Abstract

This document defines YANG identities, typedefs, the groupings useful for cryptographic applications.

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:

- "XXXX" --&gt; 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:

- "2019-06-17" --&gt; the publication date of this draft

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

- Appendix B. Change Log

Status of This Memo

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1. Introduction

This document defines a YANG 1.1 [RFC7950] module specifying identities, typedefs, and groupings useful for cryptography.

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.

2. The Crypto Types Module

2.1. Tree Diagram

This section provides a tree diagram [RFC8340] for the "ietf-crypto-types" module. Only the groupings as represented, as tree diagrams have no means to represent identities or typedefs.

```
module: ietf-crypto-types

  grouping symmetric-key-grouping:
    +---- algorithm    identityref
    +---- (key-type)
   ++--:(key)
      |   +---- key?   binary
      ++--:(hidden-key)
    +---- hidden-key?   empty

  grouping public-key-grouping:
    +---- algorithm     asymmetric-key-algorithm-ref
    +---- public-key    binary

  grouping asymmetric-key-pair-grouping:
    +---- algorithm            asymmetric-key-algorithm-ref
    +---- public-key           binary
    +---- (private-key-type)
   ++--:(private-key)
      |   +---- private-key?   binary
      ++--:(hidden-private-key)
    +---- hidden-private-key?   empty

  grouping trust-anchor-cert-grouping:
    +---- cert?                    trust-anchor-cert-cms
    +----n certificate-expiration
    +----ro expiration-date    ietf-yang-types:date-and-time
```
grouping trust-anchor-certs-grouping:
  +---- cert*  trust-anchor-cert-cms
  +---- n certificate-expiration
   +---- ro expiration-date  ietf-yang-types:date-and-time

grouping end-entity-cert-grouping:
  +---- cert?  end-entity-cert-cms
  +---- n certificate-expiration
   +---- ro expiration-date  ietf-yang-types:date-and-time

grouping end-entity-certs-grouping:
  +---- cert*  end-entity-cert-cms
  +---- n certificate-expiration
   +---- ro expiration-date  ietf-yang-types:date-and-time

grouping asymmetric-key-pair-with-cert-grouping:
  +---- algorithm
   |  +---- asymmetric-key-algorithm-ref  binary
   +---- public-key  binary
  +---- (private-key-type)
   |  +---- (private-key)
     |  +---- private-key?  binary
     |  +---- (hidden-private-key)
      |  +---- hidden-private-key?  empty
   +---- cert?  end-entity-cert-cms
  +---- n certificate-expiration
   +---- ro expiration-date  ietf-yang-types:date-and-time
  +---- x generate-certificate-signing-request
   +---- input
     |  +---- w subject  binary
     |  +---- w attributes?  binary
   +---- output
    +---- ro certificate-signing-request  binary

grouping asymmetric-key-pair-with-certs-grouping:
  +---- algorithm
   |  +---- asymmetric-key-algorithm-ref  binary
   +---- public-key  binary
  +---- (private-key-type)
   |  +---- (private-key)
     |  +---- private-key?  binary
     |  +---- (hidden-private-key)
      |  +---- hidden-private-key?  empty
   +---- certificates
     |  +---- certificate*  [name]
     |      +---- name  string
     |      +---- cert?  end-entity-cert-cms
     |      +---- n certificate-expiration
       |      +---- ro expiration-date  ietf-yang-types:date-and-time
  +---- x generate-certificate-signing-request
   +---- input
     |  +---- w subject  binary
2.2. YANG Module

This module has normative references to [RFC2404], [RFC3565], [RFC3686], [RFC4106], [RFC4253], [RFC4279], [RFC4309], [RFC4494], [RFC4543], [RFC4868], [RFC5280], [RFC5652], [RFC5656], [RFC6187], [RFC6991], [RFC7919], [RFC8268], [RFC8332], [RFC8341], [RFC8422], [RFC8446], and [ITU.X690.2015].

This module has an informational reference to [RFC2986], [RFC3174], [RFC4493], [RFC5915], [RFC6125], [RFC6234], [RFC6239], [RFC6507], [RFC8017], [RFC8032], [RFC8439].

<CODE BEGINS> file "ietf-crypto-types@2019-06-17.yang"

module ietf-crypto-types {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-crypto-types";
  prefix ct;

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

  import ietf-netconf-acm {
    prefix nacm;
    reference
      "RFC 8341: Network Configuration Access Control Model";
  }

  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:kent+ietf@watsen.net>
    Author: Wang Haiguang <wang.haiguang.shieldlab@huawei.com>"

  description
    "This module defines common YANG types for cryptographic applications."
Revision 2019-06-17 {
  description
    "Initial version";
  reference
    "RFC XXXX: Common YANG Data Types for Cryptography";
}

 /***************************************************************************/
 /*  Identities for Hash Algorithms  */
/***************************************************************************/

identity hash-algorithm {
  description
    "A base identity for hash algorithm verification.";
}

identity sha-224 {
  base hash-algorithm;
  description
    "The SHA-224 algorithm.";
  reference
    "RFC 6234: US Secure Hash Algorithms.";
}

identity sha-256 {
  base hash-algorithm;
}
description
   "The SHA-256 algorithm.";
reference
   "RFC 6234: US Secure Hash Algorithms.";
}

identity sha-384 {
    base hash-algorithm;
    description
       "The SHA-384 algorithm.";
    reference
       "RFC 6234: US Secure Hash Algorithms.";
}

identity sha-512 {
    base hash-algorithm;
    description
       "The SHA-512 algorithm.";
    reference
       "RFC 6234: US Secure Hash Algorithms.";
}

/**********************
/* Identities for Asymmetric Key Algorithms */
**********************/

identity asymmetric-key-algorithm {
    description
       "Base identity from which all asymmetric key
          encryption Algorithm.";
}

identity rsa1024 {
    base asymmetric-key-algorithm;
    description
       "The RSA algorithm using a 1024-bit key.";
    reference
       "RFC 8017: PKCS #1: RSA Cryptography Specifications Version 2.2.";
}

identity rsa2048 {
    base asymmetric-key-algorithm;
    description
       "The RSA algorithm using a 2048-bit key.";
    reference
       "RFC 8017: PKCS #1: RSA Cryptography Specifications Version 2.2.";
identity rsa3072 {
    base asymmetric-key-algorithm;
    description
        "The RSA algorithm using a 3072-bit key.";
    reference
        "RFC 8017:
           PKCS #1: RSA Cryptography Specifications Version 2.2.";
}

identity rsa4096 {
    base asymmetric-key-algorithm;
    description
        "The RSA algorithm using a 4096-bit key.";
    reference
        "RFC 8017:
           PKCS #1: RSA Cryptography Specifications Version 2.2.";
}

identity rsa7680 {
    base asymmetric-key-algorithm;
    description
        "The RSA algorithm using a 7680-bit key.";
    reference
        "RFC 8017:
           PKCS #1: RSA Cryptography Specifications Version 2.2.";
}

identity rsa15360 {
    base asymmetric-key-algorithm;
    description
        "The RSA algorithm using a 15360-bit key.";
    reference
        "RFC 8017:
           PKCS #1: RSA Cryptography Specifications Version 2.2.";
}

identity secp192r1 {
    base asymmetric-key-algorithm;
    description
        "The ECDSA algorithm using a NIST P192 Curve.";
    reference
        "RFC 6090:
           Fundamental Elliptic Curve Cryptography Algorithms.
    RFC 5480:
           Elliptic Curve Cryptography Subject Public Key Information.";
}
identity secp224r1 {
  base asymmetric-key-algorithm;
  description
    "The ECDSA algorithm using a NIST P224 Curve.";
  reference
    "RFC 6090:
      Fundamental Elliptic Curve Cryptography Algorithms.
    RFC 5480:
      Elliptic Curve Cryptography Subject Public Key Information.";
}

identity secp256r1 {
  base asymmetric-key-algorithm;
  description
    "The ECDSA algorithm using a NIST P256 Curve.";
  reference
    "RFC 6090:
      Fundamental Elliptic Curve Cryptography Algorithms.
    RFC 5480:
      Elliptic Curve Cryptography Subject Public Key Information.";
}

identity secp384r1 {
  base asymmetric-key-algorithm;
  description
    "The ECDSA algorithm using a NIST P384 Curve.";
  reference
    "RFC 6090:
      Fundamental Elliptic Curve Cryptography Algorithms.
    RFC 5480:
      Elliptic Curve Cryptography Subject Public Key Information.";
}

identity secp521r1 {
  base asymmetric-key-algorithm;
  description
    "The ECDSA algorithm using a NIST P521 Curve.";
  reference
    "RFC 6090:
      Fundamental Elliptic Curve Cryptography Algorithms.
    RFC 5480:
      Elliptic Curve Cryptography Subject Public Key Information.";
}

/************************************
/*   Identities for MAC Algorithms   */
************************************/
identity mac-algorithm {
    description
        "A base identity for mac generation.";
}

identity hmac-sha1 {
    base mac-algorithm;
    description
        "Generating MAC using SHA1 hash function";
    reference
        "RFC 3174: US Secure Hash Algorithm 1 (SHA1)";
}

identity hmac-sha1-96 {
    base mac-algorithm;
    description
        "Generating MAC using SHA1 hash function";
    reference
        "RFC 2404: The Use of HMAC-SHA-1-96 within ESP and AH";
}

identity hmac-sha2-224 {
    base mac-algorithm;
    description
        "Generating MAC using SHA2 hash function";
    reference
        "RFC 6234: US Secure Hash Algorithms (SHA and SHA-based HMAC and HKDF)";
}

identity hmac-sha2-256 {
    base mac-algorithm;
    description
        "Generating MAC using SHA2 hash function";
    reference
        "RFC 6234: US Secure Hash Algorithms (SHA and SHA-based HMAC and HKDF)";
}

identity hmac-sha2-256-128 {
    base mac-algorithm;
    description
        "Generating a 256 bits MAC using SHA2 hash function and truncate it to 128 bits";
    reference
        "RFC 4868:
Using HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512 with IPsec;
}

identity hmac-sha2-384 {
    base mac-algorithm;
    description "Generating MAC using SHA2 hash function";
    reference "RFC 6234:
      US Secure Hash Algorithms (SHA and SHA-based HMAC and HKDF)"
}

identity hmac-sha2-384-192 {
    base mac-algorithm;
    description "Generating a 384 bits MAC using SHA2 hash function and truncate it to 192 bits";
    reference "RFC 4868:
      Using HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512 with IPsec"
}

identity hmac-sha2-512 {
    base mac-algorithm;
    description "Generating MAC using SHA2 hash function";
    reference "RFC 6234:
      US Secure Hash Algorithms (SHA and SHA-based HMAC and HKDF)"
}

identity hmac-sha2-512-256 {
    base mac-algorithm;
    description "Generating a 512 bits MAC using SHA2 hash function and truncating it to 256 bits";
    reference "RFC 4868:
      Using HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512 with IPsec"
}

identity aes-128-gmac {
    base mac-algorithm;
description
"Generating MAC using the Advanced Encryption Standard (AES)
Galois Message Authentication Code (GMAC) as a mechanism to
provide data origin authentication";
reference
"RFC 4543:
The Use of Galois Message Authentication Code (GMAC) in
IPsec ESP and AH";
}

identity aes-256-gmac {
  base mac-algorithm;
  description
  "Generating MAC using the Advanced Encryption Standard (AES)
  Galois Message Authentication Code (GMAC) as a mechanism to
  provide data origin authentication";
  reference
  "RFC 4543:
The Use of Galois Message Authentication Code (GMAC) in
  IPsec ESP and AH";
}

identity aes-cmac-96 {
  base mac-algorithm;
  description
  "Generating MAC using Advanced Encryption Standard (AES)
  Cipher-based Message Authentication Code (CMAC)";
  reference
  "RFC 4494: The AES-CMAC-96 Algorithm and its Use with IPsec";
}

identity aes-cmac-128 {
  base mac-algorithm;
  description
  "Generating MAC using Advanced Encryption Standard (AES)
  Cipher-based Message Authentication Code (CMAC)";
identity encryption-algorithm {
  description
      "A base identity for encryption algorithm.";
}

identity aes-128-cbc {
  base encryption-algorithm;
  description
      "Encrypt message with AES algorithm in CBC mode with a key
      length of 128 bits";
  reference
      "RFC 3565:
       Use of the Advanced Encryption Standard (AES) Encryption
       Algorithm in Cryptographic Message Syntax (CMS)";
}

identity aes-192-cbc {
  base encryption-algorithm;
  description
      "Encrypt message with AES algorithm in CBC mode with a key
      length of 192 bits";
  reference
      "RFC 3565:
       Use of the Advanced Encryption Standard (AES) Encryption
       Algorithm in Cryptographic Message Syntax (CMS)";
}

identity aes-256-cbc {
  base encryption-algorithm;
  description
      "Encrypt message with AES algorithm in CBC mode with a key
      length of 256 bits";
  reference
      "RFC 3565:
       Use of the Advanced Encryption Standard (AES) Encryption
       Algorithm in Cryptographic Message Syntax (CMS)";
}

identity aes-128-ctr {
  base encryption-algorithm;
}

reference
  "RFC 4493: The AES-CMAC Algorithm";
}
description
"Encrypt message with AES algorithm in CTR mode with a key
length of 128 bits";
reference
"RFC 3686:
Using Advanced Encryption Standard (AES) Counter Mode with
IPsec Encapsulating Security Payload (ESP)";
}

identity aes-192-ctr {
  base encryption-algorithm;
  description
  "Encrypt message with AES algorithm in CTR mode with a key
  length of 192 bits";
  reference
  "RFC 3686:
  Using Advanced Encryption Standard (AES) Counter Mode with
  IPsec Encapsulating Security Payload (ESP)";
}

identity aes-256-ctr {
  base encryption-algorithm;
  description
  "Encrypt message with AES algorithm in CTR mode with a key
  length of 256 bits";
  reference
  "RFC 3686:
  Using Advanced Encryption Standard (AES) Counter Mode with
  IPsec Encapsulating Security Payload (ESP)";
}

/******************************
/* Identities for Encryption and MAC Algorithms */
/*******************************/

identity encryption-and-mac-algorithm {
  description
  "A base identity for encryption and MAC algorithm.";
}

identity aes-128-ccm {
  base encryption-and-mac-algorithm;
  description
  "Encrypt message with AES algorithm in CCM mode with a key
  length of 128 bits; it can also be used for generating MAC";
  reference
  "RFC 4309:
  Using Advanced Encryption Standard (AES) CCM Mode with
  IPsec Encapsulating Security Payload (ESP)";
}
IPsec Encapsulating Security Payload (ESP);
base encryption-and-mac-algorithm;
description
   "Encrypt message with AES algorithm in GCM mode with a key
   length of 128 bits; it can also be used for generating MAC";
reference
   "RFC 4106: The Use of Galois/Counter Mode (GCM) in IPsec Encapsulating
   Security Payload (ESP)";
}

identity chacha20-poly1305 {
   base encryption-and-mac-algorithm;
   description
   "Encrypt message with chacha20 algorithm and generate MAC with
   POLY1305; it can also be used for generating MAC";
reference
   "RFC 8439: ChaCha20 and Poly1305 for IETF Protocols";
}

identity signature-algorithm {
   description
   "A base identity for asymmetric key encryption algorithm.";
}

identity dsa-sha1 {
   base signature-algorithm;
   description
   "The signature algorithm using DSA algorithm with SHA1 hash
   algorithm";
reference
   "RFC 4253: The Secure Shell (SSH) Transport Layer Protocol";
}

identity rsassa-pkcs1-sha1 {
   base signature-algorithm;
   description
   "The signature algorithm using RSASSA-PKCS1-v1_5 with the SHA1
   hash algorithm.";
reference
   "RFC 4253: The Secure Shell (SSH) Transport Layer Protocol";
}

identity rsassa-pkcs1-sha256 {
   base signature-algorithm;
description
"The signature algorithm using RSASSA-PKCS1-v1_5 with the
SHA256 hash algorithm."
reference
"RFC 8332:
Use of RSA Keys with SHA-256 and SHA-512 in the Secure Shell
(SSH) Protocol
RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity rsassa-pkcs1-sha384 {
  base signature-algorithm;
  description
"The signature algorithm using RSASSA-PKCS1-v1_5 with the
SHA384 hash algorithm."
  reference
"RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity rsassa-pkcs1-sha512 {
  base signature-algorithm;
  description
"The signature algorithm using RSASSA-PKCS1-v1_5 with the
SHA512 hash algorithm."
  reference
"RFC 8332:
Use of RSA Keys with SHA-256 and SHA-512 in the Secure Shell
(SSH) Protocol
RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity rsassa-pss-rsae-sha256 {
  base signature-algorithm;
  description
"The signature algorithm using RSASSA-PSS with mask generation
function 1 and SHA256 hash algorithm. If the public key is
carried in an X.509 certificate, it MUST use the rsaEncryption
OID";
  reference
"RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity rsassa-pss-rsae-sha384 {
  base signature-algorithm;
description
"The signature algorithm using RSASSA-PSS with mask generation
function 1 and SHA384 hash algorithm. If the public key is
carried in an X.509 certificate, it MUST use the rsaEncryption
OID";
reference
"RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity rsassa-pss-rsae-sha512 {
  base signature-algorithm;
  description
    "The signature algorithm using RSASSA-PSS with mask generation
    function 1 and SHA512 hash algorithm. If the public key is
carried in an X.509 certificate, it MUST use the rsaEncryption
    OID";
  reference
    "RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity rsassa-pss-pss-sha256 {
  base signature-algorithm;
  description
    "The signature algorithm using RSASSA-PSS with mask generation
    function 1 and SHA256 hash algorithm. If the public key is
carried in an X.509 certificate, it MUST use the RSASSA-PSS
    OID";
  reference
    "RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity rsassa-pss-pss-sha384 {
  base signature-algorithm;
  description
    "The signature algorithm using RSASSA-PSS with mask generation
    function 1 and SHA256 hash algorithm. If the public key is
carried in an X.509 certificate, it MUST use the RSASSA-PSS
    OID";
  reference
    "RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity rsassa-pss-pss-sha512 {
  base signature-algorithm;

description
"The signature algorithm using RSASSA-PSS with mask generation
function 1 and SHA256 hash algorithm. If the public key is
carried in an X.509 certificate, it MUST use the RSASSA-PSS
OID";
reference
"RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity ecdsa-secp256r1-sha256 {
  base signature-algorithm;
  description
"The signature algorithm using ECDSA with curve name secp256r1
and SHA256 hash algorithm."
  reference
"RFC 5656: Elliptic Curve Algorithm Integration in the
Secure Shell Transport Layer
RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity ecdsa-secp384r1-sha384 {
  base signature-algorithm;
  description
"The signature algorithm using ECDSA with curve name secp384r1
and SHA384 hash algorithm."
  reference
"RFC 5656: Elliptic Curve Algorithm Integration in the
Secure Shell Transport Layer
RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity ecdsa-secp521r1-sha512 {
  base signature-algorithm;
  description
"The signature algorithm using ECDSA with curve name secp521r1
and SHA512 hash algorithm."
  reference
"RFC 5656: Elliptic Curve Algorithm Integration in the
Secure Shell Transport Layer
RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity ed25519 {
  base signature-algorithm;
}
description
"The signature algorithm using EdDSA as defined in RFC 8032 or its successors."
reference
"RFC 8032: Edwards-Curve Digital Signature Algorithm (EdDSA)";
}

identity ed448 {
    base signature-algorithm;
description
    "The signature algorithm using EdDSA as defined in RFC 8032 or its successors."
reference
    "RFC 8032: Edwards-Curve Digital Signature Algorithm (EdDSA)";
}

identity eccsi {
    base signature-algorithm;
description
    "The signature algorithm using ECCSI signature as defined in RFC 6507."
reference
    "RFC 6507: Elliptic Curve-Based Certificateless Signatures for Identity-based Encryption (ECCSI)";
}

/**********************************************/
/*   Identities for key exchange algorithms   */
/**********************************************/

identity key-exchange-algorithm {
    description
    "A base identity for Diffie-Hellman based key exchange algorithm.";
}

identity psk-only {
    base key-exchange-algorithm;
description
    "Using Pre-shared key for authentication and key exchange"
reference
    "RFC 4279: Pre-Shared Key cipher suites for Transport Layer Security (TLS)";
}

identity dhe-ffdhe2048 {
base key-exchange-algorithm;
description
"Ephemeral Diffie Hellman key exchange with 2048 bit finite field";
reference
"RFC 7919:
Negotiated Finite Field Diffie-Hellman Ephemeral Parameters for Transport Layer Security (TLS)";
}

identity dhe-ffdhe3072 {
  base key-exchange-algorithm;
description
"Ephemeral Diffie Hellman key exchange with 3072 bit finite field";
reference
"RFC 7919:
Negotiated Finite Field Diffie-Hellman Ephemeral Parameters for Transport Layer Security (TLS)";
}

identity dhe-ffdhe4096 {
  base key-exchange-algorithm;
description
"Ephemeral Diffie Hellman key exchange with 4096 bit finite field";
reference
"RFC 7919:
Negotiated Finite Field Diffie-Hellman Ephemeral Parameters for Transport Layer Security (TLS)";
}

identity dhe-ffdhe6144 {
  base key-exchange-algorithm;
description
"Ephemeral Diffie Hellman key exchange with 6144 bit finite field";
reference
"RFC 7919:
Negotiated Finite Field Diffie-Hellman Ephemeral Parameters for Transport Layer Security (TLS)";
}

identity dhe-ffdhe8192 {
  base key-exchange-algorithm;
description
"Ephemeral Diffie Hellman key exchange with 8192 bit finite field";
identity psk-dhe-ffdhe2048 {
    base key-exchange-algorithm;
    description
        "Key exchange using pre-shared key with Diffie-Hellman key
         generation mechanism, where the DH group is FFDHE2048";
    reference
        "RFC 8446:
         The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity psk-dhe-ffdhe3072 {
    base key-exchange-algorithm;
    description
        "Key exchange using pre-shared key with Diffie-Hellman key
         generation mechanism, where the DH group is FFDHE3072";
    reference
        "RFC 8446:
         The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity psk-dhe-ffdhe4096 {
    base key-exchange-algorithm;
    description
        "Key exchange using pre-shared key with Diffie-Hellman key
         generation mechanism, where the DH group is FFDHE4096";
    reference
        "RFC 8446:
         The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity psk-dhe-ffdhe6144 {
    base key-exchange-algorithm;
    description
        "Key exchange using pre-shared key with Diffie-Hellman key
         generation mechanism, where the DH group is FFDHE6144";
    reference
        "RFC 8446:
         The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity psk-dhe-ffdhe8192 {
    base key-exchange-algorithm;
description
"Key exchange using pre-shared key with Diffie-Hellman key
generation mechanism, where the DH group is FFDHE8192";
reference
"RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity ecdhe-secp256r1 {
base key-exchange-algorithm;
description
"Ephemeral Diffie Hellman key exchange with elliptic group
over curve secp256r1";
reference
"RFC 8422:
Elliptic Curve Cryptography (ECC) Cipher Suites for
Transport Layer Security (TLS) Versions 1.2 and Earlier";
}

identity ecdhe-secp384r1 {
base key-exchange-algorithm;
description
"Ephemeral Diffie Hellman key exchange with elliptic group
over curve secp384r1";
reference
"RFC 8422:
Elliptic Curve Cryptography (ECC) Cipher Suites for
Transport Layer Security (TLS) Versions 1.2 and Earlier";
}

identity ecdhe-secp521r1 {
base key-exchange-algorithm;
description
"Ephemeral Diffie Hellman key exchange with elliptic group
over curve secp521r1";
reference
"RFC 8422:
Elliptic Curve Cryptography (ECC) Cipher Suites for
Transport Layer Security (TLS) Versions 1.2 and Earlier";
}

identity ecdhe-x25519 {
base key-exchange-algorithm;
description
"Ephemeral Diffie Hellman key exchange with elliptic group
over curve x25519";
reference
"RFC 8422:
Elliptic Curve Cryptography (ECC) Cipher Suites for Transport Layer Security (TLS) Versions 1.2 and Earlier;

identity ecdhe-x448 {
    base key-exchange-algorithm;
    description
        "Ephemeral Diffie Hellman key exchange with elliptic group over curve x448";
    reference
        "RFC 8422: Elliptic Curve Cryptography (ECC) Cipher Suites for Transport Layer Security (TLS) Versions 1.2 and Earlier";
}

identity psk-ecdhe-secp256r1 {
    base key-exchange-algorithm;
    description
        "Key exchange using pre-shared key with elliptic group-based Ephemeral Diffie Hellman key exchange over curve secp256r1";
    reference
}

identity psk-ecdhe-secp384r1 {
    base key-exchange-algorithm;
    description
        "Key exchange using pre-shared key with elliptic group-based Ephemeral Diffie Hellman key exchange over curve secp384r1";
    reference
}

identity psk-ecdhe-secp521r1 {
    base key-exchange-algorithm;
    description
        "Key exchange using pre-shared key with elliptic group-based Ephemeral Diffie Hellman key exchange over curve secp521r1";
    reference
}

identity psk-ecdhe-x25519 {
    base key-exchange-algorithm;
    description
"Key exchange using pre-shared key with elliptic group-based Ephemeral Diffie Hellman key exchange over curve x25519";
reference
"RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity psk-ecdh-x448 {
  base key-exchange-algorithm;
  description
    "Key exchange using pre-shared key with elliptic group-based Ephemeral Diffie Hellman key exchange over curve x448";
  reference
    "RFC 8446:
The Transport Layer Security (TLS) Protocol Version 1.3";
}

identity diffie-hellman-group14-sha1 {
  base key-exchange-algorithm;
  description
    "Using DH group14 and SHA1 for key exchange";
  reference
    "RFC 4253: The Secure Shell (SSH) Transport Layer Protocol";
}

identity diffie-hellman-group14-sha256 {
  base key-exchange-algorithm;
  description
    "Using DH group14 and SHA256 for key exchange";
  reference
    "RFC 8268:
More Modular Exponentiation (MODP) Diffie-Hellman (DH)
Key Exchange (KEX) Groups for Secure Shell (SSH)";
}

identity diffie-hellman-group15-sha512 {
  base key-exchange-algorithm;
  description
    "Using DH group15 and SHA512 for key exchange";
  reference
    "RFC 8268:
More Modular Exponentiation (MODP) Diffie-Hellman (DH)
Key Exchange (KEX) Groups for Secure Shell (SSH)";
}

identity diffie-hellman-group16-sha512 {
  base key-exchange-algorithm;
  description

"Using DH group16 and SHA512 for key exchange";
reference
"RFC 8268:
More Modular Exponentiation (MODP) Diffie-Hellman (DH)
Key Exchange (KEX) Groups for Secure Shell (SSH)";
}

identity diffie-hellman-group17-sha512 {
  base key-exchange-algorithm;
  description
  "Using DH group17 and SHA512 for key exchange";
  reference
  "RFC 8268:
  More Modular Exponentiation (MODP) Diffie-Hellman (DH)
  Key Exchange (KEX) Groups for Secure Shell (SSH)";
}

identity diffie-hellman-group18-sha512 {
  base key-exchange-algorithm;
  description
  "Using DH group18 and SHA512 for key exchange";
  reference
  "RFC 8268:
  More Modular Exponentiation (MODP) Diffie-Hellman (DH)
  Key Exchange (KEX) Groups for Secure Shell (SSH)";
}

identity ecdh-sha2-secp256r1 {
  base key-exchange-algorithm;
  description
  "Elliptic curve-based Diffie Hellman key exchange over curve
  secp256r1 and using SHA2 for MAC generation";
  reference
  "RFC 6239: Suite B Cryptographic Suites for Secure Shell
  (SSH)";
}

identity ecdh-sha2-secp384r1 {
  base key-exchange-algorithm;
  description
  "Elliptic curve-based Diffie Hellman key exchange over curve
  secp384r1 and using SHA2 for MAC generation";
  reference
  "RFC 6239: Suite B Cryptographic Suites for Secure Shell
  (SSH)";
}

identity rsaes-oaep {
base key-exchange-algorithm;
description
"RSAES-OAEP combines the RSAEP and RSADP primitives with the
EME-OAEP encoding method";
reference
"RFC 8017:
    PKCS #1: RSA Cryptography Specifications Version 2.2.";
}

identity rsaes-pkcs1-v1_5 {
    base key-exchange-algorithm;
    description
    " RSAES-PKCS1-v1_5 combines the RSAEP and RSADP primitives
    with the EME-PKCS1-v1_5 encoding method";
    reference
    "RFC 8017:
        PKCS #1: RSA Cryptography Specifications Version 2.2.";
}

/**********************************************************/
/*   Typedefs for identityrefs to above base identities   */
/**********************************************************/

typedef hash-algorithm-ref {
    type identityref {
        base hash-algorithm;
    }
}

typedef signature-algorithm-ref {
    type identityref {
        base signature-algorithm;
    }
}

typedef mac-algorithm-ref {
    type identityref {
        base mac-algorithm;
    }
}
typedef encryption-algorithm-ref {
    type identityref {
        base encryption-algorithm;
    }
    description
        "This typedef enables importing modules to easily define an
        identityref to the 'encryption-algorithm' base identity.";
}

typedef encryption-and-mac-algorithm-ref {
    type identityref {
        base encryption-and-mac-algorithm;
    }
    description
        "This typedef enables importing modules to easily define an
        identityref to the 'encryption-and-mac-algorithm' base identity.";
}

typedef asymmetric-key-algorithm-ref {
    type identityref {
        base asymmetric-key-algorithm;
    }
    description
        "This typedef enables importing modules to easily define an
        identityref to the 'asymmetric-key-algorithm' base identity.";
}

typedef key-exchange-algorithm-ref {
    type identityref {
        base key-exchange-algorithm;
    }
    description
        "This typedef enables importing modules to easily define an
        identityref to the 'key-exchange-algorithm' base identity.";
}

/*!  Typedefs for ASN.1 structures from RFC 5280 */
typedef x509 {
    type binary;
    description
"A Certificate structure, as specified in RFC 5280, encoded using ASN.1 distinguished encoding rules (DER), as specified in ITU-T X.690.";
reference
"RFC 5280:
   Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile
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).";
{
typedef crl {
   type binary;
   description
   "A CertificateList structure, as specified in RFC 5280, encoded using ASN.1 distinguished encoding rules (DER), as specified in ITU-T X.690.";
   reference
   "RFC 5280:
      Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile
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).";
  }
;/* Typedefs for ASN.1 structures from 5652 */
/******************************************************************************/
typedef cms {
   type binary;
   description
   "A ContentInfo structure, as specified in RFC 5652, encoded using ASN.1 distinguished encoding rules (DER), as specified in ITU-T X.690.";
   reference
   "RFC 5652:
      Cryptographic Message Syntax (CMS)
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).";
typedef data-content-cms {
  type cms;
  description "A CMS structure whose top-most content type MUST be the
data content type, as described by Section 4 in RFC 5652.";
  reference "RFC 5652: Cryptographic Message Syntax (CMS)";
}

typedef signed-data-cms {
  type cms;
  description "A CMS structure whose top-most content type MUST be the
signed-data content type, as described by Section 5 in
RFC 5652.";
  reference "RFC 5652: Cryptographic Message Syntax (CMS)";
}

typedef enveloped-data-cms {
  type cms;
  description "A CMS structure whose top-most content type MUST be the
enveloped-data content type, as described by Section 6
in RFC 5652.";
  reference "RFC 5652: Cryptographic Message Syntax (CMS)";
}

typedef digested-data-cms {
  type cms;
  description "A CMS structure whose top-most content type MUST be the
digested-data content type, as described by Section 7
in RFC 5652.";
  reference "RFC 5652: Cryptographic Message Syntax (CMS)";
}

typedef encrypted-data-cms {
  type cms;
  description "A CMS structure whose top-most content type MUST be the
encrypted-data content type, as described by Section 8
in RFC 5652.";
}
typedef authenticated-data-cms {
  type cms;
  description
    "A CMS structure whose top-most content type MUST be the
    authenticated-data content type, as described by Section 9
    in RFC 5652."
  reference
    "RFC 5652: Cryptographic Message Syntax (CMS)";
}

typedef ssh-host-key {
  type binary;
  description
    "The binary public key data for this SSH key, as
    specified by RFC 4253, Section 6.6, i.e.:

    string    certificate or public key format
    identifier
    byte[n]   key/certificate data.";
  reference
    "RFC 4253: The Secure Shell (SSH) Transport Layer
    Protocol";
}

typedef trust-anchor-cert-x509 {
  type x509;
  description
    "A Certificate structure that MUST encode a self-signed
    root certificate.";
}

typedef end-entity-cert-x509 {
  type x509;
  description
    "A Certificate structure that MUST encode a certificate
    that is neither self-signed nor having Basic constraint
/* Typedefs for ASN.1 structures related to RFC 5652 */

typedef trust-anchor-cert-cms {
  type signed-data-cms;
  description
    "A CMS SignedData structure that MUST contain the chain of X.509 certificates needed to authenticate the certificate presented by a client or end-entity.

    The CMS MUST contain only a single chain of certificates. The client or end-entity certificate MUST only authenticate to last intermediate CA certificate listed in the chain.

    In all cases, the chain MUST include a self-signed root certificate. In the case where the root certificate is itself the issuer of the client or end-entity certificate, only one certificate is present.

    This CMS structure MAY (as applicable where this type is used) also contain suitably fresh (as defined by local policy) revocation objects with which the device can verify the revocation status of the certificates.

    This CMS encodes the degenerate form of the SignedData structure that is commonly used to disseminate X.509 certificates and revocation objects (RFC 5280).";
  reference
    "RFC 5280:
      Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile.";
}

typedef end-entity-cert-cms {
  type signed-data-cms;
  description
    "A CMS SignedData structure that MUST contain the end entity certificate itself, and MAY contain any number of intermediate certificates leading up to a trust anchor certificate. The trust anchor certificate MAY be included as well.

    The CMS MUST contain a single end entity certificate. The CMS MUST NOT contain any spurious certificates.

    CA true.";
}
This CMS structure MAY (as applicable where this type is used) also contain suitably fresh (as defined by local policy) revocation objects with which the device can verify the revocation status of the certificates.

This CMS encodes the degenerate form of the SignedData structure that is commonly used to disseminate X.509 certificates and revocation objects (RFC 5280)."

reference "RFC 5280:
Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile.";
}

/************************************************************
/* Groupings for keys and/or certificates */
/************************************************************

grouping symmetric-key-grouping {
    description "A symmetric key and algorithm.";
    leaf algorithm {
        type identityref {
            base "ct:encryption-algorithm";
        }
        mandatory true;
        description "The algorithm to be used when generating the key.";
        reference "RFC CCCC: Common YANG Data Types for Cryptography";
    }
    choice key-type {
        mandatory true;
        description "Choice between key types.";
        leaf key {
            nacm:default-deny-all;
            type binary;
            description "The binary value of the key. The interpretation of the value is defined by 'algorithm'. For example, FIXME.";
            reference "RFC XXXX: FIXME";
        }
        leaf hidden-key {
            nacm:default-deny-write;
            type empty;
        }
    }
}
description
  "A permanently hidden key. How such keys are created
  is outside the scope of this module."
}

grouping public-key-grouping {
  description
    "A public key and its associated algorithm."
  leaf algorithm {
    nacm:default-deny-write;
    type asymmetric-key-algorithm-ref;
    mandatory true;
    description
      "Identifies the key’s algorithm."
    reference
      "RFC CCCC: Common YANG Data Types for Cryptography"
  }
  leaf public-key {
    nacm:default-deny-write;
    type binary;
    mandatory true;
    description
      "The binary value of the public key. The interpretation of
      the value is defined by 'algorithm'. For example, a DSA
      key is an integer, an RSA key is represented as RSAPublicKey
      per RFC 8017, and an ECC key is represented using the
      'publicKey' described in RFC 5915."
    reference
      "RFC 8017: Public-Key Cryptography Standards (PKCS) #1:
      RSA Cryptography Specifications Version 2.2.
      RFC 5915: Elliptic Curve Private Key Structure."
  }
}

grouping asymmetric-key-pair-grouping {
  description
    "A private key and its associated public key and algorithm."
  uses public-key-grouping;
  choice private-key-type {
    mandatory true;
    description
      "Choice between key types."
  }
  leaf private-key {
    nacm:default-deny-all;
    type binary;
    description
      "A permanently hidden key. How such keys are created
      is outside the scope of this module."
"The value of the binary key. The key’s value is interpreted by the ‘algorithm’. For example, a DSA key is an integer, an RSA key is represented as RSAPrivateKey as defined in RFC 8017, and an ECC key is represented as ECPrivateKey as defined in RFC 5915.”;

reference
RFC 5915: Elliptic Curve Private Key Structure."

leaf hidden-private-key {
    nacm:default-deny-write;
    type empty;
    description
    "A permanently hidden key. How such keys are created is outside the scope of this module.";
}

grouping trust-anchor-cert-grouping {
    description
    "A trust anchor certificate, and a notification for when it is about to (or already has) expire.”;
    leaf cert {
        nacm:default-deny-write;
        type trust-anchor-cert-cms;
        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 trust-anchor-certs-grouping {
  description
    "A list of trust anchor certificates, and a notification
    for when one is about to (or already has) expire."
  leaf-list cert {
    nacm:default-deny-write;
    type trust-anchor-cert-cms;
    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 end-entity-cert-grouping {
  description
    "An end entity certificate, and a notification for when
    it is about to (or already has) expire. Implementations
    SHOULD assert that, where used, the end entity certificate
    contains the expected public key."
  leaf cert {
    nacm:default-deny-write;
    type end-entity-cert-cms;
    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 end-entity-certs-grouping {
  description "A list of end entity certificates, and a notification for when one is about to (or already has) expire.";
  leaf-list cert {
    nacm:default-deny-write;
    type end-entity-cert-cms;
    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-cert-grouping {
  description "A private/public key pair and an associated certificate. Implementations SHOULD assert that certificates contain the matching public key.";
  uses asymmetric-key-pair-grouping;
uses end-entity-cert-grouping;

action generate-certificate-signing-request {
    nacm:default-deny-all;
    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 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)."
        }
        leaf attributes {
            type binary;  // FIXME: does this need to be mandatory?
            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).";
  }
  // generate-certificate-signing-request
} // asymmetric-key-pair-with-cert-grouping

grouping asymmetric-key-pair-with-certs-grouping {
  description "A private/public key pair and associated certificates.
    Implementations SHOULD assert that certificates contain
    the matching public key.";
  uses asymmetric-key-pair-grouping;
  container certificates {
    nacm:default-deny-write;
    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. If the name
matches the name of a certificate that exists
independently in <operational> (i.e., an IDevID),
then the ‘cert’ node MUST NOT be configured.

} // certificates

action generate-certificate-signing-request {
    nacm:default-deny-all;
    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 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)."
        }
        leaf attributes {
            type binary;     // FIXME: does this need to be mandatory?
            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:"
3. Security Considerations

3.1. Support for Algorithms

In order to use YANG identities for algorithm identifiers, only the most commonly used RSA key lengths are supported for the RSA algorithm. Additional key lengths can be defined in another module or added into a future version of this document.

This document limits the number of elliptical curves supported. This was done to match industry trends and IETF best practice (e.g., matching work being done in TLS 1.3). If additional algorithms are needed, they can be defined by another module or added into a future version of this document.
3.2. No Support for CRMF

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 it was unclear if there was market demand for it. If it is desired to support CRMF in the future, a backwards compatible solution can be defined at that time.

3.3. Access to Data Nodes

The YANG module in this document defines "grouping" statements that are 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) [RFC8341] provides the means to restrict access for particular users to a pre-configured subset of all available protocol operations and content.

Since the module in this document only define groupings, these considerations are primarily for the designers of other modules that use these groupings.

There are a number of data nodes defined by the grouping statements that are writable/creatable/deletable (i.e., config true, which is the default). Some of 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:

*: All of the data nodes defined by all the groupings are considered sensitive to write operations. For instance, the modification of a public key or a certificate can dramatically alter the implemented security policy. For this reason, the NACM extension "default-deny-write" has been applied to all the data nodes defined by all the groupings.

Some of the readable data nodes in the 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:

/private-key: The "private-key" node defined in the "asymmetric-key-pair-grouping" grouping is additionally sensitive to read operations such that, in normal use cases, it should never be
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:

*: All of the "action" statements defined by groupings SHOULD only be executed by authorized users. For this reason, the NACM extension "default-deny-all" has been applied to all of them. Note that NACM uses "default-deny-all" to protect "RPC" and "action" statements; it does not define, e.g., an extension called "default-deny-execute".

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.

4. IANA Considerations

4.1. The IETF XML Registry

This document registers one URI in the "ns" subregistry of the IETF XML Registry [RFC3688]. Following the format in [RFC3688], the following registration is requested:

Registrant Contact: The NETCONF WG of the IETF.
XML: N/A, the requested URI is an XML namespace.

4.2. The YANG Module Names Registry

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

name: ietf-crypto-types
prefix: ct
reference: RFC XXXX
5. References

5.1. Normative References


5.2. Informative References


Appendix A. Examples

A.1. The "asymmetric-key-pair-with-certs-grouping" Grouping

The following example module has been constructed to illustrate use of the "asymmetric-key-pair-with-certs-grouping" grouping defined in the "ietf-crypto-types" module.

Note that the "asymmetric-key-pair-with-certs-grouping" grouping uses both the "asymmetric-key-pair-grouping" and "end-entity-cert-grouping" groupings, and that the "asymmetric-key-pair-grouping" grouping uses the "public-key-grouping" grouping. Thus, a total of four of the five groupings defined in the "ietf-crypto-types" module are illustrated through the use of this one grouping. The only grouping not represented is the "trust-anchor-cert-grouping" grouping.
module ex-crypto-types-usage {
  yang-version 1.1;

  namespace "http://example.com/ns/example-crypto-types-usage";
  prefix "ectu";

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

  organization
    "Example Corporation";

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

  description
    "This module illustrates the grouping defined in the crypto-types draft called
    'asymmetric-key-pair-with-certs-grouping'.";

  revision "1001-01-01" {
    description
      "Initial version";
    reference
      "RFC ?????: Usage Example for RFC XXXX";
  }

  container keys {
    description
      "A container of keys.";
    list key {
      key name;
      leaf name {
        type string;
        description
          "An arbitrary name for this key.";
      }
      uses ct:asymmetric-key-pair-with-certs-grouping;
      description
        "An asymmetric key pair with associated certificates.";
    }
  }
}
Given the above example usage module, the following example illustrates some configured keys.

```xml
<keys xmlns="http://example.com/ns/example-crypto-types-usage">
  <key>
    <name>ex-key</name>
      ct:rsa2048
    </algorithm>
    <public-key>base64encodedvalue==</public-key>
    <private-key>base64encodedvalue==</private-key>
    <certificates>
      <certificate>
        <name>ex-cert</name>
        <cert>base64encodedvalue==</cert>
      </certificate>
    </certificates>
  </key>

  <key>
    <name>ex-hidden-key</name>
      ct:rsa2048
    </algorithm>
    <public-key>base64encodedvalue==</public-key>
    <hidden-private-key/>
    <certificates>
      <certificate>
        <name>ex-hidden-key-cert</name>
        <cert>base64encodedvalue==</cert>
      </certificate>
    </certificates>
  </key>
</keys>
```

A.2. The "generate-certificate-signing-request" Action

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">
     <keys xmlns="http://example.com/ns/example-crypto-types-usage">
         <key>
             <name>ex-key-sect571r1</name>
             <generate-certificate-signing-request>
                 <subject>base64encodedvalue==</subject>
                 <attributes>base64encodedvalue==</attributes>
             </generate-certificate-signing-request>
         </key>
     </keys>
     </action>
 </rpc>

RESPONSE

<rpc-reply message-id="101"
            xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
            <certificate-signing-request
                xmlns="http://example.com/ns/example-crypto-types-usage">
                base64encodedvalue==
            </certificate-signing-request>
        </rpc-reply>

A.3. The "certificate-expiration" Notification

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>
  <keys xmlns="http://example.com/ns/example-crypto-types-usage">
    <key>
      <name>locally-defined key</name>
      <certificates>
        <certificate>
          <name>my-cert</name>
          <certificate-expiration>
            <expiration-date>
              2018-08-05T14:18:53-05:00
            </expiration-date>
          </certificate-expiration>
        </certificate>
      </certificates>
    </key>
  </keys>
</notification>

Appendix B. Change Log

B.1. I-D to 00

- Removed groupings and notifications.
- Added typedefs for identityrefs.
- Added typedefs for other RFC 5280 structures.
- Added typedefs for other RFC 5652 structures.
- Added convenience typedefs for RFC 4253, RFC 5280, and RFC 5652.

B.2. 00 to 01

- Moved groupings from the draft-ietf-netconf-keystore here.

B.3. 01 to 02

- Removed unwanted "mandatory" and "must" statements.
- Added many new crypto algorithms (thanks Haiguang!)
- Clarified in asymmetric-key-pair-with-certs-grouping, in certificates/certificate/name/description, that if the name MUST NOT match the name of a certificate that exists independently in
<operational>, enabling certs installed by the manufacturer (e.g.,
an IDevID).

B.4. 02 to 03

- renamed base identity ‘asymmetric-key-encryption-algorithm’ to
  ‘asymmetric-key-algorithm’.

- added new ‘asymmetric-key-algorithm’ identities for secp192r1,
  secp224r1, secp256r1, secp384r1, and secp521r1.

- removed ‘mac-algorithm’ identities for mac-aes-128-ccm, mac-aes-
  192-ccm, mac-aes-256-ccm, mac-aes-128-gcm, mac-aes-192-gcm, mac-
  aes-256-gcm, and mac-chacha20-poly1305.

- for all -cbc and -ctr identities, renamed base identity
  ‘symmetric-key-encryption-algorithm’ to ‘encryption-algorithm’.

- for all -ccm and -gcm identities, renamed base identity
  ‘symmetric-key-encryption-algorithm’ to ‘encryption-and-mac-
  algorithm’ and renamed the identity to remove the "enc-" prefix.

- for all the ‘signature-algorithm’ based identities, renamed from
  ‘rsa-’ to ‘rsassa-’.

- removed all of the "x509v3-" prefixed ‘signature-algorithm’ based
  identities.

- added ‘key-exchange-algorithm’ based identities for ‘rsaes-oaep’
  and ‘rsaes-pkcs1-v1_5’.

- renamed typedef ‘symmetric-key-encryption-algorithm-ref’ to
  ‘symmetric-key-algorithm-ref’.

- renamed typedef ‘asymmetric-key-encryption-algorithm-ref’ to
  ‘asymmetric-key-algorithm-ref’.

- added typedef ‘encryption-and-mac-algorithm-ref’.

- Updated copyright date, boilerplate template, affiliation, and
  folding algorithm.

B.5. 03 to 04

- ran YANG module through formatter.
B.6. 04 to 05

- fixed broken symlink causing reformatted YANG module to not show.

B.7. 05 to 06

- Added NACM annotations.
- Updated Security Considerations section.
- Added ‘asymmetric-key-pair-with-cert-grouping’ grouping.
- Removed text from ‘permanently-hidden’ enum regarding such keys not being backed up or restored.
- Updated the boilerplate text in module-level "description" statement to match copyeditor convention.
- Added an explanation to the ‘public-key-grouping’ and ‘asymmetric-key-pair-grouping’ statements as for why the nodes are not mandatory (e.g., because they may exist only in <operational>.
- Added ‘must’ expressions to the ‘public-key-grouping’ and ‘asymmetric-key-pair-grouping’ statements ensuring sibling nodes are either all exist or do not all exist.
- Added an explanation to the ‘permanently-hidden’ that the value cannot be configured directly by clients and servers MUST fail any attempt to do so.
- Added ‘trust-anchor-certs-grouping’ and ‘end-entity-certs-grouping’ (the plural form of existing groupings).
- Now states that keys created in <operational> by the ‘*-hidden-key’ actions are bound to the lifetime of the parent ‘config true’ node, and that subsequent invocations of either action results in a failure.

B.8. 06 to 07

- Added clarifications that implementations SHOULD assert that configured certificates contain the matching public key.
- Replaced the ‘generate-hidden-key’ and ‘install-hidden-key’ actions with special ‘crypt-hash’ -like input/output values.
B.9. 07 to 08

- Removed the 'generate-key' and 'hidden-key' features.
- Added grouping symmetric-key-grouping
- Modified 'asymmetric-key-pair-grouping' to have a 'choice' statement for the keystone module to augment into, as well as replacing the 'union' with leafs (having different NACM settings).

Acknowledgements

The authors would like to thank for following for lively discussions on list and in the halls (ordered by last name): Martin Bjorklund, Nick Hancock, Balazs Kovacs, Juergen Schoenwaelder, Eric Voit, and Liang Xia.

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