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# Simple Certificate Enrolment Protocol
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Abstract

This document specifies the Simple Certificate Enrolment Protocol (SCEP), a PKI protocol that leverages existing technology by using CMS (formerly known as PKCS #7) and PKCS #10 over HTTP. SCEP is the evolution of the enrolment protocol sponsored by Cisco Systems, which enjoys wide support in both client and server implementations, as well as being relied upon by numerous other industry standards that work with certificates.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on August 1, 2019.

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## 1. Introduction

X.509 certificates serve as the basis for several standards-based security protocols such as TLS [19], S/MIME [16], and IKE/IPsec [15]. When an X.509 certificate is issued there typically is a need for a certificate management protocol to enable a PKI client to request or

renew a certificate from a Certificate Authority (CA). This specification defines a protocol, Simple Certificate Enrolment Protocol (SCEP), for certificate management and certificate and CRL queries.

The SCEP protocol supports the following general operations:

- CA public key distribution.
- Certificate enrolment and issue.
- Certificate renewal.
- Certificate query.
- CRL query.

SCEP makes extensive use of CMS [6] and PKCS #10 [9].

## 1.1. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [1].

This document uses the Augmented Backus-Naur Form (ABNF) notation as specified in [2] for defining formal syntax of commands. Non terminals not defined in this document (for example "HTTP-version") are defined in either [2] or Section 4.1.

# 2. SCEP Overview

This section provides a high level overview of the functionality of SCEP.

## 2.1. SCEP Entities

The entity types defined in SCEP are a client requesting a certificate and a Certificate Authority (CA) that issues the certificate. These are described in the following sections.

### 2.1.1. Client

A client MUST have the following information locally configured:

1. The CA fully qualified domain name or IP address.
2. The CA HTTP SCEP path (this usually has a default value, see Section 4.1).
3. The identifying information that is used for authentication of the CA in Section 4.2.1, typically a certificate fingerprint.

### 2.1.2. Certificate Authority

A SCEP CA is the entity that signs client certificates. A CA MAY enforce any arbitrary policies and apply them to certificate requests, and MAY reject a request for any reason.

Since the client is expected to perform signature verification and optionally encryption using the CA certificate, the keyUsage extension in the CA certificate MUST indicate that it is valid for digitalSignature and keyEncipherment (if available) alongside the usual CA usages of keyCertSign and/or cRLSign.

## 2.2. CA Certificate Distribution

If the CA certificate(s) have not previously been acquired by the client through some other means, the client MUST retrieve them before any PKI operation (Section 3) can be started. Since no public key has yet been exchanged between the client and the CA, the messages cannot be secured using CMS, and the CA certificate request and response data is instead transferred in the clear.

If an intermediate CA is in use, a certificates-only CMS Signed-Data message with a certificate chain consisting of all CA certificates is returned. Otherwise the CA certificate itself is returned.

The CA certificate MAY be provided out-of-band to the client. Alternatively, the CA certificate fingerprint MAY be used to authenticate a CA Certificate distributed by the GetCACert response (Section 4.2) or via HTTP certificate-store access [13]. The fingerprint is created by calculating a SHA-256 hash over the whole CA certificate (for legacy reasons, a SHA-1 hash may be used by some implementations).

After the client gets the CA certificate, it SHOULD authenticate the certificate by comparing its fingerprint with the locally configured, out-of-band distributed, identifying information, or by some equivalent means such as a direct comparison with a locally-stored copy of the certificate. Intermediate CA certificates, if any, are signed by a higher-level CA so there is no need to authenticate them against the out-of-band data. Clients SHOULD verify intermediate-level CA certificate signatures using the issuing CA's certificate before use during protocol exchanges.

When a CA certificate expires, certificates that have been signed by it may no longer be regarded as valid. CA key rollover provides a mechanism by which the CA MAY distribute a new CA certificate which is valid in the future once the current certificate has expired. This is done in the GetNextCACert message (section Section 4.7).

## 2.3. Client authentication

As with every protocol that uses public-key cryptography, the association between the public keys used in the protocol and the identities with which they are associated must be authenticated in a cryptographically secure manner. The communications between the client and the CA are secured using SCEP Secure Message Objects as explained in Section 3, which specifies how CMS is used to encrypt and sign the data. In order to perform the signing operation the client uses an appropriate local certificate:

1. If the client does not have an appropriate existing certificate then a locally generated self-signed certificate MUST be used. The keyUsage extension in the certificate MUST indicate that it is valid for digitalSignature and keyEncipherment (if available). The self-signed certificate SHOULD use the same subject name as in the PKCS #10 request. In this case the messageType is PKCSReq (see Section 3.2.1.2).
2. If the requesting system already has a certificate issued by the SCEP CA and the CA supports renewal (see Section 2.5), that certificate SHOULD be used. In this case the messageType is RenewalReq (see Section 3.2.1.2).
3. Alternatively, if the requesting system has no certificate issued by the SCEP CA but has credentials from an alternate CA then the certificate issued by the alternate CA MAY be used in a renewal request as described above. Policy settings on the SCEP CA will determine if the request can be accepted or not.

Note that although the above text describes several different types of operations, in practice most implementations always apply the first one even if an existing certificate already exists. For this reason support for the first case is mandatory while support for the latter ones are optional (see Section 2.9).

During the certificate enrolment process, the client MUST use the selected certificate's key when signing the CMS envelope (see Section 3). This certificate will be either the self-signed one matching the PKCS #10 request or the CA-issued one used to authorise a renewal, and MUST be included in the signedData certificates field (possibly as part of a full certificate chain). If the key being certified allows encryption then the CA's CertResp will use the same certificate's public key when encrypting the response.

Note that this means that, in the case of renewal operations, the request is signed with, and the returned response may be encrypted with, the key in the previously-issued certificate used to authenticate the request, not the key in the PKCS #10 request. This has security implications, see Section 8.6.

## 2.4. Enrolment authorization

PKCS #10 [9] specifies a PKCS #9 [8] challengePassword attribute to be sent as part of the enrolment request. When utilizing the challengePassword, the CA distributes a shared secret to the client which will uniquely associate the enrolment request with the client.

Inclusion of the challengePassword by the SCEP client is OPTIONAL and allows for unauthenticated authorization of enrolment requests (which, however, requires manual approval of each certificate issue, see below), or for renewal requests that are authenticated by being signed with an existing certificate. The CMS envelope protects the privacy of the challengePassword.

A client that is performing certificate renewal as per Section 2.5 SHOULD omit the challengePassword but MAY send the originally distributed password in the challengePassword attribute. The SCEP CA MAY use the challengePassword in addition to the previously issued certificate that signs the request to authenticate the request. The SCEP CA MUST NOT attempt to authenticate a client based on a self-signed certificate unless it has been verified through out-of-band means such as a certificate fingerprint.

To perform the authorization in manual mode the client's request is placed in the PENDING state until the CA operator authorizes or rejects it. Manual authorization is used when the client has only a self-signed certificate that hasn't been previously authenticated by the CA and/or a challengePassword is not available. The SCEP CA MAY either reject unauthorized requests or mark them for manual authorization according to CA policy.

## 2.5. Certificate Enrolment/Renewal

A client starts an enrolment transaction (Section 3.3.1) by creating a certificate request using PKCS #10 and sends it to the CA enveloped using CMS (Section 3).

If the CA supports certificate renewal and if the CA policy permits then a new certificate with new validity dates can be issued even though the old one is still valid. The CA MAY automatically revoke the old client certificate. To renew an existing certificate, the client uses the RenewalReq message (see Section 3.3) and signs it with the existing client certificate. The client SHOULD use a new keypair when requesting a new certificate, but MAY request a new certificate using the old keypair.

If the CA returns a CertRep message (Section 3.3.2) with status set to PENDING, the client enters into polling mode by periodically

sending a CertPoll message (Section 3.3.3) to the CA until the CA operator completes the manual authentication (approving or denying the request). The frequency of the polling operation is a CA/client configuration issue, and may range from seconds or minutes when the issue process is automatic but not instantaneous, through to hours or days if the certificate issue operation requires manual approval.

If polling mode is being used then the client will send a single PKCSReq/RenewalReq message (Section 3.3.1), followed by 0 or more CertPoll messages (Section 3.3.3). The CA will in return send 0 or more CertRep messages (Section 3.3.2) with status set to PENDING in response to CertPolls, followed by a single CertRep message (Section 3.3.2) with status set to either SUCCESS or FAILURE.

### 2.5.1. Client State Transitions

The client state transitions during the SCEP process are indicated in Figure 1.

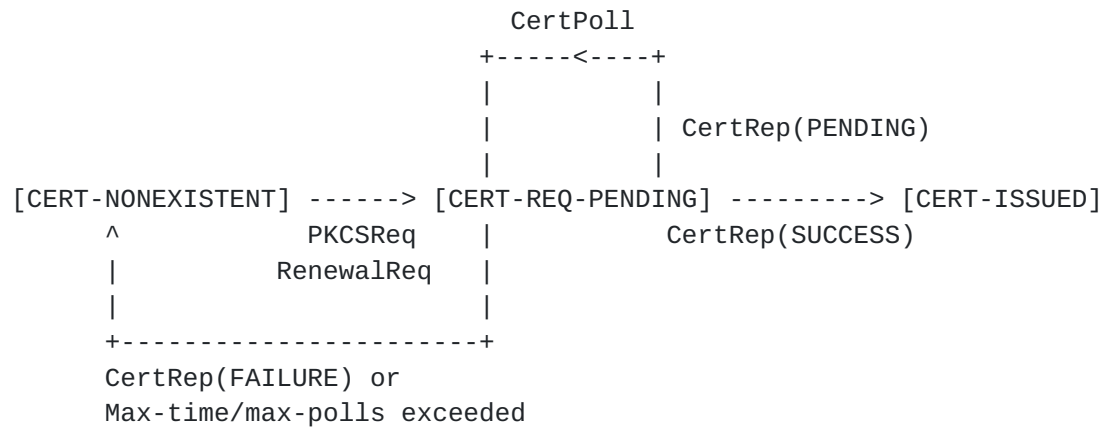



Figure 1: State Transition Diagram

The certificate issue process starts at state CERT-NONEXISTENT. Sending a PKCSReq/RenewalReq message changes the state to CERT-REQ-PENDING.

If the CA returns a CertRep message with pkiStatus set to SUCCESS then the state changes to CERT-ISSUED.

If the CA returns a CertRep message with pkiStatus set to FAILURE or there is no response then the state reverts back to CERT-NONEXISTENT.

If the CA returns a CertRep message with pkiStatus set to PENDING then the client will keep polling by sending a CertPoll message until

either a CertRep message with status set to SUCCESS or FAILURE is received or a timeout occurs or the maximum number of polls has been exceeded.

A successful transaction in automatic mode:


A successful transaction in manual mode:


## 2.6. Certificate Access

A certificate query message is defined for clients to retrieve a copy of their own certificate from the CA. It allows clients that do not store their certificates locally to obtain a copy when needed. This functionality is not intended to provide a general purpose certificate access service, which may be achieved via HTTP certificate-store access [13] or LDAP.

To query a certificate from the CA, a client sends a request consisting of the certificate's issuer name and serial number. This assumes that the client has saved the issuer name and the serial

number of the issued certificate from the previous enrolment transaction. The transaction to query a certificate consists of one GetCert (Section 3.3.4) message and one CertRep (Section 3.3.2) message, as shown below.

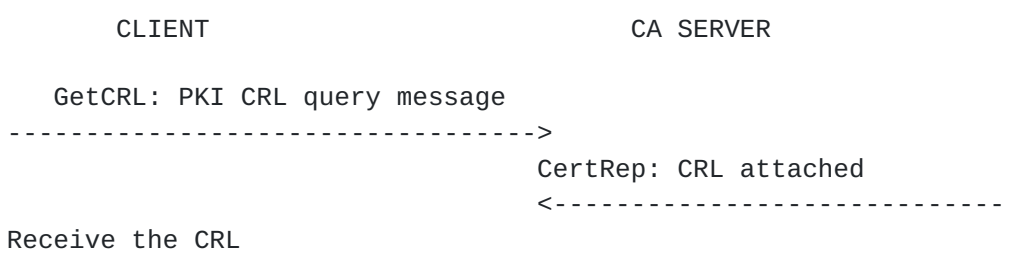

## 2.7. CRL Access

SCEP clients MAY request a CRL via one of three methods:

1. If the CA supports CRL Distribution Points (CRLDPs) [10], then the CRL MAY be retrieved via the mechanism specified in the CRDLP.
2. If the CA supports HTTP certificate-store access [13], then the CRL MAY be retrieved via the AuthorityInfoAcces [10] location specified in the certificate.
3. Only if the CA does not support CRDLPs or HTTP access should a CRL query be composed by creating a GetCRL message consisting of the issuer name and serial number from the certificate whose revocation status is being queried.

The CA SHOULD NOT support the GetCRL method because it does not scale well due to the unnecessary cryptography (see Section 8.7) and it requires the CA to be a high-availability service.

The message is sent to the SCEP CA in the same way as the other SCEP requests. The transaction to retrieve a CRL consists of one GetCRL PKI message and one CertRep PKI message, which contains only the CRL (no certificates) in a degenerate certificates-only CMS Signed-Data message (Section 3.4), as shown below.




## 2.8. Certificate Revocation

SCEP does not specify a method to request certificate revocation. In order to revoke a certificate, the client must contact the CA using a non-SCEP defined mechanism.

## 2.9. Mandatory-to-Implement Functionality

At a minimum, all SCEP implementations compliant with this specification MUST support GetCACaps (Section 3.5.1), GetCACert (Section 4.2), PKCSReq (Section 3.3.1) (and its associated response messages), communication of binary data via HTTP POST (Section 4.1), and the AES [3] and SHA-256 [4] algorithms to secure pkiMessages (Section 3.2).

For historical reasons implementations MAY support communications of binary data via HTTP GET (Section 4.1), and the triple DES and SHA-1 algorithms to secure pkiMessages (Section 3.2). Implementations MUST NOT support the obsolete and/or insecure single DES and MD5 algorithms used in earlier versions of this specification, since the unsecured nature of GetCACaps means that an in-path attacker can trivially roll back the encryption used to these insecure algorithms, see Section 8.5.

# 3. SCEP Secure Message Objects

CMS is a general enveloping mechanism that enables both signed and encrypted transmission of arbitrary data. SCEP messages that require confidentiality use two layers of CMS, as shown in Figure 2. By applying both enveloping and signing transformations, the SCEP message is protected both for the integrity of its end-to-end transaction information and the confidentiality of its information portion. Some messages do not require enveloping, in which case the EnvelopedData in Figure 2 is omitted.

```
pkiMessage {
  contentType = signedData { pkcs-7 2 },
  content {
    digestAlgorithms,
    encapsulatedContentInfo {
      eContentType = data { pkcs-7 1 },
      eContent {           -- pkcsPKIEnvelope, optional
        contentType = envelopedData { pkcs-7 3 },
        content {
          recipientInfo,
          encryptedContentInfo {
            contentType = data { pkcs-7 1 },
            contentEncrAlgorithm,
            encryptedContent {
              messageData  -- Typically PKCS #10 request
              }
            }
          }
        }
      },
    certificates,          -- Optional
    crls,                  -- Optional
    signerInfo {
      signedAttrs {
        transactionID,
        messageType,
        pkiStatus,
        failInfo,          -- Optional
        senderNonce / recipientNonce,
        },
      signature
      }
    }
  }
```

Figure 2: CMS Layering

When a particular SCEP message carries data, this data is carried in the messageData. CertRep messages will lack any signed content and consist only of a pkcsPKIEnvelope (Section 3.2.2).

The remainder of this document will refer only to 'messageData', but it is understood to always be encapsulated in the pkcsPKIEnvelope (Section 3.2.2). The format of the data in the messageData is defined by the messageType attribute (see Section 3.2) of the Signed-Data. If there is no messageData to be transmitted, the entire pkcsPKIEnvelope MUST be omitted.

Samples of SCEP messages are available through the JSCEP project [14] in the src/samples directory.

## 3.1. SCEP Message Object Processing

Creating a SCEP message consists of several stages. The content to be conveyed (in other words the messageData) is first encrypted, and the encrypted content is then signed.

The form of encryption to be applied depends on the capabilities of the recipient's public key. If the key is encryption-capable (for example RSA) then the messageData is encrypted using the recipient's public key with the CMS KeyTransRecipientInfo mechanism. If the key is not encryption-capable (for example DSA or ECDSA) then the messageData is encrypted using the challengePassword with the CMS PasswordRecipientInfo mechanism.

Once the messageData has been encrypted, it is signed with the sender's public key. This completes the SCEP message that is then sent to the recipient.

Note that some earlier implementations of this specification dealt with non-encryption-capable keys by omitting the encryption stage, based on the text in Section 3 that indicated that "the EnvelopedData is omitted". This alternative processing mechanism SHOULD NOT be used since it exposes the challengePassword used to authorise the certificate issue.

## 3.2. SCEP pkiMessage

The basic building block of all secured SCEP messages is the SCEP pkiMessage. It consists of a CMS Signed-Data content type. The following restrictions apply:

- The eContentType in encapsulatedContentInfo MUST be data ({pkcs-7 1}).
- The signed content, if present (FAILURE and PENDING CertRep messages will lack any signed content), MUST be a pkcsPKIEnvelope (Section 3.2.2), and MUST match the messageType attribute.
- The SignerInfo MUST contain a set of authenticatedAttributes (Section 3.2.1).

### 3.2.1. Signed Transaction Attributes

At a minimum, all messages MUST contain the following authenticatedAttributes:

- A transactionID attribute (see Section 3.2.1.1).

- A messageType attribute (see Section 3.2.1.2).
- A fresh senderNonce attribute (see Section 3.2.1.5).
- Any attributes required by CMS.

If the message is a CertRep, it MUST also include the following authenticatedAttributes:

- A pkiStatus attribute (see Section 3.2.1.3).
- A failInfo and optional failInfotext attribute (see Section 3.2.1.4) if pkiStatus = FAILURE.
- A recipientNonce attribute (see Section 3.2.1.5) copied from the senderNonce in the request that this is a response to.

The following transaction attributes are encoded as authenticated attributes, and are carried in the SignerInfo for this Signed-Data.

| Attribute | Encoding | Comment |
|---|---|---|
| transactionID | PrintableString | Unique ID for this transaction as a text string |
| messageType | PrintableString | Decimal value as a numeric text string |
| pkiStatus | PrintableString | Decimal value as a numeric text string |
| failInfo | PrintableString | Decimal value as a numeric text string |
| failInfoText | UTF8String | Descriptive text for the failInfo value |
| senderNonce | OCTET STRING | Random nonce as a 16-byte binary data string |
| recipientNonce | OCTET STRING | Random nonce as a 16-byte binary data string |

The OIDs used for these attributes are as follows:

| Name | ASN.1 Definition |
|---|---|
| id-VeriSign | OBJECT_IDENTIFIER ::= {2 16 US(840) 1 VeriSign(113733)} |
| id-pki | OBJECT_IDENTIFIER ::= {id-VeriSign pki(1)} |
| id-attributes | OBJECT_IDENTIFIER ::= {id-pki attributes(9)} |
| id-transactionID | OBJECT_IDENTIFIER ::= {id-attributes transactionID(7)} |
| id-messageType | OBJECT_IDENTIFIER ::= {id-attributes messageType(2)} |
| id-pkiStatus | OBJECT_IDENTIFIER ::= {id-attributes pkiStatus(3)} |
| id-failInfo | OBJECT_IDENTIFIER ::= {id-attributes failInfo(4)} |
| id-senderNonce | OBJECT_IDENTIFIER ::= {id-attributes senderNonce(5)} |
| id-recipientNonce | OBJECT_IDENTIFIER ::= {id-attributes recipientNonce(6)} |
| id-scep | OBJECT IDENTIFIER ::= {id-pkix TBD1} |
| id-scep-failInfoText | OBJECT IDENTIFIER ::= {id-scep 1} |

The attributes are detailed in the following sections.

#### 3.2.1.1. transactionID

A PKI operation is a transaction consisting of the messages exchanged between a client and the CA. The transactionID is a text string provided by the client when starting a transaction. The client MUST use a unique string as the transaction identifier, encoded as a PrintableString, which MUST be used for all PKI messages exchanged for a given operation such as a certificate issue.

Note that the transactionID must be unique, but not necessarily randomly generated. For example it may be a value assigned by the CA (alongside the challengePassword) as an equivalent to the traditional user name + password, so that the client is identified by their transactionID. This can be useful when the client doesn't have a pre-assigned Distinguished Name that the CA can identify their request through, for example when enrolling SCADA devices.

#### 3.2.1.2. messageType

The messageType attribute specifies the type of operation performed by the transaction. This attribute MUST be included in all PKI messages. The following message types are defined:

- CertRep ("3") -- Response to certificate or CRL request.
- RenewalReq ("17") -- PKCS #10 certificate request authenticated with an existing certificate.
- PKCSReq ("19") -- PKCS #10 certificate request authenticated with a password.
- CertPoll ("20") -- Certificate polling in manual enrolment.
- GetCert ("21") -- Retrieve a certificate.
- GetCRL ("22") -- Retrieve a CRL.

Undefined message types MUST BE treated as an error.

#### 3.2.1.3. pkiStatus

All response messages MUST include transaction status information, which is defined as a pkiStatus attribute:

- SUCCESS ("0") -- Request granted.
- FAILURE ("2") -- Request rejected. In this case the failInfo attribute, as defined in Section 3.2.1.4, MUST also be present.
- PENDING ("3") -- Request pending for manual approval.

Undefined pkiStatus attributes MUST be treated as an error.

#### 3.2.1.4. failInfo and failInfoText

The failInfo attribute MUST contain one of the following failure reasons:

- badAlg ("0") -- Unrecognized or unsupported algorithm.
- badMessageCheck ("1") -- Integrity check (meaning signature verification of the CMS message) failed.
- badRequest ("2") -- Transaction not permitted or supported.
- badTime ("3") -- The signingTime attribute from the CMS authenticatedAttributes was not sufficiently close to the system

time (this failure code is present for legacy reasons and is unlikely to be encountered in practice).
- o badCertId ("4") -- No certificate could be identified matching the provided criteria.

The failInfoText is a free-form UTF-8 text string that provides further information in the case of pkiStatus = FAILURE. In particular it may be used to provide details on why a certificate request was not granted that go beyond what's provided by the near-universal failInfo = badRequest status. Since this is a free-form text string intended for interpretation by humans, implementations SHOULD NOT assume that it has any type of machine-processable content.

#### 3.2.1.5. senderNonce and recipientNonce

The senderNonce and recipientNonce attributes are a 16 byte random number generated for each transaction. These are intended to prevent replay attacks.

When a sender sends a PKI message to a recipient, a fresh senderNonce MUST be included in the message. The recipient MUST copy the senderNonce into the recipientNonce of the reply as a proof of liveliness. The original sender MUST verify that the recipientNonce of the reply matches the senderNonce it sent in the request. If the nonce does not match, the message MUST be rejected.

Note that since SCEP exchanges consist of a single request followed by a single response, the use of distinct sender and recipient nonces is redundant since the client sends a nonce in its request and the CA responds with the same nonce in its reply. In effect there's just a single nonce, identified as senderNonce in the client's request and recipientNonce in the CA's reply.

### 3.2.2. SCEP pkcsPKIEnvelope

The information portion of a SCEP message is carried inside an EnvelopedData content type, as defined in CMS, with the following restrictions:

- o contentType in encryptedContentInfo MUST be data ({pkcs-7 1}).
- o encryptedContent MUST be the SCEP message being transported (see Section 4), and must match the messageType authenticated Attribute in the pkiMessage.

### 3.3. SCEP pkiMessage types

All of the messages in this section are pkiMessages (Section 3.2), where the type of the message MUST be specified in the 'messageType' authenticated Attribute. Each section defines a valid message type, the corresponding messageData formats, and mandatory authenticated attributes for that type.

#### 3.3.1. PKCSReq/RenewalReq

The messageData for this type consists of a PKCS #10 Certificate Request. The certificate request MUST contain at least the following items:

- The subject Distinguished Name.
- The subject public key.
- For a PKCSReq and if authorisation based on a password is being used, a challengePassword attribute.

In addition to the authenticatedAttributes required for a valid CMS message, the pkiMessage MUST include the following attributes:

- A transactionID attribute (Section 3.2.1.1).
- A messageType attribute (Section 3.2.1.2) set to PKCSReq or RenewalReq as appropriate.
- A fresh senderNonce attribute (Section 3.2.1.5).

#### 3.3.2. CertRep

The messageData for this type consists of a degenerate certificates-only CMS Signed-Data message (Section 3.4). The exact content required for the reply depends on the type of request that this message is a response to. The request types are detailed in Section 3.3.2.1 and in Section 4.

In addition to the authenticatedAttributes required for a valid CMS message, this pkiMessage MUST include the following attributes:

- The transactionID attribute (Section 3.2.1.1) copied from the request that this is a response to.
- A messageType attribute (Section 3.2.1.2) set to CertRep.
- A recipientNonce attribute (Section 3.2.1.5) copied from the senderNonce in the request that this is a response to.
- A pkiStatus attribute (Section 3.2.1.3) set to the status of the reply.

Earlier versions of this specification required that this message include a senderNonce alongside the recipientNonce, which was to be

used to chain to subsequent polling operations. However if a single message was lost during the potentially extended interval over which polling could take place (see Section 5 for an example of this) then if the implementation were to enforce this requirement the overall transaction would fail even though nothing had actually gone wrong. Because of this issue, implementations mostly ignored the requirement to carry this nonce over to subsequent polling messages or to verify its presence. Current versions of the specification no longer require the chaining of nonces across polling operations.

#### 3.3.2.1. CertRep SUCCESS

When the pkiStatus attribute is set to SUCCESS, the messageData for this message consists of a degenerate certificates-only CMS Signed-Data message (Section 3.4). The content of this degenerate certificates-only Signed-Data depends on what the original request was, as outlined below.

| Request-type | Reply-contents |
|---|---|
| PKCSReq | The reply MUST contain at least the issued certificate in the certificates field of the Signed-Data. The reply MAY contain additional certificates, but the issued certificate MUST be the leaf certificate. |
| RenewalReq | Same as PKCSReq |
| CertPoll | Same as PKCSReq |
| GetCert | The reply MUST contain at least the requested certificate in the certificates field of the Signed-Data. The reply MAY contain additional certificates, but the requested certificate MUST be the leaf certificate. |
| GetCRL | The reply MUST contain the CRL in the crls field of the Signed-Data. |

#### 3.3.2.2. CertRep FAILURE

When the pkiStatus attribute is set to FAILURE, the reply MUST also contain a failInfo (Section 3.2.1.4) attribute set to the appropriate error condition describing the failure. The reply MAY also contain a failInfoText attribute providing extended details on why the operation failed, typically to expand on the catch-all failInfo =

badRequest status. The pkcsPKIEnvelope (Section 3.2.2) MUST be omitted.

#### 3.3.2.3. CertRep PENDING

When the pkiStatus attribute is set to PENDING, the pkcsPKIEnvelope (Section 3.2.2) MUST be omitted.

### 3.3.3. CertPoll (GetCertInitial)

This message is used for certificate polling. For unknown reasons it was referred to as "GetCertInitial" in earlier versions of this specification. The messageData for this type consists of an IssuerAndSubject:

```
issuerAndSubject ::= SEQUENCE {
    issuer Name,
    subject Name
    }
```

The issuer is set to the subjectName of the CA (in other words the intended issuerName of the certificate that's being requested). The subject is set to the subjectName used when requesting the certificate.

Note that both of these fields are redundant, the CA is identified by the recipientInfo in the pkcsPKIEnvelope (or in most cases simply by the server that the message is being sent to) and the client/transaction being polled is identified by the transactionID. Both of these fields can be processed by the CA without going through the cryptographically expensive process of unwrapping and processing the issuerAndSubject. For this reason implementations SHOULD assume that the polling operation will be controlled by the recipientInfo and transactionID rather than the contents of the messageData.

In addition to the authenticatedAttributes required for a valid CMS message, this pkiMessage MUST include the following attributes:

- The same transactionID (Section 3.2.1.1) attribute from the original PKCSReq/RenewalReq message.
- A messageType attribute (Section 3.2.1.2) set to CertPoll.
- A fresh senderNonce attribute (Section 3.2.1.5).

### 3.3.4. GetCert and GetCRL

The messageData for these types consist of an IssuerAndSerialNumber as defined in CMS which uniquely identifies the certificate being requested, either the certificate itself for GetCert or its revocation status via a CRL for GetCRL. In addition to the authenticatedAttributes required for a valid CMS message, this pkiMessage MUST include the following attributes:

- A transactionID attribute (Section 3.2.1.1).
- A messageType attribute (Section 3.2.1.2) set to GetCert or GetCRL.
- A fresh senderNonce attribute (Section 3.2.1.5).

A self-signed certificate MAY be used in the signed envelope. This enables the client to request their own certificate if they were unable to store it previously.

These message types, while included here for completeness, apply unnecessary cryptography and messaging overhead to the simple task of transferring a certificate or CRL (see Section 8.7). Implementations SHOULD prefer HTTP certificate-store access [13] or LDAP over the use of these messages.

## 3.4. Degenerate certificates-only CMS Signed-Data

CMS includes a degenerate case of the Signed-Data content type in which there are no signers. The use of such a degenerate case is to disseminate certificates and CRLs. For SCEP the content field of the ContentInfo value of a degenerate certificates-only Signed-Data MUST be omitted.

When carrying certificates, the certificates are included in the 'certificates' field of the Signed-Data. When carrying a CRL, the CRL is included in the 'crls' field of the Signed-Data.

## 3.5. CA Capabilities

In order to provide support for future enhancements to the protocol, CAs MUST implement the GetCACaps message to allow clients to query which functionality is available from the CA.

### 3.5.1. GetCACaps HTTP Message Format

This message requests capabilities from a CA, with the format:

"GET" SP SCEPPATH "?operation=GetCACaps" SP HTTP-version CRLF

as described in Section 4.1.

### 3.5.2. CA Capabilities Response Format

The response for a GetCACaps message is a list of CA capabilities, in plain text, separated by <CR><LF> or <LF> characters, as follows (quotation marks are NOT sent):

| Keyword | Description |
|---|---|
| "AES" | CA supports the AES encryption algorithm. |
| "DES3" | CA supports the triple DES encryption algorithm. |
| "GetNextCACert" | CA supports the GetNextCACert message. |
| "POSTPKIOperation" | CA supports PKIOPeration messages sent via HTTP POST. |
| "Renewal" | CA supports the Renewal CA operation. |
| "SHA-1" | CA supports the SHA-1 hashing algorithm. |
| "SHA-256" | CA supports the SHA-256 hashing algorithm. |
| "SHA-512" | CA supports the SHA-512 hashing algorithm. |
| "SCEPStandard" | CA supports all mandatory-to-implement sections of the SCEP standard. This keyword implies "AES", "POSTPKIOperation", and "SHA-256", as well as the provisions of Section 2.9. |

The client SHOULD use SHA-256 in preference to SHA-1 hashing and AES in preference to triple DES if they are supported by the CA. Although the CMS format allows any form of AES and SHA-2 to be specified, in the interests of interoperability the de facto universal standards of AES128-CBC and SHA-256 SHOULD be used.

Announcing some of these capabilities individually is redundant since they're required as mandatory-to-implement functionality (see Section 2.9) whose presence as a whole is signalled by the "SCEPStandard" capability, but it may be useful to announce them in order to deal with old implementations that would otherwise default to obsolete, insecure algorithms and mechanisms.

The CA MUST use the text case specified here, but clients SHOULD ignore the text case when processing this message. Clients MUST accept the standard HTTP-style <CR><LF>-delimited text as well as the <LF>- delimited text specified in an earlier version of this specification. A client MUST be able to accept and ignore any unknown keywords that might be sent back by a CA.

If the CA supports none of the above capabilities it SHOULD return an empty message. A CA MAY simply return an HTTP error. A client that receives an empty message or an HTTP error SHOULD interpret the response as if none of the requested capabilities are supported by the CA.

(Note that at least one widely-deployed server implementation supports several of the above operations but doesn't support the GetCACaps message to indicate that it supports them, and will close the connection if sent a GetCACaps message. This means that the equivalent of GetCACaps must be performed through server fingerprinting, which can be done using the ID string "Microsoft-IIS". Newer versions of the same server, if sent a SCEP request using AES and SHA-2, will respond with an invalid response that can't be decrypted, requiring the use of 3DES and SHA-1 in order to obtain a response that can be processed even if AES and/or SHA-2 are allegedly supported. In addition the server will generate CA certificates that only have one, but not both, of the keyEncipherment and digitalSignature keyUsage flags set, requiring that the client ignore the keyUsage flags in order to use the certificates for SCEP).

The Content-type of the reply SHOULD be "text/plain". Clients SHOULD ignore the Content-type, as older implementations of SCEP may send various Content-types.

Example:

```
GET /cgi-bin/pkiclient.exe?operation=GetCACaps
```

might return:

```
AES
GetNextCACert
POSTPKIOperation
SCEPStandard
SHA-256
```

This means that the CA supports modern crypto algorithms, the GetNextCACert message, allows PKIOperation messages (PKCSReq/ RenewalReq, GetCert, CertPoll, ...) to be sent using HTTP POST, and is compliant with the final version of the SCEP standard.

## 4. SCEP Transactions

This section describes the SCEP Transactions and their HTTP [7] transport mechanism.

Note that SCEP doesn't follow best current practices on usage of HTTP. In particular, it uses unregistered Media Types, it recommends ignoring Media Types, and hardcodes specific URI paths. Guidance on the appropriate application of HTTP in these circumstances may be found in [12]

### 4.1. HTTP POST and GET Message Formats

SCEP uses the HTTP "POST" and "GET" HTTP methods [7] to exchange information with the CA. The following defines the ABNF syntax of HTTP POST and GET methods sent from a client to a CA:

```
POSTREQUEST = "POST" SP SCEPPATH "?operation=" OPERATION
              SP HTTP-version CRLF

GETREQUEST = "GET" SP SCEPPATH "?operation=" OPERATION
             "&message=" MESSAGE SP HTTP-version CRLF
```

where:

- SCEPPATH is the HTTP URL path for accessing CA. Clients SHOULD set SCEPPATH to the fixed string "/cgi-bin/pkiclient.exe" unless directed to do otherwise by the CA.
- OPERATION depends on the SCEP transaction and is defined in the following sections.

- HTTP-version is the HTTP version string, which is "HTTP/1.1" for [7].
- SP and CRLF are space and carriage return/linefeed as defined in [2].

The CA will typically ignore CGI-PATH and/or CGI-PROG since it's unlikely to be issuing certificates via a web server. Clients SHOULD set CGI-PATH/CGI-PROG to the fixed string "/cgi-bin/pkiclient.exe" unless directed to do otherwise by the CA. The CA SHOULD ignore the CGI-PATH and CGI-PROG unless its precise format is critical to the CA's operation.

Early SCEP drafts performed all communications via "GET" messages, including non-idempotent ones that should have been sent via "POST" messages, see [12] for details. This has caused problems because of the way that the (supposedly) idempotent GET interacts with caches and proxies, and because the extremely large GET requests created by encoding CMS messages may be truncated in transit. These issues are typically not visible when testing on a LAN, but crop up during deployment over WANs. If the remote CA supports POST, the CMS-encoded SCEP messages MUST be sent via HTTP POST instead of HTTP GET. This applies to any SCEP message except GetCACert, GetNextCACert, and GetCACaps, and avoids the need for base64- and URL-encoding that's required for GET messaging. The client can verify that the CA supports SCEP messages via POST by looking for the "POSTPKIOperation" capability (See Section 3.5.2).

If a client or CA uses HTTP GET and encounters HTTP-related problems such as messages being truncated, seeing errors such as HTTP 414 ("Request URI too long"), or simply having the message not sent/ received at all, when standard requests to the server (for example via a web browser) work, then this is a symptom of the problematic use of HTTP GET. The solution to this problem is to update the implementation to use HTTP POST instead. In addition when using GET it's recommended to test your implementation over the public internet from as many locations as possible to determine whether the use of GET will cause problems with communications.

When using GET messages to communicate binary data, base64 encoding as specified in [5] Section 4 MUST be used. The base64 encoded data is distinct from "base64url" and may contain URI reserved characters, thus it MUST be escaped as specified in [11] in addition to being base64 encoded. Finally, the encoded data is inserted into the MESSAGE portion of the HTTP GET request.

### 4.2. Get CA Certificate

To get the CA certificate(s), the client sends a GetCACert message to the CA. The OPERATION MUST be set to "GetCACert". There is no request data associated with this message.

#### 4.2.1. Get CA Certificate Response Message Format

The response for GetCACert is different between the case where the CA directly communicates with the client during the enrolment and the case where an intermediate CA exists and the client communicates with this CA during the enrolment.

##### 4.2.1.1. CA Certificate Response Message Format

If the CA does not have any intermediate CA certificates, the response consists of a single X.509 CA certificate. The response will have a Content-Type of "application/x-x509-ca-cert".

"Content-Type: application/x-x509-ca-cert"

<binary X.509>

##### 4.2.1.2. CA Certificate Chain Response Message Format

If the CA has intermediate CA certificates, the response consists of a degenerate certificates-only CMS Signed-Data message (Section 3.4) containing the certificates, with the intermediate CA certificate(s) as the leaf certificate(s). The response will have a Content-Type of "application/x-x509-ca-ra-cert". Note that this designation is used for historical reasons due to its use in older versions of this specification, no special meaning should be attached to the label.

"Content-Type: application/x-x509-ca-ra-cert"

<binary CMS>

### 4.3. Certificate Enrolment/Renewal

A PKCSReq/RenewalReq (Section 3.3.1) message is used to perform a certificate enrolment or renewal transaction. The OPERATION MUST be set to "PKIOperation". Note that when used with HTTP POST, the only OPERATION possible is "PKIOperation", so many CAs don't check this

value or even notice its absence. When implemented using HTTP POST the message might look as follows:

```
POST /cgi-bin/pkiclient.exe?operation=PKIOperation HTTP/1.1
Content-Length: <length of data>

<binary CMS data>
```

When implemented using HTTP GET this might look as follows:

```
GET /cgi-bin/pkiclient.exe?operation=PKIOperation& \
message=MIAGCSqGSIb3DQEHA6CAMIACAQAxgDCBzAIBADB2MG \
IxETAPBgNVBAcTCE......AAAAAA== HTTP/1.1
```

### 4.3.1. Certificate Enrolment/Renewal Response Message

If the request is granted, a CertRep message (Section 3.3.2) with pkiStatus set to SUCCESS is returned. The reply MUST also contain the certificate, and MAY contain any other certificates needed by the client (for example intermediate CA certificates) in the returned certificate chain.

If the request is rejected, a CertRep message (Section 3.3.2) with pkiStatus set to FAILURE is returned. The reply MUST also contain a failInfo attribute and MAY contain a failInfoText attribute.

If the CA is configured to manually authenticate the client, a CertRep message (Section 3.3.2) with pkiStatus set to PENDING MAY be returned. The CA MAY return a PENDING for other reasons.

The response will have a Content-Type of "application/x-pki-message".

```
"Content-Type: application/x-pki-message"

<binary CertRep message>
```

## 4.4. Poll for Client Initial Certificate

When the client receives a CertRep message with pkiStatus set to PENDING, it will enter the polling state by periodically sending CertPoll messages to the CA until either the request is granted and the certificate is sent back or the request is rejected or some

preconfigured time limit for polling or maximum number of polls is exceeded. The OPERATION MUST be set to "PKIOperation".

CertPoll messages exchanged during the polling period MUST carry the same transactionID attribute as the previous PKCSReq/RenewalReq. A CA receiving a CertPoll for which it does not have a matching PKCSReq/RenewalReq MUST ignore this request.

Since at this time the certificate has not been issued, the client can only use its own subject name (which was contained in the original PKCS# 10 sent via PKCSReq/RenewalReq) to identify the polled certificate request (but see the note on identification during polling in Section 3.3.3). In theory there can be multiple outstanding requests from one client (for example, if different keys and different key-usages were used to request multiple certificates), so the transactionID must also be included to disambiguate between multiple requests. In practice however the client SHOULD NOT have multiple requests outstanding at any one time, since this tends to confuse some CAs.

### 4.4.1. Polling Response Message Format

The response messages for CertPoll are the same as in Section 4.3.1.

## 4.5. Certificate Access

A client can query an issued certificate from the SCEP CA, as long as the client knows the issuer name and the issuer assigned certificate serial number.

This transaction consists of one GetCert (Section 3.3.4) message sent to the CA by a client, and one CertRep (Section 3.3.2) message sent back from the CA. The OPERATION MUST be set to "PKIOperation".

### 4.5.1. Certificate Access Response Message Format

In this case, the CertRep from the CA is same as in Section 4.3.1, except that the CA will either grant the request (SUCCESS) or reject it (FAILURE).

## 4.6. CRL Access

Clients can request a CRL from the SCEP CA as described in Section 2.7. The OPERATION MUST be set to "PKIOperation".

### 4.6.1. CRL Access Response Message Format

The CRL is sent back to the client in a CertRep (Section 3.3.2) message. The information portion of this message is a degenerate certificates-only Signed-Data (Section 3.4) that contains only the most recent CRL in the crls field of the Signed-Data.

## 4.7. Get Next Certificate Authority Certificate

When a CA certificate is about to expire, clients need to retrieve the CA's next CA certificate (i.e. the rollover certificate). This is done via the GetNextCACert message. The OPERATION MUST be set to "GetNextCACert". There is no request data associated with this message.

### 4.7.1. Get Next CA Response Message Format

The response consists of a Signed-Data CMS message, signed by the current CA signing key. Clients MUST validate the signature on the message before accepting any of its contents. The response will have a Content-Type of "application/x-x509-next-ca-cert".

"Content-Type: application/x-x509-next-ca-cert"

<binary CMS>

The content of the Signed-Data message is a degenerate certificates-only Signed-Data message (Section 3.4) containing the new CA certificate(s) to be used when the current CA certificate expires.

If the CA does not have rollover certificate(s) it MUST reject the request. It SHOULD also remove the GetNextCACert setting from the CA capabilities returned by GetCACaps until it does have rollover certificates.

# 5. SCEP Transaction Examples

The following section gives several examples of client to CA transactions. Client actions are indicated in the left column, CA actions are indicated in the right column, and the transactionID is given in parentheses. The first transaction, for example, would read like this:

"Client Sends PKCSReq message with transactionID 1 to the CA. The CA signs the certificate and constructs a CertRep Message containing the

signed certificate with a transaction ID 1. The client receives the message and installs the certificate locally".

## 5.1. Successful Transactions

Successful Enrolment Case: Automatic processing

```
PKCSReq (1)             ----------> CA issues certificate
                        <---------- CertRep (1) SUCCESS
Client installs certificate
```

Successful Enrolment Case: Manual authentication required

```
PKCSReq (2)             ----------> Cert request goes into queue
                        <---------- CertRep (2) PENDING
CertPoll (2)            ----------> Still pending
                        <---------- CertRep (2) PENDING
CertPoll (2)            ----------> CA issues certificate
                        <---------- CertRep (2) SUCCESS
Client installs certificate
```

CA certificate rollover case:

```
GetNextCACert         ---------->
                      <---------- New CA certificate

PKCSReq*              ----------> CA issues certificate with
                                  new key
                      <---------- CertRep SUCCESS
Client stores certificate
for installation when
existing certificate expires.
```

* Enveloped for the new CA certificate. The CA will use the envelope to determine which key to use to issue the client certificate.

## 5.2. Transactions with Errors

In the case of polled transactions that aren't completed automatically, there are two potential options for dealing with a transaction that's interrupted due to network or software/hardware issues. The first is for the client to preserve its transaction

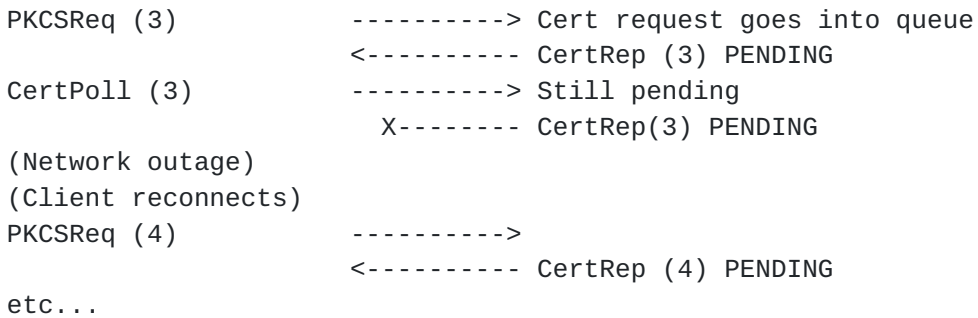
state and resume the CertPoll polling when normal service is restored. The second is for the client to begin a new transaction by sending a new PKCSReq/RenewalReq rather than continuing the previous CertPoll. Both options have their own advantages and disadvantages.

The CertPoll continuation requires that the client maintain its transaction state for the time when it resumes polling. This is relatively simple if the problem is a brief network outage, but less simple when the problem is a client crash and restart. In addition the CA may treat a lost network connection as the end of a transaction, so that a new connection followed by a CertPoll will be treated as an error.

The PKCSReq/RenewalReq continuation doesn't require any state to be maintained since it's a new transaction, however it may cause problems on the CA side if the certificate was successfully issued but the client never received it, since the resumed transaction attempt will appear to be a request for a duplicate certificate (see Section 8.4 for more on why this is a problem). In this case the CA may refuse the transaction, or require manual intervention to remove/revoke the previous certificate before the client can request another one.

Since the new-transaction resume is more robust in the presence of errors and doesn't require special-case handling by either the client or CA, clients SHOULD use the new-transaction option in preference to the resumed-CertPoll option to recover from errors.

Resync Case 1: Client resyncs via new PKCSReq (recommended):



Resync Case 2: Client resyncs via resumed CertPoll after a network outage (not recommended, use PKCSReq to resync):

```
PKCSReq (5)          ----------> Cert request goes into queue
                     <---------- CertRep (5) PENDING
CertPoll (5)         ----------> Still pending
                       X-------- CertRep(5) PENDING
(Network outage)
(Client reconnects)
CertPoll (5)         ----------> CA issues certificate
                     <---------- CertRep (5) SUCCESS
Client installs certificate
```

Resync Case 3: Special-case variation of case 2 where the CertRep SUCCESS rather than the CertRep PENDING is lost (recommended):

```
PKCSReq (6)          ----------> Cert request goes into queue
                     <---------- CertRep (6) PENDING
CertPoll (6)         ----------> Still pending
                     <---------- CertRep (6) PENDING
CertPoll (6)         ----------> CA issues certificate
                       X-------- CertRep(6) SUCCESS
(Network outage)
(Client reconnects)
PKCSReq (7)          ----------> There is already a valid
                                 certificate with this DN.
                     <---------- CertRep (7) FAILURE
                                 Admin revokes certificate
PKCSReq (7)          ----------> CA issues new certificate
                     <---------- CertRep (7) SUCCESS
Client installs certificate
```

Resync Case 4: Special-case variation of case 1 where the CertRep SUCCESS rather than the CertRep PENDING is lost (not recommended, use PKCSReq to resync):

```
PKCSReq (8)           ----------> Cert request goes into queue
                      <---------- CertRep (8) PENDING
CertPoll (8)          ----------> Still pending
                      <---------- CertRep (8) PENDING
CertPoll (8)          ----------> CA issues certificate
                        X-------- CertRep(8) SIGNED CERT
(Network outage)
(Client reconnects)
CertPoll (8)          ----------> Certificate already issued
                      <---------- CertRep (8) SUCCESS
Client installs certificate
```

As these examples indicate, resumption from an error via a resumed CertPoll is tricky due to the state that needs to be held by both the client and/or the CA. A PKCSReq/RenewalReq resume is the easiest to implement since it's stateless and is identical for both polled and non-polled transactions, while a CertPoll resume treats the two differently (a non-polled transaction is resumed with a PKCSReq/RenewalReq, a polled transaction is resumed with a CertPoll). For this reason error recovery SHOULD be handled via a new PKCSReq rather than a resumed CertPoll.

## 6. Contributors/Acknowledgements

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The earlier authors would like to thank Peter William of ValiCert, Inc. (formerly of VeriSign, Inc.) and Alex Deacon of VeriSign, Inc. and Christopher Welles of IRE, Inc. for their contributions to early versions of this protocol and this document.

## 7. IANA Considerations

One object identifier for an arc to assign SCEP Attribute Identifiers was assigned in the SMI Security for PKIX (1.3.6.1.5.5.7) registry:

```
id-scep OBJECT IDENTIFIER ::= { id-pkix TBD1 }
```

This assignment created the new SMI Security for SCEP Attribute Identifiers ((1.3.6.1.5.5.7.TBD1) registry with the following entries with references to this document:

```
id-scep-failInfoText OBJECT IDENTIFIER ::= { id-scep 1 }
```

(Editor's note: When the OID is assigned, the values in the OID table in Section 3.2 will also need to be updated).

## 8. Security Considerations

The security goal of SCEP is that no adversary can subvert the public key/identity binding from that intended. An adversary is any entity other than the client and the CA participating in the protocol.

This goal is met through the use of CMS and PKCS #10 encryption and digital signatures using authenticated public keys. The CA's public key is authenticated via out-of-band means such as the checking of the CA fingerprint and the SCEP client's public key is authenticated through manual or pre-shared secret authentication.

### 8.1. General Security

Common key-management considerations such as keeping private keys truly private and using adequate lengths for symmetric and asymmetric keys must be followed in order to maintain the security of this protocol. This is especially true for CA keys which, when compromised, compromise the security of all relying parties.

### 8.2. Use of the CA keypair

A CA key pair is generally meant for, and is usually flagged as, being usable for certificate (and CRL) signing exclusively rather than data signing or encryption. The SCEP protocol however uses the CA private key to both sign and optionally encrypt CMS transport messages. This is generally considered undesirable as it widens the possibility of an implementation weakness and provides an additional

location where the private key must be used (and hence is slightly more vulnerable to exposure) and where a side-channel attack might be applied.

### 8.3. Challenge Password

The challengePassword sent in the PKCS #10 enrolment request is signed and encrypted by way of being encapsulated in a pkiMessage. When saved by the CA, care should be taken to protect this password, for example by storing a salted iterated hash of the password rather than the password itself.

### 8.4. Lack of Certificate Issue Confirmation

SCEP provides no confirmation that the issued certificate was successfully received and processed by the client. This means that if the CertRep message is lost or can't be processed by the client then the CA will consider the certificate successfully issued while the client won't. If this situation is of concern then the correct issuance of the certificate will need to be verified by out-of-band means, for example through the client sending a message signed by the newly-issued certificate to the CA. This also provides the proof of possession that's not present in the case of a renewal operation, see Section 8.6.

### 8.5. GetCACaps Issues

The GetCACaps response is not authenticated by the CA. This allows an attacker to perform downgrade attacks on the cryptographic capabilities of the client/CA exchange. In particular if the server were to support MD5 and single DES then an in-path attacker could trivially roll back the encryption to use these insecure algorithms. By taking advantage of the presence of large amounts of static known plaintext in the SCEP messages, as of 2017 a DES rainbow table attack can recover most encryption keys in under a minute, and MD5 chosen-prefix collisions can be calculated for a few tens of cents of computing time using tools like HashClash.

### 8.6. Lack of PoP in Renewal Requests

Renewal operations (but not standard certificate-issue operations) are processed via a previously-issued certificate and its associated private key, not the key in the PKCS #10 request. This means that a client no longer demonstrates proof of possession (PoP) of the private key corresponding to the public key in the PKCS #10 request. It is therefore possible for a client to re-certify an existing key used by a third party, so that two or more certificates exist for the same key. By switching out the certificate in a signature, an

attacker can appear to have a piece of data signed by their certificate rather than the original signer's certificate. This, and other, attacks are described in S/MIME ESS [17].

Avoiding these types of attacks requires situation-specific measures. For example CMS/SMIME implementations may use the ESSCertID attribute from S/MIME ESS [17] or its successor S/MIME ESSv2 [18] to unambiguously identify the signing certificate, however other mechanisms and protocols typically don't defend against this attack.

### 8.7. Unnecessary cryptography

Some of the SCEP exchanges use unnecessary signing and encryption operations. In particular the GetCert and GetCRL exchanges are encrypted and signed in both directions. The information requested is public and thus encrypting the requests is of questionable value. In addition CRLs and certificates sent in responses are already signed by the CA and can be verified by the recipient without requiring additional signing and encryption. More lightweight means of retrieving certificates and CRLs such as HTTP certificate-store access [13] and LDAP are recommended for this reason.

### 8.8. Use of SHA-1

Virtually all of the large numbers of devices that use SCEP today default to SHA-1, with many supporting only that hash algorithm with no ability to upgrade to a newer one. SHA-1 is no longer regarded as secure in all situations, but as used in SCEP it's still safe. There are three reasons for this. The first is that attacking SCEP would require creating a SHA-1 collision in close to real time, which won't be feasible for a very long time.

The second reason is that the signature over the message doesn't serve any critical cryptographic purpose: The PKCS #10 data itself is authenticated through its own signature, protected by encryption, and the overall request is authorised by the (encrypted) password. The sole exception to this will be the small number of implementations that support the Renewal operation, which may be authorised purely through a signature, but presumably any implementation recent enough to support Renewal also supports SHA-2. Any legacy implementation that supports the historic core SCEP protocol would not be affected.

The third reason is that SCEP uses the same key for encryption and signing, so that even if an attacker were able to capture an outgoing Renewal request that didn't include a password (in other words one that was only authorised through a signature), forge the SHA-1 hash in real time, and forward the forged request to the CA, they couldn't decrypt the returned certificate, which is protected with the same

key that was used to generate the signature. While Section 8.7 points out that SCEP uses unnecessary cryptography in places, the additional level of security provided by the extra crypto makes it immune to any issues with SHA-1.

This doesn't mean that SCEP implementations should continue to use SHA-1 in perpetuity, merely that there's no need for a panicked switch to SHA-2.

# 9. References

## 9.1. Normative References

[1] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[2] Crocker, R. and P. Overell, "Augmented BNF for Syntax Specifications: ABNF", RFC 5234, January 2008.

[3] NIST, "The Advanced Encryption Standard (AES)", FIPS 197, November 2001.

[4] NIST, "Secure Hash Standard (SHS)", FIPS 180-3, October 2008.

[5] Josefsson, S., "The Base16, Base32, and Base64 Data Encodings", RFC 4648, October 2006.

[6] Housley, R., "Cryptographic Message Syntax (CMS)", RFC 5652, September 2009.

[7] Fielding, R. and J. Reschke, "Hypertext Transfer Protocol (HTTP/1.1): Message Syntax and Routing", RFC 7230, June 2014.

[8] Nystrom, M. and B. Kaliski, "PKCS #9: Selected Object Classes and Attribute Types Version 2.0", RFC 2985, November 2000.

[9] Nystrom, M. and B. Kaliski, "PKCS #10: Certification Request Syntax Specification Version 1.7", RFC 2986, November 2000.

[10] Cooper, D., Santesson, S., Farrell, S., Boeyen, S., Housley, R., and W. Polk, "Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile", RFC 5280, May 2008.

[11] Berners-Lee, T., Fielding, R., and L. Masinter, "Uniform Resource Identifiers (URI): Generic Syntax", RFC 3986, January 2005.

### 9.2. Informative References

[12] Nottingham, M., "Building Protocols with HTTP", November 2018.

[13] Gutmann, P., "Internet X.509 Public Key Infrastructure Operational Protocols: Certificate Store Access via HTTP", RFC 4387, February 2006.

[14] "A Java implementation of the Simple Certificate Enrolment Protocol", <https://github.com/jscep/jscep>.

[15] Kaufman, C., Hoffman, P., Nir, Y., Eronen, P., and T. Kivinen, "Internet Key Exchange (IKEv2) Protocol", RFC 7296, December 2005.

[16] Ramsdell, B. and S. Turner, "Secure/Multipurpose Internet Mail Extensions (S/MIME) Version 3.2 Message Specification", RFC 5751, January 2010.

[17] Hoffman, P., "Enhanced Security Services for S/MIME", RFC 2634, June 1999.

[18] Schaad, J., "Enhanced Security Services (ESS) Update: Adding CertID Algorithm Agility", RFC 5035, August 2007.

[19] Dierks, T. and E. Rescorla, "The Transport Layer Security (TLS) Protocol Version 1.2", RFC 5246, August 2008.

## Appendix A. Background Notes

This specification has spent more than seventeen years in the draft stage. Its original goal, provisioning IPsec routers with certificates, has long since changed to general device/embedded system/IoT use. To fit this role, extra features were bolted on in a haphazard manner through the addition of a growing list of appendices and by inserting additional, often conflicting, paragraphs in various locations in the body text. Since existing features were never updated as newer ones were added, the specification accumulated large amounts of historical baggage over time. If OpenPGP was described as "a museum of 1990s crypto" then the SCEP draft was its graveyard.

About five years ago the specification, which even at that point had seen only sporadic re-posts of the existing document, was more or

less abandoned by its original sponsors. Due to its widespread use in large segments of the industry, the specification was rebooted in 2015, cleaning up fifteen years worth of accumulated cruft, fixing errors, clarifying ambiguities, and bringing the algorithms and standards used into the current century (prior to the update, the de-facto lowest-common denominator algorithms used for interoperability were the insecure forty-year-old single DES and broken MD5 hash algorithms).

Note that although the text of the current specification has changed significantly due to the consolidation of features and appendices into the main document, the protocol it describes is identical on the wire to the original (with the exception of the switch from single DES and MD5 to AES and SHA-2). The only two changes introduced, the "SCEPStandard" indicator in GetCACaps and the failInfoText attribute, are both optional values and would be ignored by older implementations that don't support them, or can be omitted from messages if they are found to cause problems.

Other changes include:

- Resolved contradictions in the text, for example a requirement given as a MUST in one paragraph and a SHOULD in the next, a MUST NOT in one paragraph and a MAY a few paragraphs later, a SHOULD NOT contradicted later by a MAY, and so on.
- Merged several later fragmentary addenda placed in appendices (for example the handling of certificate renewal) with the body of the text.
- Merged the SCEP Transactions and SCEP Transport sections, since the latter mostly duplicated (with occasional inconsistencies) the former.
- Updated the algorithms to ones dating from at least this century.
- Did the same for normative references to other standards.
- Updated the text to use consistent terminology for the client and CA rather than a mixture of client, requester, end entity, server, certificate authority, certification authority, and CA.
- Corrected incorrect references to other standards, e.g. IssuerAndSerial -> IssuerAndSerialNumber.
- Corrected errors such as a statement that when both signature and encryption certificates existed, the signature certificate was used for encryption.
- Condensed redundant discussions of the same topic spread across multiple sections into a single location. For example the description of intermediate CA handling previously existed in three different locations, with slightly different reqirements in each one.
- Added a description of how pkiMessages were processed, which was never made explicit in the original specification. This led to

creative interpretations that had security problems but were employed anyway due to the lack of specific guidance on what to do.

- Relaxed some requirements that didn't serve any obvious purpose and that major implementations didn't seem to be enforcing. For example the requirement that the self-signed certificate used with a request MUST contain a subject name that matched the one in the PKCS #10 request was relaxed to a SHOULD because a number of implementations either ignored the issue entirely or at worst performed some minor action like creating a log entry after which they continued anyway.
- Removed discussion of the transactionID from the security considerations, since the instructions there were directly contradicted by the discussion of the use of the transactionID in Section 5.
- Added a requirement that the signed message include the signing certificate(s) in the signedData certificates field. This was implicit in the original specification (without it, the message couldn't be verified by the CA) and was handled by the fact that most PKCS #7/CMS libraries do this by default, but was never explicitly mentioned.
- Clarified sections that were unclear or even made no sense, for example the requirement for a "hash on the public key" [sic] encoded as a PrintableString.
- Renamed "RA certificates" to "intermediate CA certificates". The original document at some point added mention of RA certificates without specifying how the client was to determine that an RA was in use, how the RA operations were identified in the protocol, or how it was used. It's unclear whether what was meant was a true RA or merely an intermediate CA, as opposed to the default practice of having certificates issued directly from a single root CA certificate. This update uses the term "intermediate CA certificates", since this seems to have been the original intent of the text.
- Redid the PKIMessage diagram to match what was specified in CMS, the original diagram omitted a number of fields and nested data structures which meant that the diagram didn't match either the text or the CMS specification.
- Removed the requirement for a CertPoll to contain a recipientNonce, since CertPoll is a client message and will never be sent in response to a message containing a senderNonce. See also the note in Section 3.3.2.
- Clarified certificate renewal. These represent a capability that was bolted onto the original protocol with (at best) vaguely-defined semantics, including a requirement by the CA to guess whether a particular request was a renewal or not. In response to developer feedback that they either avoided renewal entirely because of this uncertainty or hardcoded in particular behaviour

on a per-CA basis, this specification explicitly identifies renewal requests as such, and provides proper semantics for them.

- Added the "SCEPStandard" keyword to GetCACaps to indicate that the CA complies with the final version of the SCEP standard, since the definition of what constitutes SCEP standards compliance has changed significantly over the years.
- Added the optional failInfoText attribute to deal with the fact that failInfo was incapable of adequately communicating to clients why a certificate request operation had been rejected.
- Removed the discussion in the security considerations of revocation issues, since SCEP doesn't support revocation as part of the protocol.
- Clarified the use of nonces, which if applied as originally specified would have made the use of polling in the presence of a lost message impossible.
- Removed the discussion of generating a given transactionID by hashing the public key, since this implied that there was some special significance in the value generated this way. Since it was neither a MUST nor a MAY, it was unsound to imply that servers could rely on the value being generated a certain way. In addition it wouldn't work if multiple transactions as discussed in Section 4.4 were initiated, since the deterministic generation via hashing would lead to duplicate transactionIDs.
- Added examples of SCEP messages to give implementers something to aim for.

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