

Workgroup: RATS Working Group  
Internet-Draft:  
draft-ietf-rats-yang-tpm-charra-11  
Published: 26 August 2021  
Intended Status: Standards Track  
Expires: 27 February 2022

A	H. Birkholz	M. Eckel	S. Bhandari		
	uFraunhofer SIT	Fraunhofer SIT	ThoughtSpot		
	t				
	h				
	o				
	r				
	s				
	:				
	E. Voit	B. Sulzen	L. Xia	T. Laffey	G. Fedorkow
	Cisco	Cisco	Huawei	HPE	Juniper

## **A YANG Data Model for Challenge-Response-based Remote Attestation Procedures using TPMs**

### **Abstract**

This document defines YANG RPCs and a small number of configuration nodes required to retrieve attestation evidence about integrity measurements from a device, following the operational context defined in TPM-based Network Device Remote Integrity Verification. Complementary measurement logs are also provided by the YANG RPCs, originating from one or more roots of trust for measurement (RTMs). The module defined requires at least one TPM 1.2 or TPM 2.0 as well as a corresponding TPM Software Stack (TSS), included in the device components of the composite device the YANG server is running on.

### **Status of This Memo**

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

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <https://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on 27 February 2022.

### **Copyright Notice**

Copyright (c) 2021 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to BCP 78 and the IETF Trust's Legal Provisions Relating to IETF Documents (<https://trustee.ietf.org/license-info>) in effect on the date of

publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

## Table of Contents

- [1. Introduction](#)
- [1.1. Requirements notation](#)
- [2. The YANG Module for Basic Remote Attestation Procedures](#)
- [2.1. YANG Modules](#)
  - [2.1.1. 'ietf-tpm-remote-attestation'](#)
  - [2.1.2. 'ietf-tcg-algs'](#)
- [3. IANA Considerations](#)
- [4. Security Considerations](#)
- [5. Change Log](#)
- [6. References](#)
  - [6.1. Normative References](#)
  - [6.2. Informative References](#)
- [Authors' Addresses](#)

## 1. Introduction

This document is based on the general terminology defined in the [[I-D.ietf-rats-architecture](#)] and uses the operational context defined in [[I-D.ietf-rats-tpm-based-network-device-attest](#)] as well as the interaction model and information elements defined in [[I-D.ietf-rats-reference-interaction-models](#)]. The currently supported hardware security modules (HSMs) are the Trusted Platform Modules (TPMs) [[TPM1.2](#)] and [[TPM2.0](#)] as specified by the Trusted Computing Group (TCG). One or more TPMs embedded in the components of a Composite Device are required in order to use the YANG module defined in this document. A TPM is used as a root of trust for reporting (RTR) in order to retrieve attestation Evidence from a composite device (*TPM Quote* primitive operation). Additionally, it is used as a root of trust for storage (RTS) in order to retain shielded secrets and store system measurements using a folding hash function (*TPM PCR Extend* primitive operation).

Specific terms imported from [[I-D.ietf-rats-architecture](#)] and used in this document include: Attester, Composite Device, Evidence.

Specific terms imported from [[TPM2.0-Key](#)] and used in this document include: Endorsement Key (EK), Initial Attestation Key (IAK), Local Attestation Key (LAK).

### 1.1. Requirements notation

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 YANG Module for Basic Remote Attestation Procedures

One or more TPMs MUST be embedded in a Composite Device that provides attestation evidence via the YANG module defined in this document. The `ietf-basic-remote-attestation` YANG module enables a composite device to take on the role of an Attester, in accordance with the Remote Attestation Procedures (RATS) architecture [[I-D.ietf-rats-architecture](#)], and the corresponding challenge-response interaction model defined in the [[I-D.ietf-rats-reference-interaction-models](#)] document. A fresh nonce with an appropriate amount of entropy MUST be supplied by the YANG client in order to enable a proof-of-freshness with respect to the attestation Evidence provided by the Attester running the YANG datastore. Further, this nonce is used to prevent replay attacks. The functions of this YANG module are restricted to 0-1 TPMs per hardware component.

### 2.1. YANG Modules

In this section the several YANG modules are defined.

#### 2.1.1. 'ietf-tpm-remote-attestation'

This YANG module imports modules from [[RFC6991](#)], [[RFC8348](#)], [[I-D.ietf-netconf-keystore](#)], and `ietf-tcg-algs.yang` [Section 2.1.2.3](#).

##### 2.1.1.1. Features

This module supports the following features:

- \*'TPMs': Indicates that multiple TPMs on the device can support remote attestation. This feature is applicable in cases where multiple line cards are present, each with its own TPM.
- \*'bios': Indicates that the device supports the retrieval of BIOS/UEFI event logs.
- \*'ima': Indicates that the device supports the retrieval of event logs from the Linux Integrity Measurement Architecture (IMA).
- \*'netequip\_boot': Indicates that the device supports the retrieval of netequip boot event logs.

##### 2.1.1.2. Identities

This module supports the following types of attestation event logs: 'bios', 'ima', and 'netequip\_boot'.

##### 2.1.1.3. Remote Procedure Calls (RPCs)

In the following, RPCs for both TPM 1.2 and TPM 2.0 attestation procedures are defined.

###### 2.1.1.3.1. 'tpm12-challenge-response-attestation'

This RPC allows a Verifier to request signed TPM PCRs (*TPM Quote* operation) from a TPM 1.2 compliant cryptoprocessor. Where the feature 'TPMs' is active, and one or more 'certificate-name' is not

provided, all TPM 1.2 compliant cryptoprocessors will respond. A YANG tree diagram of this RPC is as follows:

```
+---x tpm12-challenge-response-attestation {taa:TPM12}?
+---w input
| +---w tpm12-attestation-challenge
|   +---w pcr-index*          pcr
|   +---w nonce-value        binary
|   +---w certificate-name*   certificate-name-ref {tpm:TPMs}?
+--ro output
  +--ro tpm12-attestation-response* []
  +--ro certificate-name          certificate-name-ref
  +--ro up-time?                 uint32
  +--ro TPM_QUOTE2?              binary
```

### 2.1.1.3.2. 'tpm20-challenge-response-attestation'

This RPC allows a Verifier to request signed TPM PCRs (*TPM Quote* operation) from a TPM 2.0 compliant cryptoprocessor. Where the feature 'TPMs' is active, and one or more 'certificate-name' is not provided, all TPM 2.0 compliant cryptoprocessors will respond. A YANG tree diagram of this RPC is as follows:

```
+---x tpm20-challenge-response-attestation {taa:tpm}?
+---w input
| +---w tpm20-attestation-challenge
|   +---w nonce-value          binary
|   +---w tpm20-pcr-selection* []
|     | +---w TPM20-hash-algo?  identityref
|     | +---w pcr-index*        tpm:pcr
|     +---w certificate-name*   certificate-name-ref {tpm:TPMs}?
+--ro output
  +--ro tpm20-attestation-response* []
  +--ro certificate-name          certificate-name-ref
  +--ro TPMS_QUOTE_INFO          binary
  +--ro quote-signature?        binary
  +--ro up-time?                uint32
  +--ro unsigned-pcr-values* []
    +--ro TPM20-hash-algo?      identityref
    +--ro pcr-values* [pcr-index]
      +--ro pcr-index          pcr
      +--ro pcr-value?        binary
```

An example of an RPC challenge requesting PCRs 0-7 from a SHA-256 bank could look like the following:

```

<rpc message-id="101" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <tpm20-challenge-response-attestation>
    xmlns="urn:ietf:params:xml:ns:yang:ietf-tpm-remote-attestation">
      <certificate-name>
        (identifier of a TPM signature key with which the Verifier is
        supposed to sign the attestation data)
      </certificate-name>
      <nonce>
        0xe041307208d9f78f5b1bbeed19e2d152ad49de2fc5a7d8dbf769f6b8ffdeab9
      </nonce>
      <tpm20-pcr-selection>
        <tpm20-hash-algo
          xmlns:taa="urn:ietf:params:xml:ns:yang:ietf-tcg-algs">
            taa:TPM_ALG_SHA256
          </tpm20-hash-algo>
          <pcr-index>0</pcr-index>
          <pcr-index>1</pcr-index>
          <pcr-index>2</pcr-index>
          <pcr-index>3</pcr-index>
          <pcr-index>4</pcr-index>
          <pcr-index>5</pcr-index>
          <pcr-index>6</pcr-index>
          <pcr-index>7</pcr-index>
        </tpm20-pcr-selection>
      </tpm20-challenge-response-attestation>
    </rpc>

```

A successful response could be formatted as follows:

```

<rpc-reply message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <tpm20-attestation-response
    xmlns="urn:ietf:params:xml:ns:yang:ietf-tpm-remote-attestation">
    <certificate-name
      xmlns:ks="urn:ietf:params:xml:ns:yang:ietf-keystore">
      ks:(instance of Certificate name in the Keystore)
    </certificate-name>
    <attestation-data>
      (raw attestation data, i.e. the TPM quote; this includes
      a composite digest of requested PCRs, the nonce,
      and TPM 2.0 time information.)
    </attestation-data>
    <quote-signature>
      (signature over attestation-data using the TPM key
      identified by sig-key-id)
    </quote-signature>
  </tpm20-attestation-response>
</rpc-reply>

```

#### 2.1.1.4. 'log-retrieval'

This RPC allows a Verifier to acquire the evidence which was extended into specific TPM PCRs. A YANG tree diagram of this RPC is as follows:

```

+---x log-retrieval
+---w input
| +---w log-selector* []
| | +---w name*                string
| | +---w (index-type)?
| | | +--:(last-entry)
| | | | +---w last-entry-value?  binary
| | | | +--:(index)
| | | | +---w last-index-number?  uint64
| | | | +--:(timestamp)
| | | | +---w timestamp?          yang:date-and-time
| | | +---w log-entry-quantity?  uint16
| +---w log-type                identityref
+--ro output
+--ro system-event-logs
+--ro node-data* []
+--ro name?                    string
+--ro up-time?                 uint32
+--ro log-result
+--ro (attested_event_log_type)
+--:(bios) {bios}?
| +--ro bios-event-logs
| | +--ro bios-event-entry* [event-number]
| | | +--ro event-number        uint32
| | | +--ro event-type?         uint32
| | | +--ro pcr-index?          pcr
| | | +--ro digest-list* []
| | | | +--ro hash-algo?        identityref
| | | | +--ro digest*           binary
| | | +--ro event-size?         uint32
| | | +--ro event-data*         uint8
+--:(ima) {ima}?
| +--ro ima-event-logs
| | +--ro ima-event-entry* [event-number]
| | | +--ro event-number        uint64
| | | +--ro ima-template?       string
| | | +--ro filename-hint?      string
| | | +--ro filedata-hash?      binary
| | | +--ro filedata-hash-algorithm? string
| | | +--ro template-hash-algorithm? string
| | | +--ro template-hash?      binary
| | | +--ro pcr-index?          pcr
| | | +--ro signature?          binary
+--:(netequip_boot) {netequip_boot}?
+--ro boot-event-logs
+--ro boot-event-entry* [event-number]
+--ro event-number            uint64
+--ro ima-template?           string
+--ro filename-hint?          string
+--ro filedata-hash?          binary
+--ro filedata-hash-algorithm? string
+--ro template-hash-algorithm? string
+--ro template-hash?          binary
+--ro pcr-index?              pcr
+--ro signature?              binary

```

### 2.1.1.5. Data Nodes

This section provides a high level description of the data nodes containing the configuration and operational objects with the YANG model. For more details, please see the YANG model itself in [Figure 1](#).

**Container 'rats-support-structures':** This houses the set of information relating to a device's TPM(s).

**Container 'tpms':** Provides configuration and operational details for each supported TPM, including the tpm-firmware-version, PCRs which may be quoted, certificates which are associated with that TPM, and the current operational status. Of note are the certificates which are associated with that TPM. As a certificate is associated with a particular TPM attestation key, knowledge of the certificate allows a specific TPM to be identified.

```
+--rw tpms
  +--rw tpm* [name]
    +--rw name                string
    +--ro hardware-based?    boolean
    +--ro physical-index?    int32 {ietfhw:entity-mib}?
    +--ro path?              string
    +--ro compute-node       compute-node-ref {tpm:tpms}?
    +--ro manufacturer?      string
    +--rw firmware-version   identityref
    +--rw tpm12-hash-algo?   identityref
    +--rw tpm12-pcrs*        pcr
    +--rw tpm20-pcr-bank* [tpm20-hash-algo]
      | +--rw tpm20-hash-algo identityref
      | +--rw pcr-index*      tpm:pcr
    +--ro status              enumeration
    +--rw certificates
      +--rw certificate* [name]
        +--rw name            string
        +--rw keystore-ref?   leafref
        +--rw type?           enumeration
```

container 'attester-supported-algos' - Identifies which TCG hash algorithms are available for use on the Attesting platform. This allows an operator to limit algorithms available for use by RPCs to just a desired set from the universe of all allowed hash algorithms by the TCG.

```
+--rw attester-supported-algos
  +--rw tpm12-asymmetric-signing* identityref
  +--rw tpm12-hash*               identityref
  +--rw tpm20-asymmetric-signing* identityref
  +--rw tpm20-hash*               identityref
```

container 'compute-nodes' - When there is more than one TPM supported, this container maintains the set of information related

to the compute node associated with a specific TPM. This allows each specific TPM to identify to which 'compute-node' it belongs.

```
+--rw compute-nodes {tpm:TPMs}?  
  +--ro compute-node* [node-id]  
    +--ro node-id                string  
    +--ro node-physical-index?   int32 {ietfhw:entity-mib}?  
    +--ro node-name?             string  
    +--ro node-location?         string
```



#### 2.1.1.6. YANG Module

```

<CODE BEGINS> file "ietf-tpm-remote-attestation@2021-05-11.yang"
module ietf-tpm-remote-attestation {
  namespace "urn:ietf:params:xml:ns:yang:ietf-tpm-remote-attestation";
  prefix tpm;

  import ietf-yang-types {
    prefix yang;
  }
  import ietf-hardware {
    prefix ietfhw;
  }
  import ietf-keystore {
    prefix ks;
  }
  import ietf-tcg-algs {
    prefix taa;
  }

  organization
    "IETF RATS (Remote ATtestation procedures) Working Group";
  contact
    "WG Web : <http://datatracker.ietf.org/wg/rats/>
    WG List : <mailto:rats@ietf.org>
    Author : Eric Voit <evoit@cisco.com>
    Author : Henk Birkholz <henk.birkholz@sit.fraunhofer.de>
    Author : Michael Eckel <michael.eckel@sit.fraunhofer.de>
    Author : Shwetha Bhandari <shwetha.bhandari@thoughtspot.com>
    Author : Bill Sulzen <bsulzen@cisco.com>
    Author : Liang Xia (Frank) <frank.xialiang@huawei.com>
    Author : Tom Laffey <tom.laffey@hpe.com>
    Author : Guy Fedorkow <gfedorkow@juniper.net>";
  description
    "A YANG module to enable a TPM 1.2 and TPM 2.0 based
    remote attestation procedure using a challenge-response
    interaction model and the TPM 1.2 and TPM 2.0 Quote
    primitive operations.
    Copyright (c) 2021 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
    (https://trustee.ietf.org/license-info).
    This version of this YANG module is part of RFC XXXX
    (https://www.rfc-editor.org/info/rfcXXXX); see the RFC
    itself for full legal notices.

    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 (RFC 2119)
    (RFC 8174) when, and only when, they appear in all
    capitals, as shown here.";

  revision 2021-08-11 {
    description
      "Initial version";
  }
}

```

```

    reference
        "draft-ietf-rats-yang-tpm-charra";
}

/*****/
/*   Features   */
/*****/

feature tpms {
    description
        "The device supports the remote attestation of multiple
        TPM based cryptoprocessors.";
}

feature bios {
    description
        "The device supports the bios logs.";
    reference
        "https://trustedcomputinggroup.org/wp-content/uploads/
        PC-ClientSpecific_Platform_Profile_for_TPM_2p0_Systems_v51.pdf
        Section 9.4.5.2";
}

feature ima {
    description
        "The device supports Integrity Measurement Architecture logs.";
    reference
        "https://www.trustedcomputinggroup.org/wp-content/uploads/
        TCG_IWG_CEL_v1_r0p30_13feb2021.pdf Section 4.3";
}

feature netequip_boot {
    description
        "The device supports the netequip_boot logs.";
}

/*****/
/*   Typedefs   */
/*****/

typedef pcr {
    type uint8 {
        range "0..31";
    }
    description
        "Valid index number for a PCR. At this point 0-31 is viable.";
}

typedef compute-node-ref {
    type leafref {
        path "/tpm:rats-support-structures/tpm:compute-nodes"
            + "/tpm:compute-node/tpm:node-name";
    }
    description
        "This type is used to reference a hardware node. It is quite
        possible this leafref will eventually point to another YANG
        module's node.";
}

```

```

typedef certificate-name-ref {
    type leafref {
        path "/tpm:rats-support-structures/tpm:tpms/tpm:tpm"
            + "/tpm:certificates/tpm:certificate/tpm:name";
    }
    description
        "A type which allows identification of a TPM based certificate.";
}

/*****/
/*  Identities  */
/*****/

identity attested_event_log_type {
    description
        "Base identity allowing categorization of the reasons why and
        attested measurement has been taken on an Attester.";
}

identity ima {
    base attested_event_log_type;
    description
        "An event type recorded in IMA.";
}

identity bios {
    base attested_event_log_type;
    description
        "An event type associated with BIOS/UEFI.";
}

identity netequip_boot {
    base attested_event_log_type;
    description
        "An event type associated with Network Equipment Boot.";
}

/*****/
/*  Groupings  */
/*****/

grouping tpm20-hash-algo {
    description
        "The cryptographic algorithm used to hash the TPM2 PCRs. This
        must be from the list of platform supported options.";
    leaf tpm20-hash-algo {
        type identityref {
            base taa:hash;
        }
        must '/tpm:rats-support-structures/tpm:attester-supported-algos'
            + '/tpm:tpm20-hash' {
            error-message "This platform does not support tpm20-hash-algo";
        }
        default "taa:TPM_ALG_SHA256";
    }
    description
        "The hash scheme that is used to hash a TPM1.2 PCR. This
        must be one of those supported by a platform.";
}

```

```

    }
}

grouping tpm12-hash-algo {
  description
    "The cryptographic algorithm used to hash the TPM1.2 PCRs.";
  leaf tpm12-hash-algo {
    type identityref {
      base taa:hash;
    }
    must '/tpm:rats-support-structures/tpm:attester-supported-algos'
      + '/tpm:tpm12-hash' {
      error-message "This platform does not support tpm12-hash-algo";
    }
    default "taa:TPM_ALG_SHA1";
    description
      "The hash scheme that is used to hash a TPM1.2 PCR. This
      MUST be one of those supported by a platform. This assumes
      that an algorithm other than SHA1 can be supported on some
      TPM1.2 cryptoprocessor variant.";
  }
}

```

```

grouping nonce {
  description
    "A random number intended to be used once to show freshness
    and to allow the detection of replay attacks.";
  leaf nonce-value {
    type binary;
    mandatory true;
    description
      "A cryptographically generated random number which should
      not be predictable prior to its issuance from a random
      number generation function. The random number MUST be
      derived from an entropy source external to the Attester.";
  }
}

```

```

grouping tpm12-pcr-selection {
  description
    "A Verifier can request one or more PCR values using its
    individually created Attestation Key Certificate (AC).
    The corresponding selection filter is represented in this
    grouping.
    Requesting a PCR value that is not in scope of the AC used,
    detailed exposure via error msg should be avoided.";
  leaf-list pcr-index {
    type pcr;
    description
      "The numbers/indexes of the PCRs. At the moment this is limited
      to 32. In addition, any selection of PCRs MUST verify that
      the set of PCRs requested are a subset the set of PCRs
      exposed by in the leaf-list /tpm:rats-support-structures
      /tpm:tpms/tpm:tpm[name=current()]/tpm:tpm12-pcrs";
  }
}

```

```

grouping tpm20-pcr-selection {

```

```

description
  "A Verifier can acquire one or more PCR values, which are hashed
  together in a TPM2B_DIGEST coming from the TPM2. The selection
  list of desired PCRs and the Hash Algorithm is represented in
  this grouping.";
list tpm20-pcr-selection {
  unique "tpm20-hash-algo";
  description
    "Specifies the list of PCRs and Hash Algorithms that can be
    returned within a TPM2B_DIGEST.";
  reference
    "https://www.trustedcomputinggroup.org/wp-content/uploads/
    TPM-Rev-2.0-Part-2-Structures-01.38.pdf Section 10.9.7";
  uses tpm20-hash-algo;
  leaf-list pcr-index {
    type pcr;
    must '/tpm:rats-support-structures/tpm:tpms'
      + '/tpm:tpm[name = current()] and '
      + '/tpm:rats-support-structures/tpm:tpms/tpm:tpm'
      + '/tpm:tpm20-pcr-bank[pcr-index = current()]' {
      error-message "Acquiring this PCR index is not supported";
    }
    description
      "The numbers of the PCRs that which are being tracked
      with a hash based on the tpm20-hash-algo. In addition,
      any selection of PCRs MUST verify that the set of PCRs
      requested are a subset the set of PCR indexes exposed
      within /tpm:rats-support-structures/tpm:tpms
      /tpm:tpm[name=current()]/tpm:tpm20-pcr-bank
      /tpm:pcr-index";
  }
}
}

grouping certificate-name-ref {
  description
    "Identifies a certificate in a keystore.";
  leaf certificate-name {
    type certificate-name-ref;
    mandatory true;
    description
      "Identifies a certificate in a keystore.";
  }
}

grouping tpm-name {
  description
    "A unique TPM on a device.";
  leaf name {
    type string;
    description
      "Unique system generated name for a TPM on a device.";
  }
}

grouping tpm-name-selector {
  description
    "One or more TPM on a device.";
}

```

```

leaf-list name {
  type string;
  config false;
  description
    "Name of one or more unique TPMs on a device. If this object
    exists, a selection should pull only the objects related to
    these TPM(s). If it does not exist, all qualifying TPMs that
    are 'hardware-based' equals true on the device are selected.";
}
}

grouping node-uptime {
  description
    "Uptime in seconds of the node.";
  leaf up-time {
    type uint32;
    description
      "Uptime in seconds of this node reporting its data";
  }
}

grouping tpm12-attestation {
  description
    "Contains an instance of TPM1.2 style signed cryptoprocessor
    measurements. It is supplemented by unsigned Attester
    information.";
  uses node-uptime;
  leaf TPM_QUOTE2 {
    type binary;
    description
      "Result of a TPM1.2 Quote2 operation. This includes PCRs,
      signatures, locality, the provided nonce and other data which
      can be further parsed to appraise the Attester.";
    reference
      "TPM1.2 commands rev116 July 2007, Section 16.5";
  }
}

grouping tpm20-attestation {
  description
    "Contains an instance of TPM2 style signed cryptoprocessor
    measurements. It is supplemented by unsigned Attester
    information.";
  leaf TPMS_QUOTE_INFO {
    type binary;
    mandatory true;
    description
      "A hash of the latest PCR values (and the hash algorithm used)
      which have been returned from a Verifier for the selected PCRs
      and Hash Algorithms.";
    reference
      "https://www.trustedcomputinggroup.org/wp-content/uploads/
      TPM-Rev-2.0-Part-2-Structures-01.38.pdf Section 10.12.1";
  }
  leaf quote-signature {
    type binary;
    description
      "Quote signature returned by TPM Quote. The signature was

```

```

        generated using the key associated with the
        certificate 'name.'";
    reference
        "https://www.trustedcomputinggroup.org/wp-content/uploads/
        TPM-Rev-2.0-Part-2-Structures-01.38.pdf Section 11.2.1";
}
uses node-uptime;
list unsigned-pcr-values {
    description
        "PCR values in each PCR bank. This might appear redundant with
        the TPM2B_DIGEST, but that digest is calculated across multiple
        PCRs. Having to verify across multiple PCRs does not
        necessarily make it easy for a Verifier to appraise just the
        minimum set of PCR information which has changed since the last
        received TPM2B_DIGEST. Put another way, why should a Verifier
        reconstruct the proper value of all PCR Quotes when only a
        single PCR has changed?
        To help this happen, if the Attester does know specific PCR
        values, the Attester can provide these individual values via
        'unsigned-pcr-values'. By comparing this information to the
        what has previously been validated, it is possible for a
        Verifier to confirm the Attester's signature while eliminating
        significant processing.";
    uses tpm20-hash-algo;
    list pcr-values {
        key "pcr-index";
        description
            "List of one PCR bank.";
        leaf pcr-index {
            type pcr;
            description
                "PCR index number.";
        }
        leaf pcr-value {
            type binary;
            description
                "PCR value.";
            reference
                "https://www.trustedcomputinggroup.org/wp-content/uploads/
                TPM-Rev-2.0-Part-2-Structures-01.38.pdf Section 10.9.7";
        }
    }
}
}

grouping log-identifier {
    description
        "Identifier for type of log to be retrieved.";
    leaf log-type {
        type identityref {
            base attested_event_log_type;
        }
        mandatory true;
        description
            "The corresponding measurement log type identity.";
    }
}
grouping boot-event-log {

```



```

description
  "Defines an event log corresponding to the event that extended
  the PCR";
leaf event-number {
  type uint32;
  description
    "Unique event number of this event";
}
leaf event-type {
  type uint32;
  description
    "log event type";
}
leaf pcr-index {
  type pcr;
  description
    "Defines the PCR index that this event extended";
}
list digest-list {
  description
    "Hash of event data";
  leaf hash-algo {
    type identityref {
      base taa:hash;
    }
    description
      "The hash scheme that is used to compress the event data in
      each of the leaf-list digest items.";
  }
  leaf-list digest {
    type binary;
    description
      "The hash of the event data using the algorithm of the
      'hash-algo' against 'event data'.";
  }
}
leaf event-size {
  type uint32;
  description
    "Size of the event data";
}
leaf-list event-data {
  type uint8;
  description
    "The event data size determined by event-size";
}
}
grouping bios-event-log {
  description
    "Measurement log created by the BIOS/UEFI.";
  list bios-event-entry {
    key event-number;
    description
      "Ordered list of TCG described event log
      that extended the PCRs in the order they
      were logged";
    uses boot-event-log;
  }
}

```

```

}
grouping ima-event {
  description
    "Defines an hash log extend event for IMA measurements";
  reference
    "https://www.trustedcomputinggroup.org/wp-content/uploads/
    TCG_IWG_CEL_v1_r0p30_13feb2021.pdf Section 4.3";
  leaf event-number {
    type uint64;
    description
      "Unique number for this event for sequencing";
  }
  leaf ima-template {
    type string;
    description
      "Name of the template used for event logs
      for e.g. ima, ima-ng, ima-sig";
  }
  leaf filename-hint {
    type string;
    description
      "File that was measured";
  }
  leaf filedata-hash {
    type binary;
    description
      "Hash of filedata";
  }
  leaf filedata-hash-algorithm {
    type string;
    description
      "Algorithm used for filedata-hash";
  }
  leaf template-hash-algorithm {
    type string;
    description
      "Algorithm used for template-hash";
  }
  leaf template-hash {
    type binary;
    description
      "hash(filedata-hash, filename-hint)";
  }
  leaf pcr-index {
    type pcr;
    description
      "Defines the PCR index that this event extended";
  }
  leaf signature {
    type binary;
    description
      "The file signature";
  }
}
grouping ima-event-log {
  description
    "Measurement log created by IMA.";
  list ima-event-entry {

```

```

    key event-number;
    description
    "Ordered list of ima event logs by event-number";
    uses ima-event;
}
}

grouping network-equipment-boot-event-log {
    description
    "Measurement log created by Network Equipment Boot. The Network
    Equipment Boot format is identical to the IMA format. In
    contrast to the IMA log, the Network Equipment Boot log
    includes every measurable event from an Attester, including
    the boot stages of BIOS, Bootloader, etc. In essence, the scope
    of events represented in this format combines the scope of BIOS
    events and IMA events.";
    list boot-event-entry {
        key event-number;
        description
        "Ordered list of Network Equipment Boot event logs
        by event-number, using the IMA event format.";
        uses ima-event;
    }
}

grouping event-logs {
    description
    "A selector for the log and its type.";
    choice attested_event_log_type {
        mandatory true;
        description
        "Event log type determines the event logs content.";
        case bios {
            if-feature "bios";
            description
            "BIOS/UEFI event logs";
            container bios-event-logs {
                description
                "BIOS/UEFI event logs";
                uses bios-event-log;
            }
        }
        case ima {
            if-feature "ima";
            description
            "IMA event logs.";
            container ima-event-logs {
                description
                "IMA event logs.";
                uses ima-event-log;
            }
        }
        case netequip_boot {
            if-feature "netequip_boot";
            description
            "Network Equipment Boot event logs";
            container boot-event-logs {
                description
                "Network equipment boot event logs.";
            }
        }
    }
}

```

```

        uses network-equipment-boot-event-log;
    }
}
}

/*****/
/*  RPC operations  */
/*****/

rpc tpm12-challenge-response-attestation {
    if-feature "taa:tpm12";
    description
        "This RPC accepts the input for TSS TPM 1.2 commands made to the
        attesting device.";
    input {
        container tpm12-attestation-challenge {
            description
                "This container includes every information element defined
                in the reference challenge-response interaction model for
                remote attestation. Corresponding values are based on
                TPM 1.2 structure definitions";
            uses tpm12-pcr-selection;
            uses nonce;
            leaf-list certificate-name {
                if-feature "tpm:tpms";
                type certificate-name-ref;
                must "/tpm:rats-support-structures/tpm:tpms"
                    + "/tpm:tpm[tpm:firmware-version='taa:tpm12']"
                    + "/tpm:certificates/"
                    + "/tpm:certificate[name=current()]" {
                    error-message "Not an available TPM1.2 AIK certificate.";
                }
            }
            description
                "When populated, the RPC will only get a Quote for the
                TPMs associated with these certificate(s).";
        }
    }
}
output {
    list tpm12-attestation-response {
        unique "certificate-name";
        description
            "The binary output of TPM 1.2 TPM_Quote/TPM_Quote2, including
            the PCR selection and other associated attestation evidence
            metadata";
        uses certificate-name-ref {
            description
                "Certificate associated with this tpm12-attestation.";
        }
        uses tpm12-attestation;
    }
}
}

rpc tpm20-challenge-response-attestation {
    if-feature "taa:tpm20";
    description

```

```

    "This RPC accepts the input for TSS TPM 2.0 commands of the
    managed device. ComponentIndex from the hardware manager YANG
    module to refer to dedicated TPM in composite devices,
    e.g. smart NICs, is still a TODO.";
input {
  container tpm20-attestation-challenge {
    description
      "This container includes every information element defined
      in the reference challenge-response interaction model for
      remote attestation. Corresponding values are based on
      TPM 2.0 structure definitions";
    uses nonce;
    uses tpm20-pcr-selection;
    leaf-list certificate-name {
      if-feature "tpm:tpms";
      type certificate-name-ref;
      must "/tpm:rats-support-structures/tpm:tpms"
        + "/tpm:tpm[tpm:firmware-version='taa:tpm20']"
        + "/tpm:certificates/"
        + "/tpm:certificate[name=current()]" {
        error-message "Not an available TPM2.0 AIK certificate.";
      }
    }
    description
      "When populated, the RPC will only get a Quote for the
      TPMs associated with the certificates.";
  }
}
}
output {
  list tpm20-attestation-response {
    unique "certificate-name";
    description
      "The binary output of TPM2b_Quote in one TPM chip of the
      node which identified by node-id. An TPMS_ATTEST structure
      including a length, encapsulated in a signature";
    uses certificate-name-ref {
      description
        "Certificate associated with this tpm20-attestation.";
    }
    uses tpm20-attestation;
  }
}
}
rpc log-retrieval {
  description
    "Logs Entries are either identified via indices or via providing
    the last line received. The number of lines returned can be
    limited. The type of log is a choice that can be augmented.";
  input {
    list log-selector {
      description
        "Selection of log entries to be reported.";
      uses tpm-name-selector;
      choice index-type {
        description
          "Last log entry received, log index number, or timestamp.";
        case last-entry {

```

```

description
  "The last entry of the log already retrieved.";
leaf last-entry-value {
  type binary;
  description
    "Content of an log event which matches 1:1 with a
    unique event record contained within the log. Log
    entries subsequent to this will be passed to the
    requester. Note: if log entry values are not unique,
    this MUST return an error.";
}
}
case index {
  description
    "Numeric index of the last log entry retrieved, or
    zero.";
  leaf last-index-number {
    type uint64;
    description
      "The last numeric index number of a log entry.
      Zero means to start at the beginning of the log.
      Entries subsequent to this will be passed to the
      requester.";
  }
}
case timestamp {
  leaf timestamp {
    type yang:date-and-time;
    description
      "Timestamp from which to start the extraction. The
      next log entry subsequent to this timestamp is to
      be sent.";
  }
  description
    "Timestamp from which to start the extraction.";
}
}
leaf log-entry-quantity {
  type uint16;
  description
    "The number of log entries to be returned. If omitted, it
    means all of them.";
}
}
uses log-identifier;
}
output {
  container system-event-logs {
    description
      "The requested data of the measurement event logs";
    list node-data {
      unique "name";
      description
        "Event logs of a node in a distributed system
        identified by the node name";
      uses tpm-name;
      uses node-uptime;
      container log-result {

```

```

        description
            "The requested entries of the corresponding log.";
        uses event-logs;
    }
}
}
}

/*****/
/*  Config & Oper accessible nodes  */
/*****/

container rats-support-structures {
    description
        "The datastore definition enabling verifiers or relying
        parties to discover the information necessary to use the
        remote attestation RPCs appropriately.";
    container compute-nodes {
        if-feature "tpm:tpms";
        description
            "Holds the set device subsystems/components in this composite
            device that support TPM operations.";
        list compute-node {
            key "node-id";
            config false;
            min-elements 2;
            description
                "A component within this composite device which
                supports TPM operations.";
            leaf node-id {
                type string;
                description
                    "ID of the compute node, such as Board Serial Number.";
            }
            leaf node-physical-index {
                if-feature "ietfhw:entity-mib";
                type int32 {
                    range "1..2147483647";
                }
                config false;
                description
                    "The entPhysicalIndex for the compute node.";
                reference
                    "RFC 6933: Entity MIB (Version 4) - entPhysicalIndex";
            }
            leaf node-name {
                type string;
                description
                    "Name of the compute node.";
            }
            leaf node-location {
                type string;
                description
                    "Location of the compute node, such as slot number.";
            }
        }
    }
}
}

```

```

container tpms {
  description
    "Holds the set of TPMs within an Attester.";
  list tpm {
    key "name";
    unique "path";
    description
      "A list of TPMs in this composite device that RATS
        can be conducted with.";
    uses tpm-name;
    leaf hardware-based {
      type boolean;
      config false;
      description
        "Answers the question: is this TPM is a hardware based
          TPM?";
    }
    leaf physical-index {
      if-feature "ietfhw:entity-mib";
      type int32 {
        range "1..2147483647";
      }
      config false;
      description
        "The entPhysicalIndex for the TPM.";
      reference
        "RFC 6933: Entity MIB (Version 4) - entPhysicalIndex";
    }
    leaf path {
      type string;
      config false;
      description
        "Path to a unique TPM on a device. This can change across
          reboots.";
    }
    leaf compute-node {
      if-feature "tpm:tpms";
      type compute-node-ref;
      config false;
      mandatory true;
      description
        "Indicates the compute node measured by this TPM.";
    }
    leaf manufacturer {
      type string;
      config false;
      description
        "TPM manufacturer name.";
    }
    leaf firmware-version {
      type identityref {
        base taa:cryptoprocessor;
      }
      mandatory true;
      description
        "Identifies the cryptoprocessor API set supported. This
          is automatically configured by the device and should not
          be changed.";
    }
  }
}

```



```

}
uses tpm12-hash-algo {
  when "firmware-version = 'taa:tpm12'";
  refine "tpm12-hash-algo" {
    description
      "The hash algorithm overwrites the default used for PCRs
      on this TPM1.2 compliant cryptoprocessor.";
  }
}
leaf-list tpm12-pcrs {
  when "../firmware-version = 'taa:tpm12'";
  type pcr;
  description
    "The PCRs which may be extracted from this TPM1.2
    compliant cryptoprocessor.";
}
list tpm20-pcr-bank {
  when "../firmware-version = 'taa:tpm20'";
  key "tpm20-hash-algo";
  description
    "Specifies the list of PCRs that may be extracted for
    a specific Hash Algorithm on this TPM2 compliant
    cryptoprocessor. A bank is a set of PCRs which are
    extended using a particular hash algorithm.";
  reference
    "https://www.trustedcomputinggroup.org/wp-content/uploads/
    TPM-Rev-2.0-Part-2-Structures-01.38.pdf Section 10.9.7";
  leaf tpm20-hash-algo {
    type identityref {
      base taa:hash;
    }
    must '/tpm:rats-support-structures'
      + '/tpm:attester-supported-algos'
      + '/tpm:tpm20-hash' {
      error-message
        "This platform does not support tpm20-hash-algo";
    }
    description
      "The hash scheme actively being used to hash a
      one or more TPM2.0 PCRs.";
  }
  leaf-list pcr-index {
    type tpm:pcr;
    description
      "Defines what TPM2 PCRs are available to be extracted.";
  }
}
leaf status {
  type enumeration {
    enum operational {
      value 0;
      description
        "The TPM currently is currently running normally and
        is ready to accept and process TPM quotes.";
      reference
        "TPM-Rev-2.0-Part-1-Architecture-01.07-2014-03-13.pdf
        Section 12";
    }
  }
}

```

```

enum non-operational {
    value 1;
    description
        "TPM is in a state such as startup or shutdown which
        precludes the processing of TPM quotes.";
}
}
config false;
mandatory true;
description
    "TPM chip self-test status.";
}
container certificates {
    description
        "The TPM's certificates, including EK certificates
        and AK certificates.";
    list certificate {
        key "name";
        description
            "Three types of certificates can be accessed via
            this statement, including Initial Attestation
            Key Certificate, Local Attestation Key Certificate or
            Endorsement Key Certificate.";
        leaf name {
            type string;
            description
                "An arbitrary name uniquely identifying a certificate
                associated within key within a TPM.";
        }
        leaf keystore-ref {
            type leafref {
                path "/ks:keystore/ks:asymmetric-keys/ks:asymmetric-key"
                    + "/ks:certificates/ks:certificate/ks:name";
            }
            description
                "A reference to a specific certificate of an
                asymmetric key in the Keystore.";
        }
        leaf type {
            type enumeration {
                enum endorsement-certificate {
                    value 0;
                    description
                        "Endorsement Key (EK) Certificate type.";
                    reference
                        "https://trustedcomputinggroup.org/wp-content/
                        uploads/TCG_IWG_DevID_v1r2_02dec2020.pdf
                        Section 3.11";
                }
                enum initial-attestation-certificate {
                    value 1;
                    description
                        "Initial Attestation key (IAK) Certificate type.";
                    reference
                        "https://trustedcomputinggroup.org/wp-content/
                        uploads/TCG_IWG_DevID_v1r2_02dec2020.pdf
                        Section 3.2";
                }
            }
        }
    }
}

```



```
}
}
}
<CODE ENDS>
```

Figure 1

### 2.1.2.2. 'ietf-tcg-algs'

Cryptographic algorithm types were initially included within -v14 NETCONF's iana-crypto-types.yang. Unfortunately, all this content including the algorithms needed here failed to make the -v15 used WGLC. As a result, this document has encoded the TCG Algorithm definitions of [[TCG-Algos](#)], revision 1.32. By including this full table as a separate YANG file within this document, it is possible for other YANG models to leverage the contents of this model.

#### 2.1.2.2.1. Features

There are two types of features supported: 'TPM12' and 'TPM20'. Support for either of these features indicates that a cryptoprocessor supporting the corresponding type of TCG TPM API is present on an Attester. Most commonly, only one type of cryptoprocessor will be available on an Attester.

#### 2.1.2.2.2. Identities

There are three types of identities in this model:

1. **Cryptographic functions** supported by a TPM algorithm; these include: 'asymmetric', 'symmetric', 'hash', 'signing', 'anonymous\_signing', 'encryption\_mode', 'method', and 'object\_type'. The definitions of each of these are in Table 2 of [[TCG-Algos](#)].
2. **API specifications** for TPMs: 'tpm12' and 'tpm20'
3. **Specific algorithm types**: Each algorithm type defines what cryptographic functions may be supported, and on which type of API specification. It is not required that an implementation of a specific TPM will support all algorithm types. The contents of each specific algorithm mirrors what is in Table 3 of [[TCG-Algos](#)].

### 2.1.2.3. YANG Module

```

<CODE BEGINS> file "ietf-tcg-algs@2021-05-11.yang"
module ietf-tcg-algs {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-tcg-algs";
  prefix taa;

  organization
    "IETF RATS Working Group";

  contact
    "WG Web: <http://datatracker.ietf.org/wg/rats/>
    WG List: <mailto:rats@ietf.org>
    Author: Eric Voit <mailto:evoit@cisco.com>";

  description
    "This module defines a identities for asymmetric algorithms.

    Copyright (c) 2021 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
    (https://trustee.ietf.org/license-info).
    This version of this YANG module is part of RFC XXXX
    (https://www.rfc-editor.org/info/rfcXXXX); see the RFC
    itself for full legal notices.
    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 (RFC 2119)
    (RFC 8174) when, and only when, they appear in all
    capitals, as shown here.";

  revision 2021-05-11 {
    description
      "Initial version";
    reference
      "RFC XXXX: tbd";
  }

  /*****
  /* Features */
  /*****/

  feature tpm12 {
    description
      "This feature indicates algorithm support for the TPM 1.2 API
      as per TPM-main-1.2-Rev94-part-2, Section 4.8.";
  }

  feature tpm20 {
    description
      "This feature indicates algorithm support for the TPM 2.0 API
      as per TPM-Rev-2.0-Part-1-Architecture-01.38 Section 11.4.";
  }

```

```
/*
*****
/* Identities */
*****
/* There needs to be collasping/verification of some of the identity
types between the various algorithm types listed below */

identity asymmetric {
  description
    "A TCG recognized asymmetric algorithm with a public and
    private key.";
  reference
    "http://trustedcomputinggroup.org/resource/tcg-algorithm-registry/
    TCG_Algorithm_Registry_r1p32_pub Table 2";
}

identity symmetric {
  description
    "A TCG recognized symmetric algorithm with only a private key.";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 2";
}

identity hash {
  description
    "A TCG recognized hash algorithm that compresses input data to
    a digest value or indicates a method that uses a hash.";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 2";
}

identity signing {
  description
    "A TCG recognized signing algorithm";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 2";
}

identity anonymous_signing {
  description
    "A TCG recognized anonymous signing algorithm.";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 2";
}

identity encryption_mode {
  description
    "A TCG recognized encryption mode.";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 2";
}

identity method {
  description
    "A TCG recognized method such as a mask generation function.";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 2";
}
```

```

}

identity object_type {
  description
    "A TCG recognized object type.";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 2";
}

identity cryptoprocessor {
  description
    "Base identity identifying a cryptoprocessor.";
}

identity tpm12 {
  if-feature "tpm12";
  base cryptoprocessor;
  description
    "Supportable by a TPM1.2.";
  reference
    "TPM-Main-Part-2-TPM-Structures_v1.2_rev116_01032011.pdf
    TPM_ALGORITHM_ID values, page 18";
}

identity tpm20 {
  if-feature "tpm12";
  base cryptoprocessor;
  description
    "Supportable by a TPM2.";
  reference
    "TPM-Rev-2.0-Part-2-Structures-01.38.pdf
    The TCG Algorithm Registry. Table 9";
}

identity TPM_ALG_RSA {
  if-feature "tpm12 or tpm20";
  base tpm12;
  base tpm20;
  base asymmetric;
  base object_type;
  description
    "RSA algorithm";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    RFC 8017. ALG_ID: 0x0001";
}

identity TPM_ALG_TDES {
  if-feature "tpm12";
  base tpm12;
  base symmetric;
  description
    "Block cipher with various key sizes (Triple Data Encryption
    Algorithm, commonly called Triple Data Encryption Standard)
    Note: was banned in TPM1.2 v94";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    ISO/IEC 18033-3. ALG_ID: 0x0003";
}

```



```

}

identity TPM_ALG_SHA1 {
  if-feature "tpm12 or tpm20";
  base hash;
  base tpm12;
  base tpm20;
  description
    "SHA1 algorithm - Deprecated due to insufficient cryptographic
    protection. However it is still useful for hash algorithms
    where protection is not required.";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    ISO/IEC 10118-3. ALG_ID: 0x0004";
}

identity TPM_ALG_HMAC {
  if-feature "tpm12 or tpm20";
  base tpm12;
  base tpm20;
  base hash;
  base signing;
  description
    "Hash Message Authentication Code (HMAC) algorithm";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3,
    ISO/IEC 9797-2 and RFC2014. ALG_ID: 0x0005";
}

identity TPM_ALG_AES {
  if-feature "tpm12";
  base tpm12;
  base symmetric;
  description
    "The AES algorithm with various key sizes";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    ISO/IEC 18033-3. ALG_ID: 0x0006";
}

identity TPM_ALG_MGF1 {
  if-feature "tpm20";
  base tpm20;
  base hash;
  base method;
  description
    "hash-based mask-generation function";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3,
    IEEE Std 1363-2000 and IEEE Std 1363a -2004.
    ALG_ID: 0x0007";
}

identity TPM_ALG_KEYEDHASH {
  if-feature "tpm20";
  base tpm20;
  base hash;
  base object_type;
}

```

```

description
    "An encryption or signing algorithm using a keyed hash. These
    may use XOR for encryption or an HMAC for signing and may
    also refer to a data object that is neither signing nor
    encrypting.";
reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    TCG TPM 2.0 library specification. . ALG_ID: 0x0008";
}

identity TPM_ALG_XOR {
    if-feature "tpm12 or tpm20";
    base tpm12;
    base tpm20;
    base hash;
    base symmetric;
    description
        "The XOR encryption algorithm.";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        TCG TPM 2.0 library specification. ALG_ID: 0x000A";
}

identity TPM_ALG_SHA256 {
    if-feature "tpm20";
    base tpm20;
    base hash;
    description
        "The SHA 256 algorithm";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        ISO/IEC 10118-3. ALG_ID: 0x000B";
}

identity TPM_ALG_SHA384 {
    if-feature "tpm20";
    base tpm20;
    base hash;
    description
        "The SHA 384 algorithm";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        ISO/IEC 10118-3. ALG_ID: 0x000C";
}

identity TPM_ALG_SHA512 {
    if-feature "tpm20";
    base tpm20;
    base hash;
    description
        "The SHA 512 algorithm";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        ISO/IEC 10118-3. ALG_ID: 0x000D";
}

identity TPM_ALG_NULL {
    if-feature "tpm20";

```

```

    base tpm20;
    description
        "NULL algorithm";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        TCG TPM 2.0 library specification. ALG_ID: 0x0010";
}

identity TPM_ALG_SM3_256 {
    if-feature "tpm20";
    base tpm20;
    base hash;
    description
        "The SM3 hash algorithm.";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        GM/T 0004-2012 - SM3_256. ALG_ID: 0x0012";
}

identity TPM_ALG_SM4 {
    if-feature "tpm20";
    base tpm20;
    base symmetric;
    description
        "SM4 symmetric block cipher";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        GB/T 32907-2016. ALG_ID: 0x0013";
}

identity TPM_ALG_RSASSA {
    if-feature "tpm20";
    base tpm20;
    base asymmetric;
    base signing;
    description
        "Signature algorithm defined in section 8.2 (RSASSAPKCS1-v1_5)";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and RFC 8017.
        ALG_ID: 0x0014";
}

identity TPM_ALG_RSAES {
    if-feature "tpm20";
    base tpm20;
    base asymmetric;
    base encryption_mode;
    description
        "Signature algorithm defined in section 7.2 (RSAES-PKCS1-v1_5)";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and RFC 8017
        ALG_ID: 0x0015";
}

identity TPM_ALG_RSAPSS {
    if-feature "tpm20";
    base tpm20;
    base asymmetric;

```

```

    base signing;
    description
        "Padding algorithm defined in section 8.1 (RSASSA PSS)";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and RFC 8017.
        ALG_ID: 0x0016";
}

identity TPM_ALG_OAEP {
    if-feature "tpm20";
    base tpm20;
    base asymmetric;
    base encryption_mode;
    description
        "Padding algorithm defined in section 7.1 (RSASSA OAEP)";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and RFC 8017.
        ALG_ID: 0x0017";
}

identity TPM_ALG_ECDSA {
    if-feature "tpm20";
    base tpm20;
    base asymmetric;
    base signing;
    description
        "Signature algorithm using elliptic curve cryptography (ECC)";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        ISO/IEC 14888-3. ALG_ID: 0x0018";
}

identity TPM_ALG_ECDH {
    if-feature "tpm20";
    base tpm20;
    base asymmetric;
    base method;
    description
        "Secret sharing using ECC";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        NIST SP800-56A and RFC 7748. ALG_ID: 0x0019";
}

identity TPM_ALG_ECDAAs {
    if-feature "tpm20";
    base tpm20;
    base asymmetric;
    base signing;
    base anonymous_signing;
    description
        "Elliptic-curve based anonymous signing scheme";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        TCG TPM 2.0 library specification. ALG_ID: 0x001A";
}

identity TPM_ALG_SM2 {

```

```

if-feature "tpm20";
base tpm20;
base asymmetric;
base signing;
base encryption_mode;
base method;
description
    "SM2 - depending on context, either an elliptic-curve based,
    signature algorithm, an encryption scheme, or a key exchange
    protocol";
reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    A GM/T 0003.1-2012, GM/T 0003.2-2012, GM/T 0003.3-2012,
    GM/T 0003.5-2012 SM2. ALG_ID: 0x001B";
}

identity TPM_ALG_ECSCHNORR {
    if-feature "tpm20";
    base tpm20;
    base asymmetric;
    base signing;
    description
        "Elliptic-curve based Schnorr signature";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        TCG TPM 2.0 library specification. ALG_ID: 0x001C";
}

identity TPM_ALG_ECMQV {
    if-feature "tpm20";
    base tpm20;
    base asymmetric;
    base method;
    description
        "Two-phase elliptic-curve key";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        NIST SP800-56A. ALG_ID: 0x001D";
}

identity TPM_ALG_KDF1_SP800_56A {
    if-feature "tpm20";
    base tpm20;
    base hash;
    base method;
    description
        "Concatenation key derivation function";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        NIST SP800-56A (approved alternative1) section 5.8.1.
        ALG_ID: 0x0020";
}

identity TPM_ALG_KDF2 {
    if-feature "tpm20";
    base tpm20;
    base hash;
    base method;
}

```

```

description
    "Key derivation function";
reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    IEEE 1363a-2004 KDF2 section 13.2. ALG_ID: 0x0021";
}

identity TPM_ALG_KDF1_SP800_108 {
    base TPM_ALG_KDF2;
    description
        "A key derivation method";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        NIST SP800-108 - Section 5.1 KDF. ALG_ID: 0x0022";
}

identity TPM_ALG_ECC {
    if-feature "tpm20";
    base tpm20;
    base asymmetric;
    base object_type;
    description
        "Prime field ECC";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        ISO/IEC 15946-1. ALG_ID: 0x0023";
}

identity TPM_ALG_SYMCIPHER {
    if-feature "tpm20";
    base tpm20;
    description
        "Object type for a symmetric block cipher";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        TCG TPM 2.0 library specification. ALG_ID: 0x0025";
}

identity TPM_ALG_CAMELLIA {
    if-feature "tpm20";
    base tpm20;
    base symmetric;
    description
        "The Camellia algorithm";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        ISO/IEC 18033-3. ALG_ID: 0x0026";
}

identity TPM_ALG_SHA3_256 {
    if-feature "tpm20";
    base tpm20;
    base hash;
    description
        "ISO/IEC 10118-3 - the SHA 256 algorithm";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        NIST PUB FIPS 202. ALG_ID: 0x0027";
}

```

```

}

identity TPM_ALG_SHA3_384 {
  if-feature "tpm20";
  base tpm20;
  base hash;
  description
    "The SHA 384 algorithm";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    NIST PUB FIPS 202. ALG_ID: 0x0028";
}

identity TPM_ALG_SHA3_512 {
  if-feature "tpm20";
  base tpm20;
  base hash;
  description
    "The SHA 512 algorithm";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    NIST PUB FIPS 202. ALG_ID: 0x0029";
}

identity TPM_ALG_CMAC {
  if-feature "tpm20";
  base tpm20;
  base symmetric;
  base signing;
  description
    "block Cipher-based Message Authentication Code (CMAC)";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    ISO/IEC 9797-1:2011 Algorithm 5. ALG_ID: 0x003F";
}

identity TPM_ALG_CTR {
  if-feature "tpm20";
  base tpm20;
  base symmetric;
  base encryption_mode;
  description
    "Counter mode";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    ISO/IEC 10116. ALG_ID: 0x0040";
}

identity TPM_ALG_OFB {
  base tpm20;
  base symmetric;
  base encryption_mode;
  description
    "Output Feedback mode";
  reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    ISO/IEC 10116. ALG_ID: 0x0041";
}

```

```
identity TPM_ALG_CBC {
    if-feature "tpm20";
    base tpm20;
    base symmetric;
    base encryption_mode;
    description
        "Cipher Block Chaining mode";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        ISO/IEC 10116. ALG_ID: 0x0042";
}

identity TPM_ALG_CFB {
    if-feature "tpm20";
    base tpm20;
    base symmetric;
    base encryption_mode;
    description
        "Cipher Feedback mode";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        ISO/IEC 10116. ALG_ID: 0x0043";
}

identity TPM_ALG_ECB {
    if-feature "tpm20";
    base tpm20;
    base symmetric;
    base encryption_mode;
    description
        "Electronic Codebook mode";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        ISO/IEC 10116. ALG_ID: 0x0044";
}

identity TPM_ALG_CCM {
    if-feature "tpm20";
    base tpm20;
    base symmetric;
    base signing;
    base encryption_mode;
    description
        "Counter with Cipher Block Chaining-Message Authentication
        Code (CCM)";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        NIST SP800-38C. ALG_ID: 0x0050";
}

identity TPM_ALG_GCM {
    if-feature "tpm20";
    base tpm20;
    base symmetric;
    base signing;
    base encryption_mode;
    description
```



```

    "Galois/Counter Mode (GCM)";
reference
    "TCG_Algorithm_Registry_r1p32_pub Table 3 and
    NIST SP800-38D. ALG_ID: 0x0051";
}

identity TPM_ALG_KW {
    if-feature "tpm20";
    base tpm20;
    base symmetric;
    base signing;
    base encryption_mode;
    description
        "AES Key Wrap (KW)";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        NIST SP800-38F. ALG_ID: 0x0052";
}

identity TPM_ALG_KWP {
    if-feature "tpm20";
    base tpm20;
    base symmetric;
    base signing;
    base encryption_mode;
    description
        "AES Key Wrap with Padding (KWP)";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        NIST SP800-38F. ALG_ID: 0x0053";
}

identity TPM_ALG_EAX {
    if-feature "tpm20";
    base tpm20;
    base symmetric;
    base signing;
    base encryption_mode;
    description
        "Authenticated-Encryption Mode";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        NIST SP800-38F. ALG_ID: 0x0054";
}

identity TPM_ALG_EDDSA {
    if-feature "tpm20";
    base tpm20;
    base asymmetric;
    base signing;
    description
        "Edwards-curve Digital Signature Algorithm (PureEdDSA)";
    reference
        "TCG_Algorithm_Registry_r1p32_pub Table 3 and
        RFC 8032. ALG_ID: 0x0060";
}
}
}
<CODE ENDS>

```

Note that not all cryptographic functions are required for use by `ietf-tpm-remote-attestation.yang`. However the full definition of Table 3 of [[TCG-Algos](#)] will allow use by additional YANG specifications.

### 3. IANA Considerations

This document registers the following namespace URIs in the "[ns](#)" class of the IETF XML Registry [[IANA.xml-registry](#)] as per [[RFC3688](#)]:

**URI:** `urn:ietf:params:xml:ns:yang:ietf-tpm-remote-attestation`

**Registrant Contact:** The IESG.

**XML:** N/A; the requested URI is an XML namespace.

**URI:** `urn:ietf:params:xml:ns:yang:ietf-tcg-algs`

**Registrant Contact:** The IESG.

**XML:** N/A; the requested URI is an XML namespace.

This document registers the following YANG modules in the "[YANG Module Names](#)" registry [[IANA.yang-parameters](#)] as per [Section 14](#) of [[RFC6020](#)]:

**Name:** `ietf-tpm-remote-attestation`

**Namespace:** `urn:ietf:params:xml:ns:yang:ietf-tpm-remote-attestation`

**Prefix:** `tpm`

**Reference:** `draft-ietf-rats-yang-tpm-charra` (RFC form)

**Name:** `ietf-tcg-algs`

**Namespace:** `urn:ietf:params:xml:ns:yang:ietf-tcg-algs`

**Prefix:** `taa`

**Reference:** `draft-ietf-rats-yang-tpm-charra` (RFC form)

### 4. Security Considerations

The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as NETCONF [[RFC6241](#)] or RESTCONF [[RFC8040](#)]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [[RFC6242](#)]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [[RFC8446](#)].

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 as well as their sensitivity/vulnerability:

**Container '/rats-support-structures/attester-supported-algos':**

'tpm12-asymmetric-signing', 'tpm12-hash', 'tpm20-asymmetric-signing', and 'tpm20-hash'. All could be populated with algorithms that are not supported by the underlying physical TPM installed by the equipment vendor.

**Container: '/rats-support-structures/tpms':** 'name': Although shown as 'rw', it is system generated. Therefore it should not be possible for an operator to add or remove a TPM from the configuration.

'tpm20-pcr-bank': It is possible to configure PCRs for extraction which are not being extended by system software. This could unnecessarily use TPM resources.

'certificates': It is possible to provision a certificate which does not correspond to an Attestation Identity Key (AIK) within the TPM 1.2, or an Attestation Key (AK) within the TPM 2.0 respectively.

**RPC 'tpm12-challenge-response-attestation':** It must be verified that the certificate is for an active AIK, i. e. the certificate provided is able to support Attestation on the targeted TPM 1.2.

**RPC 'tpm20-challenge-response-attestation':** It must be verified that the certificate is for an active AK, i. e. the certificate provided is able to support Attestation on the targeted TPM 2.0.

**RPC 'log-retrieval':** Pulling lots of logs can chew up system resources.

## 5. Change Log

Changes from version 08 to version 09:

\*Minor formatting tweaks for shepherd. IANA registered.

Changes from version 05 to version 06:

\*More YANG Dr comments covered

Changes from version 04 to version 05:

\*YANG Dr comments covered

Changes from version 03 to version 04:

\*TPM1.2 Quote1 eliminated

\*YANG model simplifications so redundant info isn't exposed

Changes from version 02 to version 03:

- \*moved to tcg-algs
- \*cleaned up model to eliminate sources of errors
- \*removed key establishment RPC
- \*added lots of XPATH which must all be scrubbed still
- \*Descriptive text added on model contents.

Changes from version 01 to version 02:

- \*Extracted Crypto-types into a separate YANG file
- \*Makes the algorithms explicit, not strings
- \*Hash Algo as key the selected TPM2 PCRs
- \*PCR numbers are their own type
- \*Eliminated nested keys for node-id plus tpm-name
- \*Eliminated TPM-Name of "ALL"
- \*Added TPM-Path

Changes from version 00 to version 01:

- \*Addressed author's comments
- \*Extended complementary details about attestation-certificates
- \*Relabeled chunk-size to log-entry-quantity
- \*Relabeled location with compute-node or tpm-name where appropriate
- \*Added a valid entity-mib physical-index to compute-node and tpm-name to map it back to hardware inventory
- \*Relabeled name to tpm\_name
- \*Removed event-string in last-entry

## 6. References

### 6.1. Normative References

[I-D.ietf-netconf-keystore] Watsen, K., "A YANG Data Model for a Keystore", Work in Progress, Internet-Draft, draft-ietf-netconf-keystore-22, 18 May 2021, <<https://www.ietf.org/archive/id/draft-ietf-netconf-keystore-22.txt>>.

[I-D.ietf-rats-architecture] Birkholz, H., Thaler, D., Richardson, M., Smith, N., and W. Pan, "Remote Attestation Procedures Architecture", Work in Progress, Internet-Draft, draft-

ietf-rats-architecture-12, 23 April 2021, <<https://www.ietf.org/archive/id/draft-ietf-rats-architecture-12.txt>>.

[I-D.ietf-rats-tpm-based-network-device-attest] Fedorkow, G., Voit, E., and J. Fitzgerald-McKay, "TPM-based Network Device Remote Integrity Verification", Work in Progress, Internet-Draft, draft-ietf-rats-tpm-based-network-device-attest-08, 26 July 2021, <<https://www.ietf.org/archive/id/draft-ietf-rats-tpm-based-network-device-attest-08.txt>>.

[IANA.xml-registry] IANA, "IETF XML Registry", <<http://www.iana.org/assignments/xml-registry>>.

[IANA.yang-parameters] IANA, "YANG Parameters", <<http://www.iana.org/assignments/yang-parameters>>.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.

[RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, DOI 10.17487/RFC3688, January 2004, <<https://www.rfc-editor.org/info/rfc3688>>.

[RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020, DOI 10.17487/RFC6020, October 2010, <<https://www.rfc-editor.org/info/rfc6020>>.

[RFC6991] Schoenwaelder, J., Ed., "Common YANG Data Types", RFC 6991, DOI 10.17487/RFC6991, July 2013, <<https://www.rfc-editor.org/info/rfc6991>>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.

[RFC8348] Bierman, A., Bjorklund, M., Dong, J., and D. Romascanu, "A YANG Data Model for Hardware Management", RFC 8348,

DOI 10.17487/RFC8348, March 2018, <<https://www.rfc-editor.org/info/rfc8348>>.

- [TCG-Algos] "TCG\_Algorithm\_Registry\_r1p32\_pub", n.d., <<https://trustedcomputinggroup.org/resource/tcg-algorithm-registry/>>.
- [TPM1.2] TCG, ., "TPM 1.2 Main Specification", 2 October 2003, <<https://trustedcomputinggroup.org/resource/tpm-main-specification/>>.
- [TPM2.0] TCG, ., "TPM 2.0 Library Specification", 15 March 2013, <<https://trustedcomputinggroup.org/resource/tpm-library-specification/>>.
- [TPM2.0-Key] TCG, ., "TPM 2.0 Keys for Device Identity and Attestation, Rev10", 14 April 2021, <[https://trustedcomputinggroup.org/wp-content/uploads/TCG\\_IWG\\_DevID\\_v1r2\\_02dec2020.pdf](https://trustedcomputinggroup.org/wp-content/uploads/TCG_IWG_DevID_v1r2_02dec2020.pdf)>.

## 6.2. Informative References

- [I-D.ietf-rats-reference-interaction-models] Birkholz, H., Eckel, M., Pan, W., and E. Voit, "Reference Interaction Models for Remote Attestation Procedures", Work in Progress, Internet-Draft, draft-ietf-rats-reference-interaction-models-04, 26 July 2021, <<https://www.ietf.org/archive/id/draft-ietf-rats-reference-interaction-models-04.txt>>.
- [RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011, <<https://www.rfc-editor.org/info/rfc6241>>.
- [RFC6242] Wasserman, M., "Using the NETCONF Protocol over Secure Shell (SSH)", RFC 6242, DOI 10.17487/RFC6242, June 2011, <<https://www.rfc-editor.org/info/rfc6242>>.
- [RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", RFC 8040, DOI 10.17487/RFC8040, January 2017, <<https://www.rfc-editor.org/info/rfc8040>>.
- [RFC8446] Rescorla, E., "The Transport Layer Security (TLS) Protocol Version 1.3", RFC 8446, DOI 10.17487/RFC8446, August 2018, <<https://www.rfc-editor.org/info/rfc8446>>.

## Authors' Addresses

Henk Birkholz  
Fraunhofer SIT  
Rheinstrasse 75  
64295 Darmstadt  
Germany

Email: [henk.birkholz@sit.fraunhofer.de](mailto:henk.birkholz@sit.fraunhofer.de)

Michael Eckel

Fraunhofer SIT  
Rheinstrasse 75  
64295 Darmstadt  
Germany

Email: [michael.eckel@sit.fraunhofer.de](mailto:michael.eckel@sit.fraunhofer.de)

Shwetha Bhandari  
ThoughtSpot

Email: [shwetha.bhandari@thoughtspot.com](mailto:shwetha.bhandari@thoughtspot.com)

Eric Voit  
Cisco Systems

Email: [evoit@cisco.com](mailto:evoit@cisco.com)

Bill Sulzen  
Cisco Systems

Email: [bsulzen@cisco.com](mailto:bsulzen@cisco.com)

Liang Xia (Frank)  
Huawei Technologies  
101 Software Avenue, Yuhuatai District  
Nanjing  
Jiangsu, 210012  
China

Email: [Frank.Xialiang@huawei.com](mailto:Frank.Xialiang@huawei.com)

Tom Laffey  
Hewlett Packard Enterprise

Email: [tom.laffey@hpe.com](mailto:tom.laffey@hpe.com)

Guy C. Fedorkow  
Juniper Networks  
10 Technology Park Drive  
Westford

Email: [gfedorkow@juniper.net](mailto:gfedorkow@juniper.net)