

keyprov
Internet-Draft
Intended status: Standards Track
Expires: July 17, 2009

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January 13, 2009

Portable Symmetric Key Container (PSKC)
draft-ietf-keyprov-pskc-00.txt

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Abstract

This document specifies a symmetric key format for transport and provisioning of symmetric keys (for example One Time Password (OTP) shared secrets or symmetric cryptographic keys) to different types of crypto modules, such as a strong authentication device. The standard key transport format enables enterprises to deploy best-of-breed solutions combining components from different vendors into the same infrastructure.

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1. Introduction

With increasing use of symmetric key based authentication systems such as systems based one time password (OTP) and challenge response mechanisms, there is a need for vendor interoperability and a standard format for importing, exporting or provisioning symmetric keys from one system to another. Traditionally authentication server vendors and service providers have used proprietary formats for importing, exporting and provisioning these keys into their systems making it hard to use tokens from vendor A with a server from vendor B.

This document describes a standard format for serializing symmetric keys such as OTP shared secrets for system import, export or network/protocol transport. The goal is that the format will facilitate dynamic provisioning and transfer of symmetric keys such as OTP shared secrets or encryption keys of different types. In the case of OTP shared secrets, the format will facilitate dynamic provisioning using an online provisioning protocol to different flavors of embedded tokens or allow customers to import new or existing tokens in batch or single instances into a compliant system.

This draft also specifies the key attributes required for computation such as the initial event counter used in the HOTP algorithm [[HOTP](#)]. It is also applicable for other time-based or proprietary algorithms.

To provide an analogy, in public key environments the PKCS#12 format [[PKCS12](#)] is commonly used for importing and exporting private keys and certificates between systems. In the environments outlined in

this document where OTP keys may be transported directly down to smartcards or devices with limited computing capabilities and explicit shared secret, configuration attribute information is desirable. With PKCS#12, one would have to use opaque data to carry shared secret attributes used for OTP calculations, whereas a more explicit attribute schema definition is better for interoperability and efficiency.

2. Terminology

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 [[RFC2119](#)].

In subsequent sections of the document we highlight mandatory elements and attributes. Optional elements and attributes are not explicitly indicated.

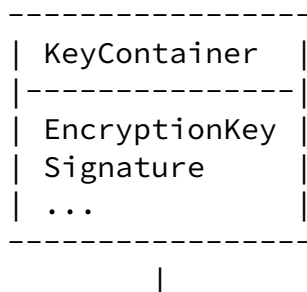
[3.](#) Portable Key Container Entities Overview and Relationships

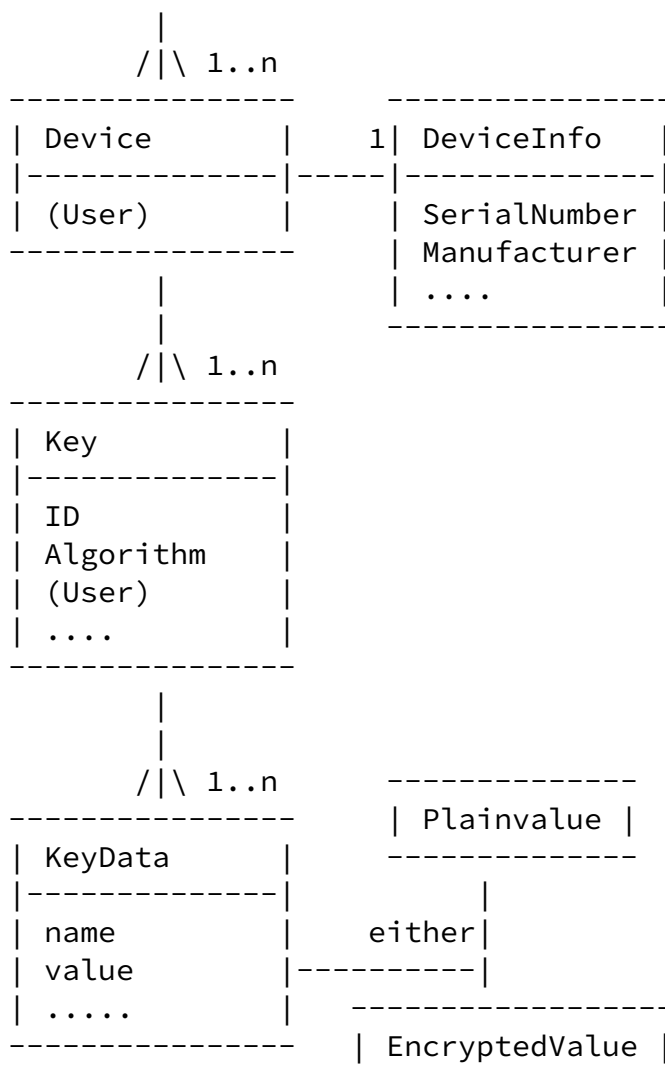
The portable key container is based on an XML schema definition and contains the following main conceptual entities:

1. KeyContainer entity - representing the container that carries the keys
2. Device entity - representing a physical or virtual device where the keys reside optionally bound to a specific user
3. DeviceInfo entity - representing the information about the device and criteria to uniquely identify the device
4. Key entity - representing the key transmitted

5. KeyData entity - representing data related to the key including value either in plain or encrypted

The figure below represents the entity relationship diagram (brackets () denote optional elements).





The following sections describe in detail all the entities and related XML schema elements and attributes.

[4.](#) <KeyContainer> Element: The Basics

In its most basic form a PSKC document uses the top-level element `<KeyContainer>` and a single `<Device>` element to carry key information.

The following example shows such a simple PSKC document. We will use it to describe the structure of the `<KeyContainer>` element and its child elements.

```
<?xml version="1.0" encoding="UTF-8"?>
<KeyContainer Version="1" id="exampleID1"
xmlns="urn:ietf:params:xml:ns:keyprov:pskc">
  <Device>
    <DeviceInfo>
      <Manufacturer>Manufacturer</Manufacturer>
      <SerialNo>987654321</SerialNo>
    </DeviceInfo>
    <Key KeyId="12345678"
KeyAlgorithm="urn:ietf:params:xml:ns:keyprov:pskc#hotp">
      <Issuer>Issuer</Issuer>
      <Usage>
        <ResponseFormat Length="8" Encoding="DECIMAL"/>
      </Usage>
      <Data>
        <Secret>
          <PlainValue>MTIzNDU2Nzg5MDEyMzQ1Njc4OTA=
          </PlainValue>
        </Secret>
        <Counter>
          <PlainValue>0</PlainValue>
        </Counter>
      </Data>
    </Key>
  </Device>
</KeyContainer>
```

Figure 1: Basic PSKC Key Container Example

The attributes of the `<KeyContainer>` element have the following semantic:

'Version:' The 'Version' attribute is used to identify the version of the PSKC schema version. This specification defines the initial version ("1") of the PSKC schema. This attribute is mandatory.

'ID:' The 'ID' attribute carries a unique identifier for the container. This is useful when needing to refer to an individual key container when more than one container is embedded into a larger XML document.

A <KeyContainer> element MUST contain at least one <Device> elements. Multiple <Device> elements may be used when for bulk provisioning, see [Section 8](#). A <Device> MUST contain at least one <Key> element. A <Device> MAY be bound to a user. A key SHOULD be bound to only one <Device> element.

[4.1](#). <DeviceInfo> Element: Unique Device Identification

The <DeviceInfo> element allows to uniquely identify the device the <Key> element refers to. Since devices can come in different form factors, such as hardware tokens, smart-cards, soft tokens in a mobile phone or as a PC, this element allows different criteria to be used. Combined though the criteria MUST uniquely identify the device. For example, for hardware tokens the combination of SerialNo and Manufacturer will uniquely identify a device but not SerialNo alone since two different token manufacturers might issue devices with the same serial number (similar to the IssuerDN and serial number of a certificate). Symmetric keys used in the payment industry are usually stored on Integrated Circuit Smart Cards.

The <DeviceInfo> element has the following child elements:

<Manufacturer>: This element indicates the manufacturer of the device.

<SerialNo>: This element contains the serial number of the device

<Model>: This element describes the model of the device (e.g., one-button-HOTP-token-V1)

<IssueNo>: This element contains the issue number in case devices with the same serial number that are distinguished by different issue numbers

<DeviceBinding>: This element carries the identifier that can be used to bind keys to the device or class of device. When loading keys into a device, this identifier can be checked against information obtained from the device to ensure that the correct device or class of device is being used.

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<StartDate>: This element indicates the start date of a device (such as the one on a payment card, used when issue numbers are not printed on cards). The date MUST be expressed in UTC form with no timezone component. Implementations SHOULD NOT rely on time resolution finer than milliseconds and MUST NOT generate time instants that specify leap seconds.

<ExpiryDate>: This field contains the expiry date of a device (such as the one on a payment card, used when issue numbers are not printed on cards). It MUST be expressed in UTC form with no timezone component. Implementations SHOULD NOT rely on time resolution finer than milliseconds and MUST NOT generate time instants that specify leap seconds.

[4.2.](#) <Key>: Embedding Keying Material

The following attributes of the <Key> element MUST be included at a minimum:

'KeyId': This attribute carries a globally unique identifier for the symmetric key. The identifier is defined as a string of alphanumeric characters.

'KeyAlgorithm': This attribute contains a unique identifier for the PSKC algorithm profile. This profile associates a specific semantic to the elements and attributes contained in the <Key> element. More information about the PSKC algorithm profile defined in this document can be found in [Section 10](#).

The <Key> element has a number of optional child elements. An initial set is described below:

<Issuer>: The key issuer name, this is normally the name of the organization that issues the key to the end user of the key. For example MyBank issuing hardware tokens to their retail banking users 'MyBank' would be the issuer.

<FriendlyName>: A human readable name for the secret key for easier reference. This element serves informational purposes only.

<Usage>: This element defines the intended usage of the key and related metadata as defined in [Section 4.4](#). There are cases where the specific context in which the key is used can be inferred but typically the context is provided explicitly.

<Data>: This element carries data about and related to the key. Further description about the <Data> element can be found subsequent to this list.

This document defines a few child element for the <Data> element, namely

<Secret>: This element carries the value of the key itself in a binary representation.

<Counter>: This element contains the event counter for event based OTP algorithms.

<Time>: This element contains the time for time based OTP algorithms. (If time interval is used, this element carries the number of time intervals passed from a specific start point, normally algorithm dependent)

<TimeInterval>: This element carries the time interval value for time based OTP algorithms.

<TimeDrift>: This element contains the device clock drift value for time based OTP algorithms. The value indicates number of seconds that the device clock may drift each day.

All these elements listed above (and those defined in the future) obey a simple structure in that they must support child element to convey the content in plaintext or in encrypted format:

Plain Text: The <PlainValue> element carries plaintext content that is typed, for example to xs:integer.

Encrypted Content: The <EncryptedValue> element carries encrypted content.

Additionally, an optional <ValueMac> element, which is populated with a MAC generated from the unencrypted value in case the encryption algorithm does not support integrity checks, may be included as a child element.

The example shown at Figure 1 illustrates the usage of the <Data> element with two child elements, namely <Secret> and <Counter>. Both elements carry plaintext value within the <PlainValue> child element.

[4.3.](#) <User> Element: User Identification

<User> element identifies the owner or the user of the device using a distinguished name, as defined in [[RFC4514](#)]. For example:

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UID=jsmith,DC=example,DC=net

There is no semantic associated with this element, i.e., there are no checks enforcing that only a specific user can use this key. As such, this element is for informational purposes only.

[4.4.](#) <Usage> Element: Supplementary Information for OTP and CR Algorithms

The <Usage> element is a child element of the <Key> element.

The optional <ChallengeFormat> element defines the characteristics of the challenge in a CR usage scenario whereby the following attributes are defined:

'Encoding': This mandatory attribute defines the encoding of the challenge accepted by the device and MUST be one of the following values:

DECIMAL Only numerical digits

HEXADECIMAL Hexadecimal response

ALPHANUMERIC All letters and numbers (case sensitive)

BASE64 Base 64 encoded

BINARY Binary data

'CheckDigit': This optional attribute indicates whether a device needs to check the appended Luhn check digit, as defined in [[LUHN](#)], contained in a provided challenge. This is only valid if the 'Encoding' attribute is 'DECIMAL'. A value of TRUE indicates that the device will check the appended Luhn check digit in a provided challenge. A value of indicates that the device will not check appended Luhn check digit in challenge.

'Min': This mandatory attribute defines the minimum size of the challenge accepted by the device for CR mode. If the 'Encoding' attribute is 'DECIMAL', 'HEXADECIMAL' or 'ALPHANUMERIC' this value indicates the minimum number of digits/characters. If the 'Encoding' attribute is 'BASE64' or 'BINARY', this value indicates the minimum number of bytes of the unencoded value.

'Max': This mandatory attribute defines the maximum size of the challenge accepted by the device for CR mode. If the 'Encoding' attribute is 'DECIMAL', 'HEXADECIMAL' or 'ALPHANUMERIC' this value indicates the maximum number of digits/characters. If the

'Encoding' attribute is 'BASE64' or 'BINARY', this value indicates the maximum number of bytes of the unencoded value.

The <ResponseFormat> element defines the characteristics of the result of a computation and defines the format of the OTP or the response to a challenge. For cases where the key is a PIN value, this element contains the format of the PIN itself (e.g., DECIMAL, length 4 for a 4 digit PIN). The following attributes are defined:

'Encoding': This mandatory attribute defines the encoding of the response generated by the device and MUST be one of the following values: DECIMAL, HEXADECIMAL, ALPHANUMERIC, BASE64, or BINARY

'CheckDigit': This optional attribute indicates whether the device needs to append a Luhn check digit, as defined in [[LUHN](#)], to the response. This is only valid if the 'Encoding' attribute is 'DECIMAL'. If the value is TRUE then the device will append a Luhn check digit to the response. If the value is FALSE then the

device will not append a Luhn check digit to the response.

'Length': This mandatory attribute defines the length of the response generated by the device. If the 'Encoding' attribute is 'DECIMAL', 'HEXADECIMAL' or 'ALPHANUMERIC' this value indicates the number of digits/characters. If the 'Encoding' attribute is 'BASE64' or 'BINARY', this value indicates the number of bytes of the unencoded value.

[5.](#) Policy

This section illustrates the functionality of the <Policy> element within PSKC that allows policy to be attached to a key and related meta data. This element is a child element of the <Key> element.

If the <Policy> element contains child elements or values within elements/attributes that are not understood by the recipient of the PSKC document then the recipient MUST assume that key usage is not permitted. This statement ensures that the lack of understanding of certain extension does not lead to unintended key usage.

We will start our description with an example that expands the example shown in Figure 2.

```
<?xml version="1.0" encoding="UTF-8"?>
<KeyContainer Version="1" id="exampleID1"
  xmlns="urn:ietf:params:xml:ns:keyprov:pskc">
  <Device>
```



```

<DeviceInfo>
  <Manufacturer>Manufacturer</Manufacturer>
  <SerialNo>987654321</SerialNo>
</DeviceInfo>
<Key KeyId="12345678"
KeyAlgorithm="urn:ietf:params:xml:ns:keyprov:pskc#hotp">
  <Issuer>Issuer</Issuer>
  <Usage>
    <ResponseFormat Length="8" Encoding="DECIMAL"/>
  </Usage>
  <Data>
    <Secret>
      <PlainValue>MTIzNDU2Nzg5MDEyMzQ1Njc4OTA=
      </PlainValue>
    </Secret>
    <Counter>
      <PlainValue>0</PlainValue>
    </Counter>
  </Data>
  <Policy>
    <PINPolicy MinLength="4" MaxLength="4"
    PINKeyId="123456781" PINEncoding="DECIMAL"
    PINUsageMode="Local"/>
    <KeyUsage>OTP</KeyUsage>
  </Policy>
</Key>
<Key KeyId="123456781"
KeyAlgorithm="urn:ietf:params:xml:ns:keyprov:pskc#pin">
  <Issuer>Issuer</Issuer>
  <Usage>
    <ResponseFormat Length="4" Encoding="DECIMAL"/>
  </Usage>
  <Data>
    <Secret>
      <PlainValue>MTIzNA==</PlainValue>
    </Secret>
  </Data>
</Key>
</Device>
</KeyContainer>

```

Figure 2: Non-Encrypted HOTP Secret Key protected by PIN

This document defines the following elements:

<StartDate>: This element denotes the start date of the key. It MUST NOT be possible to use this key before this date. The value MUST be expressed in UTC form, with no time zone component. Implementations SHOULD NOT rely on time resolution finer than milliseconds and MUST NOT generate time instants that specify leap seconds. When this element is absent then the current time is assumed as a start time.

<ExpiryDate>: This element denotes the expiry date of the key. It MUST NOT be possible to use this key after this date. The value MUST be expressed in UTC form, with no time zone component. Implementations SHOULD NOT rely on time resolution finer than milliseconds and MUST NOT generate time instants that specify leap seconds. When this element is absent then no expiry date is assumed.

<KeyUsage>: The <KeyUsage> element allows to indicate the intended usage of the key. The recipient of the PSKC document is expected to enforce the key usage. Currently, the following tokens are registered by this document:

OTP: The key MUST only be used for OTP generation.

CR: The key MUST only be used for Challenge/Response purposes.

Encrypt: The key MUST only be used for data encryption purposes.

Integrity: The key MUST only be used to generate a keyed message digest for data integrity or authentication purposes.

Unlock: The key MUST only be used for an inverse challenge response in the case a user has locked the device by entering a wrong PIN too many times (for devices with PIN-input capability).

Decrypt: The key MUST only be used for data decryption purposes.

KeyWrap: The key MUST only be used for key wrap purposes.

The element may also be repeated to allow several key usages to be expressed. When this element is absent then no key usage constraint is assumed, i.e., the key may be utilized for every usage.

<PINPolicy>: The <PINPolicy> element allows policy about the PIN usage to be associated to the key. The following attributes are specified:

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'PINKeyId': This attribute contains the unique key id of the key held within this container that contains the value of the PIN that protects the key.

'PINUsageMode': This mandatory attribute indicates the way the PIN is used during the usage of the key. The following values are defined:

Local: This value indicates that the PIN is checked locally on the device before allowing the key to be used in executing the algorithm.

Prepend: This value indicates that the PIN is prepended to the OTP or response hence it MUST be checked by the validation server.

Append: This value indicates that the PIN is appended to the OTP or response hence it MUST be checked by the validation server.

Algorithmic: This value indicates that the PIN is used as part of the algorithm computation.

'MaxFailedAttempts': This attribute indicates the maximum number of times the PIN can be entered wrongly before it MUST not be possible to use the key anymore. If the 'PinUsageMode'="Local" then the device MUST enforce this value, otherwise it MUST be enforced by the validation server.

'MinLength': This attribute indicates the minimum length of a PIN that can be set to protect this key. It MUST NOT be possible to set a PIN shorter than this value. If the 'PINFormat' attribute is 'DECIMAL', 'HEXADECIMAL' or 'ALPHANUMERIC' this value indicates the number of digits/characters. If the 'PINFormat' attribute is 'BASE64' or 'BINARY', this value indicates the number of bytes of the unencoded value. If the 'PinUsageMode' attribute is set to "Local" then the device MUST enforce this value, otherwise it MUST be enforced by the validation server.

'MaxLength': This attribute indicates the maximum length of a PIN that can be set to protect this key. It MUST NOT be possible to set a PIN longer than this value. If the 'PINFormat' attribute is 'DECIMAL', 'HEXADECIMAL' or 'ALPHANUMERIC' this value indicates the number of digits/characters. If the 'PINFormat' attribute is 'BASE64' or 'BINARY', this value indicates the number of bytes of the unencoded value. If the 'PinUsageMode' attribute is set to "Local" then the device MUST

enforce this value, otherwise it MUST be enforced by the validation server.

'PINEncoding': This attribute indicates the encoding of the PIN and MUST be one of the values: DECIMAL, HEXADECIMAL, ALPHANUMERIC, BASE64, or BINARY. If the 'PinUsageMode' attribute is set to "Local" then the device MUST enforce that the entered value is of this format, otherwise it MUST be enforced by the validation server.

[6.](#) Protection of Keys and Related Data

With the functionality described in the previous sections information related to keys had to be transmitted in clear text. With the help of the `<EncryptionKey>` element, which is a child element of the `<KeyContainer>` element, it is possible to encrypt keys and associated information. The level of encryption is applied to each individual element and the indicated encryption method **MUST** be the same for elements. In subsequent sections key encryption based on pre-shared keys, based on passphrase-based keys, and based on asymmetric keys will be discussed.

[6.1.](#) Encryption based on Pre-Shared Keys

Figure 3 shows an example that illustrates the encryption of the content of the `<Secret>` element using AES128-CBC, the plaintext value of `<Secret>` is '3132333435363738393031323334353637383930'. The name of the pre-shared secret is "Example-Key1", as set in the `<KeyName>` element (which is a child element of the `<EncryptionKey>` element). The value of the key used is '12345678901234567890123456789012'. Since AES128-CBC does not provide integrity checks a keyed MAC is applied to the encrypted value using the algorithm indicated in `<MACAlgorithm>` element (in our example "http://www.w3.org/2000/09/xmlsig#hmac-sha1" is used). The result of the keyed MAC computation is placed in the `<ValueMAC>` element.

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```
<?xml version="1.0" encoding="UTF-8"?>
<KeyContainer Version="1" xmlns="urn:ietf:params:xml:ns:keyprov:pskc"
xmlns:ds="http://www.w3.org/2000/09/xmldsig#"
xmlns:xenc="http://www.w3.org/2001/04/xmenc#">
  <EncryptionKey>
    <ds:KeyName>Pre-shared-key</ds:KeyName>
  </EncryptionKey>
  <MACAlgorithm>http://www.w3.org/2000/09/xmldsig#hmac-sha1
  </MACAlgorithm>
  <Device>
    <DeviceInfo>
      <Manufacturer>Manufacturer</Manufacturer>
      <SerialNo>987654321</SerialNo>
    </DeviceInfo>
    <Key KeyId="12345678"
KeyAlgorithm="urn:ietf:params:xml:ns:keyprov:pskc#hotp">
      <Issuer>Issuer</Issuer>
      <Usage>
        <ResponseFormat Length="8" Encoding="DECIMAL"/>
      </Usage>
    </Key>
  </Device>
</KeyContainer>
```

```

    </Usage>
    <Data>
      <Secret>
        <EncryptedValue>
          <xenc:EncryptionMethod
            Algorithm=
              "http://www.w3.org/2001/04/xmlenc#aes128-cbc"/>
          <xenc:CipherData>
            <xenc:CipherValue>
              pgznhXdDh4LJ2G3m0Y2RL7UA47yizMlXX3ADDcZd8Vs=
            </xenc:CipherValue>
          </xenc:CipherData>
        </EncryptedValue>
        <ValueMAC>zdrZbGBj9BDZJzunbfAG3kyZyYc=
        </ValueMAC>
      </Secret>
      <Counter>
        <PlainValue>0</PlainValue>
      </Counter>
    </Data>
  </Key>
</Device>
</KeyContainer>

```

Figure 3: AES-128-CBC Encrypted Pre-Shared Secret Key

When protecting the payload with pre-shared keys implementations SHOULD set the name of the specific pre-shared key in the <KeyName> element inside the <EncryptionKey> element.

The following is the list of symmetric key encryption algorithm and possible parameters for usage with pre-shared secret based encryption. Systems implementing PSKC MUST support AES128-CBC (with the URI of <http://www.w3.org/2001/04/xmlenc#aes128-cbc>).

An example list of optionally-to-implement encryption algorithms can be found below:

Algorithm	URL
AES192-CBC	http://www.w3.org/2001/04/xmlenc#aes192-cbc

AES256-CBC	http://www.w3.org/2001/04/xmlenc#aes256-cbc
TripleDES-CBC	http://www.w3.org/2001/04/xmlenc#tripledes-cbc
Camellia128	http://www.w3.org/2001/04/xmlsig-more#camellia128
Camellia192	http://www.w3.org/2001/04/xmlsig-more#camellia192
Camellia256	http://www.w3.org/2001/04/xmlsig-more#camellia256
KW-AES128	http://www.w3.org/2001/04/xmlenc#kw-aes128
KW-AES192	http://www.w3.org/2001/04/xmlenc#kw-aes192
KW-AES256	http://www.w3.org/2001/04/xmlenc#kw-aes256
KW-TripleDES	http://www.w3.org/2001/04/xmlenc#kw-tripledes
KW-Camellia128	http://www.w3.org/2001/04/xmlsig-more#kw-camellia128
KW-Camellia192	http://www.w3.org/2001/04/xmlsig-more#kw-camellia192
KW-Camellia256	http://www.w3.org/2001/04/xmlsig-more#kw-camellia256

When algorithms without integrity checks are used, such as AES12-CBC, a keyed MAC value using the same key as the key encryption key MUST be placed in the <ValueMAC> element of the <Data> element. In this case the MAC algorithm type MUST be set in the <MACAlgorithm> element of the <KeyContainer> element. Implementations of PSKC MUST support HMAC-SHA1 (with the URI of <http://www.w3.org/2000/09/xmlsig#hmac-sha1>) as the mandatory-to-implement MAC algorithm. An example list of optionally-to-implement MAC algorithms can be found below:

Algorithm	URL
HMAC-SHA256	http://www.w3.org/2001/04/xmlsig-more#hmac-sha256
HMAC-SHA384	http://www.w3.org/2001/04/xmlsig-more#hmac-sha384
HMAC-SHA512	http://www.w3.org/2001/04/xmlsig-more#hmac-sha512

6.2. Encryption based on Passphrase-based Keys

To be able to support passphrase based key encryption keys as defined in PKCS#5 the following PBE related parameters have been introduced into PSKC. Implementations of PSKC MUST support the PKCS#5 recommended PBKDF2 and PBES2 algorithms. Differing from the PKCS#5

XML schema definition, the PBKDF2 and PBES2 are specified in two separate elements in a <KeyContainer> element:

- (a) PBKDF2 is specified via the <DerivedKey> element, which is a child element of the <EncryptionKey> element.

(b) PBES2 is specified by the 'Algorithm' attribute (with the value set to <http://www.rsasecurity.com/rsalabs/pkcs/schemas/pkcs-5#pbes2>) of the <EncryptionMethod> element used inside the encrypted data elements.

The attributes of the <DerivedKey> element have the following semantic:

'xml:id': This attribute carries the unique identifier for this key.

'Type': This attribute was included for conformance with XML encryption. It is an optional attribute identifying type information about the plaintext form of the encrypted content. Please see Section 3.1 of [XMLENC] for more details.

The elements of the <DerivedKey> element have the following semantic:

<CarriedKeyName>: This element carries a friendly name of the key.

<KeyDerivationMethod>: This element defines how key encryption key is derived. The 'Algorithm' attribute is used to indicate the key derivation method. When PBKDF2 is used, the URI <http://www.rsasecurity.com/rsalabs/pkcs/schemas/pkcs-5#pbkdf2> MUST be used. When PBKDF2 is used, it MUST include the <PBKDF2-params> child element to indicate the PBKDF2 parameters, such as salt and iteration count.

<ReferenceList>: This element contains a list of IDs of the elements that have been encrypted by this key.

When PBES2 is used for encryption, the URL <http://www.rsasecurity.com/rsalabs/pkcs/schemas/pkcs-5#pbes2> MUST be specified as the 'Algorithm' attribute of <xenc:EncryptionMethod> element. The underlying encryption scheme and initialization vector MUST be expressed in the <pskc:EncryptionScheme> element, which is a child element of <xenc:EncryptionMethod>.

When PKCS#5 password based encryption is used, the <EncryptionKey> element and <xenc:EncryptionMethod> element MUST be used in exactly the form as shown in Figure 4.

In the example below, the following data is used.

Password: qwerty

Salt: 0x123eff3c4a72129c

Iteration Count: 1000

OTP Secret: 12345678901234567890

The derived encryption key is "0x651e63cd57008476af1ff6422cd02e41". This key is also used to calculate MAC value of the secret key "12345678901234567890". The encryption with algorithm "AES-128-CBC" follows the specification defined in [\[XMLENC\]](#).

```
<?xml version="1.0" encoding="UTF-8"?>
<KeyContainer
  xmlns="urn:ietf:params:xml:ns:keyprov:pskc"
  xmlns:pkcs5=
    "http://www.rsasecurity.com/rsalabs/pkcs/schemas/pkcs-5v2-0#"
  xmlns:xenc="http://www.w3.org/2001/04/xmenc#"
  Version="1">
  <EncryptionKey>
    <DerivedKey>
      <CarriedKeyName>Passphrase1</CarriedKeyName>
      <KeyDerivationMethod
        Algorithm=
"http://www.rsasecurity.com/rsalabs/pkcs/schemas/pkcs-5v2-0#pbkdf2">
        <pkcs5:PBKDF2-params>
          <pkcs5:Salt>
            <pkcs5:Specified>Ej7/PEpyEpw=</pkcs5:Specified>
          </pkcs5:Salt>
          <pkcs5:IterationCount>1000</pkcs5:IterationCount>
          <pkcs5:KeyLength>16</pkcs5:KeyLength>
          <pkcs5:PRF/>
        </pkcs5:PBKDF2-params>
      </KeyDerivationMethod>
      <xenc:ReferenceList>
        <xenc:DataReference URI="#ED"/>
      </xenc:ReferenceList>
    </DerivedKey>
  </EncryptionKey>
</Device>
  <DeviceInfo>
    <Manufacturer>TokenVendorAcme</Manufacturer>
    <SerialNo>987654321</SerialNo>
  </DeviceInfo>
```

```

    <Key KeyAlgorithm="urn:ietf:params:xml:ns:keyprov:pskc#hotp"
    KeyId="123456">
      <Issuer>Example-Issuer</Issuer>
      <Usage>
        <ResponseFormat Length="8" Encoding="DECIMAL"/>
      </Usage>
      <Data>
        <Secret>
          <EncryptedValue Id="ED">
            <xenc:EncryptionMethod Algorithm=
"http://www.rsasecurity.com/rsalabs/pkcs/schemas/pkcs-5#pbcs2">
              <EncryptionScheme Algorithm=
"http://www.w3.org/2001/04/xmlenc#aes128-cbc">
                </EncryptionScheme>
              </xenc:EncryptionMethod>
            <xenc:CipherData>
              <xenc:CipherValue>
oTvo+S22nsmS2Z/RtcoF8Hfh+jzMe0RkiafpoDpnoZTjPYZu6V+A4aEn032yCr4f
              </xenc:CipherValue>
            </xenc:CipherData>
            <ns2:ValueMAC>c0piQ/H7Zlj6ywiYWtwgz9cRa0A=
            </ns2:ValueMAC>
          </EncryptedValue>
        </Secret>
      </Data>
    </Key>
  </Device>
</KeyContainer>

```

Figure 4: Example of a PSKC Document using Encryption based on
Passphrase-based Keys

6.3. Encryption based on Asymmetric Keys

When using asymmetric keys to encrypt child element of the <Data> element information about the certificate being used MUST be stated in the <X509Data> element, which is a child element of the <EncryptionKey> element. The encryption algorithm MUST be indicated in the 'Algorithm' attribute of the <EncryptionMethod> element. In the example shown in Figure 5 the algorithm is set to "http://www.w3.org/2001/04/xmlenc#rsa_1_5".

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```
<?xml version="1.0" encoding="UTF-8"?>
<KeyContainer Version="1"
  xmlns="urn:ietf:params:xml:ns:keyprov:pskc"
  xmlns:ds="http://www.w3.org/2000/09/xmldsig#"
  xmlns:xenc="http://www.w3.org/2001/04/xmlenc#">
  <EncryptionKey>
    <ds:X509Data>
      <ds:X509Certificate>miib</ds:X509Certificate>
    </ds:X509Data>
  </EncryptionKey>
  <Device>
    <DeviceInfo>
      <Manufacturer>Manufacturer</Manufacturer>
      <SerialNo>0755225266</SerialNo>
    </DeviceInfo>
    <Key KeyAlgorithm=
      "urn:ietf:params:xml:ns:keyprov:pskc#hotp"
      KeyId="0755225266">
      <Issuer>AnIssuer</Issuer>
      <Usage>
        <ResponseFormat Length="8"
          Encoding="DECIMAL"/>
      </Usage>
      <Data>
        <Secret>
          <EncryptedValue Id="ED">
            <xenc:EncryptionMethod
              Algorithm=
                "http://www.w3.org/2001/04/xmlenc#rsa_1_5"/>
            <xenc:CipherData>
              <xenc:CipherValue>rf4dx3rvEP00vKtKL14NbeVu8nk=
            </xenc:CipherValue>
            </xenc:CipherData>
          </EncryptedValue>
        </Secret>
      </Data>
    </Key>
  </Device>
</KeyContainer>
```

```

        <Counter>
          <PlainValue>0</PlainValue>
        </Counter>
      </Data>
    </Key>
  </Device>
</KeyContainer>

```

Figure 5: Example of a PSKC Document using Encryption based on Asymmetric Keys

Systems implementing PSKC MUST support the http://www.w3.org/2001/04/xmlenc#rsa-1_5 algorithm.

<http://www.w3.org/2001/04/xmlenc#rsa-oaep-mgf1p> is an example of an optional-to-implement algorithm.

6.4. Transmission of Key Derivation Values

<KeyProfileId> element, which is a child element of the <Key> element, carries a unique identifier used between the sending and receiving party to establish a set of key attribute values that are not transmitted within the container but agreed between the two parties out of band. This element will then represent the unique reference to a set of attribute values. For example, a smart card application personalisation profile id related to attributes present on a smart card application that have influence when computing a response. The sending and the receiving party would agree to a set of values related to the MasterCard's Chip Authentication Protocol (CAP) [[CAP](#)].

For example, sending and receiving party would agree that KeyProfileId='1' would represent a certain set of values (e.g., Internet authentication flag set to a specific value). When sending keys these values would not be transmitted as key attributes but only referred to via the <KeyProfileId> element set to the specific agreed profile (in this case '1'). When the receiving party receives the keys it can then associate all relevant key attributes contained in the out of band agreed profile with the imported keys. Often this methodology is used between the manufacturing and the validation service to avoid transmission of mainly the same set of values.

<MasterKeyId> element uniquely references an external master key when key derivation schemes are used and no specific key is transported but only the reference to the master key used to derive a specific key and some derivation data (e.g., the PKCS#11 key label).

```
<?xml version="1.0" encoding="UTF-8"?>
<KeyContainer Version="1" id="exampleID1"
xmlns="urn:ietf:params:xml:ns:keyprov:pskc">
  <Device>
    <DeviceInfo>
      <Manufacturer>Manufacturer</Manufacturer>
      <SerialNo>987654321</SerialNo>
    </DeviceInfo>
    <Key KeyId="12345678"
KeyAlgorithm="urn:ietf:params:xml:ns:keyprov:pskc#hotp">
      <Issuer>Issuer</Issuer>
      <Usage>
        <ResponseFormat Length="8" Encoding="DECIMAL"/>
      </Usage>
      <KeyProfileId>keyProfile1</KeyProfileId>
      <MasterKeyId>MasterKeyLabel</MasterKeyId>
      <Data>
        <Counter>
          <PlainValue>0</PlainValue>
        </Counter>
      </Data>
    </Key>
  </Device>
</KeyContainer>
```

```

        <Policy>
            <KeyUsage>OTP</KeyUsage>
        </Policy>
    </Key>
</Device>
</KeyContainer>

```

Figure 6: Example of a PSKC Document transmitting a HOTP key via key derivation values (the key value will be derived using the serialnumber and a pre-shared masterkey identified by 'MasterKeyLabel')

7. Digital Signature

PSKC allows a digital signature to be added to the XML document, as a child element of the <KeyContainer> element. The description of the XML digital signature can be found in [[XMLDSIG](#)].

```

<?xml version="1.0" encoding="UTF-8"?>
<KeyContainer
  xmlns="urn:ietf:params:xml:ns:keyprov:pskc"
  xmlns:pkcs5=
    "http://www.rsasecurity.com/rsalabs/pkcs/schemas/pkcs-5v2-0#"
  xmlns:ds="http://www.w3.org/2000/09/xmlsig#"
  xmlns:xenc="http://www.w3.org/2001/04/xmlenc#"

```

```

Version="1">
<Device>
  <DeviceInfo>
    <Manufacturer>TokenVendorAcme</Manufacturer>
    <SerialNo>0755225266</SerialNo>
  </DeviceInfo>
  <Key KeyAlgorithm="urn:ietf:params:xml:ns:keyprov:pskc#hotp"
KeyId="123">
    <Issuer>Example-Issuer</Issuer>
    <Usage>
      <ResponseFormat Length="6" Encoding="DECIMAL"/>
    </Usage>
    <Data>
      <Secret>
        <PlainValue>
          MTIzNDU2Nzg5MDEyMzQ1Njc4OTA=
        </PlainValue>
      </Secret>
      <Counter>
        <PlainValue>0</PlainValue>
      </Counter>
    </Data>
  </Key>
</Device>
<Signature>
  <ds:SignedInfo>
    <ds:CanonicalizationMethod
      Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#" />
    <ds:SignatureMethod
      Algorithm="http://www.w3.org/2000/09/xmldsig#rsa-sha1" />
    <ds:Reference URI="#Device">
      <ds:DigestMethod
        Algorithm="http://www.w3.org/2000/09/xmldsig#sha1" />
      <ds:DigestValue>

```

```

      j6lwx3rvEP00vKtMup4NbeVu8nk=
    </ds:DigestValue>
  </ds:Reference>
</ds:SignedInfo>
<ds:SignatureValue>
  j6lwx3rvEP00vKtMup4NbeVu8nk=
</ds:SignatureValue>

```



```
<ds:KeyInfo>
  <ds:X509Data>
    <ds:X509IssuerSerial>
      <ds:X509IssuerName>
        CN=Example.com,C=US
      </ds:X509IssuerName>
      <ds:X509SerialNumber>
        12345678
      </ds:X509SerialNumber>
    </ds:X509IssuerSerial>
  </ds:X509Data>
</ds:KeyInfo>
</Signature>
</KeyContainer>
```

Figure 7: Digital Signature Example

8. Bulk Provisioning

The functionality of bulk provisioning can be accomplished by repeating the <Device> element multiple times within the <KeyContainer> element indicating that multiple keys are provided to different devices. The <EncryptionKey> element then applies to all <Device> elements. Furthermore, within a single <Device> element the <Key> element may also be repeated providing different keys and meta data for a single device.

Figure 8 shows an example utilizing these capabilities.

```
<?xml version="1.0" encoding="UTF-8"?>
<KeyContainer Version="1"
  xmlns="urn:ietf:params:xml:ns:keyprov:pskc">
  <Device>
    <DeviceInfo>
      <Manufacturer>TokenVendorAcme</Manufacturer>
      <SerialNo>654321</SerialNo>
    </DeviceInfo>
    <Key KeyAlgorithm="urn:ietf:params:xml:ns:keyprov:pskc#hotp"
      KeyId="1">
      <Issuer>Issuer</Issuer>
      <Usage>
        <ResponseFormat Length="8" Encoding="DECIMAL"/>
      </Usage>
      <Data>
        <Secret>
          <PlainValue>
            MTIzNDU2Nzg5MDEyMzQ1Njc4OTA=
          </PlainValue>
        </Secret>
        <Counter>
          <PlainValue>0</PlainValue>
        </Counter>
      </Data>
      <Policy>
        <StartDate>2006-05-01T00:00:00Z</StartDate>
        <ExpiryDate>2006-05-31T00:00:00Z</ExpiryDate>
      </Policy>
    </Key>
  </Device>
  <Device>
    <DeviceInfo>
      <Manufacturer>TokenVendorAcme</Manufacturer>
      <SerialNo>123456</SerialNo>
    </DeviceInfo>
```

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```
<Key KeyAlgorithm="urn:ietf:params:xml:ns:keyprov:pskc#hotp"
KeyId="2">
  <Issuer>Issuer</Issuer>
  <Usage>
    <ResponseFormat Length="8" Encoding="DECIMAL"/>
  </Usage>
  <Data>
    <Secret>
      <PlainValue>
        MTIzNDU2Nzg5MDEyMzQ1Njc4OTA=
      </PlainValue>
    </Secret>
    <Counter>
      <PlainValue>0</PlainValue>
    </Counter>
  </Data>
  <Policy>
    <StartDate>2006-05-01T00:00:00Z</StartDate>
    <ExpiryDate>2006-05-31T00:00:00Z</ExpiryDate>
  </Policy>
</Key>
</Device>
<Device>
  <DeviceInfo>
    <Manufacturer>TokenVendorAcme</Manufacturer>
    <SerialNo>9999999</SerialNo>
  </DeviceInfo>
  <Key KeyAlgorithm="urn:ietf:params:xml:ns:keyprov:pskc#hotp"
KeyId="3">
    <Issuer>Issuer</Issuer>
    <Usage>
      <ResponseFormat Length="8" Encoding="DECIMAL"/>
    </Usage>
    <Data>
      <Secret>
        <PlainValue>
          MTIzNDU2Nzg5MDEyMzQ1Njc4OTA=
        </PlainValue>
      </Secret>
      <Counter>
        <PlainValue>0</PlainValue>
      </Counter>
    </Data>
```

```

    <Policy>
      <StartDate>2006-03-01T00:00:00Z</StartDate>
      <ExpiryDate>2006-03-31T00:00:00Z</ExpiryDate>
    </Policy>
  </Key>

```

```

<Key KeyAlgorithm="urn:ietf:params:xml:ns:keyprov:pskc#hotp"
KeyId="4">
  <Issuer>Issuer</Issuer>
  <Usage>
    <ResponseFormat Length="8" Encoding="DECIMAL"/>
  </Usage>
  <Data>
    <Secret>
      <PlainValue>
        MTIzNDU2Nzg5MDEyMzQ1Njc4OTA=
      </PlainValue>
    </Secret>
    <Counter>
      <PlainValue>0</PlainValue>
    </Counter>
  </Data>
  <Policy>
    <StartDate>2006-04-01T00:00:00Z</StartDate>
    <ExpiryDate>2006-04-30T00:00:00Z</ExpiryDate>
  </Policy>
</Key>
</Device>
</KeyContainer>

```

Figure 8: Bulk Provisioning Example

9. Extensibility

This section lists a few common extension points provided by PSKC:

New PSKC Version: Whenever it is necessary to define a new version of this document then a new version number has to be allocated to refer to the new specification version. The version number is carried inside the 'Algorithm' attribute, as described in [Section 4](#), and rules for extensibility are defined in [Section 12](#).

New XML Elements: The usage of the XML schema and the available extension points allows new XML elements to be added. Depending of type of XML elements different ways for extensibility are offered. In some places the <Extensions> element can be used and elsewhere the "<xs:any namespace='##other' processContents='lax' minOccurs='0' maxOccurs='unbounded'/>" XML extension point is utilized.

New XML Attributes: The XML schema allows new XML attributes to be added where XML extension points have been defined (see "<xs:anyAttribute namespace='##other'/>" in [Section 11](#)).

New PSKC Algorithm Profiles: This document defines two PSKC algorithm profiles, see [Section 10](#). Further PSKC algorithm profiles can be registered as described in [Section 12.4](#).

Algorithm URIs: [Section 6](#) defines how keys and related data can be protected. A number of algorithms can be used. The usage of new algorithms can be used by pointing to a new algorithm URI.

Policy: [Section 5](#) defines policies that can be attached to a key and keying related data. The <Policy> element is one such item that allows to restrict the usage of the key to certain functions, such as "OTP usage only". Further values may be registered as described in [Section 12](#).

[10](#). PSKC Algorithm Profile

[10.1](#). HOTP

Common Name: HOTP

Class: OTP

URN: urn:ietf:params:xml:ns:keyprov:pskc#hotp

Algorithm Definition: <http://www.ietf.org/rfc/rfc4226.txt>

Identifier Definition: (this RFC)

Registrant Contact: IESG

Profiling:

The <Usage> element MUST be present. The <ResponseFormat> element of the <Usage> element MUST be used to indicate the OTP length and the value format.

The <Counter> element (see [Section 4.2](#)) MUST be provided as meta-data for the key.

The following additional constraints apply:

- + The value of the <Secret> element MUST contain key material with a length of at least 16 octets (128 bits), if it is present.
- + The <ResponseFormat> element MUST have the 'Format' attribute set to "DECIMAL", and the 'Length' attribute MUST indicate a length value between 6 and 9.
- + The <PINPolicy> element MAY be present but the 'PINUsageMode' attribute cannot be set to "Algorithmic".

An example can be found in Figure 1.

[10.2.](#) KEYPROV-PIN

Common Name: KEYPROV-PIN

Class: Symmetric static credential comparison

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URN: urn:ietf:params:xml:ns:keyprov:pskc#pin

Algorithm Definition: (this document)

Identifier Definition (this document)

Registrant Contact: IESG

Profiling:

The <Usage> element MAY be present but no attribute of the <Usage> element is required. The <ResponseFormat> element MAY be used to indicate the PIN value format.

The <Secret> element (see [Section 4.2](#)) MUST be provided.

See the example in Figure 2

[11](#). XML Schema

This section defines the XML schema for PSKC.

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema
  targetNamespace="urn:ietf:params:xml:ns:keyprov:pskc"
```



```

xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:pskc="urn:ietf:params:xml:ns:keyprov:pskc"
xmlns:ds="http://www.w3.org/2000/09/xmlsig#"
xmlns:xenc="http://www.w3.org/2001/04/xmlenc#"
elementFormDefault="qualified"
attributeFormDefault="unqualified">
  <xs:import namespace="http://www.w3.org/2000/09/xmlsig#"
schemaLocation=
"http://www.w3.org/TR/2002/REC-xmlsig-core-20020212/
xmlsig-core-schema.xsd"/>
  <xs:import namespace="http://www.w3.org/2001/04/xmlenc#"
schemaLocation=
"http://www.w3.org/TR/2002/REC-xmlenc-core-20021210/
xenc-schema.xsd"/>
    <xs:import namespace="http://www.w3.org/XML/1998/namespace"/>

    <xs:complexType name="KeyContainerType">
      <xs:sequence>
        <xs:element name="EncryptionKey" type="ds:KeyInfoType"
minOccurs="0"/>
        <xs:element name="MACAlgorithm" type="pskc:KeyAlgorithmType"
minOccurs="0"/>
        <xs:element name="Device" type="pskc:DeviceType"
minOccurs="1" maxOccurs="unbounded"/>
        <xs:element name="Signature" type="ds:SignatureType"
minOccurs="0"/>
        <xs:element name="Extensions"
type="pskc:ExtensionsType" minOccurs="0"
maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attribute name="Version" type="xs:unsignedInt"
use="required"/>
      <xs:attribute name="id" type="xs:ID" use="optional"/>
    </xs:complexType>
    <xs:complexType name="KeyType">
      <xs:sequence>
        <xs:element name="Issuer"
type="xs:string" minOccurs="0"/>
        <xs:element name="Usage"
type="pskc:UsageType"/>

```

```

<xs:element name="KeyProfileId"

```

```

        type="xs:string" minOccurs="0"/>
        <xs:element name="MasterKeyId"
            type="xs:string" minOccurs="0"/>
        <xs:element name="FriendlyName"
            type="xs:string" minOccurs="0"/>
        <xs:element name="Data" type="pskc:KeyDataType"
            minOccurs="0" maxOccurs="1"/>
        <xs:element name="UserId" type="xs:string"
            minOccurs="0"/>
        <xs:element name="Policy"
            type="pskc:PolicyType" minOccurs="0"/>
        <xs:element name="Extensions"
            type="pskc:ExtensionsType" minOccurs="0"
            maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attribute name="KeyId"
        type="xs:string" use="required"/>
    <xs:attribute name="KeyAlgorithm"
        type="pskc:KeyAlgorithmType"
        use="optional"/>
    <xs:attribute name="KeyProperties"
        type="xs:IDREF" use="optional"/>
</xs:complexType>

<xs:complexType name="PolicyType">
    <xs:sequence>
        <xs:element name="StartDate"
            type="xs:dateTime" minOccurs="0"/>
        <xs:element name="ExpiryDate"
            type="xs:dateTime" minOccurs="0"/>
        <xs:element name="PINPolicy"
            type="pskc:PINPolicyType" minOccurs="0"/>
        <xs:element name="KeyUsage"
            type="pskc:KeyUsageType" minOccurs="0"/>
        <xs:any namespace="##other"
            minOccurs="0" maxOccurs="unbounded"/>
    </xs:sequence>
</xs:complexType>

<xs:complexType name="KeyDataType">
    <xs:sequence>
        <xs:element name="Secret"
            type="pskc:binaryDataType"
            minOccurs="0" maxOccurs="1"/>
        <xs:element name="Counter"
            type="pskc:longDataType"
            minOccurs="0" maxOccurs="1"/>
    </xs:sequence>
</xs:complexType>

```

```
<xs:element name="Time"
  type="pskc:intDataType"
  minOccurs="0" maxOccurs="1"/>
<xs:element name="TimeInterval"
  type="pskc:intDataType"
  minOccurs="0" maxOccurs="1"/>
<xs:element name="TimeDrift"
  type="pskc:intDataType"
  minOccurs="0" maxOccurs="1"/>
<xs:any namespace="##other" processContents="lax"
  minOccurs="0" maxOccurs="unbounded"/>
</xs:sequence>
</xs:complexType>
<xs:complexType name="binaryDataType">
  <xs:sequence>
    <xs:choice>
      <xs:element name="PlainValue"
        type="xs:base64Binary"/>
      <xs:element name="EncryptedValue"
        type="xenc:EncryptedDataType"/>
    </xs:choice>
    <xs:element name="ValueMAC"
      type="xs:base64Binary" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="intDataType">
  <xs:sequence>
    <xs:choice>
      <xs:element name="PlainValue"
        type="xs:int"/>
      <xs:element name="EncryptedValue"
        type="xenc:EncryptedDataType"/>
    </xs:choice>
    <xs:element name="ValueMAC"
      type="xs:base64Binary" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="stringDataType">
  <xs:sequence>
    <xs:choice>
      <xs:element name="PlainValue"
        type="xs:string"/>
      <xs:element name="EncryptedValue"
        type="xenc:EncryptedDataType"/>
    </xs:choice>
    <xs:element name="ValueMAC"
```

```
        type="xs:base64Binary" minOccurs="0"/>
    </xs:sequence>
```

```
</xs:complexType>
<xs:complexType name="longDataType">
  <xs:sequence>
    <xs:choice>
      <xs:element name="PlainValue"
        type="xs:long"/>
      <xs:element name="EncryptedValue"
        type="xenc:EncryptedDataType"/>
    </xs:choice>
    <xs:element name="ValueMAC"
      type="xs:base64Binary" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="DerivedKeyType">
  <xs:sequence>
    <xs:element name="KeyDerivationMethod"
      type="pskc:KeyDerivationMethodType" minOccurs="0"/>
    <xs:element ref="xenc:ReferenceList" minOccurs="0"/>
    <xs:element name="CarriedKeyName" type="xs:string"
      minOccurs="0"/>
  </xs:sequence>
  <xs:attribute name="id" type="xs:ID" use="optional"/>
  <xs:attribute name="Type" type="xs:anyURI" use="optional"/>
</xs:complexType>
<xs:complexType name="KeyDerivationMethodType">
  <xs:sequence>
    <xs:any namespace="##other" processContents="lax"
      minOccurs="0"
      maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="Algorithm" type="xs:anyURI"
    use="required"/>
</xs:complexType>
<xs:complexType name="PINPolicyType">
  <xs:attribute name="PINKeyId" type="xs:string"
    use="optional"/>
  <xs:attribute name="PINUsageMode"
    type="pskc:PINUsageModeType"/>
  <xs:attribute name="MaxFailedAttempts" type="xs:unsignedInt"
```

```

        use="optional"/>
<xs:attribute name="MinLength"
    type="xs:unsignedInt" use="optional"/>
<xs:attribute name="MaxLength"
    type="xs:unsignedInt" use="optional"/>
<xs:attribute name="PINEncoding"
    type="pskc:ValueFormatType" use="optional"/>
<xs:anyAttribute namespace="##other"/>
</xs:complexType>

```

```

<xs:simpleType name="PINUsageModeType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="Local"/>
    <xs:enumeration value="Prepend"/>
    <xs:enumeration value="Append"/>
    <xs:enumeration value="Algorithmic"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="KeyUsageType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="OTP"/>
    <xs:enumeration value="CR"/>
    <xs:enumeration value="Encrypt"/>
    <xs:enumeration value="Integrity"/>
    <xs:enumeration value="Unlock"/>
    <xs:enumeration value="Decrypt"/>
    <xs:enumeration value="KeyWrap"/>
  </xs:restriction>
</xs:simpleType>
<xs:complexType name="DeviceInfoType">
  <xs:sequence>
    <xs:element name="Manufacturer" type="xs:string"
      minOccurs="0"/>
    <xs:element name="SerialNo" type="xs:string"
      minOccurs="0"/>
    <xs:element name="Model" type="xs:string"
      minOccurs="0"/>
    <xs:element name="IssueNo" type="xs:string"
      minOccurs="0"/>
    <xs:element name="DeviceBinding" type="xs:string"
      minOccurs="0"/>
    <xs:element name="StartDate" type="xs:dateTime"

```

```

minOccurs="0"/>
<xs:element name="ExpiryDate" type="xs:dateTime"
minOccurs="0"/>
<xs:element name="Extensions"
type="pskc:ExtensionsType" minOccurs="0"
maxOccurs="unbounded"/>
</xs:sequence>
</xs:complexType>
<xs:complexType name="DeviceType">
<xs:sequence>
<xs:element name="DeviceInfo" type="pskc:DeviceInfoType"
minOccurs="0"/>
<xs:element name="Key" type="pskc:KeyType"
maxOccurs="unbounded"/>
<xs:element name="User" type="xs:string"
minOccurs="0"/>

```

```

<xs:element name="Extensions"
type="pskc:ExtensionsType" minOccurs="0"
maxOccurs="unbounded"/>
</xs:sequence>
</xs:complexType>
<xs:complexType name="UsageType">
<xs:choice>
<xs:element name="ChallengeFormat" minOccurs="0">
<xs:complexType>
<xs:attribute name="Encoding"
type="pskc:ValueFormatType" use="required"/>
<xs:attribute name="Min" type="xs:unsignedInt"
use="required"/>
<xs:attribute name="Max" type="xs:unsignedInt"
use="required"/>
<xs:attribute name="CheckDigits" type="xs:boolean"
default="false"/>
</xs:complexType>
</xs:element>
<xs:element name="ResponseFormat" minOccurs="0">
<xs:complexType>
<xs:attribute name="Encoding"
type="pskc:ValueFormatType" use="required"/>
<xs:attribute name="Length" type="xs:unsignedInt"
use="required"/>

```

```

        <xs:attribute name="CheckDigits" type="xs:boolean"
            default="false"/>
    </xs:complexType>
</xs:element>
<xs:element name="Extensions"
    type="pskc:ExtensionsType" minOccurs="0"
    maxOccurs="unbounded"/>
</xs:choice>
</xs:complexType>
<xs:complexType name="ExtensionsType">
    <xs:sequence>
        <xs:any namespace="##other" processContents="lax"
            maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attribute name="definition" type="xs:anyURI"
        use="optional"/>
</xs:complexType>
<xs:simpleType name="KeyAlgorithmType">
    <xs:restriction base="xs:anyURI"/>
</xs:simpleType>
<xs:simpleType name="ValueFormatType">
    <xs:restriction base="xs:string">
        <xs:enumeration value="DECIMAL"/>

```

```

        <xs:enumeration value="HEXADECIMAL"/>
        <xs:enumeration value="ALPHANUMERIC"/>
        <xs:enumeration value="BASE64"/>
        <xs:enumeration value="BINARY"/>
    </xs:restriction>
</xs:simpleType>

<xs:element name="DerivedKey" type="pskc:DerivedKeyType"/>
<xs:element name="EncryptionScheme"
    type="xenc:EncryptionMethodType"/>
<xs:element name="KeyContainer" type="pskc:KeyContainerType"/>
</xs:schema>

```

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[12.](#) IANA Considerations

[12.1.](#) Content-type registration for 'application/pskc+xml'

This specification requests the registration of a new MIME type according to the procedures of [RFC 4288](#) [[RFC4288](#)] and guidelines in [RFC 3023](#) [[RFC3023](#)].

MIME media type name: application

MIME subtype name: pskc+xml

Mandatory parameters: none

Optional parameters: charset

Indicates the character encoding of enclosed XML.

Encoding considerations: Uses XML, which can employ 8-bit characters, depending on the character encoding used. See [RFC 3023 \[RFC3023\], Section 3.2](#).

Security considerations: This content type is designed to carry PSKC protocol payloads.

Interoperability considerations: None

Published specification: RFCXXXX [NOTE TO IANA/RFC-EDITOR: Please replace XXXX with the RFC number of this specification.]

Applications which use this media type: This MIME type is being used as a symmetric key container format for transport and provisioning of symmetric keys (One Time Password (OTP) shared secrets or symmetric cryptographic keys) to different types of strong authentication devices. As such, it is used for key provisioning systems.

Additional information:

Magic Number: None

File Extension: .pskcxm1

Macintosh file type code: 'TEXT'

Author: This specification is a work item of the IETF KEYPROV working group, with mailing list address <keyprov@ietf.org>.

Change controller: The IESG <iesg@ietf.org>

[12.2.](#) XML Schema Registration

This section registers an XML schema as per the guidelines in [\[RFC3688\]](#).

URI: urn:ietf:params:xml:ns:keyprov:pskc

Registrant Contact: IETF KEYPROV Working Group, Philip Hoyer (Philip.Hoyer@actividentity.com).

XML Schema: The XML schema to be registered is contained in [Section 11](#). Its first line is

```
<?xml version="1.0" encoding="UTF-8"?>
```

and its last line is

```
</xs:schema>
```

[12.3.](#) URN Sub-Namespace Registration

This section registers a new XML namespace, "urn:ietf:params:xml:ns:keyprov:pskc", per the guidelines in [\[RFC3688\]](#).

URI: urn:ietf:params:xml:ns:keyprov:pskc

Registrant Contact: IETF KEYPROV Working Group, Philip Hoyer (Philip.Hoyer@actividentity.com).

XML:

```
BEGIN
<?xml version="1.0"?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML Basic 1.0//EN"
  "http://www.w3.org/TR/xhtml-basic/xhtml-basic10.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
  <meta http-equiv="content-type"
    content="text/html; charset=iso-8859-1"/>
  <title>PSKC Namespace</title>
</head>
<body>
  <h1>Namespace for PSKC</h1>
  <h2>urn:ietf:params:xml:ns:keyprov:pskc:1.0</h2>
<p>See <a href="[URL of published RFC]">RFCXXXX
  [NOTE TO IANA/RFC-EDITOR:
    Please replace XXXX with the RFC number of this
    specification.]</a>.</p>
</body>
</html>
END
```

[12.4.](#) PSKC Algorithm Profile Registry

This specification requests the creation of a new IANA registry for PSKC algorithm profiles in accordance with the principles set out in [RFC 5226](#) [[RFC5226](#)].

As part of this registry IANA will maintain the following information:

Common Name: The name by which the PSKC algorithm profile is generally referred.

Class: The type of PSKC algorithm profile registry entry being created, such as encryption, Message Authentication Code (MAC), One Time Password (OTP), Digest.

URN: The URN to be used to identify the profile.

Identifier Definition: IANA will be asked to add a pointer to the specification containing information about the PSKC algorithm profile registration.

Algorithm Definition: A reference to the stable document in which the algorithm being used with the PSKC is defined.

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Registrant Contact: Contact information about the party submitting the registration request.

PSKC Profiling: Information about PSKC XML elements and attributes being used (or not used) with this specific profile of PSKC.

PSKC algorithm profile identifier registrations are to be subject to Expert Review as per [RFC 5226](#) [[RFC5226](#)].

IANA is asked to add an initial value to the registry based on the PSKC HOTP algorithm profile described in [Section 10](#).

[12.5](#). PSKC Version Registry

IANA is requested to create a registry for PSKC version numbers. The registry has the following structure:

PSKC Version	Specification
1	[This document]

Standards action is required to define new versions of PSKC. It is not envisioned to depreciate, delete, or modify existing PSKC versions.

[12.6](#). Key Usage Registry

IANA is requested to create a registry for key usage. A description of the 'KeyUsage' element can be found in [Section 5](#). The registry has the following structure:

Key Usage Token	Specification
OTP	[Section 5 of this document]
CR	[Section 5 of this document]
Encrypt	[Section 5 of this document]
Integrity	[Section 5 of this document]
Unlock	[Section 5 of this document]
Decrypt	[Section 5 of this document]
KeyWrap	[Section 5 of this document]

+-----+-----

Expert Review is required to define new key usage tokens. Each registration request has to provide a description of the semantic. Using the same procedure it is possible to depreciate, delete, or modify existing key usage tokens.

[13.](#) Security Considerations

The portable key container carries sensitive information (e.g., cryptographic keys) and may be transported across the boundaries of one secure perimeter to another. For example, a container residing within the secure perimeter of a back-end provisioning server in a secure room may be transported across the internet to an end-user device attached to a personal computer. This means that special care must be taken to ensure the confidentiality, integrity, and authenticity of the information contained within.

[13.1.](#) Payload confidentiality

By design, the container allows two main approaches to guaranteeing the confidentiality of the information it contains while transported.

First, the container key data payload may be encrypted.

In this case no transport layer security is required. However, standard security best practices apply when selecting the strength of the cryptographic algorithm for payload encryption. Symmetric cryptographic cipher should be used - the longer the cryptographic key, the stronger the protection. At the time of this writing both 3DES and AES are mandatory algorithms but 3DES may be dropped in the relatively near future. Applications concerned with algorithm longevity are advised to use AES-256-CBC. In cases where the exchange of key encryption keys between the sender and the receiver is not possible, asymmetric encryption of the secret key payload may be employed. Similarly to symmetric key cryptography, the stronger the asymmetric key, the more secure the protection is.

If the payload is encrypted with a method that uses one of the password-based encryption methods provided above, the payload may be

subjected to password dictionary attacks to break the encryption password and recover the information. Standard security best practices for selection of strong encryption passwords apply [[Schneier](#)].

Practical implementations should use PBESalt and PBEIterationCount when PBE encryption is used. Different PBESalt value per key container should be used for best protection.

The second approach to protecting the confidentiality of the payload is based on using transport layer security. The secure channel established between the source secure perimeter (the provisioning server from the example above) and the target perimeter (the device attached to the end-user computer) utilizes encryption to transport the messages that travel across. No payload encryption is required

in this mode. Secure channels that encrypt and digest each message provide an extra measure of security, especially when the signature of the payload does not encompass the entire payload.

Because of the fact that the plain text payload is protected only by the transport layer security, practical implementation must ensure protection against man-in-the-middle attacks [[Schneier](#)]. Validating the secure channel end-points is critically important for eliminating intruders that may compromise the confidentiality of the payload.

[13.2.](#) Payload integrity

The portable symmetric key container provides a mean to guarantee the integrity of the information it contains through digital signatures. For best security practices, the digital signature of the container should encompass the entire payload. This provides assurances for the integrity of all attributes. It also allows verification of the integrity of a given payload even after the container is delivered through the communication channel to the target perimeter and channel message integrity check is no longer possible.

[13.3.](#) Payload authenticity

The digital signature of the payload is the primary way of showing its authenticity. The recipient of the container may use the public key associated with the signature to assert the authenticity of the

sender by tracing it back to a preloaded public key or certificate. Note that the digital signature of the payload can be checked even after the container has been delivered through the secure channel of communication.

A weaker payload authenticity guarantee may be provided by the transport layer if it is configured to digest each message it transports. However, no authenticity verification is possible once the container is delivered at the recipient end. This approach may be useful in cases where the digital signature of the container does not encompass the entire payload.

[14.](#) Contributors

We would like Hannes Tschofenig for his text contributions to this document.

[15.](#) Acknowledgements

The authors of this draft would like to thank the following people for their contributions and support to make this a better specification: Apostol Vassilev, Shuh Chang, Jon Martinson, Siddhart Bajaj, Stu Veath, Kevin Lewis, Philip Hallam-Baker, Andrea Doherty, Magnus Nystrom, Tim Moses, Anders Rundgren, Sean Turner and especially Robert Philpott.

This work is based on earlier work by the members of OATH (Initiative for Open AuTHentication) to specify a format that can be freely distributed to the technical community.

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[Appendix A.](#) Use Cases

This section describes a comprehensive list of use cases that inspired the development of this specification. These requirements were used to derive the primary requirement that drove the design. These requirements are covered in the next section.

These use cases also help in understanding the applicability of this specification to real world situations.

[A.1.](#) Online Use Cases

This section describes the use cases related to provisioning the keys using an online provisioning protocol such as [\[DSKPP\]](#)

[A.1.1.](#) Transport of keys from Server to Cryptographic Module

For example, a mobile device user wants to obtain a symmetric key for use with a Cryptographic Module on the device. The Cryptographic Module from vendor A initiates the provisioning process against a provisioning system from vendor B using a standards-based provisioning protocol such as [\[DSKPP\]](#). The provisioning entity delivers one or more keys in a standard format that can be processed by the mobile device.

For example, in a variation of the above, instead of the user's mobile phone, a key is provisioned in the user's soft token application on a laptop using a network-based online protocol. As before, the provisioning system delivers a key in a standard format that can be processed by the soft token on the PC.

For example, the end-user or the key issuer wants to update or configure an existing key in the Cryptographic Module and requests a replacement key container. The container may or may not include a new key and may include new or updated key attributes such as a new counter value in HOTP key case, a modified response format or length, a new friendly name, etc.

[A.1.2.](#) Transport of keys from Cryptographic Module to Cryptographic Module

For example, a user wants to transport a key from one Cryptographic

Module to another. There may be two cryptographic modules, one on a computer one on a mobile phone, and the user wants to transport a key from the computer to the mobile phone. The user can export the key and related data in a standard format for input into the other Cryptographic Module.

[A.1.3.](#) Transport of keys from Cryptographic Module to Server

For example, a user wants to activate and use a new key and related data against a validation system that is not aware of this key. This key may be embedded in the Cryptographic Module (e.g. SD card, USB drive) that the user has purchased at the local electronics retailer. Along with the Cryptographic Module, the user may get the key on a CD or a floppy in a standard format. The user can now upload via a secure online channel or import this key and related data into the new validation system and start using the key.

[A.1.4.](#) Server to server Bulk import/export of keys

From time to time, a key management system may be required to import or export keys in bulk from one entity to another.

For example, instead of importing keys from a manufacturer using a file, a validation server may download the keys using an online protocol. The keys can be downloaded in a standard format that can be processed by a validation system.

For example, in a variation of the above, an Over-The-Air (OTA) key provisioning gateway that provisions keys to mobile phones may obtain key material from a key issuer using an online protocol. The keys are delivered in a standard format that can be processed by the key provisioning gateway and subsequently sent to the end-user's mobile phone.

[A.2.](#) Offline Use Cases

This section describes the use cases relating to offline transport of keys from one system to another, using some form of export and import model.

[A.2.1.](#) Server to server Bulk import/export of keys

For example, Cryptographic Modules such as OTP authentication tokens, may have their symmetric keys initialized during the manufacturing process in bulk, requiring copies of the keys and algorithm data to be loaded into the authentication system through a file on portable media. The manufacturer provides the keys and related data in the form of a file containing records in standard format, typically on a CD. Note that the token manufacturer and the vendor for the validation system may be the same or different. Some crypto modules will allow local PIN management (the device will have a PIN pad) hence random initial PINs set at manufacturing should be transmitted together with the respective keys they protect.

For example, an enterprise wants to port keys and related data from an existing validation system A into a different validation system B. The existing validation system provides the enterprise with a functionality that enables export of keys and related data (e.g. for OTP authentication tokens) in a standard format. Since the OTP tokens are in the standard format, the enterprise can import the token records into the new validation system B and start using the existing tokens. Note that the vendors for the two validation systems may be the same or different.

[Appendix B](#). Requirements

This section outlines the most relevant requirements that are the basis of this work. Several of the requirements were derived from use cases described above.

- R1: The format MUST support transport of multiple types of symmetric keys and related attributes for algorithms including HOTP, other OTP, challenge-response, etc.
- R2: The format MUST handle the symmetric key itself as well of attributes that are typically associated with symmetric keys. Some of these attributes may be
- * Unique Key Identifier
 - * Issuer information
 - * Algorithm ID
 - * Algorithm mode

- * Issuer Name
- * Key friendly name
- * Event counter value (moving factor for OTP algorithms)
- * Time value

- R3: The format SHOULD support both offline and online scenarios. That is it should be serializable to a file as well as it should be possible to use this format in online provisioning protocols such as [[DSKPP](#)]
- R4: The format SHOULD allow bulk representation of symmetric keys
- R5: The format SHOULD allow bulk representation of PINs related to specific keys
- R6: The format SHOULD be portable to various platforms. Furthermore, it SHOULD be computationally efficient to process.
- R7: The format MUST provide appropriate level of security in terms of data encryption and data integrity.

- R8: For online scenarios the format SHOULD NOT rely on transport level security (e.g., SSL/TLS) for core security requirements.
- R9: The format SHOULD be extensible. It SHOULD enable extension points allowing vendors to specify additional attributes in the future.
- R10: The format SHOULD allow for distribution of key derivation data without the actual symmetric key itself. This is to support symmetric key management schemes that rely on key derivation algorithms based on a pre-placed master key. The key derivation data typically consists of a reference to the key, rather than the key value itself.

- R11: The format SHOULD allow for additional lifecycle management operations such as counter resynchronization. Such processes require confidentiality between client and server, thus could use a common secure container format, without the transfer of key material.
- R12: The format MUST support the use of pre-shared symmetric keys to ensure confidentiality of sensitive data elements.
- R13: The format MUST support a password-based encryption (PBE) [[PKCS5](#)] scheme to ensure security of sensitive data elements. This is a widely used method for various provisioning scenarios.
- R14: The format SHOULD support asymmetric encryption algorithms such as RSA to ensure end-to-end security of sensitive data elements. This is to support scenarios where a pre-set shared key encryption key is difficult to use.

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