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# YANG Data Model for a Centralized Keystore Mechanism
# draft-ietf-netconf-keystore-05

## Abstract

This document defines a YANG 1.1 module called "ietf-keystore" that enables centralized configuration of asymmetric keys and their associated certificates, and notification for when configured certificates are about to expire.

## Editorial Note (To be removed by RFC Editor)

This draft contains many placeholder values that need to be replaced with finalized values at the time of publication. This note summarizes all of the substitutions that are needed. No other RFC Editor instructions are specified elsewhere in this document.

Artwork in this document contains shorthand references to drafts in progress. Please apply the following replacements:

- "VVVV" --> the assigned RFC value for this draft

Artwork in this document contains placeholder values for the date of publication of this draft. Please apply the following replacement:

- "2018-06-04" --> the publication date of this draft

The following Appendix section is to be removed prior to publication:

- Appendix A. Change Log

## 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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## 1. Introduction

This document defines a YANG 1.1 [RFC7950] module called "ietf-keystore" that enables centralized configuration of asymmetric keys and their associated certificates, and notification for when configured certificates are about to expire.

This module also defines Six groupings designed for maximum reuse. These groupings include one for the public half of an asymmetric key, one for both the public and private halves of an asymmetric key, one for both halves of an asymmetric key and a list of associated certificates, one for an asymmetric key that may be configured locally or via a reference to an asymmetric key in the keystore, one for a trust anchor certificate and, lastly, one for an end entity certificate.

Special consideration has been given for systems that have cryptographic hardware, such as a Trusted Protection Module (TPM). These systems are unique in that the cryptographic hardware completely hides the private keys and must perform all private key operations. To support such hardware, the "private-key" can be the special value "hardware-protected" and the actions "generate-private-key" and "generate-certificate-signing-request" can be used to direct these operations to the hardware .

This document in compliant with Network Management Datastore Architecture (NMDA) [RFC8342]. For instance, to support keys and associated certificates installed during manufacturing (e.g., for a IDevID [Std-802.1AR-2009] certificate), it is expected that such data may appear only in <operational>.

While only asymmetric keys are currently supported, the module has been designed to enable other key types to be introduced in the future.

The module does not support protecting the contents of the keystore (e.g., via encryption), though it could be extended to do so in the future.

It is not required that a system has an operating system level keystore utility to implement this module.

## 2. Requirements Language

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

14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

## 3. The Keystore Model

### 3.1. Tree Diagram

This section provides a tree diagrams [RFC8340] for the "ietf-keystore" module that presents both the protocol-accessible "keystore" as well the all the groupings intended for external usage.

```
module: ietf-keystore
  +--rw keystore
     +--rw asymmetric-keys
        +--rw asymmetric-key* [name]
        |  +--rw name                                    string
        |  +--rw algorithm
        |  |       ct:key-algorithm-ref
        |  +--rw public-key                              binary
        |  +--rw private-key                             union
        |  +--rw certificates
        |  |  +--rw certificate* [name]
        |  |     +--rw name                      string
        |  |     +--rw cert
        |  |     |       ct:end-entity-cert-cms
        |  |     +---n certificate-expiration
        |  |        +-- expiration-date?   yang:date-and-time
        |  +---x generate-certificate-signing-request
        |     +---w input
        |     |  +---w subject       binary
        |     |  +---w attributes?   binary
        |     +--ro output
        |        +--ro certificate-signing-request    binary
        +---x generate-asymmetric-key
           +---w input
              +---w name         string
              +---w algorithm    ct:key-algorithm-ref

  grouping end-entity-cert-grouping
    +-- cert                      ct:end-entity-cert-cms
    +---n certificate-expiration
       +-- expiration-date?   yang:date-and-time
  grouping local-or-keystore-end-entity-certificate-grouping
    +-- (local-or-keystore)
       +--:(local)
       |  +-- algorithm                ct:key-algorithm-ref
       |  +-- public-key               binary
       |  +-- private-key              union
```

```
         |  +-- cert                      ct:end-entity-cert-cms
         |  +---n certificate-expiration
         |     +-- expiration-date?   yang:date-and-time
         +--:(keystore) {keystore-implemented}?
            +-- reference
                  ks:asymmetric-key-certificate-ref
    grouping local-or-keystore-asymmetric-key-with-certs-grouping
      +-- (local-or-keystore)
         +--:(local)
         |  +-- algorithm
         |  |       ct:key-algorithm-ref
         |  +-- public-key                              binary
         |  +-- private-key                             union
         |  +-- certificates
         |  |  +-- certificate* [name]
         |  |     +-- name?                    string
         |  |     +-- cert                     ct:end-entity-cert-cms
         |  |     +---n certificate-expiration
         |  |        +-- expiration-date?   yang:date-and-time
         |  +---x generate-certificate-signing-request
         |     +---w input
         |     |  +---w subject       binary
         |     |  +---w attributes?   binary
         |     +--ro output
         |        +--ro certificate-signing-request    binary
         +--:(keystore) {keystore-implemented}?
            +-- reference
                  ks:asymmetric-key-ref
    grouping trust-anchor-cert-grouping
      +-- cert    ct:trust-anchor-cert-cms
    grouping asymmetric-key-pair-grouping
      +-- algorithm      ct:key-algorithm-ref
      +-- public-key     binary
      +-- private-key    union
    grouping public-key-grouping
      +-- algorithm     ct:key-algorithm-ref
      +-- public-key    binary
    grouping asymmetric-key-pair-with-certs-grouping
      +-- algorithm                              ct:key-algorithm-ref
      +-- public-key                             binary
      +-- private-key                            union
      +-- certificates
      |  +-- certificate* [name]
      |     +-- name?                    string
      |     +-- cert                     ct:end-entity-cert-cms
      |     +---n certificate-expiration
      |        +-- expiration-date?   yang:date-and-time
      +---x generate-certificate-signing-request
```

```
         +---w input
         |  +---w subject       binary
         |  +---w attributes?   binary
         +--ro output
            +--ro certificate-signing-request    binary
  grouping local-or-keystore-asymmetric-key-grouping
    +-- (local-or-keystore)
       +--:(local)
       |  +-- algorithm      ct:key-algorithm-ref
       |  +-- public-key     binary
       |  +-- private-key    union
       +--:(keystore) {keystore-implemented}?
          +-- reference      ks:asymmetric-key-ref
```

## 3.2. Example Usage

The following example illustrates what a fully configured keystore might look like in <operational>, as described by Section 5.3 in [RFC8342]. This datastore view illustrates data set by the manufacturing process alongside conventional configuration. This keystore instance has three keys, two having one associated certificate and one having two associated certificates.

```
<keystore xmlns="urn:ietf:params:xml:ns:yang:ietf-keystore"
          xmlns:or="urn:ietf:params:xml:ns:yang:ietf-origin"
          xmlns:ct="urn:ietf:params:xml:ns:yang:ietf-crypto-types">
  <asymmetric-keys>

    <asymmetric-key or:origin="or:intended">
      <name>ex-rsa-key</name>
      <algorithm>ct:rsa1024</algorithm>
      <private-key>base64encodedvalue==</private-key>
      <public-key>base64encodedvalue==</public-key>
      <certificates>
        <certificate>
          <name>ex-rsa-cert</name>
          <cert>base64encodedvalue==</cert>
        </certificate>
      </certificates>
    </asymmetric-key>

    <asymmetric-key or:origin="or:intended">
      <name>tls-ec-key</name>
      <algorithm>ct:secp256r1</algorithm>
      <private-key>base64encodedvalue==</private-key>
      <public-key>base64encodedvalue==</public-key>
      <certificates>
        <certificate>
```

```
            <name>tls-ec-cert</name>
            <cert>base64encodedvalue==</cert>
          </certificate>
        </certificates>
      </asymmetric-key>

      <asymmetric-key or:origin="or:system">
        <name>tpm-protected-key</name>
        <algorithm>ct:rsa2048</algorithm>
        <private-key>hardware-protected</private-key>
        <public-key>base64encodedvalue==</public-key>
        <certificates>
          <certificate>
            <name>builtin-idevid-cert</name>
            <cert>base64encodedvalue==</cert>
          </certificate>
          <certificate or:origin="or:intended">
            <name>my-ldevid-cert</name>
            <cert>base64encodedvalue==</cert>
          </certificate>
        </certificates>
      </asymmetric-key>

    </asymmetric-keys>
  </keystore>
```

The following example illustrates the "generate-private-key" action in use with the NETCONF protocol.

```
REQUEST
-------
<rpc message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <action xmlns="urn:ietf:params:xml:ns:yang:1">
    <keystore xmlns="urn:ietf:params:xml:ns:yang:ietf-keystore">
      <asymmetric-keys>
        <generate-asymmetric-key>
          <name>ex-key-sect571r1</name>
          <algorithm
           xmlns:ct="urn:ietf:params:xml:ns:yang:ietf-crypto-types">
              ct:secp521r1
          </algorithm>
        </generate-asymmetric-key>
      </asymmetric-keys>
    </keystore>
  </action>
</rpc>

RESPONSE
--------
<rpc-reply message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ok/>
</rpc-reply>
```

The following example illustrates the "generate-certificate-signing-request" action in use with the NETCONF protocol.

```
REQUEST
-------
<rpc message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <action xmlns="urn:ietf:params:xml:ns:yang:1">
    <keystore xmlns="urn:ietf:params:xml:ns:yang:ietf-keystore">
      <asymmetric-keys>
        <asymmetric-key>
          <name>ex-key-sect571r1</name>
          <generate-certificate-signing-request>
            <subject>base64encodedvalue==</subject>
            <attributes>base64encodedvalue==</attributes>
          </generate-certificate-signing-request>
        </asymmetric-key>
      </asymmetric-keys>
    </keystore>
  </action>
</rpc>

RESPONSE
--------
<rpc-reply message-id="101"
   xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
   <certificate-signing-request
     xmlns="urn:ietf:params:xml:ns:yang:ietf-keystore">
     base64encodedvalue==
   </certificate-signing-request>
</rpc-reply>
```

The following example illustrates the "certificate-expiration" notification in use with the NETCONF protocol.

```
<notification
  xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <eventTime>2018-05-25T00:01:00Z</eventTime>
  <keystore xmlns="urn:ietf:params:xml:ns:yang:ietf-keystore">
    <asymmetric-keys>
      <asymmetric-key>
        <name>tpm-protected-key</name>
        <certificates>
          <certificate>
            <name>my-ldevid-cert</name>
            <certificate-expiration>
              <expiration-date>
                2018-08-05T14:18:53-05:00
              </expiration-date>
            </certificate-expiration>
          </certificate>
        </certificates>
      </asymmetric-key>
    </asymmetric-keys>
  </keystore>
</notification>
```

The following example module has been constructed to illustrate the "local-or-keystore-asymmetric-key-grouping" grouping defined in the "ietf-keystore" module.

```
   module ex-keystore-usage {
     yang-version 1.1;

     namespace "http://example.com/ns/example-keystore-usage";
     prefix "eku";

     import ietf-keystore {
       prefix ks;
       reference
         "RFC VVVV: YANG Data Model for a 'Keystore' Mechanism";
     }

     organization
      "Example Corporation";

     contact
      "Author: YANG Designer <mailto:yang.designer@example.com>";

     description
      "This module illustrates the grouping defined in the keystore
       draft called 'local-or-keystore-asymmetric-key-grouping'.";

     revision "YYYY-MM-DD" {
       description
        "Initial version";
       reference
        "RFC XXXX: YANG Data Model for a 'Keystore' Mechanism";
     }

     container keys {
       description
         "A container of keys.";
       list key {
         key name;
         leaf name {
           type string;
           description
             "An arbitrary name for this key.";
         }
         uses ks:local-or-keystore-asymmetric-key-grouping;
         description
           "A key which may be configured locally or be a reference to
            a key in the keystore.";
       }
     }
   }
```

The following example illustrates what two configured keys, one local and the other remote, might look like. This example consistent with other examples above (i.e., the referenced key is in an example above).

```
<keys xmlns="http://example.com/ns/example-keystore-usage">
  <key>
    <name>locally-defined key</name>
    <algorithm
      xmlns:ct="urn:ietf:params:xml:ns:yang:ietf-crypto-types">
      ct:secp521r1
    </algorithm>
    <private-key>base64encodedvalue==</private-key>
    <public-key>base64encodedvalue==</public-key>
  </key>
  <key>
    <name>keystore-defined key</name>
    <reference>ex-rsa-key</reference>
  </key>
</keys>
```

### 3.3. YANG Module

This YANG module imports modules defined in [RFC6536], [RFC6991], and [I-D.ietf-netconf-crypto-types]. This module uses data types defined in [RFC2986], [RFC3447], [RFC5652], [RFC5915], [RFC6125], and [ITU.X690.2015].

```
<CODE BEGINS> file "ietf-keystore@2018-06-04.yang"
module ietf-keystore {
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-keystore";
  prefix "ks";

  import ietf-yang-types {
    prefix yang;
    reference
      "RFC 6991: Common YANG Data Types";
  }

  import ietf-crypto-types {
    prefix ct;
    reference
      "RFC CCCC: Common YANG Data Types for Cryptography";
  }

  organization
```

```
      "IETF NETCONF (Network Configuration) Working Group";

    contact
     "WG Web:   <http://datatracker.ietf.org/wg/netconf/>
      WG List:  <mailto:netconf@ietf.org>

      Author:   Kent Watsen
                <mailto:kwatsen@juniper.net>";


    description
     "This module defines a keystore to centralize management
      of security credentials.

      Copyright (c) 2018 IETF Trust and the persons identified
      as authors of the code. All rights reserved.

      Redistribution and use in source and binary forms, with
      or without modification, is permitted pursuant to, and
      subject to the license terms contained in, the Simplified
      BSD License set forth in Section 4.c of the IETF Trust's
      Legal Provisions Relating to IETF Documents
      (http://trustee.ietf.org/license-info).

      This version of this YANG module is part of RFC VVVV; see
      the RFC itself for full legal notices.";

    revision "2018-06-04" {
      description
       "Initial version";
      reference
       "RFC VVVV: YANG Data Model for a 'Keystore' Mechanism";
    }

    // Features

    feature keystore-implemented {
      description
       "The 'keystore-implemented' feature indicates that the server
        implements the keystore, and therefore groupings defined in
        this module that reference the keystore are usable.";
    }


    // Typedefs

    typedef asymmetric-key-ref {
      type leafref {
```

```
        path "/ks:keystore/ks:asymmetric-keys/ks:asymmetric-key"
             + "/ks:name";
        require-instance false;
      }
      description
        "This typedef enables modules to easily define a reference
         to an asymmetric key stored in the keystore. The require
         instance attribute is false to enable the referencing of
         asymmetric keys that exist only in <operational>.";
      reference
        "RFC 8342: Network Management Datastore Architecture (NMDA)";
    }

    typedef asymmetric-key-certificate-ref {
      type leafref {
        path "/ks:keystore/ks:asymmetric-keys/ks:asymmetric-key"
             + "/ks:certificates/ks:certificate/ks:name";
        require-instance false;
      }
      description
        "This typedef enables modules to easily define a reference
         to a specific certificate associated with an asymmetric key
         stored in the keystore.  The require instance attribute is
         false to enable the referencing of certificates that exist
         only in <operational>.";
      reference
        "RFC 8342: Network Management Datastore Architecture (NMDA)";
    }


    // Groupings
    //
    // These groupings are factored out more than needed for
    // reusability purposes.

    grouping public-key-grouping {
      description
        "A public key.";
      leaf algorithm {
        type ct:key-algorithm-ref;
        mandatory true;
        description
          "Identifies the key's algorithm.  More specifically,
           this leaf specifies how the 'public-key' binary leaf
           is encoded.";
        reference
          "RFC CCCC: Common YANG Data Types for Cryptography";
      }
```

```
        leaf public-key {
          type binary;
          mandatory true;
          description
            "A binary that contains the value of the public key.  The
             interpretation of the content is defined by the key
             algorithm.  For example, a DSA key is an integer, an RSA
             key is represented as RSAPublicKey as defined in
             RFC 3447, and an Elliptic Curve Cryptography (ECC) key
             is represented using the 'publicKey' described in
             RFC 5915.";
          reference
            "RFC 3447: Public-Key Cryptography Standards (PKCS) #1:
                       RSA Cryptography Specifications Version 2.1.
             RFC 5915: Elliptic Curve Private Key Structure.";
        }
      }

      grouping asymmetric-key-pair-grouping {
        description
          "A private/public key pair.";
        uses public-key-grouping;
        leaf private-key {
          type union {
            type binary;
            type enumeration {
              enum "hardware-protected" {
                description
                 "The private key is inaccessible due to being
                  protected by a cryptographic hardware module
                  (e.g., a TPM).";
              }
            }
          }
          mandatory true;
          description
            "A binary that contains the value of the private key.  The
             interpretation of the content is defined by the key
             algorithm.  For example, a DSA key is an integer, an RSA
             key is represented as RSAPrivateKey as defined in
             RFC 3447, and an Elliptic Curve Cryptography (ECC) key
             is represented as ECPrivateKey as defined in RFC 5915.";
          reference
            "RFC 3447: Public-Key Cryptography Standards (PKCS) #1:
                       RSA Cryptography Specifications Version 2.1.
             RFC 5915: Elliptic Curve Private Key Structure.";
        }
      }
```

```
    grouping trust-anchor-cert-grouping {
      description
       "A certificate, and a notification for when it might expire.";
      leaf cert {
        type ct:trust-anchor-cert-cms;
        mandatory true;
        description
         "The binary certificate data for this certificate.";
        reference
         "RFC YYYY: Common YANG Data Types for Cryptography";
      }
    }

    grouping end-entity-cert-grouping {
      description
       "A certificate, and a notification for when it might expire.";
      leaf cert {
        type ct:end-entity-cert-cms;
        mandatory true;
        description
         "The binary certificate data for this certificate.";
        reference
          "RFC YYYY: Common YANG Data Types for Cryptography";
      }
      notification certificate-expiration {
        description
          "A notification indicating that the configured certificate
           is either about to expire or has already expired.  When to
           send notifications is an implementation specific decision,
           but it is RECOMMENDED that a notification be sent once a
           month for 3 months, then once a week for four weeks, and
           then once a day thereafter until the issue is resolved.";
        leaf expiration-date {
          type yang:date-and-time;
          //mandatory true;
          description
            "Identifies the expiration date on the certificate.";
        }
      }
    }

    grouping asymmetric-key-pair-with-certs-grouping {
      description
        "A private/public key pair and associated certificates.";
      uses asymmetric-key-pair-grouping;
      container certificates {
        description
          "Certificates associated with this asymmetric key.
```

```
           More than one certificate supports, for instance,
           a TPM-protected asymmetric key that has both IDevID
           and LDevID certificates associated.";
        list certificate {
          key name;
          description
            "A certificate for this asymmetric key.";
          leaf name {
            type string;
            description
              "An arbitrary name for the certificate.";
          }
          uses end-entity-cert-grouping;
        } // end certifcate
      } // end certificates
      action generate-certificate-signing-request {
        description
          "Generates a certificate signing request structure for
           the associated asymmetric key using the passed subject
           and attribute values.  The specified assertions need
           to be appropriate for the certificate's use.  For
           example, an entity certificate for a TLS server
           SHOULD have values that enable clients to satisfy
           RFC 6125 processing.";
        input {
          leaf subject {
            type binary;
            mandatory true;
            description
             "The 'subject' field per the CertificationRequestInfo
               structure as specified by RFC 2986, Section 4.1
               encoded using the ASN.1 distinguished encoding
               rules (DER), as specified in ITU-T X.690.";
            reference
              "RFC 2986:
                 PKCS #10: Certification Request Syntaxi
                           Specification Version 1.7.
               ITU-T X.690:
                 Information technology - ASN.1 encoding rules:
                 Specification of Basic Encoding Rules (BER),
                 Canonical Encoding Rules (CER) and Distinguished
                 Encoding Rules (DER).";
          }
          leaf attributes {
            type binary;
            description
              "The 'attributes' field from the structure
               CertificationRequestInfo as specified by RFC 2986,
```

```
                Section 4.1 encoded using the ASN.1 distinguished
                encoding rules (DER), as specified in ITU-T X.690.";
              reference
                "RFC 2986:
                  PKCS #10: Certification Request Syntax
                            Specification Version 1.7.
                ITU-T X.690:
                  Information technology - ASN.1 encoding rules:
                  Specification of Basic Encoding Rules (BER),
                  Canonical Encoding Rules (CER) and Distinguished
                  Encoding Rules (DER).";
            }
          }
          output {
            leaf certificate-signing-request {
              type binary;
              mandatory true;
              description
                "A CertificationRequest structure as specified by
                 RFC 2986, Section 4.2 encoded using the ASN.1
                 distinguished encoding rules (DER), as specified
                 in ITU-T X.690.";
              reference
                "RFC 2986:
                  PKCS #10: Certification Request Syntax
                            Specification Version 1.7.
                ITU-T X.690:
                  Information technology - ASN.1 encoding rules:
                  Specification of Basic Encoding Rules (BER),
                  Canonical Encoding Rules (CER) and Distinguished
                  Encoding Rules (DER).";

            }
          } // end output
        } // end generate-certificate-signing-request
      }

      grouping local-or-keystore-asymmetric-key-grouping {
        description
          "A grouping that expands to allow the key to be either stored
           locally within the using data model, or be a reference to an
           asymmetric key stored in the keystore.";
        choice local-or-keystore {
          mandatory true;
          case local {
            uses asymmetric-key-pair-grouping;
          }
          case keystore {
```

```
          if-feature "keystore-implemented";
          leaf reference {
            type ks:asymmetric-key-ref;
            mandatory true;
            description
              "A reference to a value that exists in the keystore.";
          }
        }
        description
          "A choice between an inlined definition and a definition
           that exists in the keystore.";
      }
    }

    grouping local-or-keystore-asymmetric-key-with-certs-grouping {
      description
        "A grouping that expands to allow the key to be either stored
         locally within the using data model, or be a reference to an
         asymmetric key stored in the keystore.";
      choice local-or-keystore {
        mandatory true;
        case local {
          uses asymmetric-key-pair-with-certs-grouping;
        }
        case keystore {
          if-feature "keystore-implemented";
          leaf reference {
            type ks:asymmetric-key-ref;
            mandatory true;
            description
              "A reference to a value that exists in the keystore.";
          }
        }
        description
          "A choice between an inlined definition and a definition
           that exists in the keystore.";
      }
    }

    grouping local-or-keystore-end-entity-certificate-grouping {
      description
        "A grouping that expands to allow the end-entity certificate
         (and the associated private key) to be either stored locally
         within the using data model, or be a reference to a specific
         certificate in the keystore.";
      choice local-or-keystore {
        mandatory true;
        case local {
```

```
          uses ks:asymmetric-key-pair-grouping;
          uses ks:end-entity-cert-grouping;
        }
        case keystore {
          if-feature "keystore-implemented";
          leaf reference {
            type ks:asymmetric-key-certificate-ref;
            mandatory true;
            description
              "A reference to a value that exists in the keystore.";
          }
        }
        description
          "A choice between an inlined definition and a definition
           that exists in the keystore.";
      }
    }


    // protocol accessible nodes

    container keystore {
      description
        "The keystore contains a list of keys.";

      container asymmetric-keys {
        description
          "A list of asymmetric keys.";
        list asymmetric-key {
          key name;
          description
            "An asymmetric key.";
          leaf name {
            type string;
            description
              "An arbitrary name for the asymmetric key.";
          }
          uses asymmetric-key-pair-with-certs-grouping;
        } // end asymmetric-key

        action generate-asymmetric-key {
          description
            "Requests the device to generate an asymmetric key using
             the specified asymmetric key algorithm.  This action is
             primarily to support cryptographic processors that must
             generate the asymmetric key themselves.  The resulting
             asymmetric key is considered operational state and hence
             present only in <operational>.";
```

```
          input {
            leaf name {
              type string;
              mandatory true;
              description
                "The name the asymmetric key should have when listed
                 in /keystore/asymmetric-keys/asymmetric-key, in
                 <operational>.";
            }
            leaf algorithm {
              type ct:key-algorithm-ref;
              mandatory true;
              description
                "The algorithm to be used when generating the
                 asymmetric key.";
              reference
                "RFC CCCC: Common YANG Data Types for Cryptography";
            }
          }
        } // end generate-asymmetric-key
      } // end asymmetric-keys
    } // end keystore


  }
  <CODE ENDS>
```

## 4. Security Considerations

The YANG module defined in this document is designed to be accessed via YANG based management protocols, such as NETCONF [RFC6241] and RESTCONF [RFC8040]. Both of these protocols have mandatory-to-implement secure transport layers (e.g., SSH, TLS) with mutual authentication.

The NETCONF access control model (NACM) [RFC6536] provides the means to restrict access for particular users to a pre-configured subset of all available protocol operations and content.

There are a number of data nodes defined in this YANG module that are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations. These are the subtrees and data nodes and their sensitivity/vulnerability:

/: The entire data tree defined by this module is sensitive to write operations. For instance, the addition or removal of keys, certificates, trusted anchors, etc., can dramatically alter the implemented security policy. However, no NACM annotations are applied as the data SHOULD be editable by users other than a designated 'recovery session'.

/keystore/asymmetric-keys/asymmetric-key/private-key: When writing this node, implementations MUST ensure that the strength of the key being configured is not greater than the strength of the underlying secure transport connection over which it is communicated. Implementations SHOULD fail the write-request if ever the strength of the private key is greater then the strength of the underlying transport, and alert the client that the strength of the key may have been compromised. Additionally, when deleting this node, implementations SHOULD automatically (without explicit request) zeroize these keys in the most secure manner available, so as to prevent the remnants of their persisted storage locations from being analyzed in any meaningful way.

Some of the readable data nodes in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus important to control read access (e.g., via get, get-config, or notification) to these data nodes. These are the subtrees and data nodes and their sensitivity/vulnerability:

/keystore/asymmetric-keys/asymmetric-key/private-key: This node is additionally sensitive to read operations such that, in normal use cases, it should never be returned to a client. The best reason for returning this node is to support backup/ restore type workflows. However, no NACM annotations are applied as the data SHOULD be editable by users other than a designated 'recovery session'.

Some of the operations in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus important to control access to these operations. These are the operations and their sensitivity/vulnerability:

generate-certificate-signing-request: For this action, it is RECOMMENDED that implementations assert channel binding [RFC5056], so as to ensure that the application layer that sent the request is the same as the device authenticated when the secure transport layer was established.

This document uses PKCS #10 [RFC2986] for the "generate-certificate-signing-request" action. The use of Certificate Request Message

Format (CRMF) [RFC4211] was considered, but is was unclear if there was market demand for it. If it is desired to support CRMF in the future, placing a "choice" statement in both the input and output statements, along with an "if-feature" statement on the CRMF option, would enable a backwards compatible solution.

# 5. IANA Considerations

## 5.1. The IETF XML Registry

This document registers one URI in the IETF XML registry [RFC3688]. Following the format in [RFC3688], the following registration is requested:

```
URI: urn:ietf:params:xml:ns:yang:ietf-keystore
Registrant Contact: The NETCONF WG of the IETF.
XML: N/A, the requested URI is an XML namespace.
```

## 5.2. The YANG Module Names Registry

This document registers one YANG module in the YANG Module Names registry [RFC6020]. Following the format in [RFC6020], the the following registration is requested:

```
name:         ietf-keystore
namespace:    urn:ietf:params:xml:ns:yang:ietf-keystore
prefix:       ks
reference:    RFC VVVV
```

# 6. References

## 6.1. Normative References

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# Appendix A. Change Log

## A.1. 00 to 01

- Replaced the 'certificate-chain' structures with PKCS#7 structures. (Issue #1)
- Added 'private-key' as a configurable data node, and removed the 'generate-private-key' and 'load-private-key' actions. (Issue #2)
- Moved 'user-auth-credentials' to the ietf-ssh-client module. (Issues #4 and #5)

## A.2. 01 to 02

- Added back 'generate-private-key' action.
- Removed 'RESTRICTED' enum from the 'private-key' leaf type.
- Fixed up a few description statements.

## A.3. 02 to 03

- Changed draft's title.
- Added missing references.
- Collapsed sections and levels.
- Added RFC 8174 to Requirements Language Section.
- Renamed 'trusted-certificates' to 'pinned-certificates'.
- Changed 'public-key' from config false to config true.
- Switched 'host-key' from OneAsymmetricKey to definition from RFC 4253.

## A.4. 03 to 04

- Added typedefs around leafrefs to common keystore paths
- Now tree diagrams reference ietf-netmod-yang-tree-diagrams
- Removed Design Considerations section
- Moved key and certificate definitions from data tree to groupings

### A.5. 04 to 05

- FIXME
- FIXME
- FIXME

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