for example, cases in which the CA wishes to check POP or other information on the original EE message). The infoType to be used in this situation is {id-it 15} (see Section 5.3.19 for the value of id-it) and the infoValue is PKIMessages (contents MUST be in the same order as the message in PKIBody).

*A PKI management entity collects several messages that are to be forwarded in the same direction and forwards them in a batch. Request messages can be transferred as batch upstream (towards the CA); response or announce messages can be transferred as batch downstream (towards an RA, but not to the EE). This can for instance be used when bridging an off-line connection between two PKI management entities.

These use cases are accomplished by nesting the messages within a new PKI message. The structure used is as follows:

NestedMessageContent ::= PKIMessages

2.7. Replace Section 5.2.2. - Encrypted Values

Section 5.2.2 of RFC 4210 [RFC4210] describes the use of EncryptedValue to transport encrypted data. This document extends the encryption of data to preferably use EnvelopedData.

Replace the text of the section with the following text:

5.2.2. Encrypted Values

Where encrypted data (in this specification, private keys, certificates, or revocation passphrase) are sent in PKI messages, the EncryptedKey data structure is used.

```
EncryptedKey ::= CHOICE {
   encryptedValue        EncryptedValue, -- deprecated
   envelopedData     [0] EnvelopedData }
```

See CRMF [RFC4211] for EncryptedKey and EncryptedValue syntax and CMS [RFC5652] for EnvelopedData syntax. Using the EncryptedKey data structure offers the choice to either use EncryptedValue (for backward compatibility only) or EnvelopedData. The use of the EncryptedValue structure has been deprecated in favor of the EnvelopedData structure. Therefore, it is RECOMMENDED to use EnvelopedData.

Note: The EncryptedKey structure defined in CRMF [RFC4211] is reused here, which makes the update backward compatible. Using the new syntax with the untagged default choice EncryptedValue is bits-on-the-wire compatible with the old syntax.

To indicate support for EnvelopedData the pvno cmp2021 is introduced by this document. Details on the usage of pvno values is described in Section 7.

The EncryptedKey data structure is used in CMP to transport a private key, certificate, or revocation passphrase in encrypted form.

EnvelopedData is used as follows:

* It contains only one RecipientInfo structure because the content is encrypted only for one recipient.

* It may contain a private key in the AsymmetricKeyPackage structure as defined in RFC 5958 [RFC5958] wrapped in a SignedData structure as specified in CMS section 5 [RFC5652] and [RFC8933] signed by the Key Generation Authority.

* It may contain a certificate or revocation passphrase directly in the encryptedContent field.

The content of the EnvelopedData structure, as specified in CMS section 6 [RFC5652], MUST be encrypted using a newly generated symmetric content-encryption key. This content-encryption key MUST be securely provided to the recipient using one of three key management techniques.

The choice of the key management technique to be used by the sender depends on the credential available at the recipient:

* Recipient's certificate that contains a key usage extension asserting keyAgreement: The content-encryption key will be protected using the key agreement key management technique, as specified in CMS section 6.2.2 [RFC5652]. This is the preferred technique.

* Recipient's certificate that contains a key usage extension asserting keyEncipherment: The content-encryption key will be protected using the key transport key management technique, as specified in CMS section 6.2.1 [RFC5652].

* A password or shared secret: The content-encryption key will be protected using the password-based key management technique, as specified in CMS section 6.2.4 [RFC5652].

2.8. New Section 5.2.9 - GeneralizedTime

The following subsection point implementers to [RFC5280] regarding usage of GeneralizedTime.

Insert this section after Section 5.2.8.4:

5.2.9 GeneralizedTime

GeneralizedTime is a standard ASN.1 type and SHALL be used as specified in RFC 5280 Section 4.1.2.5.2 [RFC5280].

2.9. Update Section 5.3.4. - Certification Response

Section 5.3.4 of RFC 4210 [RFC4210] describes the Certification Response. This document updates the syntax by using the parent structure EncryptedKey instead of EncryptedValue as described in Section 2.7 above. Moreover, it clarifies the certReqId to be used in response to a p10cr message.

Replace the ASN.1 syntax with the following text (Note: This also fixes Errata ID 3949 and 4078):

```
CertRepMessage ::= SEQUENCE {
    caPubs          [1] SEQUENCE SIZE (1..MAX) OF CMPCertificate
                        OPTIONAL,
    response            SEQUENCE OF CertResponse
}

CertResponse ::= SEQUENCE {
    certReqId           INTEGER,
    status              PKIStatusInfo,
    certifiedKeyPair    CertifiedKeyPair    OPTIONAL,
    rspInfo             OCTET STRING        OPTIONAL
    -- analogous to the id-regInfo-utf8Pairs string defined
    -- for regInfo in CertReqMsg [RFC4211]
}

CertifiedKeyPair ::= SEQUENCE {
   certOrEncCert       CertOrEncCert,
   privateKey      [0] EncryptedKey        OPTIONAL,
   -- see [RFC4211] for comment on encoding
   publicationInfo [1] PKIPublicationInfo  OPTIONAL
}

CertOrEncCert ::= CHOICE {
   certificate     [0] CMPCertificate,
   encryptedCert   [1] EncryptedKey
}
```

Add the following as a new paragraph right after the ASN.1 syntax:

A p10cr message contains exactly one CertificationRequestInfo data structure as specified in PKCS#10 [RFC2986] but no certReqId. Therefore, the certReqId in the corresponding certification response (cp) message MUST be set to -1.

Add the following as new paragraphs to the end of the section:

The use of EncryptedKey is described in Section 5.2.2.

Note: To indicate support for EnvelopedData the pvno cmp2021 is introduced by this document. Details on the usage of different pvno values are described in Section 7.

2.10. Update Section 5.3.18. - Certificate Confirmation Content

This section introduces an optional hashAlg field to the CertStatus type used in certConf messages to explicitly specify the hash algorithm for those certificates where no hash algorithm is specified in the signatureAlgorithm field.

Replace the ASN.1 Syntax of CertStatus with the following text:

```
CertStatus ::= SEQUENCE {
   certHash    OCTET STRING,
   certReqId   INTEGER,
   statusInfo  PKIStatusInfo OPTIONAL,
   hashAlg [0] AlgorithmIdentifier{DIGEST-ALGORITHM, {...}}
               OPTIONAL
}
```

The hashAlg field SHOULD be used only in exceptional cases where the signatureAlgorithm of the certificate to be confirmed does not specify a hash algorithm in the OID or in the parameters. In such cases, e.g., for EdDSA, the hashAlg MUST be used to specify the hash algorithm to be used for calculating the certHash value. Otherwise, the certHash value SHALL be computed using the same hash algorithm as used to create and verify the certificate signature. If hashAlg is used, the CMP version indicated by the certConf message header must be cmp2021(3).

2.11. Update Section 5.3.19.2. - Signing Key Pair Types

The following section clarifies the usage of the Signing Key Pair Types on referencing EC curves.

Insert this note at the end of Section 5.3.19.2:

Note: In case several EC curves are supported, several id-ecPublicKey elements need to be given, one per named curve.

2.12. Update Section 5.3.19.3. - Encryption/Key Agreement Key Pair Types

The following section clarifies the use of the Encryption/Key Agreement Key Pair Types on referencing EC curves.

Insert this note at the end of Section 5.3.19.3:

Note: In case several EC curves are supported, several id-ecPublicKey elements need to be given, one per named curve.

2.13. Replace Section 5.3.19.9. - Revocation Passphrase

Section 5.3.19.9 of RFC 4210 [RFC4210] describes the provisioning of a revocation passphrase for authenticating a later revocation request. This document updates the handling by using the parent structure EncryptedKey instead of EncryptedValue to transport this information as described in Section 2.7 above.

Replace the text of the section with the following text:

5.3.19.9. Revocation Passphrase

This MAY be used by the EE to send a passphrase to a CA/RA for the purpose of authenticating a later revocation request (in the case that the appropriate signing private key is no longer available to authenticate the request). See Appendix B for further details on the use of this mechanism.

```
GenMsg:    {id-it 12}, EncryptedKey
GenRep:    {id-it 12}, < absent >
```

The use of EncryptedKey is described in Section 5.2.2.

2.14. New Section 5.3.19.14 - CA Certificates

The following subsection describes PKI general messages using id-it-caCerts. The intended use is specified in Lightweight CMP Profile Section 4.3 [I-D.ietf-lamps-lightweight-cmp-profile].

Insert this section after Section 5.3.19.13:

2.3.19.14 CA Certificates

This MAY be used by the client to get CA certificates.

```
GenMsg:    {id-it 17}, < absent >
GenRep:    {id-it 17}, SEQUENCE SIZE (1..MAX) OF
                       CMPCertificate | < absent >
```

2.15. New Section 5.3.19.15 - Root CA Certificate Update

The following subsection describes PKI general messages using id-it-rootCaCert and id-it-rootCaKeyUpdate. The use is specified in Lightweight CMP Profile Section 4.3 [I-D.ietf-lamps-lightweight-cmp-profile].

Insert this section after new Section 5.3.19.14:

5.3.19.15. Root CA Certificate Update

This MAY be used by the client to get an update of a root CA certificate, which is provided in the body of the request message. In contrast to the ckuann message this approach follows the request/response model.

The EE SHOULD reference its current trust anchor in a TrustAnchor structure in the request body, giving the root CA certificate if available, otherwise the public key value of the trust anchor.

```
GenMsg:    {id-it 20}, RootCaCertValue | < absent >
GenRep:    {id-it 18}, RootCaKeyUpdateContent | < absent >

RootCaCertValue ::= CMPCertificate

RootCaKeyUpdateValue ::= RootCaKeyUpdateContent

RootCaKeyUpdateContent ::= SEQUENCE {
   newWithNew       CMPCertificate,
   newWithOld   [0] CMPCertificate OPTIONAL,
   oldWithNew   [1] CMPCertificate OPTIONAL
   }
```

Note: In contrast to CAKeyUpdAnnContent, this type offers omitting newWithOld and oldWithNew in the GenRep message, depending on the needs of the EE.

2.16. New Section 5.3.19.16 - Certificate Request Template

The following subsection introduces the PKI general message using id-it-certReqTemplate. Details are specified in the Lightweight CMP Profile Section 4.3 [I-D.ietf-lamps-lightweight-cmp-profile].

Insert this section after new Section 5.3.19.15:

5.3.19.16. Certificate Request Template

This MAY be used by the client to get a template containing requirements for certificate request attributes and extensions. The controls id-regCtrl-algId and id-regCtrl-rsaKeyLen MAY contain details on the types of subject public keys the CA is willing to certify.

The id-regCtrl-algId control MAY be used to identify a cryptographic algorithm, see RFC 5280 Section 4.1.2.7 [RFC5280], other than rsaEncryption. The algorithm field SHALL identify a cryptographic algorithm. The contents of the optional parameters field will vary according to the algorithm identified. For example, when the algorithm is set to id-ecPublicKey, the parameters identify the elliptic curve to be used, see [RFC5480].

The id-regCtrl-rsaKeyLen control SHALL be used for algorithm rsaEncryption and SHALL contain the intended modulus bit length of the RSA key.

```
GenMsg:    {id-it 19}, < absent >
GenRep:    {id-it 19}, CertReqTemplateContent | < absent >

CertReqTemplateValue  ::= CertReqTemplateContent

CertReqTemplateContent ::= SEQUENCE {
  certTemplate          CertTemplate,
  keySpec               Controls OPTIONAL }

Controls  ::= SEQUENCE SIZE (1..MAX) OF AttributeTypeAndValue

id-regCtrl-algId OBJECT IDENTIFIER ::= { iso(1)
   identified-organization(3) dod(6) internet(1) security(5)
   mechanisms(5) pkix(7) pkip(5) regCtrl(1) 11 }

AlgIdCtrl ::= AlgorithmIdentifier{ALGORITHM, {...}}

id-regCtrl-rsaKeyLen OBJECT IDENTIFIER ::= { iso(1)
   identified-organization(3) dod(6) internet(1) security(5)
   mechanisms(5) pkix(7) pkip(5) regCtrl(1) 12 }

RsaKeyLenCtrl ::= INTEGER (1..MAX)
```

The CertReqTemplateValue contains the prefilled certTemplate to be used for a future certificate request. The publicKey field in the certTemplate MUST NOT be used. In case the PKI management entity wishes to specify supported public-key algorithms, the keySpec field MUST be used. One AttributeTypeAndValue per supported algorithm or RSA key length MUST be used.

Note: The Controls ASN.1 type is defined in CRMF Section 6 [RFC4211]

2.17. New Section 5.3.19.17 - CRL Update Retrieval

The following subsection introduces the PKI general message using id-it-crlStatusList and id-it-crls. Details are specified in the Lightweight CMP Profile Section 4.3 [I-D.ietf-lamps-lightweight-cmp-profile]. Insert this section after new Section 5.3.19.16:

5.3.19.17. CRL Update Retrieval

This MAY be used by the client to get new CRLs, specifying the source of the CRLs and the thisUpdate value of the latest CRL it already has, if available. A CRL source is given either by a DistributionPointName or the GeneralNames of the issuing CA. The DistributionPointName should be treated as an internal pointer to identify a CRL that the server already has and not as a way to ask the server to fetch CRLs from external locations. The server shall

provide only those CRLs that are more recent than the ones indicated by the client.

```
GenMsg:    {id-it 22}, SEQUENCE SIZE (1..MAX) OF CRLStatus
GenRep:    {id-it 23}, SEQUENCE SIZE (1..MAX) OF
                          CertificateList  |  < absent >

CRLSource ::= CHOICE {
   dpn          [0] DistributionPointName,
   issuer       [1] GeneralNames }

CRLStatus ::= SEQUENCE {
   source       CRLSource,
   thisUpdate   Time OPTIONAL }
```

2.18. Update Section 5.3.21 - Error Message Content

Section 5.3.21 of RFC 4210 [RFC4210] describes the regular use of error messages. This document adds a use by a PKI management entity to initiate delayed delivery in response to certConf, rr, and genm requests and to error messages.

Replace the first sentence of the first paragraph with the following one:

This data structure MAY be used by EE, CA, or RA to convey error info and by a PKI management entity to initiate delayed delivery of responses.

Replace the second paragraph with the following text:

This message MAY be generated at any time during a PKI transaction. If the client sends this request, the server MUST respond with a PKIConfirm response, or another ErrorMsg if any part of the header is not valid. In case a PKI management entity sends an error message to the EE with the pKIStatusInfo field containing the status "waiting", the EE will initiate polling as described in Section 5.3.22. Otherwise, both sides MUST treat this message as the end of the transaction (if a transaction is in progress).

2.19. Replace Section 5.3.22 - Polling Request and Response

Section 5.3.22 of RFC 4210 [RFC4210] describes when and how polling messages are used for ir, cr, and kur messages. This document extends the polling mechanism for outstanding responses to any kind of request message. This update also fixes the inconsistent use of the terms 'rReq' vs. 'pollReq' and 'pRep' vs. 'pollRep'.

Replace Section 5.3.22 with following text:

This pair of messages is intended to handle scenarios in which the client needs to poll the server to determine the status of an outstanding response (i.e., when the "waiting" PKIStatus has been received).

```
PollReqContent ::= SEQUENCE OF SEQUENCE {
   certReqId    INTEGER }

PollRepContent ::= SEQUENCE OF SEQUENCE {
   certReqId    INTEGER,
   checkAfter   INTEGER,  -- time in seconds
   reason       PKIFreeText OPTIONAL }
```

In response to an ir, cr, p10cr, or kur request message, polling is initiated with an ip, cp, or kup response message containing status "waiting". For any type of request message, polling can be initiated with an error response messages with status "waiting". The following clauses describe how polling messages are used. It is assumed that multiple certConf messages can be sent during transactions. There will be one sent in response to each ip, cp, or kup that contains a CertStatus for an issued certificate.

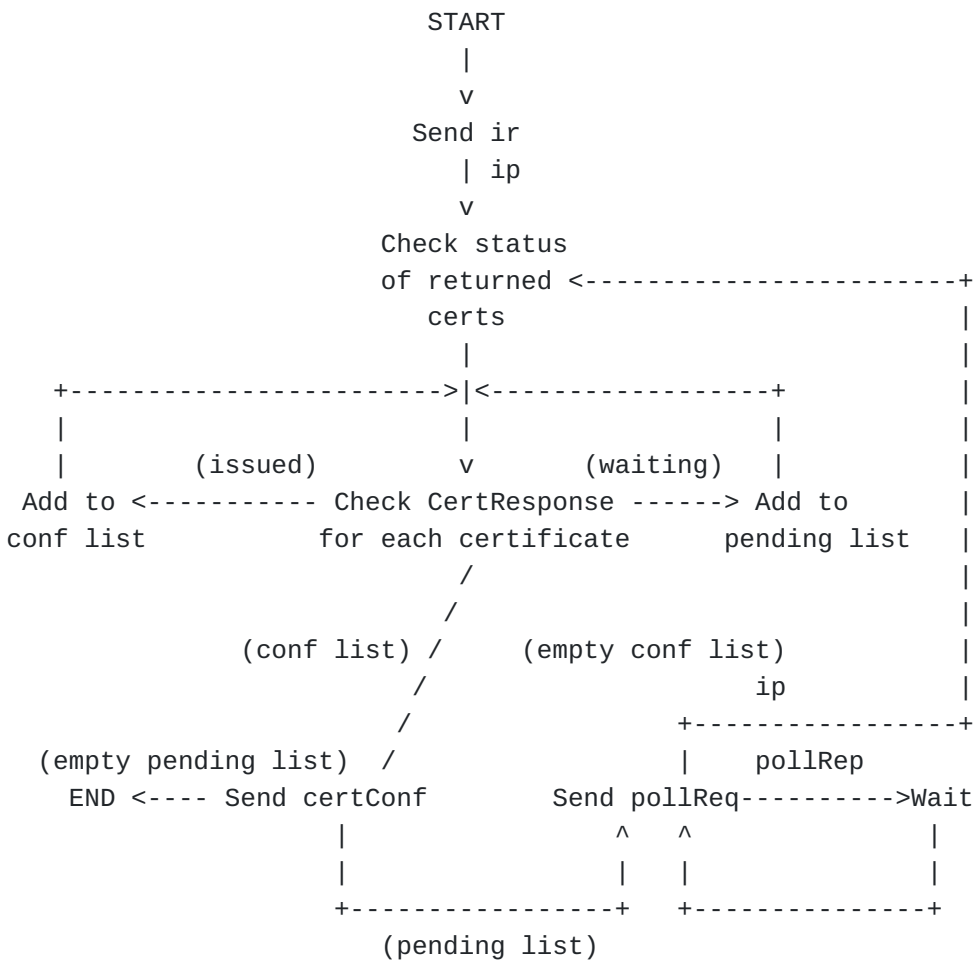
1 In response to an ip, cp, or kup message, an EE will send a certConf for all issued certificates and expect a PKIconf for each certConf. An EE will send a pollReq message in response to each CertResponse element of an ip, cp, or kup message with status "waiting" and in response to an error message with status "waiting". Its certReqId MUST be either the index of a CertResponse data structure with status "waiting" or -1 referring to the complete response.

2 In response to a pollReq, a CA/RA will return an ip, cp, or kup if one or more of still pending requested certificates are ready or the final response to some other type of request is available; otherwise, it will return a pollRep.

3 If the EE receives a pollRep, it will wait for at least the number of seconds given in the checkAfter field before sending another pollReq.

4 If the EE receives an ip, cp, or kup, then it will be treated in the same way as the initial response; if it receives any other response, then this will be treated as the final response to the original request.

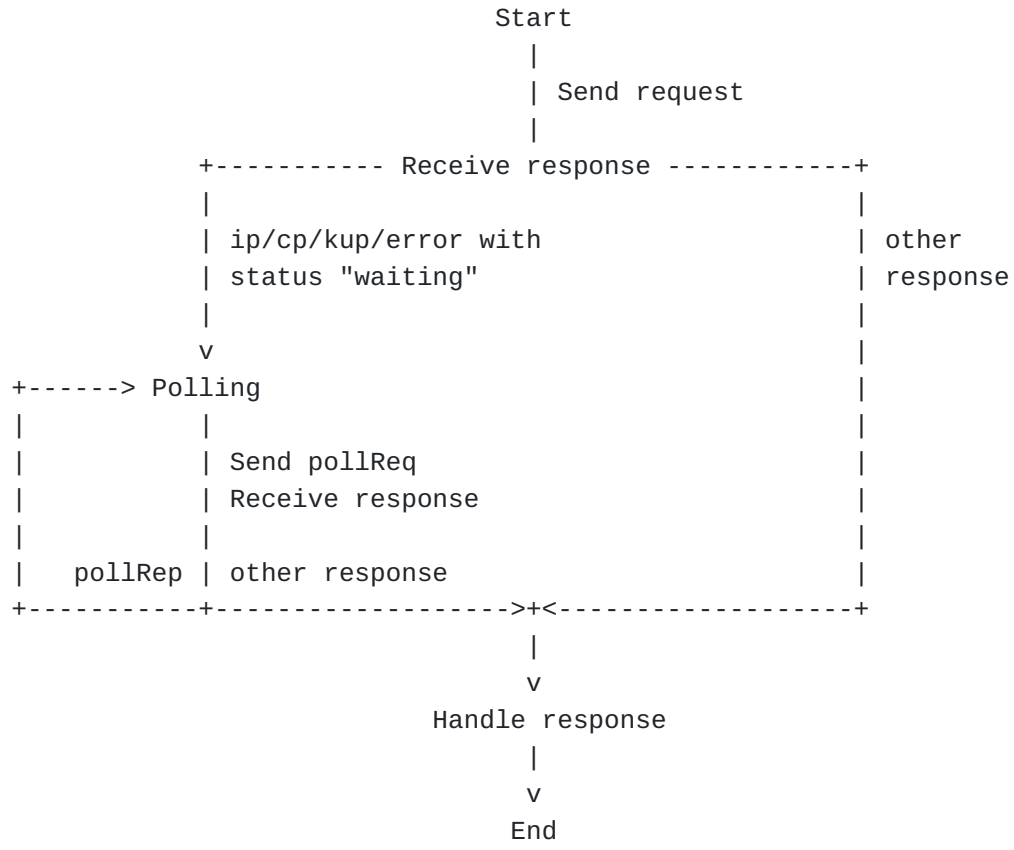
The following client-side state machine describes polling for individual CertResponse elements.



In the following exchange, the end entity is enrolling for two certificates in one request.

```
Step  End Entity                        PKI
-------------------------------------------------------------------
1   Format ir
2                    -> ir      ->
3                                       Handle ir
4                                       Manual intervention is
                                        required for both certs.
5                    <- ip      <-
6   Process ip
7   Format pollReq
8                    -> pollReq  ->
9                                       Check status of cert requests
10                                      Certificates not ready
11                                      Format pollRep
12                   <- pollRep  <-
13  Wait
14  Format pollReq
15                   -> pollReq  ->
16                                      Check status of cert requests
17                                      One certificate is ready
18                                      Format ip
19                   <- ip       <-
20  Handle ip
21  Format certConf
22                   -> certConf ->
23                                      Handle certConf
24                                      Format ack
25                   <- pkiConf   <-
26  Format pollReq
27                   -> pollReq  ->
28                                      Check status of certificate
29                                      Certificate is ready
30                                      Format ip
31                   <- ip       <-
31  Handle ip
32  Format certConf
33                   -> certConf ->
34                                      Handle certConf
35                                      Format ack
36                   <- pkiConf  <-
```

The following client-side state machine describes polling for a complete response message.



In the following exchange, the end-entity is sending a general message request, and the response is delayed by the server.

```
Step  End Entity                        PKI
-------------------------------------------------------------------
1   Format genm
2                  -> genm     ->
3                                  Handle genm
4                                  delay in response is necessary
5                                  Format error message "waiting"
                                     with certReqId set to -1
6                   <- error   <-
7   Process error
8   Format pollReq
9                   -> pollReq ->
10                                 Check status of original request
                                   general message response not ready
11                                 Format pollRep
12                  <- pollRep <-
13  Wait
14  Format pollReq
15                  -> pollReq ->
16                                 Check status of original request
                                   general message response is ready
17                                 Format genp
18                  <- genp    <-
19  Handle genp
```

2.20. Update Section 7 - Version Negotiation

Section 7 of RFC 4210 [RFC4210] describes the use of CMP protocol versions. This document describes the handling of the additional CMP version cmp2021 introduced to indicate support of EnvelopedData and hashAlg.

Replace the text of the first three paragraphs with the following text:

This section defines the version negotiation between client and server used to choose among cmp1999 (specified in RFC 2510 [RFC2510]), cmp2000 (specified in RFC 4210 [RFC4210]), and cmp2021 (specified in this document). The only difference between protocol versions cmp2021 and cmp2000 is that EnvelopedData replaces EncryptedValue and the optional hashAlg field is added to CertStatus.

If a client does not support cmp2021 it chooses the versions for a request as follows:

- If the client knows the protocol version(s) supported by the server (e.g., from a previous PKIMessage exchange or via some out-of-band means), then it MUST send a PKIMessage with the highest version supported by both itself and the server.

- If the client does not know what version(s) the server supports, then it MUST send a PKIMessage using the highest version it supports.

If a client supports cmp2021 and encrypted values are supposed to be transferred in the PKI management operation the client MUST choose the version for a request message containing the CertReqMessages data structure as follows:

- If the client accepts EnvelopedData, but not EncryptedValue, then it MUST use cmp2021.

- If the client does not accept EnvelopedData, but EncryptedValue, then it MUST use cmp2000.

- If the client accepts both EnvelopedData and EncryptedValue:

  - If the client knows that the Server supports EnvelopedData (e.g., from a previous PKIMessage exchange or via some out-of-band means), then it MUST use cmp2021.

  - If the client knows that the server supports only EncryptedValue, then it MUST use cmp2000.

  - If the client does not know whether the server supports EnvelopedData or EncryptedValue, then it MUST send the request message using cmp2021.

If a client sends a certConf message and the signatureAlgorithm of the certificate to be confirmed does not specify a hash algorithm (neither in its OID nor in its parameters) there are two cases:

- A client supporting cmp2021 MUST use cmp2021 in the certConf message.

- A client not supporting cmp2021 will not be able to handle this situation and will fail or reject the certificate.

If a server receives a message with version cmp1999 and supports it, then the version of the response message MUST also be cmp1999. If a server receives a message with a version higher or lower than it supports, then it MUST send back an ErrorMsg with the

unsupportedVersion bit set (in the failureInfo field of the pKIStatusInfo). If the received version is higher than the highest supported version for this request message, then the version in the error message MUST be the highest version the server supports for this message type; if the received version is lower than the lowest supported version for this request message then the version in the error message MUST be the lowest version the server supports for this message type.

2.21. Update Section 7.1.1. - Clients Talking to RFC 2510 Servers

Section 7.1.1 of RFC 4210 [RFC4210] describes the behavior of a client sending a cmp2000 message talking to a cmp1999 server. This document extends the section to clients with any higher version than cmp1999.

Replace the first sentence of Section 7.1.1 with the following text:

If, after sending a message with a protocol version number higher than cmp1999, a client receives an ErrorMsgContent with a version of cmp1999, then it MUST abort the current transaction.

2.22. Add Section 8.4 - Private Keys for Certificate Signing and CMP Message Protection

The following subsection addresses the risk arising from reusing the CA private key for CMP message protection.

Insert this section after Section 8.3 (Note: This fixes Errata ID 5731):

8.4. Private Keys for Certificate Signing and CMP Message Protection

When a CA acts as a CMP endpoint, it should not use the same private key for issuing certificates and for protecting CMP responses, to reduce the number of usages of the key to the minimum required.

2.23. Add Section 8.5 - Entropy of Random Numbers, Key Pairs, and Shared Secret Information

The following subsection addresses the risk arising from low entropy of random numbers, asymmetric keys, and shared secret information.

8.5. Entropy of Random Numbers, Key Pairs, and Shared Secret Information

Implementations must generate nonces and private keys from random input. The use of inadequate pseudo-random number generators (PRNGs) to generate cryptographic keys can result in little or no security. An attacker may find it much easier to reproduce the PRNG

environment that produced the keys and to search the resulting small set of possibilities than brute-force searching the whole key space. As an example of predictable random numbers see CVE-2008-0166 [CVE-2008-0166]; consequences of low-entropy random numbers are discussed in Mining Your Ps and Qs [MiningPsQs]. The generation of quality random numbers is difficult. ISO/IEC 20543:2019 [ISO.20543-2019], NIST SP 800-90A Rev.1 [NIST.SP.800-90Ar1], BSI AIS 31 V2.0 [AIS31], and others offer valuable guidance in this area.

If shared secret information is generated by a cryptographically secure random-number generator (CSRNG) it is safe to assume that the entropy of the shared secret information equals its bit length. If no CSRNG is used, the entropy of a shared secret information depends on the details of the generation process and cannot be measure securely after it has been generated. If user-generated passwords are used as shared secret information, their entropy cannot be measured and are typically insufficient for protected delivery of centrally generated keys or trust anchors.

If the entropy of a shared secret information protecting the delivery of a centrally generated key pair is known, it should not be less than the security strength of that key pair; if the shared secret information is re-used for different key pairs, the security of the shared secret information should exceed the security strength of each key pair.

For the case of a PKI management operation that delivers a new trust anchor (e.g., a root CA certificate) using caPubs or genm (a) that is not concluded in a timely manner or (b) where the shared secret information is re-used for several key management operations, the entropy of the shared secret information, if known, should not be less than the security strength of the trust anchor being managed by the operation. The shared secret information should have an entropy that at least matches the security strength of the key material being managed by the operation. Certain use cases may require shared secret information that may be of a low security strength, e.g., a human generated password. It is RECOMMENDED that such secret information be limited to a single PKI management operation.

2.24. Add Section 8.6 - Trust Anchor Provisioning Using CMP Messages

The following subsection addresses the risk arising from in-band provisioning of new trust anchors in a PKI management operation.

Insert this section after new Section 8.5:

8.6. Trust Anchor Provisioning Using CMP Messages

A provider of trust anchors, which may be an RA involved in configuration management of its clients, MUST NOT include to-be-

trusted CA certificates in a CMP message unless the specific deployment scenario can ensure that it is adequate that the receiving EE trusts these certificates, e.g., by loading them into its trust store.

Whenever an EE receives in a CMP message, e.g., in the caPubs field of a certificate response or in a general response (genp), a CA certificate for use as a trust anchor, it MUST properly authenticate the message sender without already trusting any of the CA certificates given in the message.

Moreover, the EE MUST verify that the sender is an authorized source of trust anchors. This authorization is governed by local policy and typically indicated using shared secret information or with a signature-based message protection using a certificate issued by a PKI that is explicitly authorized for this purpose.

2.25. Update Section 9 - IANA Considerations

Section 9 of RFC 4210 [RFC4210] contains the IANA Considerations of that document. As this document defines a new Extended Key Usage, the IANA Considerations need to be updated accordingly.

Replace the fourth paragraph of this section with the following text:

In the SMI-numbers registry "SMI Security for PKIX Extended Key Purpose Identifiers (1.3.6.1.5.5.7.3)" (see https://www.iana.org/assignments/smi-numbers/smi-numbers.xhtml#smi-numbers-1.3.6.1.5.5.7.3) as defined in RFC 7299 [RFC7299] one addition has been performed.

One new entry has been added:

Decimal	Description	References
32	id-kp-cmKGA	[thisRFC]

Table 1: Addition to the PKIX Extended Key Purpose Identifiers Registry

In the SMI-numbers registry "SMI Security for PKIX CMP Information Types (1.3.6.1.5.5.7.4)" (see https://www.iana.org/assignments/smi-numbers/smi-numbers.xhtml#smi-numbers-1.3.6.1.5.5.7.4) as defined in RFC 7299 [RFC7299] seven additions have been performed.

Seven new entries have been added:

Decimal	Description	References
17	id-it-caCerts	[thisRFC]
18	id-it-rootCaKeyUpdate	[thisRFC]
19	id-it-certReqTemplate	[thisRFC]
20	id-it-rootCaCert	[thisRFC]
21	id-it-certProfile	[thisRFC]
22	id-it-crlStatusList	[thisRFC]
23	id-it-crls	[thisRFC]

Table 2: Addition to the PKIX CMP Information Types Registry

In the SMI-numbers registry " SMI Security for PKIX CRMF Registration Controls (1.3.6.1.5.5.7.5.1)" (see https://www.iana.org/assignments/smi-numbers/smi-numbers.xhtml#smi-numbers-1.3.6.1.5.5.7.5.1) as defined in RFC 7299 [RFC7299] two additions have been performed.

Two new entries have been added:

Decimal	Description	References
11	id-regCtrl-algId	[thisRFC]
12	id-regCtrl-rsaKeyLen	[thisRFC]

Table 3: Addition to the PKIX CRMF Registration Controls Registry

2.26. Update Appendix B - The Use of Revocation Passphrase

Appendix B of RFC 4210 [RFC4210] describes the use of the revocation passphrase. As this document updates RFC 4210 [RFC4210] to utilize the parent structure EncryptedKey instead of EncryptedValue as described in Section 2.7 above, the description is updated accordingly.

Replace the first bullet point of this section with the following text:

*The OID and value specified in Section 5.3.19.9 MAY be sent in a GenMsg message at any time, or MAY be sent in the generalInfo field of the PKIHeader of any PKIMessage at any time. (In particular, the EncryptedKey structure as described in section 5.2.2 may be sent in the header of the certConf message that confirms acceptance of certificates requested in an initialization request or certificate request message.) This conveys a revocation passphrase chosen by the entity to the relevant CA/RA. When EnvelopedData is used, this is in the decrypted bytes of encryptedContent field. When EncryptedValue is used, this is in the decrypted bytes of the encValue field.

Furthermore, the transfer is accomplished with appropriate confidentiality characteristics.

Replace the third bullet point of this section with the following text:

*Either the localKeyId attribute of EnvelopedData as specified in RFC 2985 [RFC2985] or the valueHint field of EncryptedValue MAY contain a key identifier (chosen by the entity, along with the passphrase itself) to assist in later retrieval of the correct passphrase (e.g., when the revocation request is constructed by the entity and received by the CA/RA).

2.27. Update Appendix C - Request Message Behavioral Clarifications

Appendix C of RFC 4210 [RFC4210] provides clarifications to the request message behavior. As this document updates RFC 4210 [RFC4210] to utilize the parent structure EncryptedKey instead of EncryptedValue as described in Section 2.7 above, the description is updated accordingly.

Replace the comment within the ASN.1 syntax coming after the definition of POPOSigningKey with the following text (Note: This fixes Errata ID 2615):

```
-- **********
-- * For the purposes of this specification, the ASN.1 comment
-- * given in [RFC4211] pertains not only to certTemplate, but
-- * also to the altCertTemplate control.
-- **********
-- * The signature (using "algorithmIdentifier") is on the
-- * DER-encoded value of poposkInput (i.e., the "value" OCTETs
-- * of the POPOSigningKeyInput DER).  NOTE: If CertReqMsg
-- * certReq certTemplate (or the altCertTemplate control)
-- * contains the subject and publicKey values, then poposkInput
-- * MUST be omitted and the signature MUST be computed on the
-- * DER-encoded value of CertReqMsg certReq (or the DER-
-- * encoded value of AltCertTemplate).  If
-- * certTemplate/altCertTemplate does not contain both the
-- * subject and public key values (i.e., if it contains only
-- * one of these, or neither), then poposkInput MUST be present
-- * and MUST be signed.
-- **********
```

Replace the comment within the ASN.1 syntax coming after the definition of POPOPrivKey with the following text:

```
-- **********
-- *  the type of "thisMessage" is given as BIT STRING in RFC 4211
-- *  [RFC4211]; it should be "EncryptedKey" (in accordance with
-- *  Section 5.2.2 of this specification). Therefore, this
-- *  document makes the behavioral clarification of specifying
-- *  that the contents of "thisMessage" MUST be encoded either as
-- *  "EnvelopedData" or "EncryptedValue" (only for backward
-- *  compatibility) and then wrapped in a BIT STRING.  This
-- *  allows the necessary conveyance and protection of the
-- *  private key while maintaining bits-on-the-wire compatibility
-- *  with RFC 4211 [RFC4211].
-- **********
```

2.28. Update Appendix D.1. - General Rules for Interpretation of These Profiles

Appendix D.1 of RFC 4210 [RFC4210] provides general rules for interpretation of the PKI management messages profiles specified in Appendix D and Appendix E of RFC 4210 [RFC4210]. This document updates a sentence regarding the new protocol version cmp2021.

Replace the last sentence of the first paragraph of the section with the following text:

Mandatory fields are not mentioned if they have an obvious value (e.g., in this version of these profiles, pvno is always cmp2000).

2.29. Update Appendix D.2. - Algorithm Use Profile

Appendix D.2 of RFC 4210 [RFC4210] provides a list of algorithms that implementations must support when claiming conformance with PKI Management Message Profiles as specified in CMP Appendix D.2 [RFC4210]. This document redirects to the new algorithm profile as specified in Appendix A.1 of CMP Algorithms [I-D.ietf-lamps-cmp-algorithms].

Replace the text of the section with the following text:

D.2. Algorithm Use Profile

For specifications of algorithm identifiers and respective conventions for conforming implementations, please refer to CMP Algorithms Appendix A.1 [I-D.ietf-lamps-cmp-algorithms].

2.30. Update Appendix D.4. - Initial Registration/Certification (Basic Authenticated Scheme)

Appendix D.4 of RFC 4210 [RFC4210] provides the initial registration/certification scheme. This scheme shall continue using EncryptedValue for backward compatibility reasons.

Replace the line specifying protectionAlg of the Initialization Response message with the following text (Note: This fixes Errata ID 5201):

```
protectionAlg        MSG_MAC_ALG
```

Replace the comment after the privateKey field of crc[1].certifiedKeyPair in the syntax of the Initialization Response message with the following text:

```
-- see Appendix C, Request Message Behavioral Clarifications
-- for backward compatibility reasons, use EncryptedValue
```

3. Updates to RFC 6712 - HTTP Transfer for the Certificate Management Protocol (CMP)

3.1. Update Section 1. - Introduction

To indicate and explain why delayed delivery of all kinds of PKIMessages may be handled at transfer level and/or at CMP level, the introduction of RFC 6712 [RFC6712] is updated.

Replace the third paragraph of this section with the following text:

In addition to reliable transport, CMP requires connection and error handling from the transfer protocol, which is all covered by HTTP. Moreover, delayed delivery of CMP response messages may be handled at transfer level regardless of the message contents. Since CMP Updates [thisRFC] extends the polling mechanism specified in the second version of CMP [RFC4210] to cover all types of PKI management transactions, delays detected at application level may also be handled within CMP, using pollReq and pollReq messages.

3.2. New Section 1.1. - Changes Since RFC 6712

The following subsection describes feature updates to RFC 6712 [RFC6712]. They are related to the base specification. Hence references to the original sections in RFC 6712 [RFC6712] are used whenever possible.

Insert this section at the end of the current Section 1:

1.1 Changes Since RFC 6712

The following updates are made in [thisRFC]:

*Introduce the HTTP path '/.well-known/cmp'.

*Extend the URI structure.

3.3. Replace Section 3.6. - HTTP Request-URI

Section 3.6 of RFC 6712 [RFC6712] specifies the used HTTP URIs. This document introduces the HTTP path '/.well-known/cmp' and extends the URIs.

Replace the text of the section with the following text:

3.6. HTTP Request-URI

Each CMP server on a PKI management entity supporting HTTP or HTTPS transfer MUST support the use of the path prefix '/.well-known/' as defined in RFC 8615 [RFC8615] and the registered name 'cmp' to ease interworking in a multi-vendor environment.

The CMP client needs to be configured with sufficient information to form the CMP server URI. This is at least the authority portion of the URI, e.g., 'www.example.com:80', or the full operation path segment of the PKI management entity. Additionally, OPTIONAL path segments MAY be added after the registered application name as part of the full operation path to provide further distinction. The path segment 'p' followed by an arbitraryLabel <name> could for example support the differentiation of specific CAs or certificate profiles. Further path segments, e.g., as specified in the Lightweight CMP Profile [I-D.ietf-lamps-lightweight-cmp-profile], could indicate PKI management operations using an operationLabel <operation>. A valid full CMP URI can look like this:

```
http://www.example.com/.well-known/cmp
http://www.example.com/.well-known/cmp/<operation>
http://www.example.com/.well-known/cmp/p/<name>
http://www.example.com/.well-known/cmp/p/<name>/<operation>
```

3.4. Update Section 6. - IANA Considerations

Section 6 of RFC 6712 [RFC6712] contains the IANA Considerations of that document. As this document defines a new well-known URI suffix, the IANA Considerations need to be updated accordingly.

Replace the second paragraph of this section with the following text:

6.1. Well-Known URI Registration

This document defines a new entry with the following content in the "Well-Known URIs" registry (see https://www.iana.org/assignments/well-known-uris/) as defined in RFC 8615 [RFC8615].

URI Suffix: cmp
Change Controller: IETF
References: [thisRFC] [I-D.ietf-ace-cmpv2-coap-transport]
Related Information: CMP has a sub-registry at [https://www.iana.org/assignments/cmp/]

< TBD: The temporary registration of cmp URI suffix must be updated from provisional to permanent. >

6.2. CMP Well-Known URI Registry

This document defines a new protocol registry group entitled "Certificate Management Protocol (CMP)" (at https://www.iana.org/assignments/cmp/) with a new registry "CMP Well-Known URI Path Segments" containing three columns: Path Segment, Description, and Reference. New items can be added using the Specification Required RFC 8615 [RFC8615] process. The initial contents of this registry is:

Path Segment: p
Description: Indicates that the next path segment specifies, e.g., a CA or certificate profile name
References: [thisRFC] [I-D.ietf-ace-cmpv2-coap-transport]

< TBD: A new protocol registry group "Certificate Management Protocol (CMP)" (at https://www.iana.org/assignments/cmp) and an initial entry 'p' must be registered. >

4. IANA Considerations

This document contains an update to the IANA Consideration sections to be added to [RFC4210] and [RFC6712].

This document updates the ASN.1 modules of RFC 4210 Appendix F [RFC4210] and RFC 5912 Section 9 [RFC5912]. The OIDs 99 (id-mod-cmp2021-88) and 100 (id-mod-cmp2021-02) were registered in the SMI Security for PKIX Module Identifier registry to identify the updated ASN.1 modules.

5. Security Considerations

The security considerations of RFC 4210 [RFC4210] are extended in Section 2.22 to Section 2.24. No changes are made to the existing security considerations of RFC 6712 [RFC6712].

6. Acknowledgements

Special thank goes to Jim Schaad for his guidance and the inspiration on structuring and writing this document we got from [RFC6402] which updates CMC. Special thank also goes also to Russ Housley, Lijun Liao, Martin Peylo, and Tomas Gustavsson for reviewing and providing valuable suggestions on improving this document.

We also thank all reviewers of this document for their valuable feedback.

7. References

7.1. Normative References

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Appendix A. ASN.1 Modules

A.1. 1988 ASN.1 Module

This section contains the updated ASN.1 module for [RFC4210]. This module replaces the module in Appendix F of that document. Although a 2002 ASN.1 module is provided, this 1988 ASN.1 module remains the normative module as per the policy of the PKIX working group.

```
PKIXCMP {iso(1) identified-organization(3)
      dod(6) internet(1) security(5) mechanisms(5) pkix(7)
      id-mod(0) id-mod-cmp2021-88(99)}

DEFINITIONS EXPLICIT TAGS ::=

BEGIN

-- EXPORTS ALL --

IMPORTS

    Certificate, CertificateList, Extensions, Name, Time,
    AlgorithmIdentifier, id-kp
    --, UTF8String -- -- if required; otherwise, comment out
           FROM PKIX1Explicit88 {iso(1) identified-organization(3)
           dod(6) internet(1) security(5) mechanisms(5) pkix(7)
           id-mod(0) id-pkix1-explicit-88(18)}
    -- The import of Name is added to define CertificationRequest
    -- instead of importing it from PKCS#10 [RFC2986]

    DistributionPointName, GeneralNames, GeneralName, KeyIdentifier
           FROM PKIX1Implicit88 {iso(1) identified-organization(3)
           dod(6) internet(1) security(5) mechanisms(5) pkix(7)
           id-mod(0) id-pkix1-implicit-88(19)}

    CertTemplate, PKIPublicationInfo, EncryptedKey, CertId,
    CertReqMessages, Controls, AttributeTypeAndValue, id-regCtrl
           FROM PKIXCRMF-2005 {iso(1) identified-organization(3)
           dod(6) internet(1) security(5) mechanisms(5) pkix(7)
           id-mod(0) id-mod-crmf2005(36)}
    -- The import of EncryptedKey is added due to the updates made
    -- in CMP Updates [thisRFC]]. EncryptedValue does not need to
    -- be imported anymore and is therefore removed here.

    -- see also the behavioral clarifications to CRMF codified in
    -- Appendix C of this specification

    EnvelopedData, SignedData, Attribute
           FROM CryptographicMessageSyntax2004 { iso(1)
           member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)
           smime(16) modules(0) cms-2004(24) }
    -- The import of EnvelopedData and SignedData is added due to
    -- the updates made in CMP Updates [thisRFC]
    -- The import of Attribute is added to define
    -- CertificationRequest instead of importing it from
    -- PKCS#10 [RFC2986]

    ;
```

```
-- the rest of the module contains locally-defined OIDs and
-- constructs

CMPCertificate ::= CHOICE {
    x509v3PKCert        Certificate
}
-- This syntax, while bits-on-the-wire compatible with the
-- standard X.509 definition of "Certificate", allows the
-- possibility of future certificate types (such as X.509
-- attribute certificates, WAP WTLS certificates, or other kinds
-- of certificates) within this certificate management protocol,
-- should a need ever arise to support such generality.  Those
-- implementations that do not foresee a need to ever support
-- other certificate types MAY, if they wish, comment out the
-- above structure and "un-comment" the following one prior to
-- compiling this ASN.1 module.  (Note that interoperability
-- with implementations that don't do this will be unaffected by
-- this change.)

-- CMPCertificate ::= Certificate

PKIMessage ::= SEQUENCE {
    header           PKIHeader,
    body             PKIBody,
    protection   [0] PKIProtection OPTIONAL,
    extraCerts   [1] SEQUENCE SIZE (1..MAX) OF CMPCertificate
                     OPTIONAL
}

PKIMessages ::= SEQUENCE SIZE (1..MAX) OF PKIMessage

PKIHeader ::= SEQUENCE {
    pvno                INTEGER     { cmp1999(1), cmp2000(2),
                                      cmp2021(3) },
    sender              GeneralName,
    -- identifies the sender
    recipient           GeneralName,
    -- identifies the intended recipient
    messageTime     [0] GeneralizedTime         OPTIONAL,
    -- time of production of this message (used when sender
    -- believes that the transport will be "suitable"; i.e.,
    -- that the time will still be meaningful upon receipt)
    protectionAlg   [1] AlgorithmIdentifier     OPTIONAL,
    -- algorithm used for calculation of protection bits
    senderKID       [2] KeyIdentifier           OPTIONAL,
    recipKID        [3] KeyIdentifier           OPTIONAL,
    -- to identify specific keys used for protection
    transactionID   [4] OCTET STRING            OPTIONAL,
    -- identifies the transaction; i.e., this will be the same in
```

```
    -- corresponding request, response, certConf, and PKIConf
    -- messages
    senderNonce     [5] OCTET STRING            OPTIONAL,
    recipNonce      [6] OCTET STRING            OPTIONAL,
    -- nonces used to provide replay protection, senderNonce
    -- is inserted by the creator of this message; recipNonce
    -- is a nonce previously inserted in a related message by
    -- the intended recipient of this message
    freeText        [7] PKIFreeText             OPTIONAL,
    -- this may be used to indicate context-specific instructions
    -- (this field is intended for human consumption)
    generalInfo     [8] SEQUENCE SIZE (1..MAX) OF
                            InfoTypeAndValue     OPTIONAL
    -- this may be used to convey context-specific information
    -- (this field not primarily intended for human consumption)
}

PKIFreeText ::= SEQUENCE SIZE (1..MAX) OF UTF8String
    -- text encoded as UTF-8 String [RFC3629]

PKIBody ::= CHOICE {       -- message-specific body elements
    ir       [0]  CertReqMessages,        --Initialization Request
    ip       [1]  CertRepMessage,         --Initialization Response
    cr       [2]  CertReqMessages,        --Certification Request
    cp       [3]  CertRepMessage,         --Certification Response
    p10cr    [4]  CertificationRequest,   --imported from [RFC2986]
    popdecc  [5]  POPODecKeyChallContent, --pop Challenge
    popdecr  [6]  POPODecKeyRespContent,  --pop Response
    kur      [7]  CertReqMessages,        --Key Update Request
    kup      [8]  CertRepMessage,         --Key Update Response
    krr      [9]  CertReqMessages,        --Key Recovery Request
    krp      [10] KeyRecRepContent,       --Key Recovery Response
    rr       [11] RevReqContent,          --Revocation Request
    rp       [12] RevRepContent,          --Revocation Response
    ccr      [13] CertReqMessages,        --Cross-Cert. Request
    ccp      [14] CertRepMessage,         --Cross-Cert. Response
    ckuann   [15] CAKeyUpdAnnContent,     --CA Key Update Ann.
    cann     [16] CertAnnContent,         --Certificate Ann.
    rann     [17] RevAnnContent,          --Revocation Ann.
    crlann   [18] CRLAnnContent,          --CRL Announcement
    pkiconf  [19] PKIConfirmContent,      --Confirmation
    nested   [20] NestedMessageContent,   --Nested Message
    genm     [21] GenMsgContent,          --General Message
    genp     [22] GenRepContent,          --General Response
    error    [23] ErrorMsgContent,        --Error Message
    certConf [24] CertConfirmContent,     --Certificate confirm
    pollReq  [25] PollReqContent,         --Polling request
    pollRep  [26] PollRepContent          --Polling response
}
```

```
PKIProtection ::= BIT STRING

ProtectedPart ::= SEQUENCE {
    header    PKIHeader,
    body      PKIBody
}

id-PasswordBasedMac OBJECT IDENTIFIER ::= {1 2 840 113533 7 66 13}
PBMParameter ::= SEQUENCE {
    salt                OCTET STRING,
    -- note:  implementations MAY wish to limit acceptable sizes
    -- of this string to values appropriate for their environment
    -- in order to reduce the risk of denial-of-service attacks
    owf                 AlgorithmIdentifier,
    -- AlgId for a One-Way Function (SHA-1 recommended)
    iterationCount      INTEGER,
    -- number of times the OWF is applied
    -- note:  implementations MAY wish to limit acceptable sizes
    -- of this integer to values appropriate for their environment
    -- in order to reduce the risk of denial-of-service attacks
    mac                 AlgorithmIdentifier
    -- the MAC AlgId (e.g., DES-MAC, Triple-DES-MAC [PKCS11],
}   -- or HMAC [RFC2104, RFC2202])

id-DHBasedMac OBJECT IDENTIFIER ::= {1 2 840 113533 7 66 30}
DHBMParameter ::= SEQUENCE {
    owf                 AlgorithmIdentifier,
    -- AlgId for a One-Way Function (SHA-1 recommended)
    mac                 AlgorithmIdentifier
    -- the MAC AlgId (e.g., DES-MAC, Triple-DES-MAC [PKCS11],
}   -- or HMAC [RFC2104, RFC2202])


NestedMessageContent ::= PKIMessages

PKIStatus ::= INTEGER {
    accepted               (0),
    -- you got exactly what you asked for
    grantedWithMods        (1),
    -- you got something like what you asked for; the
    -- requester is responsible for ascertaining the differences
    rejection              (2),
    -- you don't get it, more information elsewhere in the message
    waiting                (3),
    -- the request body part has not yet been processed; expect to
    -- hear more later (note: proper handling of this status
    -- response MAY use the polling req/rep PKIMessages specified
    -- in Section 5.3.22; alternatively, polling in the underlying
```

```
    -- transport layer MAY have some utility in this regard)
    revocationWarning      (4),
    -- this message contains a warning that a revocation is
    -- imminent
    revocationNotification (5),
    -- notification that a revocation has occurred
    keyUpdateWarning       (6)
    -- update already done for the oldCertId specified in
    -- CertReqMsg
}

PKIFailureInfo ::= BIT STRING {
-- since we can fail in more than one way!
-- More codes may be added in the future if/when required.
    badAlg              (0),
    -- unrecognized or unsupported Algorithm Identifier
    badMessageCheck     (1),
    -- integrity check failed (e.g., signature did not verify)
    badRequest          (2),
    -- transaction not permitted or supported
    badTime             (3),
    -- messageTime was not sufficiently close to the system time,
    -- as defined by local policy
    badCertId           (4),
    -- no certificate could be found matching the provided criteria
    badDataFormat       (5),
    -- the data submitted has the wrong format
    wrongAuthority      (6),
    -- the authority indicated in the request is different from the
    -- one creating the response token
    incorrectData       (7),
    -- the requester's data is incorrect (for notary services)
    missingTimeStamp    (8),
    -- when the timestamp is missing but should be there
    -- (by policy)
    badPOP              (9),
    -- the proof-of-possession failed
    certRevoked         (10),
       -- the certificate has already been revoked
    certConfirmed       (11),
       -- the certificate has already been confirmed
    wrongIntegrity      (12),
       -- invalid integrity, password based instead of signature or
       -- vice versa
    badRecipientNonce   (13),
       -- invalid recipient nonce, either missing or wrong value
    timeNotAvailable    (14),
       -- the TSA's time source is not available
    unacceptedPolicy    (15),
```

```
       -- the requested TSA policy is not supported by the TSA.
    unacceptedExtension (16),
       -- the requested extension is not supported by the TSA.
    addInfoNotAvailable (17),
       -- the additional information requested could not be
       -- understood or is not available
    badSenderNonce      (18),
       -- invalid sender nonce, either missing or wrong size
    badCertTemplate     (19),
       -- invalid cert. template or missing mandatory information
    signerNotTrusted    (20),
       -- signer of the message unknown or not trusted
    transactionIdInUse  (21),
       -- the transaction identifier is already in use
    unsupportedVersion  (22),
       -- the version of the message is not supported
    notAuthorized       (23),
       -- the sender was not authorized to make the preceding
       -- request or perform the preceding action
    systemUnavail       (24),
    -- the request cannot be handled due to system unavailability
    systemFailure       (25),
    -- the request cannot be handled due to system failure
    duplicateCertReq    (26)
    -- certificate cannot be issued because a duplicate
    -- certificate already exists
}

PKIStatusInfo ::= SEQUENCE {
    status        PKIStatus,
    statusString  PKIFreeText     OPTIONAL,
    failInfo      PKIFailureInfo  OPTIONAL
}

OOBCert ::= CMPCertificate

OOBCertHash ::= SEQUENCE {
    hashAlg     [0] AlgorithmIdentifier     OPTIONAL,
    certId      [1] CertId                  OPTIONAL,
    hashVal         BIT STRING
    -- hashVal is calculated over the DER encoding of the
    -- self-signed certificate with the identifier certID.
}

POPODecKeyChallContent ::= SEQUENCE OF Challenge
-- One Challenge per encryption key certification request (in the
-- same order as these requests appear in CertReqMessages).

Challenge ::= SEQUENCE {
```

```
    owf                 AlgorithmIdentifier  OPTIONAL,
    -- MUST be present in the first Challenge; MAY be omitted in
    -- any subsequent Challenge in POPODecKeyChallContent (if
    -- omitted, then the owf used in the immediately preceding
    -- Challenge is to be used).
    witness             OCTET STRING,
    -- the result of applying the one-way function (owf) to a
    -- randomly-generated INTEGER, A.  [Note that a different
    -- INTEGER MUST be used for each Challenge.]
    challenge           OCTET STRING
    -- the encryption (under the public key for which the cert.
    -- request is being made) of Rand.
}

-- Added in CMP Updates [thisRFC]

Rand ::= SEQUENCE {
-- Rand is encrypted under the public key to form the challenge
-- in POPODecKeyChallContent
   int                  INTEGER,
   -- the randomly-generated INTEGER A (above)
   sender               GeneralName
   -- the sender's name (as included in PKIHeader)
}

POPODecKeyRespContent ::= SEQUENCE OF INTEGER
-- One INTEGER per encryption key certification request (in the
-- same order as these requests appear in CertReqMessages).  The
-- retrieved INTEGER A (above) is returned to the sender of the
-- corresponding Challenge.

CertRepMessage ::= SEQUENCE {
    caPubs       [1] SEQUENCE SIZE (1..MAX) OF CMPCertificate
                     OPTIONAL,
    response         SEQUENCE OF CertResponse
}

CertificationRequest ::= SEQUENCE {
    certificationRequestInfo  SEQUENCE {
      version                   INTEGER,
      subject                   Name,
      subjectPublicKeyInfo      SEQUENCE {
        algorithm                 AlgorithmIdentifier,
        subjectPublicKey          BIT STRING },
      attributes                [0] IMPLICIT SET OF Attribute },
    signatureAlgorithm        AlgorithmIdentifier,
    signature                 BIT STRING
}
```

```
CertResponse ::= SEQUENCE {
    certReqId           INTEGER,
    -- to match this response with corresponding request (a value
    -- of -1 is to be used if certReqId is not specified in the
    -- corresponding request, which can only be a p10cr)
    status              PKIStatusInfo,
    certifiedKeyPair    CertifiedKeyPair    OPTIONAL,
    rspInfo             OCTET STRING        OPTIONAL
    -- analogous to the id-regInfo-utf8Pairs string defined
    -- for regInfo in CertReqMsg [RFC4211]
}

CertifiedKeyPair ::= SEQUENCE {
    certOrEncCert       CertOrEncCert,
    privateKey      [0] EncryptedKey        OPTIONAL,
    -- see [RFC4211] for comment on encoding
    -- Changed from Encrypted Value to EncryptedKey as a CHOICE of
    -- EncryptedValue and EnvelopedData due to the changes made in
    -- CMP Updates [thisRFC]
    -- Using the choice EncryptedValue is bit-compatible to the
    -- syntax without this change
    publicationInfo [1] PKIPublicationInfo  OPTIONAL
}

CertOrEncCert ::= CHOICE {
    certificate     [0] CMPCertificate,
    encryptedCert   [1] EncryptedKey
    -- Changed from Encrypted Value to EncryptedKey as a CHOICE of
    -- EncryptedValue and EnvelopedData due to the changes made in
    -- CMP Updates [thisRFC]
    -- Using the choice EncryptedValue is bit-compatible to the
    -- syntax without this change
}

KeyRecRepContent ::= SEQUENCE {
    status                  PKIStatusInfo,
    newSigCert          [0] CMPCertificate OPTIONAL,
    caCerts             [1] SEQUENCE SIZE (1..MAX) OF
                                    CMPCertificate OPTIONAL,
    keyPairHist         [2] SEQUENCE SIZE (1..MAX) OF
                                    CertifiedKeyPair OPTIONAL
}

RevReqContent ::= SEQUENCE OF RevDetails

RevDetails ::= SEQUENCE {
    certDetails         CertTemplate,
    -- allows requester to specify as much as they can about
    -- the cert. for which revocation is requested
```

```
    -- (e.g., for cases in which serialNumber is not available)
    crlEntryDetails     Extensions       OPTIONAL
    -- requested crlEntryExtensions
}

RevRepContent ::= SEQUENCE {
    status       SEQUENCE SIZE (1..MAX) OF PKIStatusInfo,
    -- in same order as was sent in RevReqContent
    revCerts [0] SEQUENCE SIZE (1..MAX) OF CertId
                                        OPTIONAL,
    -- IDs for which revocation was requested
    -- (same order as status)
    crls     [1] SEQUENCE SIZE (1..MAX) OF CertificateList
                                        OPTIONAL
    -- the resulting CRLs (there may be more than one)
}

CAKeyUpdAnnContent ::= SEQUENCE {
    oldWithNew   CMPCertificate, -- old pub signed with new priv
    newWithOld   CMPCertificate, -- new pub signed with old priv
    newWithNew   CMPCertificate  -- new pub signed with new priv
}

CertAnnContent ::= CMPCertificate

RevAnnContent ::= SEQUENCE {
    status              PKIStatus,
    certId              CertId,
    willBeRevokedAt     GeneralizedTime,
    badSinceDate        GeneralizedTime,
    crlDetails          Extensions  OPTIONAL
    -- extra CRL details (e.g., crl number, reason, location, etc.)
}

CRLAnnContent ::= SEQUENCE OF CertificateList

CertConfirmContent ::= SEQUENCE OF CertStatus

CertStatus ::= SEQUENCE {
   certHash    OCTET STRING,
   -- the hash of the certificate, using the same hash algorithm
   -- as is used to create and verify the certificate signature
   certReqId   INTEGER,
   -- to match this confirmation with the corresponding req/rep
   statusInfo  PKIStatusInfo OPTIONAL,
   hashAlg [0] AlgorithmIdentifier OPTIONAL
   -- the hash algorithm to use for calculating certHash
   -- SHOULD NOT be used in all cases where the AlgorithmIdentifier
   -- of the certificate signature specifies a hash algorithm
```

```
}

PKIConfirmContent ::= NULL

-- CertReqTemplateContent, id-regCtrl-algId, id-regCtrl-algId, and
-- id-regCtrl-rsaKeyLen were added in CMP Updates [thisRFC]

CertReqTemplateContent ::= SEQUENCE {
   certTemplate           CertTemplate,
   -- prefilled certTemplate structure elements
   -- The SubjectPublicKeyInfo field in the certTemplate MUST NOT
   -- be used.
   keySpec                Controls OPTIONAL
   -- MAY be used to specify supported algorithms.
   -- Controls  ::= SEQUENCE SIZE (1..MAX) OF AttributeTypeAndValue
   -- as specified in CRMF (RFC4211)
   }

id-regCtrl-altCertTemplate OBJECT IDENTIFIER ::= { id-regCtrl 7 }
   AltCertTemplate ::= AttributeTypeAndValue
   -- specifies a template for a certificate other than an X.509v3
   -- public-key certificate

id-regCtrl-algId OBJECT IDENTIFIER ::= { id-regCtrl 11 }
   AlgIdCtrl ::= AlgorithmIdentifier
   -- SHALL be used to specify supported algorithms other than RSA

id-regCtrl-rsaKeyLen OBJECT IDENTIFIER ::= { id-regCtrl 12 }
   RsaKeyLenCtrl ::= INTEGER (1..MAX)
   -- SHALL be used to specify supported RSA key lengths

-- RootCaKeyUpdateContent, CRLSource, and CRLStatus were added in
-- CMP Updates [thisRFC]

RootCaKeyUpdateContent ::= SEQUENCE {
   newWithNew       CMPCertificate,
   -- new root CA certificate
   newWithOld   [0] CMPCertificate OPTIONAL,
   -- X.509 certificate containing the new public root CA key
   -- signed with the old private root CA key
   oldWithNew   [1] CMPCertificate OPTIONAL
   -- X.509 certificate containing the old public root CA key
   -- signed with the new private root CA key
   }

CRLSource ::= CHOICE {
   dpn          [0] DistributionPointName,
   issuer       [1] GeneralNames }

CRLStatus ::= SEQUENCE {
```

```
   source       CRLSource,
   thisUpdate   Time OPTIONAL }

InfoTypeAndValue ::= SEQUENCE {
    infoType               OBJECT IDENTIFIER,
    infoValue              ANY DEFINED BY infoType  OPTIONAL
}
-- Example InfoTypeAndValue contents include, but are not limited
-- to, the following (un-comment in this ASN.1 module and use as
-- appropriate for a given environment):
--
--   id-it-caProtEncCert    OBJECT IDENTIFIER ::= {id-it 1}
--      CAProtEncCertValue      ::= CMPCertificate
--   id-it-signKeyPairTypes OBJECT IDENTIFIER ::= {id-it 2}
--      SignKeyPairTypesValue   ::= SEQUENCE SIZE (1..MAX) OF
--                                      AlgorithmIdentifier
--   id-it-encKeyPairTypes  OBJECT IDENTIFIER ::= {id-it 3}
--      EncKeyPairTypesValue    ::= SEQUENCE SIZE (1..MAX) OF
--                                      AlgorithmIdentifier
--   id-it-preferredSymmAlg OBJECT IDENTIFIER ::= {id-it 4}
--      PreferredSymmAlgValue   ::= AlgorithmIdentifier
--   id-it-caKeyUpdateInfo  OBJECT IDENTIFIER ::= {id-it 5}
--      CAKeyUpdateInfoValue    ::= CAKeyUpdAnnContent
--   id-it-currentCRL       OBJECT IDENTIFIER ::= {id-it 6}
--      CurrentCRLValue         ::= CertificateList
--   id-it-unsupportedOIDs  OBJECT IDENTIFIER ::= {id-it 7}
--      UnsupportedOIDsValue    ::= SEQUENCE SIZE (1..MAX) OF
--                                        OBJECT IDENTIFIER
--   id-it-keyPairParamReq  OBJECT IDENTIFIER ::= {id-it 10}
--      KeyPairParamReqValue    ::= OBJECT IDENTIFIER
--   id-it-keyPairParamRep  OBJECT IDENTIFIER ::= {id-it 11}
--      KeyPairParamRepValue    ::= AlgorithmIdentifier
--   id-it-revPassphrase    OBJECT IDENTIFIER ::= {id-it 12}
--      RevPassphraseValue      ::= EncryptedKey
--      - Changed from Encrypted Value to EncryptedKey as a CHOICE
--      - of EncryptedValue and EnvelopedData due to the changes
--      - made in CMP Updates [thisRFC]
--      - Using the choice EncryptedValue is bit-compatible to the
--      - syntax without this change
--   id-it-implicitConfirm  OBJECT IDENTIFIER ::= {id-it 13}
--      ImplicitConfirmValue    ::= NULL
--   id-it-confirmWaitTime  OBJECT IDENTIFIER ::= {id-it 14}
--      ConfirmWaitTimeValue    ::= GeneralizedTime
--   id-it-origPKIMessage   OBJECT IDENTIFIER ::= {id-it 15}
--      OrigPKIMessageValue     ::= PKIMessages
--   id-it-suppLangTags     OBJECT IDENTIFIER ::= {id-it 16}
--      SuppLangTagsValue       ::= SEQUENCE OF UTF8String
--   id-it-caCerts          OBJECT IDENTIFIER ::= {id-it 17}
--      CaCertsValue            ::= SEQUENCE SIZE (1..MAX) OF
```

```
--                                              CMPCertificate
--      - id-it-caCerts added in CMP Updates [thisRFC]
--   id-it-rootCaKeyUpdate  OBJECT IDENTIFIER ::= {id-it 18}
--      RootCaKeyUpdateValue    ::= RootCaKeyUpdateContent
--      - id-it-rootCaKeyUpdate added in CMP Updates [thisRFC]
--   id-it-certReqTemplate  OBJECT IDENTIFIER ::= {id-it 19}
--      CertReqTemplateValue    ::= CertReqTemplateContent
--      - id-it-certReqTemplate added in CMP Updates [thisRFC]
--   id-it-rootCaCert       OBJECT IDENTIFIER ::= {id-it 20}
--      RootCaCertValue         ::= CMPCertificate
--      - id-it-rootCaCert added in CMP Updates [thisRFC]
--   id-it-certProfile      OBJECT IDENTIFIER ::= {id-it 21}
--      CertProfileValue        ::= SEQUENCE SIZE (1..MAX) OF
--                                                UTF8String
--      - id-it-certProfile added in CMP Updates [thisRFC]
--   id-it-crlStatusList    OBJECT IDENTIFIER ::= {id-it 22}
--   CRLStatusListValue         ::= SEQUENCE SIZE (1..MAX) OF
--                                                 CRLStatus
--      - id-it-crlStatusList added in CMP Updates [thisRFC]
--   id-it-crls             OBJECT IDENTIFIER ::= {id-it 23}
--   CRLsValue                  ::= SEQUENCE SIZE (1..MAX) OF
--                                               CertificateList
--      - id-it-crls added in CMP Updates [thisRFC]
--
-- where
--
--   id-pkix OBJECT IDENTIFIER ::= {
--      iso(1) identified-organization(3)
--      dod(6) internet(1) security(5) mechanisms(5) pkix(7)}
-- and
--   id-it   OBJECT IDENTIFIER ::= {id-pkix 4}
--
--
-- This construct MAY also be used to define new PKIX Certificate
-- Management Protocol request and response messages, or general-
-- purpose (e.g., announcement) messages for future needs or for
-- specific environments.

GenMsgContent ::= SEQUENCE OF InfoTypeAndValue

-- May be sent by EE, RA, or CA (depending on message content).
-- The OPTIONAL infoValue parameter of InfoTypeAndValue will
-- typically be omitted for some of the examples given above.
-- The receiver is free to ignore any contained OBJ. IDs that it
-- does not recognize. If sent from EE to CA, the empty set
-- indicates that the CA may send
-- any/all information that it wishes.

GenRepContent ::= SEQUENCE OF InfoTypeAndValue
```

```
-- Receiver MAY ignore any contained OIDs that it does not
-- recognize.

ErrorMsgContent ::= SEQUENCE {
    pKIStatusInfo          PKIStatusInfo,
    errorCode              INTEGER           OPTIONAL,
    -- implementation-specific error codes
    errorDetails           PKIFreeText       OPTIONAL
    -- implementation-specific error details
}

PollReqContent ::= SEQUENCE OF SEQUENCE {
    certReqId              INTEGER
}

PollRepContent ::= SEQUENCE OF SEQUENCE {
    certReqId              INTEGER,
    checkAfter             INTEGER,  -- time in seconds
    reason                 PKIFreeText OPTIONAL
}

--
-- Extended Key Usage extension for PKI entities used in CMP
-- operations, added due to the changes made in
-- CMP Updates [thisRFC]
-- The EKUs for the CA and RA are reused from CMC as defined in
-- [RFC6402]
--

-- id-kp-cmcCA OBJECT IDENTIFIER ::= { id-kp 27 }
-- id-kp-cmcRA OBJECT IDENTIFIER ::= { id-kp 28 }
id-kp-cmKGA OBJECT IDENTIFIER ::= { id-kp 32 }

-- There is no 1988 ASN.1 module of PKCS#9 available to import the
-- syntax of the localKeyId attribute type and value from. Therefore,
-- the syntax is added here as needed for the updates made in
-- CMP Updates [thisRFC]

pkcs-9 OBJECT IDENTIFIER ::= {iso(1) member-body(2) us(840)
                              rsadsi(113549) pkcs(1) 9}

pkcs-9-at-localKeyId OBJECT IDENTIFIER ::= {pkcs-9 21}

LocalKeyIdValue ::= OCTET STRING

END -- of CMP module
```

A.2. 2002 ASN.1 Module

This section contains the updated 2002 ASN.1 module for [RFC5912]. This module replaces the module in Section 9 of that document. The module contains those changes to the normative ASN.1 module from RFC4210 Appendix F [RFC4210] that were to update to 2002 ASN.1 standard done in [RFC5912] as well as changes made in this document.

```
PKIXCMP-2021
    { iso(1) identified-organization(3) dod(6) internet(1)
    security(5) mechanisms(5) pkix(7) id-mod(0)
    id-mod-cmp2021-02(100) }
DEFINITIONS EXPLICIT TAGS ::=
BEGIN
IMPORTS

AttributeSet{}, SingleAttribute{}, Extensions{}, EXTENSION, ATTRIBUTE
FROM PKIX-CommonTypes-2009
    {iso(1) identified-organization(3) dod(6) internet(1) security(5)
    mechanisms(5) pkix(7) id-mod(0) id-mod-pkixCommon-02(57)}

AlgorithmIdentifier{}, SIGNATURE-ALGORITHM, ALGORITHM,
    DIGEST-ALGORITHM, MAC-ALGORITHM
FROM AlgorithmInformation-2009
    {iso(1) identified-organization(3) dod(6) internet(1) security(5)
    mechanisms(5) pkix(7) id-mod(0)
    id-mod-algorithmInformation-02(58)}

Certificate, CertificateList, Time, id-kp
FROM PKIX1Explicit-2009
    {iso(1) identified-organization(3) dod(6) internet(1) security(5)
    mechanisms(5) pkix(7) id-mod(0) id-mod-pkix1-explicit-02(51)}

DistributionPointName, GeneralNames, GeneralName, KeyIdentifier
FROM PKIX1Implicit-2009
    {iso(1) identified-organization(3) dod(6) internet(1) security(5)
    mechanisms(5) pkix(7) id-mod(0) id-mod-pkix1-implicit-02(59)}

CertTemplate, PKIPublicationInfo, EncryptedKey, CertId,
    CertReqMessages, Controls, RegControlSet, id-regCtrl
FROM PKIXCRMF-2009
    { iso(1) identified-organization(3) dod(6) internet(1)
    security(5) mechanisms(5) pkix(7) id-mod(0)
    id-mod-crmf2005-02(55) }
    -- The import of EncryptedKey is added due to the updates made
    -- in CMP Updates [thisRFC]. EncryptedValue does not need to
    -- be imported anymore and is therefore removed here.

-- see also the behavioral clarifications to CRMF codified in
-- Appendix C of this specification

CertificationRequest
FROM PKCS-10
    {iso(1) identified-organization(3) dod(6) internet(1) security(5)
    mechanisms(5) pkix(7) id-mod(0) id-mod-pkcs10-2009(69)}
-- (specified in RFC 2986 with 1993 ASN.1 syntax and IMPLICIT
-- tags).  Alternatively, implementers may directly include
```

```
-- the [RFC2986] syntax in this module

localKeyId
FROM PKCS-9
    {iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)
    modules(0) pkcs-9(1)}
    -- The import of localKeyId is added due to the updates made in
    -- CMP Updates [thisRFC]

EnvelopedData, SignedData
FROM CryptographicMessageSyntax-2009
    {iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs-9(9)
    smime(16) modules(0) id-mod-cms-2004-02(41)}
    -- The import of EnvelopedData and SignedData is added due to
    -- the updates made in CMP Updates [thisRFC]
;

-- the rest of the module contains locally defined OIDs and
-- constructs

CMPCertificate ::= CHOICE { x509v3PKCert Certificate, ... }
-- This syntax, while bits-on-the-wire compatible with the
-- standard X.509 definition of "Certificate", allows the
-- possibility of future certificate types (such as X.509
-- attribute certificates, WAP WTLS certificates, or other kinds
-- of certificates) within this certificate management protocol,
-- should a need ever arise to support such generality.  Those
-- implementations that do not foresee a need to ever support
-- other certificate types MAY, if they wish, comment out the
-- above structure and "uncomment" the following one prior to
-- compiling this ASN.1 module.  (Note that interoperability
-- with implementations that don't do this will be unaffected by
-- this change.)

-- CMPCertificate ::= Certificate

PKIMessage ::= SEQUENCE {
    header           PKIHeader,
    body             PKIBody,
    protection   [0] PKIProtection OPTIONAL,
    extraCerts   [1] SEQUENCE SIZE (1..MAX) OF CMPCertificate
                  OPTIONAL }

PKIMessages ::= SEQUENCE SIZE (1..MAX) OF PKIMessage

PKIHeader ::= SEQUENCE {
    pvno                INTEGER     { cmp1999(1), cmp2000(2),
                                      cmp2012(3) },
    sender              GeneralName,
    -- identifies the sender
```

```
    recipient           GeneralName,
    -- identifies the intended recipient
    messageTime     [0] GeneralizedTime         OPTIONAL,
    -- time of production of this message (used when sender
    -- believes that the transport will be "suitable"; i.e.,
    -- that the time will still be meaningful upon receipt)
    protectionAlg   [1] AlgorithmIdentifier{ALGORITHM, {...}}
                            OPTIONAL,
    -- algorithm used for calculation of protection bits
    senderKID       [2] KeyIdentifier           OPTIONAL,
    recipKID        [3] KeyIdentifier           OPTIONAL,
    -- to identify specific keys used for protection
    transactionID   [4] OCTET STRING            OPTIONAL,
    -- identifies the transaction; i.e., this will be the same in
    -- corresponding request, response, certConf, and PKIConf
    -- messages
    senderNonce     [5] OCTET STRING            OPTIONAL,
    recipNonce      [6] OCTET STRING            OPTIONAL,
    -- nonces used to provide replay protection, senderNonce
    -- is inserted by the creator of this message; recipNonce
    -- is a nonce previously inserted in a related message by
    -- the intended recipient of this message
    freeText        [7] PKIFreeText             OPTIONAL,
    -- this may be used to indicate context-specific instructions
    -- (this field is intended for human consumption)
    generalInfo     [8] SEQUENCE SIZE (1..MAX) OF
                        InfoTypeAndValue     OPTIONAL
    -- this may be used to convey context-specific information
    -- (this field not primarily intended for human consumption)
}

PKIFreeText ::= SEQUENCE SIZE (1..MAX) OF UTF8String
    -- text encoded as UTF-8 String [RFC3629]

PKIBody ::= CHOICE {       -- message-specific body elements
    ir       [0]  CertReqMessages,        --Initialization Request
    ip       [1]  CertRepMessage,         --Initialization Response
    cr       [2]  CertReqMessages,        --Certification Request
    cp       [3]  CertRepMessage,         --Certification Response
    p10cr    [4]  CertificationRequest,   --imported from [RFC2986]
    popdecc  [5]  POPODecKeyChallContent, --pop Challenge
    popdecr  [6]  POPODecKeyRespContent,  --pop Response
    kur      [7]  CertReqMessages,        --Key Update Request
    kup      [8]  CertRepMessage,         --Key Update Response
    krr      [9]  CertReqMessages,        --Key Recovery Request
    krp      [10] KeyRecRepContent,       --Key Recovery Response
    rr       [11] RevReqContent,          --Revocation Request
    rp       [12] RevRepContent,          --Revocation Response
    ccr      [13] CertReqMessages,        --Cross-Cert. Request
```

```
    ccp      [14] CertRepMessage,         --Cross-Cert. Response
    ckuann   [15] CAKeyUpdAnnContent,     --CA Key Update Ann.
    cann     [16] CertAnnContent,         --Certificate Ann.
    rann     [17] RevAnnContent,          --Revocation Ann.
    crlann   [18] CRLAnnContent,          --CRL Announcement
    pkiconf  [19] PKIConfirmContent,      --Confirmation
    nested   [20] NestedMessageContent,   --Nested Message
    genm     [21] GenMsgContent,          --General Message
    genp     [22] GenRepContent,          --General Response
    error    [23] ErrorMsgContent,        --Error Message
    certConf [24] CertConfirmContent,     --Certificate confirm
    pollReq  [25] PollReqContent,         --Polling request
    pollRep  [26] PollRepContent          --Polling response
}

PKIProtection ::= BIT STRING

ProtectedPart ::= SEQUENCE {
    header    PKIHeader,
    body      PKIBody }

id-PasswordBasedMac OBJECT IDENTIFIER ::= { iso(1) member-body(2)
    usa(840) nt(113533) nsn(7) algorithms(66) 13 }
PBMParameter ::= SEQUENCE {
    salt                OCTET STRING,
    -- note:  implementations MAY wish to limit acceptable sizes
    -- of this string to values appropriate for their environment
    -- in order to reduce the risk of denial-of-service attacks
    owf                 AlgorithmIdentifier{DIGEST-ALGORITHM, {...}},
    -- AlgId for a One-Way Function (SHA-1 recommended)
    iterationCount      INTEGER,
    -- number of times the OWF is applied
    -- note:  implementations MAY wish to limit acceptable sizes
    -- of this integer to values appropriate for their environment
    -- in order to reduce the risk of denial-of-service attacks
    mac                 AlgorithmIdentifier{MAC-ALGORITHM, {...}}
    -- the MAC AlgId (e.g., DES-MAC, Triple-DES-MAC [PKCS11],
    -- or HMAC [RFC2104, RFC2202])
}

id-DHBasedMac OBJECT IDENTIFIER ::= { iso(1) member-body(2)
    usa(840) nt(113533) nsn(7) algorithms(66) 30 }
DHBMParameter ::= SEQUENCE {
    owf                 AlgorithmIdentifier{DIGEST-ALGORITHM, {...}},
    -- AlgId for a One-Way Function (SHA-1 recommended)
    mac                 AlgorithmIdentifier{MAC-ALGORITHM, {...}}
    -- the MAC AlgId (e.g., DES-MAC, Triple-DES-MAC [PKCS11],
    -- or HMAC [RFC2104, RFC2202])
}
```

```
PKIStatus ::= INTEGER {
    accepted               (0),
    -- you got exactly what you asked for
    grantedWithMods        (1),
    -- you got something like what you asked for; the
    -- requester is responsible for ascertaining the differences
    rejection              (2),
    -- you don't get it, more information elsewhere in the message
    waiting                (3),
    -- the request body part has not yet been processed; expect to
    -- hear more later (note: proper handling of this status
    -- response MAY use the polling req/rep PKIMessages specified
    -- in Section 5.3.22; alternatively, polling in the underlying
    -- transport layer MAY have some utility in this regard)
    revocationWarning      (4),
    -- this message contains a warning that a revocation is
    -- imminent
    revocationNotification (5),
    -- notification that a revocation has occurred
    keyUpdateWarning       (6)
    -- update already done for the oldCertId specified in
    -- CertReqMsg
}

PKIFailureInfo ::= BIT STRING {
-- since we can fail in more than one way!
-- More codes may be added in the future if/when required.
    badAlg              (0),
    -- unrecognized or unsupported Algorithm Identifier
    badMessageCheck     (1),
    -- integrity check failed (e.g., signature did not verify)
    badRequest          (2),
    -- transaction not permitted or supported
    badTime             (3),
    -- messageTime was not sufficiently close to the system time,
    -- as defined by local policy
    badCertId           (4),
    -- no certificate could be found matching the provided criteria
    badDataFormat       (5),
    -- the data submitted has the wrong format
    wrongAuthority      (6),
    -- the authority indicated in the request is different from the
    -- one creating the response token
    incorrectData       (7),
    -- the requester's data is incorrect (for notary services)
    missingTimeStamp    (8),
    -- when the timestamp is missing but should be there
    -- (by policy)
```

```
    badPOP              (9),
    -- the proof-of-possession failed
    certRevoked         (10),
    -- the certificate has already been revoked
    certConfirmed       (11),
    -- the certificate has already been confirmed
    wrongIntegrity      (12),
    -- invalid integrity, password based instead of signature or
    -- vice versa
    badRecipientNonce   (13),
    -- invalid recipient nonce, either missing or wrong value
    timeNotAvailable    (14),
    -- the TSA's time source is not available
    unacceptedPolicy    (15),
    -- the requested TSA policy is not supported by the TSA
    unacceptedExtension (16),
    -- the requested extension is not supported by the TSA
    addInfoNotAvailable (17),
    -- the additional information requested could not be
    -- understood or is not available
    badSenderNonce      (18),
    -- invalid sender nonce, either missing or wrong size
    badCertTemplate     (19),
    -- invalid cert. template or missing mandatory information
    signerNotTrusted    (20),
    -- signer of the message unknown or not trusted
    transactionIdInUse  (21),
    -- the transaction identifier is already in use
    unsupportedVersion  (22),
    -- the version of the message is not supported
    notAuthorized       (23),
    -- the sender was not authorized to make the preceding
    -- request or perform the preceding action
    systemUnavail       (24),
    -- the request cannot be handled due to system unavailability
    systemFailure       (25),
    -- the request cannot be handled due to system failure
    duplicateCertReq    (26)
    -- certificate cannot be issued because a duplicate
    -- certificate already exists
}

PKIStatusInfo ::= SEQUENCE {
    status        PKIStatus,
    statusString  PKIFreeText     OPTIONAL,
    failInfo      PKIFailureInfo  OPTIONAL }

OOBCert ::= CMPCertificate
```

```
OOBCertHash ::= SEQUENCE {
    hashAlg     [0] AlgorithmIdentifier{DIGEST-ALGORITHM, {...}}
                        OPTIONAL,
    certId      [1] CertId                  OPTIONAL,
    hashVal         BIT STRING
    -- hashVal is calculated over the DER encoding of the
    -- self-signed certificate with the identifier certID.
}

POPODecKeyChallContent ::= SEQUENCE OF Challenge
-- One Challenge per encryption key certification request (in the
-- same order as these requests appear in CertReqMessages).

Challenge ::= SEQUENCE {
    owf                 AlgorithmIdentifier{DIGEST-ALGORITHM, {...}}
                            OPTIONAL,
    -- MUST be present in the first Challenge; MAY be omitted in
    -- any subsequent Challenge in POPODecKeyChallContent (if
    -- omitted, then the owf used in the immediately preceding
    -- Challenge is to be used).
    witness             OCTET STRING,
    -- the result of applying the one-way function (owf) to a
    -- randomly-generated INTEGER, A.  [Note that a different
    -- INTEGER MUST be used for each Challenge.]
    challenge           OCTET STRING
    -- the encryption (under the public key for which the cert.
    -- request is being made) of Rand.
}

-- Added in CMP Updates [thisRFC]

Rand ::= SEQUENCE {
-- Rand is encrypted under the public key to form the challenge
-- in POPODecKeyChallContent
   int                  INTEGER,
   -- the randomly-generated INTEGER A (above)
   sender               GeneralName
   -- the sender's name (as included in PKIHeader)
}

POPODecKeyRespContent ::= SEQUENCE OF INTEGER
-- One INTEGER per encryption key certification request (in the
-- same order as these requests appear in CertReqMessages).  The
-- retrieved INTEGER A (above) is returned to the sender of the
-- corresponding Challenge.

CertRepMessage ::= SEQUENCE {
    caPubs       [1] SEQUENCE SIZE (1..MAX) OF CMPCertificate
                  OPTIONAL,
```

```
    response         SEQUENCE OF CertResponse }

CertResponse ::= SEQUENCE {
    certReqId           INTEGER,
    -- to match this response with the corresponding request (a value
    -- of -1 is to be used if certReqId is not specified in the
    -- corresponding request, which can only be a p10cr)
    status              PKIStatusInfo,
    certifiedKeyPair    CertifiedKeyPair    OPTIONAL,
    rspInfo             OCTET STRING        OPTIONAL
    -- analogous to the id-regInfo-utf8Pairs string defined
    -- for regInfo in CertReqMsg [RFC4211]
}

CertifiedKeyPair ::= SEQUENCE {
    certOrEncCert       CertOrEncCert,
    privateKey      [0] EncryptedKey      OPTIONAL,
    -- see [RFC4211] for comment on encoding
    -- Changed from Encrypted Value to EncryptedKey as a CHOICE of
    -- EncryptedValue and EnvelopedData due to the changes made in
    -- CMP Updates [thisRFC]
    -- Using the choice EncryptedValue is bit-compatible to the
    -- syntax without this change
    publicationInfo [1] PKIPublicationInfo  OPTIONAL }

CertOrEncCert ::= CHOICE {
    certificate     [0] CMPCertificate,
    encryptedCert   [1] EncryptedKey
    -- Changed from Encrypted Value to EncryptedKey as a CHOICE of
    -- EncryptedValue and EnvelopedData due to the changes made in
    -- CMP Updates [thisRFC]
    -- Using the choice EncryptedValue is bit-compatible to the
    -- syntax without this change
}

KeyRecRepContent ::= SEQUENCE {
    status                  PKIStatusInfo,
    newSigCert          [0] CMPCertificate OPTIONAL,
    caCerts             [1] SEQUENCE SIZE (1..MAX) OF
                                CMPCertificate OPTIONAL,
    keyPairHist         [2] SEQUENCE SIZE (1..MAX) OF
                                CertifiedKeyPair OPTIONAL }

RevReqContent ::= SEQUENCE OF RevDetails

RevDetails ::= SEQUENCE {
    certDetails         CertTemplate,
    -- allows requester to specify as much as they can about
    -- the cert. for which revocation is requested
```

```
    -- (e.g., for cases in which serialNumber is not available)
    crlEntryDetails     Extensions{{...}}    OPTIONAL
    -- requested crlEntryExtensions
}

RevRepContent ::= SEQUENCE {
    status       SEQUENCE SIZE (1..MAX) OF PKIStatusInfo,
    -- in same order as was sent in RevReqContent
    revCerts [0] SEQUENCE SIZE (1..MAX) OF CertId OPTIONAL,
    -- IDs for which revocation was requested
    -- (same order as status)
    crls     [1] SEQUENCE SIZE (1..MAX) OF CertificateList OPTIONAL
    -- the resulting CRLs (there may be more than one)
}

CAKeyUpdAnnContent ::= SEQUENCE {
    oldWithNew   CMPCertificate, -- old pub signed with new priv
    newWithOld   CMPCertificate, -- new pub signed with old priv
    newWithNew   CMPCertificate  -- new pub signed with new priv
}

CertAnnContent ::= CMPCertificate

RevAnnContent ::= SEQUENCE {
    status              PKIStatus,
    certId              CertId,
    willBeRevokedAt     GeneralizedTime,
    badSinceDate        GeneralizedTime,
    crlDetails          Extensions{{...}}  OPTIONAL
    -- extra CRL details (e.g., crl number, reason, location, etc.)
}

CRLAnnContent ::= SEQUENCE OF CertificateList
PKIConfirmContent ::= NULL

NestedMessageContent ::= PKIMessages

-- CertReqTemplateContent, AttributeTypeAndValue,
-- ExpandedRegControlSet, id-regCtrl-altCertTemplate,
-- AltCertTemplate, regCtrl-algId, id-regCtrl-algId, AlgIdCtrl,
-- regCtrl-rsaKeyLen, id-regCtrl-rsaKeyLen, and RsaKeyLenCtrl
-- were added in CMP Updates [thisRFC]

CertReqTemplateContent ::= SEQUENCE {
   certTemplate           CertTemplate,
   -- prefilled certTemplate structure elements
   -- The SubjectPublicKeyInfo field in the certTemplate MUST NOT
   -- be used.
   keySpec                Controls OPTIONAL
   -- MAY be used to specify supported algorithms.
```

```
   -- Controls  ::= SEQUENCE SIZE (1..MAX) OF AttributeTypeAndValue
   -- as specified in CRMF (RFC4211)
   }

AttributeTypeAndValue ::= SingleAttribute{{ ... }}

ExpandedRegControlSet ATTRIBUTE ::= { RegControlSet |
   regCtrl-altCertTemplate | regCtrl-algId | regCtrl-rsaKeyLen, ... }

regCtrl-altCertTemplate ATTRIBUTE ::=
   { TYPE AltCertTemplate IDENTIFIED BY id-regCtrl-altCertTemplate }

id-regCtrl-altCertTemplate OBJECT IDENTIFIER ::= { id-regCtrl 7 }

AltCertTemplate ::= AttributeTypeAndValue
   -- specifies a template for a certificate other than an X.509v3
   -- public-key certificate

regCtrl-algId ATTRIBUTE ::=
   { TYPE AlgIdCtrl IDENTIFIED BY id-regCtrl-algId }

id-regCtrl-algId OBJECT IDENTIFIER ::= { id-regCtrl 11 }

AlgIdCtrl ::= AlgorithmIdentifier{ALGORITHM, {...}}
   -- SHALL be used to specify supported algorithms other than RSA

regCtrl-rsaKeyLen ATTRIBUTE ::=
   { TYPE RsaKeyLenCtrl IDENTIFIED BY id-regCtrl-rsaKeyLen }

id-regCtrl-rsaKeyLen OBJECT IDENTIFIER ::= { id-regCtrl 12 }

RsaKeyLenCtrl ::= INTEGER (1..MAX)
   -- SHALL be used to specify supported RSA key lengths

-- RootCaKeyUpdateContent, CRLSource, and CRLStatus were added in
-- CMP Updates [thisRFC]

RootCaKeyUpdateContent ::= SEQUENCE {
   newWithNew       CMPCertificate,
   -- new root CA certificate
   newWithOld   [0] CMPCertificate OPTIONAL,
   -- X.509 certificate containing the new public root CA key
   -- signed with the old private root CA key
   oldWithNew   [1] CMPCertificate OPTIONAL
   -- X.509 certificate containing the old public root CA key
   -- signed with the new private root CA key
   }

CRLSource ::= CHOICE {
   dpn          [0] DistributionPointName,
```

```
   issuer       [1] GeneralNames }

CRLStatus ::= SEQUENCE {
   source       CRLSource,
   thisUpdate   Time OPTIONAL }

INFO-TYPE-AND-VALUE ::= TYPE-IDENTIFIER

InfoTypeAndValue ::= SEQUENCE {
    infoType    INFO-TYPE-AND-VALUE.
                    &id({SupportedInfoSet}),
    infoValue   INFO-TYPE-AND-VALUE.
                    &Type({SupportedInfoSet}{@infoType}) }

SupportedInfoSet INFO-TYPE-AND-VALUE ::= { ... }

-- Example InfoTypeAndValue contents include, but are not limited
-- to, the following (uncomment in this ASN.1 module and use as
-- appropriate for a given environment):
--
--   id-it-caProtEncCert    OBJECT IDENTIFIER ::= {id-it 1}
--      CAProtEncCertValue      ::= CMPCertificate
--   id-it-signKeyPairTypes OBJECT IDENTIFIER ::= {id-it 2}
--      SignKeyPairTypesValue   ::= SEQUENCE SIZE (1..MAX) OF
--                                      AlgorithmIdentifier{{...}}
--   id-it-encKeyPairTypes  OBJECT IDENTIFIER ::= {id-it 3}
--      EncKeyPairTypesValue    ::= SEQUENCE SIZE (1..MAX) OF
--                                      AlgorithmIdentifier{{...}}
--   id-it-preferredSymmAlg OBJECT IDENTIFIER ::= {id-it 4}
--      PreferredSymmAlgValue   ::= AlgorithmIdentifier{{...}}
--   id-it-caKeyUpdateInfo  OBJECT IDENTIFIER ::= {id-it 5}
--      CAKeyUpdateInfoValue    ::= CAKeyUpdAnnContent
--   id-it-currentCRL       OBJECT IDENTIFIER ::= {id-it 6}
--      CurrentCRLValue         ::= CertificateList
--   id-it-unsupportedOIDs  OBJECT IDENTIFIER ::= {id-it 7}
--      UnsupportedOIDsValue    ::= SEQUENCE SIZE (1..MAX) OF
--                                          OBJECT IDENTIFIER
--   id-it-keyPairParamReq  OBJECT IDENTIFIER ::= {id-it 10}
--      KeyPairParamReqValue    ::= OBJECT IDENTIFIER
--   id-it-keyPairParamRep  OBJECT IDENTIFIER ::= {id-it 11}
--      KeyPairParamRepValue    ::= AlgorithmIdentifier{{...}}
--   id-it-revPassphrase    OBJECT IDENTIFIER ::= {id-it 12}
--      RevPassphraseValue      ::= EncryptedKey
--      - Changed from Encrypted Value to EncryptedKey as a CHOICE
--      - of EncryptedValue and EnvelopedData due to the changes
--      - made in CMP Updates [thisRFC]
--      - Using the choice EncryptedValue is bit-compatible to
--      - the syntax without this change
--   id-it-implicitConfirm  OBJECT IDENTIFIER ::= {id-it 13}
```

```
--      ImplicitConfirmValue    ::= NULL
--   id-it-confirmWaitTime  OBJECT IDENTIFIER ::= {id-it 14}
--      ConfirmWaitTimeValue    ::= GeneralizedTime
--   id-it-origPKIMessage   OBJECT IDENTIFIER ::= {id-it 15}
--      OrigPKIMessageValue     ::= PKIMessages
--   id-it-suppLangTags     OBJECT IDENTIFIER ::= {id-it 16}
--      SuppLangTagsValue       ::= SEQUENCE OF UTF8String
--   id-it-caCerts          OBJECT IDENTIFIER ::= {id-it 17}
--      CaCertsValue            ::= SEQUENCE SIZE (1..MAX) OF
--                                          CMPCertificate
--      - id-it-caCerts added in CMP Updates [thisRFC]
--   id-it-rootCaKeyUpdate  OBJECT IDENTIFIER ::= {id-it 18}
--      RootCaKeyUpdateValue    ::= RootCaKeyUpdateContent
--      - id-it-rootCaKeyUpdate added in CMP Updates [thisRFC]
--   id-it-certReqTemplate  OBJECT IDENTIFIER ::= {id-it 19}
--      CertReqTemplateValue    ::= CertReqTemplateContent
--      - id-it-certReqTemplate added in CMP Updates [thisRFC]
--   id-it-rootCaCert       OBJECT IDENTIFIER ::= {id-it 20}
--      RootCaCertValue         ::= CMPCertificate
--      - id-it-rootCaCert added in CMP Updates [thisRFC]
--   id-it-certProfile      OBJECT IDENTIFIER ::= {id-it 21}
--      CertProfileValue        ::= SEQUENCE SIZE (1..MAX) OF
--                                             UTF8String
--      - id-it-certProfile added in CMP Updates [thisRFC]
--   id-it-crlStatusList    OBJECT IDENTIFIER ::= {id-it 22}
--   CRLStatusListValue         ::= SEQUENCE SIZE (1..MAX) OF
--                                               CRLStatus
--      - id-it-crlStatusList added in CMP Updates [thisRFC]
--   id-it-crls             OBJECT IDENTIFIER ::= {id-it 23}
--   CRLsValue                  ::= SEQUENCE SIZE (1..MAX) OF
--                                           CertificateList
--      - id-it-crls added in CMP Updates [thisRFC]
--
-- where
--
--   id-pkix OBJECT IDENTIFIER ::= {
--      iso(1) identified-organization(3)
--      dod(6) internet(1) security(5) mechanisms(5) pkix(7)}
-- and
--   id-it   OBJECT IDENTIFIER ::= {id-pkix 4}
--
--
-- This construct MAY also be used to define new PKIX Certificate
-- Management Protocol request and response messages, or general-
-- purpose (e.g., announcement) messages for future needs or for
-- specific environments.

GenMsgContent ::= SEQUENCE OF InfoTypeAndValue
```

```
-- May be sent by EE, RA, or CA (depending on message content).
-- The OPTIONAL infoValue parameter of InfoTypeAndValue will
-- typically be omitted for some of the examples given above.
-- The receiver is free to ignore any contained OBJECT IDs that it
-- does not recognize.  If sent from EE to CA, the empty set
-- indicates that the CA may send
-- any/all information that it wishes.

GenRepContent ::= SEQUENCE OF InfoTypeAndValue
-- Receiver MAY ignore any contained OIDs that it does not
-- recognize.

ErrorMsgContent ::= SEQUENCE {
    pKIStatusInfo          PKIStatusInfo,
    errorCode              INTEGER           OPTIONAL,
    -- implementation-specific error codes
    errorDetails           PKIFreeText       OPTIONAL
    -- implementation-specific error details
}

CertConfirmContent ::= SEQUENCE OF CertStatus

CertStatus ::= SEQUENCE {
    certHash    OCTET STRING,
    -- the hash of the certificate, using the same hash algorithm
    -- as is used to create and verify the certificate signature
    certReqId   INTEGER,
    -- to match this confirmation with the corresponding req/rep
    statusInfo  PKIStatusInfo OPTIONAL,
    hashAlg [0] AlgorithmIdentifier{DIGEST-ALGORITHM, {...}} OPTIONAL
    -- the hash algorithm to use for calculating certHash
    -- SHOULD NOT be used in all cases where the AlgorithmIdentifier
    -- of the certificate signature specifies a hash algorithm
   }

PollReqContent ::= SEQUENCE OF SEQUENCE {
    certReqId              INTEGER }

PollRepContent ::= SEQUENCE OF SEQUENCE {
    certReqId              INTEGER,
    checkAfter             INTEGER,  -- time in seconds
    reason                 PKIFreeText OPTIONAL }

--
-- Extended Key Usage extension for PKI entities used in CMP
-- operations, added due to the changes made in
-- CMP Updates [thisRFC]
-- The EKUs for the CA and RA are reused from CMC as defined in
-- [RFC6402]
```

```
--

-- id-kp-cmcCA OBJECT IDENTIFIER ::= { id-kp 27 }
-- id-kp-cmcRA OBJECT IDENTIFIER ::= { id-kp 28 }
id-kp-cmKGA OBJECT IDENTIFIER ::= { id-kp 32 }

END
```

Appendix B. History of Changes

Note: This appendix will be deleted in the final version of the document.

From version 18 -> 19:

- Deleted the Comments on IANA ToDos and changed the decimals TBD1 -> 22 and TBD2 -> 23
- Updated Section 3.4 regarding ToDos updating the well-known URI registration.

From version 17 -> 18:

- Addressed comments from AD Evaluation (see thread "AD Review of draft-ietf-lamps-cmp-updates-17")
- Added Section 2.8 to clarify on the usage of GeneralizedTime (see thread "draft-ietf-lamps-cmp-updates: fractional seconds")
- Updated Section 3.4 introducing the path segment 'p' to indicate the following arbitrary label according to the discussion during IETF 113 (see thread "/.well-known/brski reference to brski-registry")
- Capitalized all headlines

From version 16 -> 17:

- Removed the pre-RFC5378 work disclaimer after the RFC 4210 authors granted BCP78 rights to the IETF Trust
- Removed note on usage of language tags in UTF8String due to reference to references to outdated/historic RFCs
- Resolved some nits reported by I-D nit checker tool

From version 15 -> 16:

- Updated IPR disclaimer

From version 14 -> 15:

- Updated Section 2.16 clarifying the usage of CRLSource (see thread "CRL update retrieval - WG Last Call for draft-ietf-lamps-cmp-updates-14 and draft-ietf-lamps-lightweight-cmp-profile-08")
- Updated Section 2.22 adding further references regarding random number generation (see thread "CMP draft WGLC: measuring entropy, CA certificates")
- Fixed some nits

From version 13 -> 14:

- Extended id-it-caCerts support message to allow transporting to-be-trusted root CA certificates; added respective security consideration (see thread "Generalizing the CMP "Get CA certificates" use case")
- Rolled back changes made in previous version regarding root CA update to avoid registration of new OIDs. Yet we sticked to using id-it-rootCaCert in the genm body instead its headers' generalInfo field and removed the ToDos and TBDs on re-arranging id-it OIDs (see thread "Allocation of OIDs for CRL update retrieval (draft-ietf-lamps-cmp-updates-13)")

From version 12 -> 13:

- Added John Gray to the list of authors due to fruitful discussion and important proposals
- Fixed errata no. 2615, 2616, 3949, 4078, and 5201 on RFC 4210
- Added reference on RFC 8933 regarding CMS signedAttrs to Section 2.7
- Updated Section 2.9 and the ASN.1 modules moving the position of the hashAlg field (see thread "[CMP Updates] position of hashAlg in certStatus")
- Changed "rootCaCert" from generalInfo to genm body and generalized to "oldTrustAnchor", renaming "rootCaKeyUpdate" to "trustAnchorUpdate" in Sections 2.14, A.1, and A.2, removing former Section 2.4
- Added genm use case "CRL update retrieval" in Section 2.16, A.1, and A.2. (see thread "[CMP Updates] Requesting a current CRL")
- Updated Section 2.18 and 2.17 to support polling for all kinds of CMP request messages initiated by an error message with status "waiting" as initially discussed at IETF 111
- Updated Sections 2.19 and 2.20 regarding version handling
- Added further OIDs and a TBD regarding reordering of the OIDs
- Added Sections 2.21 to 2.23 with new security considerations and updated Section 5 accordingly
- Added a ToDo regarding OID registration, renaming, and re-ordering
- Added Section 3.1 updating the introduction of RFC 6712

* Fixed some nits in the ASN.1 modules (see thread "draft-ietf-lamps-cmp-updates-12: Comments on A.1. 1988 ASN.1 Module" and "draft-ietf-lamps-cmp-updates-12: Comments on A.2. 2002 ASN.1 Module")
* Replaced the term "transport" by "transfer" where appropriate to prevent confusion
* Minor editorial changes

From version 11 -> 12:

* Extended Section 2.5 and the ASN.1 modules in Appendix A to allow a sequence of certificate profiles in CertProfileValue (see thread "id-it-CertProfile in draft-ietf-lamps-cmp-updates")

From version 10 -> 11:

* Add Section 2.10 to add an additional hashAlg field to the CertStatus type to support certificates signed with a signature algorithm not explicitly indicating a hash algorithm in the AlgorithmIdentifier (see thread "Hash algorithm to us for calculating certHash")
* Added newly registered OIDs and temporarily registered URI suffix
* Exchanged the import of CertificationRequest from RFC 2986 to the definition from RFC 6402 Appendix A.1 (see thread "CMP Update of CertificationRequest")
* Corrected the definition of LocalKeyIdValue in Appendix A.1
* Updated new RFC numbers for draft-lamps-crmf-update-algs

From version 9 -> 10:

* Added 1988 ASN.1 syntax for localKeyId attribute to Appendix A.1

From version 08 -> 09:

* Deleted specific definition of CMP CA and CMP RA in Section 2.2 and only reference RFC 6402 for definition of id-kp-cmcCA and id-kp-cmcRA to resolve the ToDo below based on feedback of Tomas Gustavsson
* Added Section 2.4. and 2.5 to define id-it-rootCaCert and id-it-certProfile to be used in Section 2.14 and 2.15
* Added reference to CMP Algorithms in Section 2.8
* Extended Section 2.14 to explicitly indicate the root CA an update is requested for by using id-it-rootCaCert and changing the ASN.1 syntax to require providing the newWithOld certificate in the response message
* Extended Section 2.15 to explicitly indicate the certificate request template by using id-it-certProfile and on further details of the newly introduced controls
* Deleted the table on id-kp-cmcCA and id-kp-cmcRA and adding id-it-rootCaCert and id-it-certProfile in Section 2.19

*Adding the definition of id-it-rootCaCert and id-it-certProfile in both ASN.1 modules in Appendix A
*Minor editorial changes reflecting the above changes

From version 07 -> 08:

*Added a ToDo to Section 2.2 to reflect a current discussion on the need of an additional CMP-CA role and EKU and differentiation from CMP-RA
*Added ToDos to Section 2.12 and 2.13

From version 06 -> 07:

*Added David von Oheimb as co-author
*Changed to XML V3
*Added Section 2.3 to enable a CMP protocol version number 3 in the PKIHeader for cases where EnvelopedData is to be used (see thread "Mail regarding draft-ietf-lamps-cmp-updates").
*Added Section 2.4 to refer to draft-ietf-lamps-crmf-update-algs for the update of id-PasswordBasedMac for PKI message protection using passwords or shared secrets.
*Updated Section 2.6 to introduce the protocol version number 3 to properly indicate support of EnvelopedData instead of EncryptedValue in case a transaction requires use of EnvelopedData (see thread "Mail regarding draft-ietf-lamps-cmp-updates").
*Update Section 2.14 to make the minimal changes to the respective section in CMP more explicit.
*Added Sections 2.15 and 2.16 to address the new cmp2021 protocol version in Section 7 Version Negotiation.
*Updated Section 2.17 to add new OIDs for id-regCtrl-algId and id-regCtrl-rsaKeyLen for registration at IANA.
*Added Section 2.20 to update the general rules of interpretation in Appendix D.1 regarding the new cmp2021 version.
*Added Section 2.21 to update the Algorithm Use Profile in Appendix D.2 with the reference to the new CMP Algorithms document as decided at IETF 108.
*Updates Section 3.1 to delete the description of a discovery mechanism as decided at IETF 108.
*Various changes and corrections in wording.

From version 05 -> 06:

*Added the update of Appendix D.2 with the reference to the new CMP Algorithms document as decided in IETF 108
*Updated the IANA considerations to register new OIDs for id-regCtrl-algId and d-regCtrl-rsaKeyLen.
*Minor changes and corrections

From version 04 -> 05:

- Added Section 2.11 and Section 2.12 to clarify the usage of these general messages types with EC curves (see thread "AlgorithmIdentifier parameters NULL value - Re: InfoTypeAndValue in CMP headers")
- Split former section 2.7 on adding 'CA Certificates', 'Root CA Certificates Update', and 'Certificate Request Template' in three separate sections for easier readability
- Changed in Section 2.15 the ASN.1 syntax of CertReqTemplateValue from using rsaKeyLen to usage of controls as specified in CRMF Section 6 [RFC4211] (see thread "dtaft-ietf-lamps-cmp-updates and rsaKeyLen")
- Updated the IANA considerations in Section 2.25 to introduce new OID for id-regCtrl-algId and id-regCtrl-rsaKeyLen (see thread "dtaft-ietf-lamps-cmp-updates and rsaKeyLen")
- Updated the IANA Considerations in and the Appendixes to introduce new OID for the updates ASN.1 modules (see thread "I-D Action: draft-ietf-lamps-cmp-updates-04.txt")
- Removed EncryptedValue from and added Controls to the list of types imported from CRMF [RFC4211] in ASN.1 modules (see thread "draft-ietf-lamps-cmp-updates and the ASN.1 modules")
- Moved declaration of Rand out of the comment in ASN.1 modules (see thread "draft-ietf-lamps-cmp-updates and the ASN.1 modules")
- Minor changes and corrections

From version 03 -> 04:

- Added Section 2.7 to introduce three new id-it IDs for uses in general messages as discussed (see thread "draft-ietf-lamps-cmp-updates add section to introduce id-it-caCerts, id-it-rootCaKeyUpdate, and id-it-certReqTemplate")
- Added the new id-it IDs and the /.well-known/cmp to the IANA Considerations of [RFC4210] in Section 2.9
- Updated the IANA Considerations of [RFC4210] in Section 2.26
- Some changes in wording on Section 3 due to review comments from Martin Peylo

From version 02 -> 03:

- Added a ToDo on aligning with the CMP Algorithms draft that will be set up as decided in IETF 108
- Updated section on Encrypted Values in Section 2.7 to add the AsymmetricKey Package structure to transport a newly generated private key as decided in IETF 108
- Updated the IANA Considerations of [RFC4210] in Section 2.26
- Added the pre-registered OID in Section 2.26 and the ASN.1 module

*Added Section 3 to document the changes to RFC 6712 [RFC6712] regarding URI discovery and using the path-prefix of '/.well-known/' as discussed in IETF 108
*Updated the IANA Considerations section
*Added a complete updated ASN.1 module in 1988 syntax to update Appendix F of [RFC4210] and a complete updated ASN.1 module in 2002 syntax to update Section 9 of [RFC5912]
*Minor changes in wording

From version 01 -> 02:

*Updated section on EKU OIDs in Section 2.2 as decided in IETF 107
*Changed from symmetric key-encryption to password-based key management technique in Section 2.7 as discussed with Russ and Jim on the mailing list
*Defined the attribute containing the key identifier for the revocation passphrase in Section 2.26
*Moved the change history to the Appendix

From version 00 -> 01:

*Minor changes in wording

From draft-brockhaus-lamps-cmp-updates-03 -> draft-ietf-lamps-cmp-updates-00:

*Changes required to reflect WG adoption

From version 02 -> 03:

*Added some clarification in Section 2.1

From version 01 -> 02:

*Added clarification to section on multiple protection
*Added clarification on new EKUs after some exchange with Tomas Gustavsson
*Reused OIDs from RFC 6402 [RFC6402] as suggested by Sean Turner at IETF 106
*Added clarification on the field containing the key identifier for a revocation passphrase
*Minor changes in wording

From version 00 -> 01:

*Added a section describing the new extended key usages
*Completed the section on changes to the specification of encrypted values
*Added a section on clarification to Appendix D.4

*Minor generalization in RFC 4210 [RFC4210] Sections 5.1.3.4 and 5.3.22
*Minor changes in wording

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