TEEP   M. Pei
Internet-Draft   Symantec
Intended status: Informational   A. Atyeo
Expires: November 16, 2019   Intercede
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                                                         May 15, 2019

The Open Trust Protocol (OTrP)
draft-ietf-teep-opentrustprotocol-03.txt

Abstract

   This document specifies the Open Trust Protocol (OTrP), a protocol
   that follows the Trust Execution Environment Provisioning (TEEP)
   architecture and provides a message protocol that provisions and
   manages Trusted Applications into a device with a Trusted Execution
   Environment (TEE).

Status of This Memo

   This Internet-Draft is submitted in full conformance with the
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   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 November 16, 2019.

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1. Introduction

   The Trusted Execution Environment (TEE) concept has been designed to
   separate a regular operating system, also referred as a Rich
   Execution Environment (REE), from security-sensitive applications.
   In an TEE ecosystem, different device vendors may use different TEE
   implementations. Different application providers or device
   administrators may choose to use different TAM providers. There
   calls for an interoperable protocol for managing TAs running in
   different TEEs of various devices is needed.

   The Trusted Execution Environment Provisioning (TEEP) architecture
   document [TEEPArch] has set to provide a design guidance for such an
   interoperable protocol. This document specifies an Open Trust
   Protocol (OTrP) that follows the architecture guidance.

   OTrP defines a mutual trust message protocol between a TAM and a TEE
   and relies on IETF-defined end-to-end security mechanisms, namely
   JSON Web Encryption (JWE), JSON Web Signature (JWS), and JSON Web Key
   (JWK). Other message encoding methods may be supported.

   This specification defines message payloads exchanged between devices
   and a TAM. The messages are designed in anticipation of the use of
   the most common transport methods such as HTTPS.

   Each TA binary and configuration data can be from either of two
   sources:

   1. A TAM supplies the signed and encrypted TA binary and any
       required configuration data

   2. A Client Application supplies the TA binary

   This specification considers the first case where TA binary and
   configuration data are encrypted by recipient's public key that TAM

has to be involved. The second case will also be addressed
separately.

2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
"SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
document are to be interpreted as described in [RFC2119].

3. Terminology

3.1. Definitions

The definitions provided below are defined as used in this document.
All the terms defined in the TEEP Architecture document [TEEPArch]
will be used, which are not repeated in this document.

OTrP Broker: It is the Broker as defined in the TEEP Architecture
     document [TEEPArch].

3.2. Abbreviations

CA   Certificate Authority

OTrP   Open Trust Protocol

REE   Rich Execution Environment

SD   Security Domain

SP   Service Provider

TA   Trusted Application

TEE   Trusted Execution Environment

TFW   Trusted Firmware

TAM   Trusted Application Manager

4. OTrP Entities and Trust Model

4.1. System Components

The same system components as defined in the TEEP Architecture
document [TEEPArch] are used in OTrP, including TAM, CA, TEE, REE,
and OTrP Broker (a.k.a Broker).

Secure boot (for the purposes of OTrP) is optional in enabling
authenticity checking of TEEs by the TAM. A TAM provider can choose
it policy whether it trusts a TEE if the underlying firmware
attestation information is not included.

OTrP uses trust anchors to establish trust between TEEs and TAMs and
verifies that they communicate in a trusted way when performing
lifecycle management transactions.

4.2. Trust Anchors in TEE

This assumes the Trust Anchor specification defined in the TEEP
Architecture document [TEEPArch].

Each TEE comes with a trust store that contains a whitelist of root
CA certificates that are used to validate a TAM's certificate. A TEE
will accept a TAM to create new Security Domains and install new TAs
on behalf of a SP only if the TAM's certificate is chained to one of
the root CA certificates in the TEE's trust store.

4.3. Trust Anchors in TAM

The Trust Anchor set in a TAM consists of a list of Certificate
Authority certificates that signs various device TEE certificates. A
TAM decides what TEE and optionally TFW it will trust when TFW
signature data is present in an attestation.

4.4. Keys and Certificate Types

OTrP leverages the following list of trust anchors and identities in
generating signed and encrypted command messages that are exchanged
between a device's TEE and a TAM. With these security artifacts,
OTrP Messages are able to deliver end-to-end security without relying
on any transport security.

```
+-------------+----------+--------+------------------+-------------+
| Key Entity  | Location | Issuer | Trust Implication | Cardinality |
| Name        |          |        |                  |             |
+-------------+----------+--------+------------------+-------------+
| 1. TFW key  | Device   | FW CA  | A whitelist of FW | 1 per       |
| pair and    | secure   |        | root CA trusted   | device      |
| certificate | storage  |        | by TAMs          |             |
|             |          |        |                  |             |
| 2. TEE key  | Device   | TEE CA | A whitelist of   | 1 per       |
| pair and    | TEE      | under  | TEE root CA      | device      |
| certificate |          | a root | trusted by TAMs  |             |
|             |          | CA     |                  |             |
|             |          |        |                  |             |
| 3. TAM key  | TAM      | TAM CA | A whitelist of   | 1 or        |
| pair and    | provider | under  | TAM root CA      | multiple    |
| certificate |          | a root | embedded in TEE  | can be used |
|             |          | CA     |                  | by a TAM    |
|             |          |        |                  |             |
| 4. SP key   | SP       | SP     | TAM manages SP.  | 1 or        |
| pair and    |          | signer | TA trust is      | multiple    |
| certificate |          | CA     | delegated to TAM.| can be used |
|             |          |        | TEE trusts TAM to| by a TAM    |
|             |          |        | ensure that a TA |             |
|             |          |        | is trustworthy.  |             |
+-------------+----------+--------+------------------+-------------+
```

                   Table 1: Key and Certificate Types

1. TFW key pair and certificate: A key pair and certificate for
    evidence of trustworthy firmware in a device. This key pair is
    optional. Some TEE may present its trusted attributes to a TAM
    using signed attestation with a TFW key. For example, a platform
    that uses a hardware based TEE can have attestation data signed
    by a hardware protected TFW key.

    Location: Device secure storage

    Supported Key Type: RSA and ECC

    Issuer: OEM CA

    Trust Implication: A whitelist of FW root CA trusted by TAMs

    Cardinality: One per device

2. TEE key pair and certificate: It is used for device attestation
    to a remote TAM and SP.

This key pair is burned into the device at device manufacturer. The key pair and its certificate are valid for the expected lifetime of the device.

Location: Device TEE

Supported Key Type: RSA and ECC

Issuer: A CA that chains to a TEE root CA

Trust Implication: A whitelist of TEE root CA trusted by TAMs

Cardinality: One per device

3. TAM key pair and certificate: A TAM provider acquires a certificate from a CA that a TEE trusts.

   Location: TAM provider

   Supported Key Type: RSA and ECC.

   Supported Key Size: RSA 2048-bit, ECC P-256 and P-384. Other sizes should be anticipated in future.

   Issuer: TAM CA that chains to a root CA

   Trust Implication: A whitelist of TAM root CA embedded in TEE

   Cardinality: One or multiple can be used by a TAM

4. SP key pair and certificate: an SP uses its own key pair and certificate to sign a TA.

   Location: SP

   Supported Key Type: RSA and ECC

   Supported Key Size: RSA 2048-bit, ECC P-256 and P-384. Other sizes should be anticipated in future.

   Issuer: an SP signer CA that chains to a root CA

   Trust Implication: TAM manages SP. TA trusts an SP by validating trust against a TAM that the SP uses. A TEE trusts TAM to ensure that a TA from the TAM is trustworthy.

   Cardinality: One or multiple can be used by an SP

5. Protocol Scope and Entity Relations

This document specifies messages and key properties that can
establish mutual trust between a TEE and a TAM. The protocol
provides specifications for the following three entities:

1. Key and certificate types required for device firmware, TEEs,
    TAs, SPs, and TAMs

2. Data message formats that should be exchanged between a TEE in a
    device and a TAM

3. An OTrP Broker in the REE that can relay messages between a
    Client Application and TEE

Figure 1: Protocol Scope and Entity Relationship

```
PKI     CA     -- CA                                CA --
         |      |                                    |
         |      |                                    |
         |      |                                    |
Device  |      |    --- OTrP Broker / Client App ---       |
SW      |      |    |                              |       |
         |      |    |                              |       |
         |      |    |                              |       |
OTrP    |      -- TEE                            TAM-------
         |
         |
        FW
```
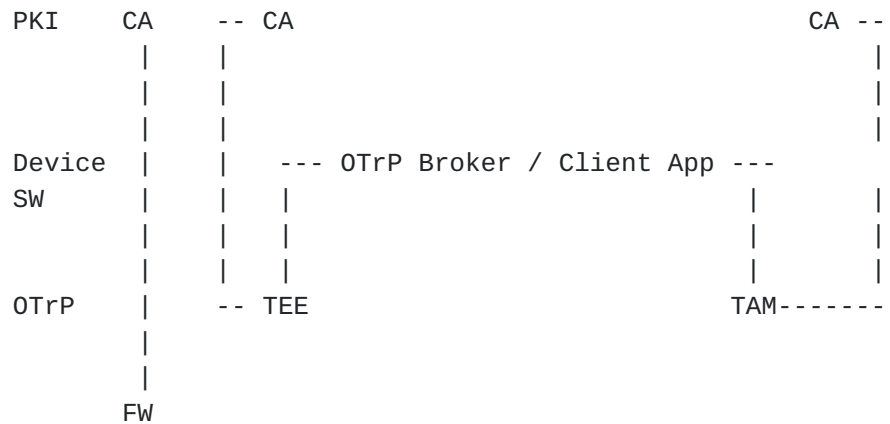
Figure 2: OTrP System Diagram

```
             -------OTrP Message Protocol---
                |                     |
                |                     |
   --------------------       --------------       ----------
   |  REE   |  TEE    |       |   TAM     |       | SP    |
   |  ---   |  ---    |       |   ---     |       | --    |
   |        |         |       |           |       |       |
   | Client | SD (TAs)|       |  SD / TA  |       | TA    |
   | Apps   |         |       |    Mgmt   |       |       |
   |    |   |         |       |           |       |       |
   |    |   | List of |       |  List of  |       |       |
   | OTrP   | Trusted |       |  Trusted  |       |       |
   | Broker |  TAM/SP |       |   FW/TEE  |       |       |
   |        |   CAs   |       |    CAs    |       |       |
   |        |         |       |           |       |       |
   |        |TEE Key/ |       |  TAM Key/ |       | SP Key/|
   |        |  Cert   |       |    Cert   |       | Cert  |
   |        | FW Key/ |       |           |       |       |
   |        |  Cert   |       |           |       |       |
   --------------------       --------------       ----------
            |                       |                   |
            |                       |                   |
      -------------            ----------          ---------
      | TEE CA    |            | TAM CA |          | SP CA |
      -------------            ----------          ---------
```

In the previous diagram, different Certificate Authorities can be
used respectively for different types of certificates. OTrP Messages
are always signed, where the signer keys is the message creator's
private key such as a FW's private key, a TEE's private key, or a
TAM's private key.

The main OTrP component consists of a set of standard JSON messages
created by a TAM to deliver device SD and TA management commands to a
device, and device attestation and response messages created by a TEE
that responds to a TAM's OTrP message.

The communication method of OTrP Messages between a TAM and TEE in a
device may vary between TAM and TEE providers. A mandatory transport
protocol is specified for a compliant TAM and a device TEE.

An OTrP Broker is used to bridge communication between a TAM and a
TEE. The OTrP Broker doesn't need to know the actual content of OTrP
Messages except for the TEE routing information.

5.1. A Sample Device Setup Flow

   Step 1: Prepare Images for Devices

   1. [TEE vendor] Deliver TEE Image (CODE Binary) to device OEM

   2. [CA] Deliver root CA Whitelist

   3. [Soc] Deliver TFW Image

   Step 2: Inject Key Pairs and Images to Devices

   1. [OEM] Generate Secure Boot Key Pair (May be shared among multiple
       devices)

   2. [OEM] Flash signed TFW Image and signed TEE Image onto devices
       (signed by Secure Boot Key)

   Step 3: Setup attestation key pairs in devices

   1. [OEM] Flash TFW Public Key and a bootloader key.

   2. [TFW/TEE] Generate a unique attestation key pair and get a
       certificate for the device.

   Step 4: Setup trust anchors in devices

   1. [TFW/TEE] Store the key and certificate encrypted with the eFuse
       key

   2. [TEE vendor or OEM] Store trusted CA certificate list into
       devices

5.2. Derived Keys in The Protocol

   The protocol generates one key pair in run time to assist message
   communication and anonymous verification between a TAM and a TEE.

   TEE SP Anonymous Key (AIK): one derived key pair per SP in a device

   The purpose of the key pair is to sign data by a TEE without using
   its TEE device key for anonymous attestation to a Client Application.
   This key pair is generated in the first SD creation for an SP. It is
   deleted when all SDs are removed for a SP in a device. The public
   key of the key pair is given to the caller Client Application and TAM
   for future TEE returned data validation. The public key of this AIK
   is also used by a TAM to encrypt TA binary data and personalization
   data when it sends a TA to a device for installation.

5.3. Security Domain Hierarchy and Ownership

The primary job of a TAM is to help an SP to manage its trusted
application components. A TA is typically installed in an SD. An SD
is commonly created for an SP.

When an SP delegates its SD and TA management to a TAM, an SD is
created on behalf of a TAM in a TEE and the owner of the SD is
assigned to the TAM. An SD may be associated with an SP but the TAM
has full privilege to manage the SD for the SP.

Each SD for an SP is associated with only one TAM. When an SP
changes TAM, a new SP SD must be created to associate with the new
TAM. The TEE will maintain a registry of TAM ID and SP SD ID
mapping.

From an SD ownership perspective, the SD tree is flat and there is
only one level. An SD is associated with its owner. It is up to TEE
implementation how it maintains SD binding information for a TAM and
different SPs under the same TAM.

It is an important decision in this protocol specification that a TEE
doesn't need to know whether a TAM is authorized to manage the SD for
an SP. This authorization is implicitly triggered by an SP Client
Application, which instructs what TAM it wants to use. An SD is
always associated with a TAM in addition to its SP ID. A rogue TAM
isn't able to do anything on an unauthorized SP's SD managed by
another TAM.

Since a TAM may support multiple SPs, sharing the same SD name for
different SPs creates a dependency in deleting an SD. An SD can be
deleted only after all TAs associated with this SD is deleted. An SP
cannot delete a Security Domain on its own with a TAM if a TAM
decides to introduce such sharing. There are cases where multiple
virtual SPs belong to the same organization, and a TAM chooses to use
the same SD name for those SPs. This is totally up to the TAM
implementation and out of scope of this specification.

5.4. SD Owner Identification and TAM Certificate Requirements

There is a need of cryptographically binding proof about the owner of
an SD in a device. When an SD is created on behalf of a TAM, a
future request from the TAM must present itself as a way that the TEE
can verify it is the true owner. The certificate itself cannot
reliably used as the owner because TAM may change its certificate.

To this end, each TAM will be associated with a trusted identifier
defined as an attribute in the TAM certificate. This field is kept

the same when the TAM renew its certificates. A TAM CA is
responsible to vet the requested TAM attribute value.

This identifier value must not collide among different TAM providers,
and one TAM shouldn't be able to claim the identifier used by another
TAM provider.

The certificate extension name to carry the identifier can initially
use SubjectAltName:registeredID. A dedicated new extension name may
be registered later.

One common choice of the identifier value is the TAM's service URL.
A CA can verify the domain ownership of the URL with the TAM in the
certificate enrollment process.

A TEE can assign this certificate attribute value as the TAM owner ID
for the SDs that are created for the TAM.

An alternative way to represent an SD ownership by a TAM is to have a
unique secret key upon SD creation such that only the creator TAM is
able to produce a Proof-of-Possession (POP) data with the secret.

5.5. **Service Provider Container**

A sample Security Domain hierarchy for the TEE is shown below.

```
    ----------
    |  TEE   |
    ----------
         |
         |            ----------
         |----------| SP1 SD1 |
         |            ----------
         |            ----------
         |----------| SP1 SD2 |
         |            ----------
         |            ----------
         |----------| SP2 SD1 |
                      ----------
```
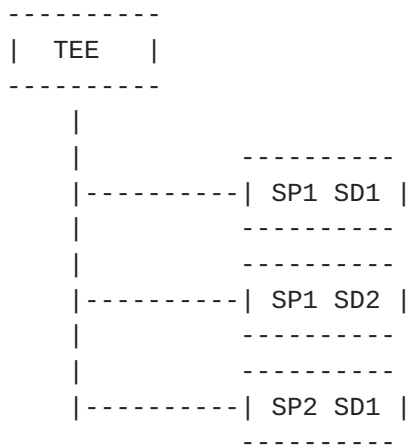
OTrP segregates SDs and TAs such that a TAM can only manage or
retrieve data for SDs and TAs that it previously created for the SPs
it represents.

6. OTrP Broker

A TEE and TAs that run inside the TEE don't generally have capability
to communicate to the outside of the hosting device, for example, the
TEE specified by Global Platform groups [GPTEE]. This calls for a
software module in the REE world to handle the network communication.
Each Client Application in REE may carry this communication
functionality but it must also interact with the TEE for the message
exchange. The TEE interaction will vary according to different TEEs.
In order for a Client Application to transparently support different
TEEs, it is imperative to have a common interface for a Client
Application to invoke for exchanging messages with TEEs.

A shared OTrP Broker comes to meed this need. An OTrP Broker is a
Rich Application or SDK that facilitates communication between a TAM
and TEE. It also provides interfaces for TAM SDK or Client
Applications to query and trigger TA installation that the
application needs to use.

This interface for Client Applications may be commonly an Android
service call for an Android powered device. A Client Application
interacts with a TAM, and turns around to pass messages received from
TAM to OTrP Broker.

In all cases, a Client Application needs to be able to identify an
OTrP Broker that it can use.

6.1. Role of OTrP Broker

An OTrP Broker abstracts the message exchanges with the TEE in a
device. The input data is originated from a TAM that a Client
Application connects. A Client Application may also directly call
OTrP Broker for some TA query functions.

OTrP Broker may internally process a request from TAM. At least, it
needs to know where to route a message, e.g. TEE instance. It
doesn't need to process or verify message content.

OTrP Broker returns TEE / TFW generated response messages to the
caller. OTrP Broker isn't expected to handle any network connection
with an application or TAM.

OTrP Broker only needs to return an OTrP Broker error message if the
TEE is not reachable for some reason. Other errors are represented
as response messages returned from the TEE which will then be passed
to the TAM.

6.2. OTrP Broker and Global Platform TEE Client API

   A Client Application may use Global Platform (GP) TEE API for TA
   communication. OTrP may use the GP TEE Client API but it is internal
   to OTrP implementation that converts given messages from TAM. More
   details can be found at [GPTEECLAPI].

6.3. OTrP Broker Implementation Consideration

   A Provider should consider methods of distribution, scope and
   concurrency on device and runtime options when implementing an OTrP
   Broker. Several non-exhaustive options are discussed below.
   Providers are encouraged to take advantage of the latest
   communication and platform capabilities to offer the best user
   experience.

6.3.1. OTrP Broker Distribution

   OTrP Broker installation is commonly carried out at OEM time. A user
   can dynamically download and install an OTrP Broker on-demand.

   It is important to ensure a legitimate OTrP Broker is installed and
   used. If an OTrP Broker is compromised it may send rogue messages to
   TAM and TEE and introduce additional risks.

6.3.2. Number of OTrP Broker

   We anticipate only one shared OTrP Broker instance in a device. The
   device's TEE vendor will most probably supply one OTrP Broker.
   Potentially we expect some open source.

   With one shared OTrP Broker, the OTrP Broker provider is responsible
   to allow multiple TAMs and TEE providers to achieve interoperability.
   With a standard OTrP Broker interface, TAM can implement its own SDK
   for its SP Client Applications to work with this OTrP Broker.

   Multiple independent OTrP Broker providers can be used as long as
   they have standard interface to a Client Application or TAM SDK.
   Only one OTrP Broker is expected in a device.

   TAM providers are generally expected to provide SDK for SP
   applications to interact with an OTrP Broker for the TAM and TEE
   interaction.

6.4. OTrP Broker Interfaces for Client Applications

A Client Application shall be responsible for relaying messages
between the OTrP Broker and the TAM.

If a failure occurs during calling OTrP Broker, an error message
described in "Common Errors" section (see Section 7.6) will be
returned.

6.4.1. ProcessOTrPMessage call

Description

A Client Application will use this method of the OTrP Broker in a
device to pass OTrP messages from a TAM. The method is
responsible for interacting with the TEE and for forwarding the
input message to the TEE. It also returns TEE generated response
message back to the Client Application.

Inputs:

TAMInMsg - OTrP message generated in a TAM that is passed to this
method from a Client Application.

Outputs:

A TEE-generated OTrP response message (which may be a successful
response or be a response message containing an error raised
within the TEE) for the client application to forward to the TAM.
In the event of the OTrP Broker not being able to communicate with
the TEE, a OTrPBrokerException shall be thrown.

6.4.2. GetTAInformation call

Description

A Client Application may quickly query local TEE about a
previously installed TA without requiring TAM each time if it has
had the TA's identifier and previously saved TEE SP AIK public key
for TA information integrity verification.

Inputs:

```
      {
        "TAQuery": {
            "spid": "<SP identifier value of the TA>",
            "taid": "<The identifier value of the TA>"
        }
      }
```

Outputs:

   The OTrP Broker is expected to return TA signer and TAM signer
   certificate along with other metadata information about the TA
   associated with the given identifier. It follows the underlying
   TEE trust model for authoring the local TA query from a Client
   Application.

   The output is a JSON message that is generated by the TEE. It
   contains the following information:

   * tamid

   * SP ID

   * TA signer certificate

   * TAM certificate

   The message is signed with TEE SP AIK private key.

   The Client Application is expected to consume the response as
   follows.

   The Client Application gets signed TA metadata, in particular, the
   TA signer certificate. It is able to verify that the result is
   from device by checking signer against TEE SP AIK public key it
   gets in some earlier interaction with TAM.

   If this is a new Client Application in the device that hasn't had
   TEE SP AIK public key for the response verification, the
   application can contact the TAM first to do GetDeviceState, and
   TAM will return TEE SP AIK public key to the app for this
   operation to proceed.

   Output Message:

```
   {
     "TAInformationTBS": {
       "taid": "<TA Identifier from the input>",
       "tamid": "<TAM ID for the Security Domain where this TA
                  resides>",
       "spid": "<The service provider identifier of this TA>",
       "signercert": "<The BASE64 encoded certificate data of the
                      TA binary application's signer certificate>",
       "signercacerts": [ < The full list of CA certificate chain
                          including the root CA>
       ],
       "cacert": "<The BASE64 encoded CA certificate data of the TA
                   binary application's signer certificate>"
       ],
       "tamcert": "<The BASE64 encoded certificate data of the TAM
                   that manages this TA.>",
       "tamcacerts": [ < The full list of CA certificate chain
                       including the root CA>
       ],
       "cacert":"<The BASE64 encoded CA certificate data of the TAM
                  that manages this TA>"
       ]
     }
   }

   {
     "TAInformation": {
         "payload": "<The BASE64URL encoding of the TAInformationTBS
                     JSON above>",
         "protected": "<BASE64URL encoded signing algorithm>",
         "header": {
             "signer": {"<JWK definition of the TEE SP AIK public
                          key>"}
         },
         "signature": "<signature contents signed by TEE SP AIK
                        private key BASE64URL encoded>"
     }
   }
```

where the definitions of BASE64 and BASE64URL refer to [RFC4648].

A sample JWK public key representation refers to an example in
[RFC7517].

6.5. **Sample End-to-End Client Application Flow**

6.5.1. **Case 1: A New Client Application Uses a TA**

   1.   During the Client Application installation time, the Client
         Application calls TAM to initialize the device preparation step.

         A.   The Client Application knows it wants to use a Trusted
              Application TA1 but the application doesn't know whether TA1
              has been installed or not. It can use GP TEE Client API
              [GPTEECLAPI] to check the existence of TA1 first. If it
              detects that TA1 doesn't exist, it will contact TAM to
              initiate the installation of TA1. Note that TA1 could have
              been previously installed by other Client Applications from
              the same service provider in the device.

         B.   The Client Application sends the TAM the TA list that it
              depends on. The TAM will query a device for the Security
              Domains and TAs that have been installed, and instructs the
              device to install any dependent TAs that have not been
              installed.

         C.   In general, the TAM has the latest TA list and their status
              in a device because all operations are instructed by TAM.
              TAM has such visibility because all Security Domain deletion
              and TA deletion are managed by the TAM; the TAM could have
              stored the state when a TA is installed, updated and
              deleted. There is also the possibility that an update
              command is carried out inside TEE but a response is never
              received in TAM. There is also possibility that some manual
              local reset is done in a device that the TAM isn't aware of
              the changes.

   2.   The TAM generates message: GetDeviceStateRequest

   3.   The Client Application passes the JSON message
         GetDeviceStateRequest to OTrP Broker call ProcessOTrPMessage.
         The communication between a Client Application and an OTrP
         Broker is up to the implementation of the OTrP Broker.

   4.   The OTrP Broker routes the message to the active TEE. Multiple
         TEE case: it is up to OTrP Broker to figure this out. This
         specification limits the support to only one active TEE, which
         is the typical case today.

   5.   The target active TEE processes the received OTrP message, and
         returns a JSON message GetDeviceStateResponse.

6. The OTrP Broker passes the GetDeviceStateResponse to the Client
    Application.

7. The Client Application sends GetDeviceStateResponse to the TAM.

8. The TAM processes the GetDeviceStateResponse.

    A. Extract TEEspaik for the SP, signs TEEspaik with TAM signer
        key

    B. Examine SD list and TA list

9. The TAM continues to carry out other actions based on the need.
    The next call could be instructing the device to install a
    dependent TA.

    A. Assume a dependent TA isn't in the device yet, the TAM may
        do the following: (1) create an SD in which to install the
        TA by sending a CreateSDRequest message. The message is
        sent back to the Client Application, and then the OTrP
        Broker and TEE to process; (2) install a TA with an
        InstallTARequest message.

    B. If a Client Application depends on multiple TAs, the Client
        Application should expect multiple round trips of the TA
        installation message exchanges.

10. At the last TAM and TEE operation, the TAM returns the signed
    TEE SP AIK public key to the application.

11. The Client Application stores the TEEspaik for future loaded TA
    trust check.

12. If the TAM finds that this is a fresh device that does not have
    any SD for the SP yet, then the TAM may next create an SD for
    the SP.

13. During Client Application installation, the application checks
    whether required Trusted Applications are already installed,
    which may have been provided by the TEE. If needed, it will
    contact its TAM service to determine whether the device is ready
    or install TA list that this application needs.

6.5.2. Case 2: A Previously Installed Client Application Calls a TA

1. The Client Application checks the device readiness: (a) whether
    it has a TEE; (b) whether it has TA that it depends. It may
    happen that TAM has removed the TA this application depends on.

2. The Client Application calls the OTrP Broker to query the TA.

3. The OTrP Broker queries the TEE to get TA information. If the
    given TA doesn't exist, an error is returned.

4. The Client Application parses the TAInformation message.

5. If the TA doesn't exist, the Client Application calls its TAM to
    install the TA. If the TA exists, the Client Application
    proceeds to call the TA.

7. OTrP Messages

The main OTrP component is the set of standard JSON messages created
by a TAM to deliver device SD and TA management commands to a device,
and device attestation and response messages created by TEE to
respond to TAM OTrP Messages.

An OTrP Message is designed to provide end-to-end security. It is
always signed by its creator. In addition, an OTrP Message is
typically encrypted such that only the targeted device TEE or TAM is
able to decrypt and view the actual content.

7.1. Message Format

OTrP Messages use the JSON format for JSON's simple readability and
moderate data size in comparison with alternative TLV and XML
formats. More compact CBOR format may be used as an alternative
choice.

JSON Message security has developed JSON Web Signing and JSON Web
Encryption standard in the IETF Workgroup JOSE, see JWS [RFC7515] and
JWE [RFC7516]. The OTrP Messages in this protocol will leverage the
basic JWS and JWE to handle JSON signing and encryption.

7.2. Message Naming Convention

For each TAM command "xyz"", OTrP use the following naming convention
to represent its raw message content and complete request and
response messages:

```
+-----------------------+---------------+--------------------+
| Purpose               | Message Name  | Example            |
+-----------------------+---------------+--------------------+
| Request to be signed  | xyzTBSRequest | CreateSDTBSRequest |
|                       |               |                    |
| Request message       | xyzRequest    | CreateSDRequest    |
|                       |               |                    |
| Response to be signed | xyzTBSResponse| CreateSDTBSResponse|
|                       |               |                    |
| Response message      | xyzResponse   | CreateSDResponse   |
+-----------------------+---------------+--------------------+
```

7.3. Request and Response Message Template

An OTrP Request message uses the following format:

```
{
  "<name>TBSRequest": {
    <request message content>
  }
}
```

A corresponding OTrP Response message will be as follows.

```
{
  "<name>TBSResponse": {
    <response message content>
  }
}
```

7.4. Signed Request and Response Message Structure

A signed request message will generally include only one signature,
and uses the flattened JWS JSON Serialization Syntax, see
Section 7.2.2 in [RFC7515].

A general JWS object looks like the following.

```
{
  "payload": "<payload contents>",
  "protected": "<integrity-protected header contents>",
  "header": {
    <non-integrity-protected header contents>,
  },
  "signature": "<signature contents>"
}
```

OTrP signed messages only require the signing algorithm as the
mandate header in the property "protected". The "non-integrity-
protected header contents" is optional.

OTrP signed message will be given an explicit Request or Response
property name. In other words, a signed Request or Response uses the
following template.

A general JWS object looks like the following.

```
{
  "<name>[Request | Response]": {
    <JWS Message of <name>TBS[Request | Response]
  }
}
```

With the standard JWS message format, a signed OTrP Message looks
like the following.

```
{
  "<name>[Request | Response]": {
    "payload": "<payload contents of <name>TBS[Request | Response]>",
    "protected": "<integrity-protected header contents>",
    "header":  <non-integrity-protected header contents>,
    "signature": "<signature contents>"
  }
}
```

The top element "<name>[Signed][Request|Response]" cannot be fully
trusted to match the content because it doesn't participate in the
signature generation. However, a recipient can always match it with
the value associated with the property "payload". It purely serves
to provide a quick reference for reading and method invocation.

Furthermore, most properties in an unsigned OTrP messages are
encrypted to provide end-to-end confidentiality. The only OTrP
message that isn't encrypted is the initial device query message that
asks for the device state information.

Thus a typical OTrP Message consists of an encrypted and then signed
JSON message. Some transaction data such as transaction ID and TEE
information may need to be exposed to the OTrP Broker for routing
purpose. Such information is excluded from JSON encryption. The
device's signer certificate itself is encrypted. The overall final
message is a standard signed JSON message.

As required by JSW/JWE, those JWE and JWS related elements will be
BASE64URL encoded. Other binary data elements specific to the OTrP

specification are BASE64-encoded. This specification indicates
elements that should be BASE64 and those elements that are to be
BASE64URL encoded.

7.4.1. Identifying Signing and Encryption Keys for JWS/JWE Messaging

JWS and JWE messaging allow various options for identifying the
signing and encryption keys, for example, it allows optional elements
including "x5c", "x5t" and "kid" in the header to cover various
possibilities.

To protect privacy, it is important that the device's certificate is
released only to a trusted TAM, and that it is encrypted. The TAM
will need to know the device certificate, but untrusted parties must
not be able to get the device certificate. All OTrP messaging
conversations between a TAM and device begin with
GetDeviceStateRequest / GetDeviceStateResponse. These messages have
elements built into them to exchange signing certificates, described
in the section Section 9. Any subsequent messages in the
conversation that follow on from this implicitly use the same
certificates for signing/encryption, and as a result the certificates
or references may be omitted in those subsequent messages.

In other words, the signing key identifier in the use of JWS and JWE
here may be absent in the subsequent messages after the initial
GetDeviceState query.

This has an implication on the TEE and TAM implementation: they have
to cache the signer certificates for the subsequent message signature
validation in the session. It may be easier for a TAM service to
cache transaction session information but not so for a TEE in a
device. A TAM can get a device's capability by checking the response
message from a TEE to decide whether it should include its TAM signer
certificate and OCSP data in each subsequent request message. The
device's caching capability is reported in GetDeviceStateResponse
signerreq parameter.

7.5. JSON Signing and Encryption Algorithms

The OTrP JSON signing algorithm shall use SHA256 or a stronger hash
method with respective key type. JSON Web Algorithm RS256 or ES256
[RFC7518] SHALL be used for RSA with SHA256 and ECDSA with SHA256.
If RSA with SHA256 is used, the JSON web algorithm representation is
as follows.

    {"alg":"RS256"}

The (BASE64URL encoded) "protected" header property in a signed
message looks like the following:

```
"protected":"eyJhbGciOiJSUzI1NiJ9"
```

If ECSDA with P-256 curve and SHA256 are used for signing, the JSON
signing algorithm representation is as follows.

```
{"alg":"ES256"}
```

The value for the "protected" field will be the following.

```
eyJhbGciOiJFUzI1NiJ9
```

Thus, a common OTrP signed message with ES256 looks like the
following.

```
  {
    "payload": "<payload contents>",
    "protected": "eyJhbGciOiJFUzI1NiJ9",
    "signature": "<signature contents>"
  }
```

The OTrP JSON message encryption algorithm SHOULD use one of the
supported algorithms defined in the later chapter of this document.
JSON encryption uses a symmetric key as its "Content Encryption Key
(CEK)". This CEK is encrypted or wrapped by a recipient's key. The
OTrP recipient typically has an asymmetric key pair. Therefore, the
CEK will be encrypted by the recipient's public key.

A compliant implementation shall support the following symmetric
encryption algorithm and anticipate future new algorithms.

```
{"enc":"A128CBC-HS256"}
```

This algorithm represents encryption with AES 128 in CBC mode with
HMAC SHA 256 for integrity. The value of the property "protected" in
a JWE message will be

```
eyJlbmMiOiJBMTI4Q0JDLUhTMjU2In0
```

An encrypted JSON message looks like the following.

```
{
  "protected": "eyJlbmMiOiJBMTI4Q0JDLUhTMjU2In0",
   "recipients": [
      {
          "header": {
              "alg": "<RSA1_5 etc.>"
          },
          "encrypted_key": "<encrypted value of CEK>"
      }
  ],
  "iv": "<BASE64URL encoded IV data>",
  "ciphertext": "<Encrypted data over the JSON plaintext
                 (BASE64URL)>",
  "tag": "<JWE authentication tag (BASE64URL)>"
}
```

OTrP doesn't use JWE AAD (Additional Authenticated Data) because each
message is always signed after the message is encrypted.

7.5.1. Supported JSON Signing Algorithms

The following JSON signature algorithm is mandatory support in the
TEE and TAM:

o   RS256

ES256 is optional to support.

7.5.2. Support JSON Encryption Algorithms

The following JSON authenticated encryption algorithm is mandatory
support in TEE and TAM.

o   A128CBC-HS256

A256CBC-HS512 is optional to support.

7.5.3. Supported JSON Key Management Algorithms

The following JSON key management algorithm is mandatory support in
TEE and TAM.

o   RSA1_5

ECDH-ES+A128KW and ECDH-ES+A256KW are optional to support.

7.6. **Common Errors**

   An OTrP Response message typically needs to report the operation
   status and error causes if an operation fails. The following JSON
   message elements should be used across all OTrP Messages.

   "status": "pass | fail"

    "reason": {
        "error-code": "<error code if there is any>",
        "error-message": "<error message>"
      }

   "ver": "<version string>"

7.7. **OTrP Message List**

   The following table lists the OTrP commands and therefore
   corresponding Request and Response messages defined in this
   specification. Additional messages may be added in the future when
   new task messages are needed.

   GetDeviceState -
       A TAM queries a device's current state with a message
       GetDeviceStateRequest. A device TEE will report its version, its
       FW version, and list of all SDs and TAs in the device that is
       managed by the requesting TAM. TAM may determine whether the
       device is trustworthy and decide to carry out additional commands
       according to the response from this query.

   CreateSD -
       A TAM instructs a device TEE to create an SD for an SP. The
       recipient TEE will check whether the requesting TAM is
       trustworthy.

   UpdateSD -
       A TAM instructs a device TEE to update an existing SD. A typical
       update need comes from SP certificate change, TAM certificate
       change and so on. The recipient TEE will verify whether the TAM
       is trustworthy and owns the SD.

   DeleteSD -
       A TAM instructs a device TEE to delete an existing SD. A TEE
       conditionally deletes TAs loaded in the SD according to a request
       parameter. An SD cannot be deleted until all TAs in this SD are
       deleted. If this is the last SD for an SP, TEE MAY also delete
       TEE SP AIK key for this SP.

InstallTA -
    A TAM instructs a device to install a TA into an SD for a SP.
    The TEE in a device will check whether the TAM and TA are
    trustworthy.

UpdateTA -
    A TAM instructs a device to update a TA into an SD for an SP.
    The change may commonly be bug fix for a previously installed TA.

DeleteTA -
    A TAM instructs a device to delete a TA. The TEE in a device
    will check whether the TAM and TA are trustworthy.

7.8. OTrP Request Message Routing Rules

For each command that a TAM wants to send to a device, the TAM
generates a request message. This is typically triggered by a Client
Application that uses the TAM. The Client Application initiates
contact with the TAM and receives TAM OTrP Request messages according
to the TAM's implementation. The Client Application forwards the
OTrP message to an OTrP Broker in the device, which in turn sends the
message to the active TEE in the device.

The current version of this specification assumes that each device
has only one active TEE, and the OTrP Broker is responsible to
connect to the active TEE. This is the case today with devices in
the market.

When the TEE responds to a request, the OTrP Broker gets the OTrP
response messages back to the Client Application that sent the
request. In case the target TEE fails to respond to the request, the
OTrP Broker will be responsible to generate an error message to reply
the Client Application. The Client Application forwards any data it
received to its TAM.

7.8.1. SP Anonymous Attestation Key (SP AIK)

When the first new Security Domain is created in a TEE for an SP, a
new key pair is generated and associated with this SP. This key pair
is used for future device attestation to the service provider instead
of using the device's TEE key pair.

8. Transport Protocol Support

The OTrP message exchange between a TEE device and TAM generally
takes place between a Client Application in REE and TAM. A device
that is capable to run a TEE and PKI based cryptographic attestation

isn't generally resource constraint to carry out standard HTTPS
connections. A compliant device and TAM SHOULD support HTTPs.

9. Detailed Messages Specification

For each message in the following sections all JSON elements are
mandatory if not explicitly indicated as optional.

9.1. GetDeviceState

This is the first command that a TAM will send to a device. This
command is triggered when an SP's Client Application contacts its TAM
to check whether the underlying device is ready for TA operations.

This command queries a device's current TEE state. A device TEE will
report its version, its FW version, and list of all SDs and TAs in
the device that is managed by the requesting TAM. TAM may determine
whether the device is trustworthy and decide to carry out additional
commands according to the response from this query.

The request message of this command is signed by the TAM. The
response message from the TEE is encrypted. A random message
encryption key (MK) is generated by TEE, and this encrypted key is
encrypted by the TAM's public key such that only the TAM that sent
the request is able to decrypt and view the response message.

9.1.1. GetDeviceStateRequest message

```
{
   "GetDeviceStateTBSRequest": {
      "ver": "1.0",
      "rid": "<Unique request ID>",
      "tid": "<transaction ID>",
      "ocspdat": [<a list of OCSP stapling data>"],
      "supportedsigalgs": [<array of supported signing algorithms>]
   }
}
```

The request message consists of the following data elements:

ver -   version of the message format

rid -   a unique request ID generated by the TAM

tid -   a unique transaction ID to trace request and response. This
        can be from a prior transaction's tid field, and can be used in
        subsequent message exchanges in this TAM session. The
        combination of rid and tid MUST be made unique.

   ocspdat -   A list of OCSP stapling data respectively for the TAM
      certificate and each of the CA certificates up to the root
      certificate. The TAM provides OCSP data such that a recipient
      TEE can validate the TAM certificate chain revocation status
      without making its own external OCSP service call. A TEE MAY
      cache the CA OCSP data such that the array may contain only the
      OCSP stapling data for the TAM certificate in subsequent
      exchanges. This is a mandatory field.

   supportedsigalgs -   an optional property to list the signing
      algorithms that the TAM is able to support. A recipient TEE MUST
      choose an algorithm in this list to sign its response message if
      this property is present in a request. If it is absent, the TEE
      may use any compliant signing algorithm that is listed as
      mandatory support in this specification.

   The final request message is JSON signed message of the above raw
   JSON data with TAM's certificate.

```
{
  "GetDeviceStateRequest": {
    "payload": "<BASE64URL encoding of the GetDeviceStateTBSRequest
                JSON above>",
    "protected": "<BASE64URL encoded signing algorithm>",
    "header": {
        "x5c": "<BASE64 encoded TAM certificate chain up to the
                 root CA certificate>"
    },
    "signature":"<signature contents signed by TAM private key>"
  }
}
```

   The signing algorithm SHOULD use SHA256 with respective key type.
   The mandatory algorithm support is the RSA signing algorithm. The
   signer header "x5c" is used to include the TAM signer certificate up
   to the root CA certificate.

9.1.2. Request processing requirements at a TEE

   Upon receiving a request message GetDeviceStateRequest at a TEE, the
   TEE MUST validate a request:

   1. Validate JSON message signing. If it doesn't pass, an error
       message is returned.

   2. Validate that the request TAM certificate is chained to a trusted
       CA that the TEE embeds as its trust anchor.

       * Cache the CA OCSP stapling data and certificate revocation
          check status for other subsequent requests.

       * A TEE can use its own clock time for the OCSP stapling data
          validation.

   3. Optionally collect Firmware signed data

       * This is a capability in ARM architecture that allows a TEE to
          query Firmware to get FW signed data. It isn't required for
          all TEE implementations. When TFW signed data is absent, it
          is up to a TAM's policy how it will trust a TEE.

   4. Collect SD information for the SD owned by this TAM

9.1.3. Firmware Signed Data

   Firmware isn't expected to process or produce JSON data. It is
   expected to just sign some raw bytes of data.

   The data to be signed by TFW key needs be some unique random data
   each time. The (UTF-8 encoded) "tid" value from the
   GetDeviceStateTBSRequest shall be signed by the firmware. TAM isn't
   expected to parse TFW data except the signature validation and signer
   trust path validation.

   It is possible that a TEE can get some valid TFW signed data from
   another device. The TEE is responsible to validate TFW integrity to
   ensure that the underlying device firmware is trustworthy. In some
   cases, a TEE isn't able to get a TFW signed data, in which case the
   TEE trust validation is up to a TAM to decide. A TAM may opt to
   trust a TEE basing on the TEE signer and additional information about
   a TEE out-of-band.

   When TFW signed data is available, a TAM validates the TEE and trusts
   that a trusted TEE has carried out appropriate trust check about a
   TFW.

```
   TfwData: {
       "tbs": "<TFW to be signed data, BASE64 encoded>",
       "cert": "<BASE64 encoded TFW certificate>",
       "sigalg": "Signing method",
       "sig": "<TFW signed data,  BASE64 encoded>"
   }
```

   It is expected that a FW uses standard signature methods for maximal
   interoperability with TAM providers. The mandatory support list of
   signing algorithm is RSA with SHA256.

The JSON object above is constructed by a TEE with data returned from
the FW. It isn't a standard JSON signed object. The signer
information and data to be signed must be specially processed by a
TAM according to the definition given here. The data to be signed is
the raw data.

9.1.3.1. Supported Firmware Signature Methods

TAM providers shall support the following signature methods. A
firmware provider can choose one of the methods in signature
generation.

o   RSA with SHA256

o   ECDSA with SHA 256

The value of "sigalg" in the TfwData JSON message SHOULD use one of
the following:

o   RS256

o   ES256

9.1.4. Post Conditions

Upon successful request validation, the TEE information is collected.
There is no change in the TEE in the device.

The response message shall be encrypted where the encryption key
shall be a symmetric key that is wrapped by TAM's public key. The
JSON Content Encryption Key (CEK) is used for this purpose.

9.1.5. GetDeviceStateResponse Message

The message has the following structure.

```
  {
    "GetDeviceTEEStateTBSResponse": {
        "ver": "1.0",
        "status": "pass | fail",
        "rid": "<the request ID from the request message>",
        "tid": "<the transaction ID from the request message>",
        "signerreq": true | false // about whether TAM needs to send
                     signer data again in subsequent messages,
        "edsi": "<Encrypted JSON DSI information>"
    }
  }
```

where

signerreq -   true if the TAM should send its signer certificate and
     OCSP data again in the subsequent messages. The value may be
     "false" if the TEE caches the TAM's signer certificate and OCSP
     status.

rid -   the request ID from the request message

tid -   the tid from the request message

edsi -   the main data element whose value is JSON encrypted message
     over the following Device State Information (DSI).

The Device State Information (DSI) message consists of the following.

```
{
    "dsi": {
        "tfwdata": {
            "tbs": "<TFW to be signed data is the tid>"
            "cert": "<BASE64 encoded TFW certificate>",
            "sigalg": "Signing method",
            "sig": "<TFW signed data, BASE64 encoded>"
        },
        "tee": {
            "name": "<TEE name>",
            "ver": "<TEE version>",
            "cert": "<BASE64 encoded TEE cert>",
            "cacert": "<JSON array value of CA certificates up to
                        the root CA>",
            "sdlist": {
                "cnt": "<Number of SD owned by this TAM>",
                "sd": [
                    {
                        "name": "<SD name>",
                        "spid": "<SP owner ID of this SD>",
                        "talist": [
                          {
                              "taid": "<TA application identifier>",
                              "taname": "<TA application friendly
                                          name>" // optional
                          }
                        ]
                    }
                ]
            },
            "teeaiklist": [
                {
                    "spaik": "<SP AIK public key, BASE64 encoded>",
                    "spaiktype": "<RSA | ECC>",
                    "spid": "<sp id>"
                }
            ]
        }
    }
}
```

The encrypted JSON message looks like the following.

```
{
    "protected": "<BASE64URL encoding of encryption algorithm header
                  JSON data>",
    "recipients": [
        {
            "header": {
                "alg": "RSA1_5"
            },
            "encrypted_key": "<encrypted value of CEK>"
        }
    ],
    "iv": "<BASE64URL encoded IV data>",
    "ciphertext": "<Encrypted data over the JSON object of dsi
                  (BASE64URL)>",
    "tag": "<JWE authentication tag (BASE64URL)>"
}
```

Assume we encrypt plaintext with AES 128 in CBC mode with HMAC SHA
256 for integrity, the encryption algorithm header is:

```
{"enc":"A128CBC-HS256"}
```

The value of the property "protected" in the above JWE message will
be

```
eyJlbmMiOiJBMTI4Q0JDLUhTMjU2In0
```

In other words, the above message looks like the following:

```
{
    "protected": "eyJlbmMiOiJBMTI4Q0JDLUhTMjU2In0",
     "recipients": [
        {
            "header": {
                "alg": "RSA1_5"
            },
            "encrypted_key": "<encrypted value of CEK>"
        }
    ],
    "iv": "<BASE64URL encoded IV data>",
    "ciphertext": "<Encrypted data over the JSON object of dsi
                  (BASE64URL)>",
    "tag": "<JWE authentication tag (BASE64URL)>"
}
```

The full response message looks like the following:

```
   {
     "GetDeviceTEEStateTBSResponse": {
       "ver": "1.0",
       "status": "pass | fail",
       "rid": "<the request ID from the request message>",
       "tid": "<the transaction ID from the request message>",
       "signerreq": "true | false",
       "edsi": {
         "protected": "<BASE64URL encoding of encryption algorithm
                        header JSON data>",
         "recipients": [
           {
             "header": {
               "alg": "RSA1_5"
             },
             "encrypted_key": "<encrypted value of CEK>"
           }
         ],
         "iv": "<BASE64URL encoded IV data>",
         "ciphertext": "<Encrypted data over the JSON object of dsi
                        (BASE64URL)>",
         "tag": "<JWE authentication tag (BASE64URL)>"
       }
     }
   }
```

   The CEK will be encrypted by the TAM public key in the device. The
   TEE signed message has the following structure.

```
   {
     "GetDeviceTEEStateResponse": {
       "payload": "<BASE64URL encoding of the JSON message
                    GetDeviceTEEStateTBSResponse>",
       "protected": "<BASE64URL encoding of signing algorithm>",
       "signature": "<BASE64URL encoding of the signature value>"
     }
   }
```

   The signing algorithm shall use SHA256 with respective key type, see
   Section 7.5.1.

   The final GetDeviceStateResponse response message consists of an
   array of TEE responses.

```
   {
       "GetDeviceStateResponse": [ // JSON array
          {"GetDeviceTEEStateResponse": ...},
          ...
          {"GetDeviceTEEStateResponse": ...}
       ]
   }
```

9.1.6. Error Conditions

An error may occur if a request isn't valid or the TEE runs into some
error. The list of possible error conditions is the following.

ERR_REQUEST_INVALID The TEE meets the following conditions with a
   request message: (1) The request from a TAM has an invalid message
   structure; mandatory information is absent in the message; or an
   undefined member or structure is included. (2) TEE fails to verify
   the signature of the message or fails to decrypt its contents.

ERR_UNSUPPORTED_MSG_VERSION The TEE receives a version of message
   that the TEE can't deal with.

ERR_UNSUPPORTED_CRYPTO_ALG The TEE receives a request message
   encoded with a cryptographic algorithm that the TEE doesn't
   support.

ERR_TFW_NOT_TRUSTED The TEE considers the underlying device firmware
   be not trustworthy.

ERR_TAM_NOT_TRUSTED The TEE needs to make sure whether the TAM is
   trustworthy by checking the validity of the TAM certificate and
   OCSP stapling data and so on. If the TEE finds the TAM is not
   reliable, it returns this error code.

ERR_TEE_FAIL If the TEE fails to process a request because of its
   internal error but is able to sign an error response message, it
   will return this error code.

The response message will look like the following if the TEE signing
can work to sign the error response message.

```
   {
       "GetDeviceTEEStateTBSResponse": {
           "ver": "1.0",
           "status": "fail",
           "rid": "<the request ID from the request message>",
           "tid": "<the transaction ID from the request message>",
           "reason": {"error-code":"<error code>"}
           "supportedsigalgs": [<an array of signature algorithms that
                                the TEE supports>]
       }
   }
```

where

supportedsigalgs - an optional property to list the JWS signing
    algorithms that the active TEE supports. When a TAM sends a
    signed message that the TEE isn't able to validate, it can
    include signature algorithms that it is able to consume in this
    status report. A TAM can generate a new request message to retry
    the management task with a TEE-supported signing algorithm.

If the TEE isn't able to sign an error message due to an internal
device error, a general error message should be returned by the OTrP
Broker.

9.1.7. TAM Processing Requirements

Upon receiving a GetDeviceStateResponse message at a TAM, the TAM
MUST validate the following.

o Parse to get list of GetDeviceTEEStateResponse JSON objects

o Parse the JSON "payload" property and decrypt the JSON element
   "edsi". The decrypted message contains the TEE signer
   certificate.

o Validate the GetDeviceTEEStateResponse JSON signature. The signer
   certificate is extracted from the decrypted message in the last
   step.

o Extract TEE information and check it against its TEE acceptance
   policy.

o Extract the TFW signed element, and check the signer and data
   integration against its TFW policy.

o Check the SD list and TA list and prepare for a subsequent command
   such as "CreateSD" if it needs to have a new SD for an SP.

9.2. Security Domain Management

9.2.1. CreateSD

   This command is typically preceded with a GetDeviceState command that
   has acquired the device information of the target device by the TAM.
   The TAM sends such a command to instruct a TEE to create a new
   Security Domain for an SP.

   A TAM sends an OTrP CreateSDRequest Request message to a device TEE
   to create a Security Domain for an SP. Such a request is signed by
   the TAM where the TAM signer may or may not be the same as the SP's
   TA signer certificate. The resulting SD is associated with two
   identifiers for future management:

   o TAM as the owner. The owner identifier is a registered unique TAM
      ID that is stored in the TAM certificate.

   o SP identified by its TA signer certificate as the authorization.
      A TAM can add more than one SP certificate to an SD.

   A Trusted Application that is signed by a matching SP signer
   certificate for an SD is eligible to be installed into that SD. The
   TA installation into an SD by a subsequent InstallTARequest message
   may be instructed from a TAM.

9.2.1.1. CreateSDRequest Message

The request message for CreateSD has the following JSON format.

```
{
  "CreateSDTBSRequest": {
    "ver": "1.0",
    "rid": "<unique request ID>",
    "tid": "<transaction ID>", // this may be from prior message
    "tee": "<TEE routing name from the DSI for the SD's target>",
    "nextdsi": true | false,
    "dsihash": "<hash of DSI returned in the prior query>",
    "content": ENCRYPTED { // this piece of JSON data will be
                           // encrypted
        "spid": "<SP ID value>",
      "sdname": "<SD name for the domain to be created>",
      "spcert": "<BASE64 encoded SP certificate>",
      "tamid": "<An identifiable attribute of the TAM
                  certificate>",
      "did": "<SHA256 hash of the TEE cert>"
    }
  }
}
```

In the message,

rid - A unique value to identify this request

tid - A unique value to identify this transaction. It can have the
   same value for the tid in the preceding GetDeviceStateRequest.

tee - TEE ID returned from the previous GetDeviceStateResponse.

nextdsi - Indicates whether the up-to-date Device State Information
   (DSI) is expected in the response from the TEE to this request.

dsihash - The BASE64-encoded SHA256 hash value of the DSI data
   returned in the prior TAM operation with this target TEE. This
   value is always included such that a receiving TEE can check
   whether the device state has changed since its last query. It
   helps enforce SD update order in the right sequence without
   accidentally overwriting an update that was done simultaneously.

content - The "content" is a JSON encrypted message that includes
   actual input for the SD creation. The encryption key is TAMmk that
   is encrypted by the target TEE's public key. The entire message is
   signed by the TAM private key TAMpriv. A separate TAMmk isn't used
   in the latest specification because JSON encryption will use a
   content encryption key for exactly the same purpose.

spid - A unique id assigned by the TAM for its SP. It should be
   unique within a TAM namespace.

sdname - a name unique to the SP. TAM should ensure it is unique
   for each SP.

spcert - The SP's TA signer certificate is included in the request.
   This certificate will be stored by the device TEE which uses it to
   check against TA installation. Only if a TA is signed by a
   matching spcert associated with an SD will the TA be installed into
   the SD.

tamid - SD owner claim by TAM - an SD owned by a TAM will be
   associated with a trusted identifier defined as an attribute in the
   signer TAM certificate. TEE will be responsible to assign this ID
   to the SD. The TAM certificate attribute for this attribute tamid
   MUST be vetted by the TAM signer issuing CA. With this trusted
   identifier, the SD query at TEE can be fast upon TAM signer
   verification.

did - The SHA256 hash of the binary-encoded device TEE certificate.
   The encryption key CEK will be encrypted the recipient TEE's public
   key. This hash value in the "did" property allows the recipient
   TEE to check whether it is the expected target to receive such a
   request. If this isn't given, an OTrP message for device 2 could
   be sent to device 1. It is optional for the TEE to check because
   the successful decryption of the request message with this device's
   TEE private key already proves it is the target. This explicit
   hash value makes the protocol not dependent on message encryption
   method in future.

A CreateSDTBSRequest message is signed to generate a final
CreateSDRequest message as follows.

```
{
    "CreateSDRequest": {
        "payload": "<CreateSDTBSRequest JSON above>",
        "protected": "<integrity-protected header contents>",
        "header": "<non-integrity-protected header contents>",
        "signature": "<signature contents signed by TAM private key>"
    }
}
```

The TAM signer certificate is included in the "header" property.

9.2.1.2. **Request Processing Requirements at a TEE**

   Upon receiving a CreateSDRequest request message at a TEE, the TEE
   MUST do the following:

   1. Validate the JSON request message as follows

       * Validate JSON message signing.

       * Validate that the request TAM certificate is chained to a
          trusted CA that the TEE embeds as its trust anchor.

       * Compare dsihash with its current state to make sure nothing
          has changed since this request was sent.

       * Decrypt to get the plaintext of the content: (a) spid, (b) sd
          name, (c) did.

       * Check that an SPID is supplied.

       * spcert check: check it is a valid certificate (signature and
          format verification only).

       * Check "did" is the SHA256 hash of its TEEcert BER raw binary
          data.

       * Check whether the requested SD already exists for the SP.

       * Check that the tamid in the request matches the TAM
          certificate's TAM ID attribute.

   2. If the request was valid, create action

       * Create an SD for the SP with the given name.

       * Assign the tamid from the TAMCert to this SD.

       * Assign the SPID and SPCert to this SD.

       * Check whether a TEE SP AIK key pair already exists for the
          given SP ID.

       * Create TEE SP AIK key pair if it doesn't exist for the given
          SP ID.

       * Generate new DSI data if the request asks for updated DSI.

   3. Construct a CreateSDResponse message

* Create raw content

    + Operation status

    + "did" or full signer certificate information,

    + TEE SP AIK public key if DSI isn't going to be included

    + Updated DSI data if requested

* The response message is encrypted with the same JWE CEK of the request without recreating a new content encryption key.

* The encrypted message is signed with TEEpriv. The signer information ("did" or TEEcert) is encrypted.

4. Deliver the response message. (a) The OTrP Broker returns this to the Client Application; (b) The Client App passes this back to the TAM.

5. TAM processing. (a) The TAM processes the response message; (b) the TAM can look up signer certificate from the device ID "did".

If a request is illegitimate or signature doesn't pass, a "status" property in the response will indicate the error code and cause.

9.2.1.3. CreateSDResponse Message

The response message for a CreateSDRequest contains the following content.

```
{
  "CreateSDTBSResponse": {
    "ver": "1.0",
    "status": "<operation result>",
    "rid": "<the request ID received>",
    "tid": "<the transaction ID received>",
    "content": ENCRYPTED {
      "reason": "<failure reason detail>", // optional
      "did": "<the device id received from the request>",
      "sdname": "<SD name for the domain created>",
      "teespaik": "<TEE SP AIK public key, BASE64 encoded>",
      "dsi": "<Updated TEE state, including all SDs owned by
        this TAM>"
    }
  }
}
```

In the response message, the following fields MUST be supplied.

did -   The SHA256 hash of the device TEE certificate. This shows
  the device ID explicitly to the receiving TAM.

teespaik -   The newly generated SP AIK public key for the given SP.
  This is an optional value if the device has had another domain for
  the SP that has triggered TEE SP AIK key pair for this specific SP.

There is a possible extreme error case where the TEE isn't reachable
or the TEE final response generation itself fails. In this case, the
TAM might still receive a response from the OTrP Broker if the OTrP
Broker is able to detect such error from TEE. In this case, a
general error response message should be returned by the OTrP Broker,
assuming OTrP Broker even doesn't know any content and information
about the request message.

In other words, the TAM should expect to receive a TEE successfully
signed JSON message, a general "status" message, or none when a
client experiences a network error.

```
{
  "CreateSDResponse": {
    "payload": "<CreateSDTBSResponse JSON above>",
    "protected": {
       "<BASE64URL of signing algorithm>"
    },
    "signature": "<signature contents signed by the TEE device private
                  key (BASE64URL)>"
  }
}
```

When the TEE fails to respond, the OTrP Broker will not provide a
subsequent response to the TAM. The TAM should treat this as if the
device has gone offline where a response is never delivered back.

9.2.1.4. Error Conditions

An error might occur if a request isn't valid or the TEE runs into
some error. The list of possible errors are as follows. Refer to
the Error Code List (Section 13.1) for detailed causes and actions.

ERR_REQUEST_INVALID

ERR_UNSUPPORTED_MSG_VERSION

ERR_UNSUPPORTED_CRYPTO_ALG

ERR_DEV_STATE_MISMATCH

ERR_SD_ALREADY_EXIST

ERR_SD_NOT_FOUND

ERR_SPCERT_INVALID

ERR_TEE_FAIL

ERR_TAM_NOT_AUTHORIZED

ERR_TAM_NOT_TRUSTED

9.2.2. UpdateSD

This TAM initiated command can update an SP's SD that it manages for
any of the following needs: (a) Update an SP signer certificate; (b)
Add an SP signer certificate when an SP uses multiple to sign TA
binaries; (c) Update an SP ID.

The TAM presents the proof of the SD ownership to the TEE, and
includes related information in its signed message. The entire
request is also encrypted for end-to-end confidentiality.

9.2.2.1. UpdateSDRequest Message

The UpdateSD request message has the following JSON format.

```
{
  "UpdateSDTBSRequest": {
    "ver": "1.0",
    "rid": "<unique request ID>",
    "tid": "<transaction ID>", // this may be from prior message
    "tee": "<TEE routing name from the DSI for the SD's target>",
    "nextdsi": true | false,
    "dsihash": "<hash of DSI returned in the prior query>",
    "content": ENCRYPTED { // this piece of JSON will be encrypted
      "tamid": "<tamid associated with this SD>",
      "spid": "<SP ID>",
      "sdname": "<SD name for the domain to be updated>",
      "changes": {
        "newsdname": "<Change the SD name to this new name>",
                    // Optional
        "newspid": "<Change SP ID of the domain to this new value>",
                    // Optional
        "spcert": ["<BASE64 encoded new SP signer cert to be added>"],
                    // Optional
        "deloldspcert": ["<The SHA256 hex value of an old SP cert
                   assigned into this SD that should be deleted >"],
                    // Optional
        "renewteespaik": true | false
      }
    }
  }
}
```

In the message,

rid - A unique value to identify this request

tid - A unique value to identify this transaction. It can have the
  same value as the tid in the preceding GetDeviceStateRequest.

tee - TEE ID returned from the previous GetDeviceStateResponse

nextdsi - Indicates whether the up-to-date Device State Information
  (DSI) is expected to be returned in the response from the TEE to
  this request.

dsihash - The BASE64-encoded SHA256 hash value of the DSI data
  returned in the prior TAM operation with this target TEE. This
  value is always included such that a receiving TEE can check
  whether the device state has changed since its last query. It

helps enforce SD update order in the right sequence without
accidentally overwriting an update that was done simultaneously.

content - The "content" is a JSON encrypted message that includes
   actual input for the SD update. The standard JSON content
   encryption key (CEK) is used, and the CEK is encrypted by the
   target TEE's public key.

tamid - SD owner claim by TAM - an SD owned by a TAM will be
   associated with a trusted identifier defined as an attribute in the
   signer TAM certificate.

spid - the identifier of the SP whose SD will be updated. This
   value is still needed because the SD name is considered unique only
   within an SP.

sdname - the name of the target SD to be updated.

changes - its content consists of changes are to be updated in the
   given SD.

newsdname - the new name of the target SD to be assigned if this
   value is present.

newspid - the new SP ID of the target SD to be assigned if this
   value is present.

spcert - a new TA signer certificate of this SP to be added to the
   SD if this is present.

deloldspcert - an SP certificate assigned into the SD is to be
   deleted if this is present. The value is the SHA256 fingerprint of
   the old SP certificate.

renewteespaik - the value should be true or false. If it is present
   and the value is true, the TEE MUST regenerate TEE SP AIK for this
   SD's owner SP. The newly generated TEE SP AIK for the SP must be
   returned in the response message of this request. If there is more
   than one SD for the SP, a new SPID for one of the domains will
   always trigger a new teespaik generation as if a new SP were
   introduced to the TEE.

The UpdateSDTBSRequest message is signed to generate the final
UpdateSDRequest message.

```
{
  "UpdateSDRequest": {
    "payload": "<UpdateSDTBSRequest JSON above>",
    "protected": "<integrity-protected header contents>",
    "header": "<non-integrity-protected header contents>",
    "signature":"<signature contents signed by TAM private key>"
  }
}
```

TAM signer certificate is included in the "header" property.

9.2.2.2. Request Processing Requirements at a TEE

Upon receiving a request message UpdateSDRequest at a TEE, the TEE
must validate a request:

1. Validate the JSON request message

    * Validate JSON message signing

    * Validate that the request TAM certificate is chained to a
       trusted CA that the TEE embeds as its trust anchor.The TAM
       certificate status check is generally not needed anymore in
       this request. The prior request should have validated the TAM
       certificate's revocation status.

    * Compare dsihash with the TEE cached last response DSI data to
       this TAM.

    * Decrypt to get the plaintext of the content.

    * Check that the target SD name is supplied.

    * Check whether the requested SD exists.

    * Check that the TAM owns this TAM by verifying tamid in the SD
       matches TAM certificate's TAM ID attribute.

    * Now the TEE is ready to carry out update listed in the
       "content" message.

2. If the request is valid, update action

    * If "newsdname" is given, replace the SD name for the SD to the
       new value

   *   If "newspid" is given, replace the SP ID assigned to this SD
       with the given new value

   *   If "spcert" is given, add this new SP certificate to the SD.

   *   If "deloldspcert" is present in the content, check previously
       assigned SP certificates to this SD, and delete the one that
       matches the given certificate hash value.

   *   If "renewteespaik" is given and has a value of 'true',
       generate a new TEE SP AIK key pair, and replace the old one
       with this.

   *   Generate new DSI data if the request asks for updated DSI

   *   Now the TEE is ready to construct the response message

3. Construct UpdateSDResponse message

   *   Create raw content

       +   Operation status

       +   "did" or full signer certificate information,

       +   TEE SP AIK public key if DSI isn't going to be included

       +   Updated DSI data if requested

   *   The response message is encrypted with the same JWE CEK of the
       request without recreating a new content encryption key.

   *   The encrypted message is signed with TEEpriv. The signer
       information ("did" or TEEcert) is encrypted.

4. Deliver response message. (a) The OTrP Broker returns this to the
    app; (b) The app passes this back to the TAM.

5. TAM processing. (a) The TAM processes the response message; (b)
    The TAM can look up the signer certificate from the device ID
    "did".

   If a request is illegitimate or the signature doesn't pass, a
   "status" property in the response will indicate the error code and
   cause.

9.2.2.3. UpdateSDResponse Message

The response message for a UpdateSDRequest contains the following
content.

```
{
  "UpdateSDTBSResponse": {
    "ver": "1.0",
    "status": "<operation result>",
    "rid": "<the request ID received>",
    "tid": "<the transaction ID received>",
    "content": ENCRYPTED {
      "reason": "<failure reason detail>", // optional
      "did": "<the device id hash>",
      "cert": "<TEE certificate>", // optional
      "teespaik": "<TEE SP AIK public key, BASE64 encoded>",
      "teespaiktype": "<TEE SP AIK key type: RSA or ECC>",
      "dsi": "<Updated TEE state, including all SD owned by
        this TAM>"
    }
  }
}
```

In the response message, the following fields MUST be supplied.

did -   The request should have known the signer certificate of this
   device from a prior request. This hash value of the device TEE
   certificate serves as a quick identifier only. A full device
   certificate isn't necessary.

teespaik -   the newly generated SP AIK public key for the given SP
   if the TEE SP AIK for the SP is asked to be renewed in the request.
   This is an optional value if "dsi" is included in the response,
   which will contain all up-to-date TEE SP AIK key pairs.

Similar to the template for the creation of the encrypted and signed
CreateSDResponse, the final UpdateSDResponse looks like the
following.

```
   {
     "UpdateSDResponse": {
       "payload": "<UpdateSDTBSResponse JSON above>",
       "protected": {
           "<BASE64URL of signing algorithm>"
       },
       "signature": "<signature contents signed by TEE device private
                      key (BASE64URL)>"
     }
   }
```

When the TEE fails to respond, the OTrP Broker will not provide a
subsequent response to the TAM. The TAM should treat this as if the
device has gone offline where a response is never delivered back.

9.2.2.4. Error Conditions

An error may occur if a request isn't valid or the TEE runs into some
error. The list of possible errors are as follows. Refer to the
Error Code List (Section 13.1) for detailed causes and actions.

ERR_REQUEST_INVALID

ERR_UNSUPPORTED_MSG_VERSION

ERR_UNSUPPORTED_CRYPTO_ALG

ERR_DEV_STATE_MISMATCH

ERR_SD_NOT_FOUND

ERR_SDNAME_ALREADY_USED

ERR_SPCERT_INVALID

ERR_TEE_FAIL

ERR_TAM_NOT_AUTHORIZED

ERR_TAM_NOT_TRUSTED

9.2.3. DeleteSD

A TAM sends a DeleteSDRequest message to a TEE to delete a specified
SD that it owns. An SD can be deleted only if there is no TA
associated with this SD in the device. The request message can

contain a flag to instruct the TEE to delete all related TAs in an SD
and then delete the SD.

The target TEE will operate with the following logic.

1. Look up the given SD specified in the request message

2. Check that the TAM owns the SD

3. Check that the device state hasn't changed since the last
    operation

4. Check whether there are TAs in this SD

5. If TA exists in an SD, check whether the request instructs
    whether the TA should be deleted. If the request instructs the
    TEE to delete TAs, delete all TAs in this SD. If the request
    doesn't instruct the TEE to delete TAs, return an error
    "ERR_SD_NOT_EMPTY".

6. Delete the SD

7. If this is the last SD of this SP, delete the TEE SP AIK key.

9.2.3.1. DeleteSDRequest Message

The request message for DeleteSD has the following JSON format.

```
{
  "DeleteSDTBSRequest": {
    "ver": "1.0",
    "rid": "<unique request ID>",
    "tid": "<transaction ID>", // this may be from prior message
    "tee": "<TEE routing name from the DSI for the SD's target>",
    "nextdsi": true | false,
    "dsihash": "<hash of DSI returned in the prior query>",
    "content": ENCRYPTED { // this piece of JSON will be encrypted
      "tamid": "<tamid associated with this SD>",
      "sdname": "<SD name for the domain to be updated>",
      "deleteta": true | false
    }
  }
}
```

In the message,

rid - A unique value to identify this request

tid - A unique value to identify this transaction. It can have the
   same value for the tid in the preceding GetDeviceStateRequest.

tee - TEE ID returned from the previous response
   GetDeviceStateResponse

nextdsi - Indicates whether the up-to-date Device State Information
   (DSI) is to be returned in the response to this request.

dsihash - The BASE64-encoded SHA256 hash value of the DSI data
   returned in the prior TAM operation with this target TEE. This
   value is always included such that a receiving TEE can check
   whether the device state has changed since its last query. It
   helps enforce SD update order in the right sequence without
   accidentally overwriting an update that was done simultaneously.

content - The "content" is a JSON encrypted message that includes
   actual input for the SD update. The standard JSON content
   encryption key (CEK) is used, and the CEK is encrypted by the
   target TEE's public key.

tamid - SD owner claim by TAM - an SD owned by a TAM will be
   associated with a trusted identifier defined as an attribute in the
   signer TAM certificate.

sdname - the name of the target SD to be updated.

deleteta - the value should be boolean 'true' or 'false'. If it is
   present and the value is 'true', the TEE should delete all TAs
   associated with the SD in the device.

According to the OTrP message template, the full request
DeleteSDRequest is a signed message over the DeleteSDTBSRequest as
follows.

```
{
    "DeleteSDRequest": {
        "payload": "<DeleteSDTBSRequest JSON above>",
        "protected": "<integrity-protected header contents>",
        "header": "<non-integrity-protected header contents>",
        "signature": "<signature contents signed by TAM private key>"
    }
}
```

TAM signer certificate is included in the "header" property.

9.2.3.2. **Request Processing Requirements at a TEE**

   Upon receiving a request message DeleteSDRequest at a TEE, the TEE
   must validate a request:

   1. Validate the JSON request message

       * Validate JSON message signing

       * Validate that the request TAM certificate is chained to a
          trusted CA that the TEE embeds as its trust anchor. The TAM
          certificate status check is generally not needed anymore in
          this request. The prior request should have validated the TAM
          certificate's revocation status.

       * Compare dsihash with the TEE cached last response DSI data to
          this TAM

       * Decrypt to get the plaintext of the content

       * Check that the target SD name is supplied

       * Check whether the requested SD exists

       * Check that the TAM owns this TAM by verifying that the tamid
          in the SD matches the TAM certificate's TAM ID attribute

       * Now the TEE is ready to carry out the update listed in the
          "content" message

   2. If the request is valid, deletion action

       * Check TA existence in this SD

       * If "deleteta" is "true", delete all TAs in this SD. If the
          value of "deleteta" is false and some TA exists, return an
          error "ERR_SD_NOT_EMPTY"

       * Delete the SD

       * Delete the TEE SP AIK key pair if this SD is the last one for
          the SP

       * Now the TEE is ready to construct the response message

   3. Construct a DeleteSDResponse message

       * Create response content

                 + Operation status

                 + "did" or full signer certificate information,

                 + Updated DSI data if requested

           * The response message is encrypted with the same JWE CEK of the
              request without recreating a new content encryption key.

           * The encrypted message is signed with TEEpriv. The signer
              information ("did" or TEEcert) is encrypted.

   4. Deliver response message. (a) The OTrP Broker returns this to the
       app; (b) The app passes this back to the TAM

   5. TAM processing. (a) The TAM processes the response message; (b)
       The TAM can look up signer certificate from the device ID "did".

   If a request is illegitimate or the signature doesn't pass, a
   "status" property in the response will indicate the error code and
   cause.

9.2.3.3. DeleteSDResponse Message

   The response message for a DeleteSDRequest contains the following
   content.

```
{
  "DeleteSDTBSResponse": {
    "ver": "1.0",
    "status": "<operation result>",
    "rid": "<the request ID received>",
    "tid": "<the transaction ID received>",
    "content": ENCRYPTED {
      "reason": "<failure reason detail>", // optional
      "did": "<the device id hash>",
      "dsi": "<Updated TEE state, including all SD owned by
        this TAM>"
    }
  }
}
```

   In the response message, the following fields MUST be supplied.

   did -   The request should have known the signer certificate of this
      device from a prior request. This hash value of the device TEE
      certificate serves as a quick identifier only. A full device
      certificate isn't necessary.

The final DeleteSDResponse looks like the following.

```
{
  "DeleteSDResponse": {
    "payload": "<DeleteSDTBSResponse JSON above>",
    "protected": {
        "<BASE64URL of signing algorithm>"
    },
    "signature": "<signature contents signed by TEE device
      private key (BASE64URL)>"
  }
}
```

When the TEE fails to respond, the OTrP Broker will not provide a
subsequent response to the TAM. The TAM should treat this as if the
device has gone offline where a response is never delivered back.

9.2.3.4. Error Conditions

An error may occur if a request isn't valid or the TEE runs into some
error. The list of possible errors is as follows. Refer to the
Error Code List (Section 13.1) for detailed causes and actions.

ERR_REQUEST_INVALID

ERR_UNSUPPORTED_MSG_VERSION

ERR_UNSUPPORTED_CRYPTO_ALG

ERR_DEV_STATE_MISMATCH

ERR_SD_NOT_EMPTY

ERR_SD_NOT_FOUND

ERR_TEE_FAIL

ERR_TAM_NOT_AUTHORIZED

ERR_TAM_NOT_TRUSTED

9.3. Trusted Application Management

This protocol doesn't introduce a TA container concept. All TA
authorization and management will be up to the TEE implementation.

The following three TA management commands are supported.

o InstallTA - provision a TA by TAM

o UpdateTA - update a TA by TAM

o DeleteTA - remove TA registration information with an SD, remove
   the TA binary and all TA-related data in a TEE

9.3.1. InstallTA

TA binary data and related personalization data if there is any can
be from two sources:

1. A TAM supplies the signed and encrypted TA binary

2. A Client Application supplies the TA binary

This specification primarily considers the first case where a TAM
supplies a TA binary. This is to ensure that a TEE can properly
validate whether a TA is trustworthy. Further, TA personalization
data will be encrypted by the TEE device's SP public key for end-to-
end protection. A Client Application bundled TA case will be
addressed separately later.

A TAM sends the following information in a InstallTARequest message
to a target TEE:

o The target SD information: SP ID and SD name

o Encrypted TA binary data. TA data is encrypted with the TEE SP
   AIK.

o TA metadata. It is optional to include the SP signer certificate
   for the SD to add if the SP has changed signer since the SD was
   created.

The TEE processes the command given by the TAM to install a TA into
an SP's SD. It does the following:

o Validation

   * The TEE validates the TAM message authenticity

   * Decrypt to get request content

   * Look up the SD with the SD name

   * Checks that the TAM owns the SD

* Checks that the DSI hash matches which shows that the device state hasn't changed

o If the request is valid, continue to do the TA validation

* Decrypt to get the TA binary data and any personalization data with the "TEE SP AIK private key"

* Check that SP ID is the one that is registered with the SP SD

* Check that the TA signer is either a newly given SP certificate or the one that is already trusted by the SD from the previous TA installation. The TA signing method is specific to a TEE. This specification doesn't define how a TA should be signed; a TAM should support TEE specific TA signing when it supports that TEE.

* If a TA signer is given in the request, add this signer into the SD.

o If the above validation passed, continue to do TA installation

* The TEE re-encrypts the TA binary and its personalization data with its own method.

* The TEE enrolls and stores the TA in a secure storage.

o Construct a response message. This involves signing encrypted status information for the requesting TAM.

9.3.1.1. **InstallTARequest Message**

The request message for InstallTA has the following JSON format.

```
{
  "InstallTATBSRequest": {
    "ver": "1.0",
    "rid": "<unique request ID>",
    "tid": "<transaction ID>",
    "tee": "<TEE routing name from the DSI for the SD's target>",
    "nextdsi": true | false,
    "dsihash": "<hash of DSI returned in the prior query>",
    "content": ENCRYPTED {
      "tamid": "<TAM ID previously assigned to the SD>",
      "spid": "<SPID value>",
      "sdname": "<SD name for the domain to install the TA>",
      "spcert": "<BASE64 encoded SP certificate >", // optional
      "taid": "<TA identifier>"
    },
    "encrypted_ta": {
      "key": "<JWE enveloped data of a 256-bit symmetric key by
                the recipient's TEEspaik public key>",
      "iv": "<hex of 16 random bytes>",
      "alg": "<encryption algoritm. AESCBC by default.",
      "ciphertadata": "<BASE64 encoded encrypted TA binary data>",
      "cipherpdata": "<BASE64 encoded encrypted TA personalization
                      data>"
    }
  }
}
```

In the message,

rid - A unique value to identify this request

tid - A unique value to identify this transaction. It can have the
   same value for the tid in the preceding GetDeviceStateRequest.

tee - TEE ID returned from the previous GetDeviceStateResponse

nextdsi - Indicates whether the up-to-date Device State Information
   (DSI) is to be returned in the response to this request.

dsihash - The BASE64-encoded SHA256 hash value of the DSI data
   returned in the prior TAM operation with this target TEE. This
   value is always included such that a receiving TEE can check
   whether the device state has changed since its last query. It
   helps enforce SD update order in the right sequence without
   accidentally overwriting an update that was done simultaneously.

content - The "content" is a JSON encrypted message that includes
   actual input for the SD update. The standard JSON content
   encryption key (CEK) is used, and the CEK is encrypted by the
   target TEE's public key.

tamid - SD owner claim by TAM - An SD owned by a TAM will be
   associated with a trusted identifier defined as an attribute in the
   signer TAM certificate.

spid - SP identifier of the TA owner SP

sdname - the name of the target SD where the TA is to be installed

spcert - an optional field to specify the SP certificate that signed
   the TA. This is sent if the SP has a new certificate that hasn't
   been previously registered with the target SD where the TA should
   be installed.

taid - the identifier of the TA application to be installed

encrypted_ta - the message portion contains encrypted TA binary data
   and personalization data. The TA data encryption key is placed in
   "key", which is encrypted by the recipient's public key, using JWE
   enveloped structure. The TA data encryption uses symmetric key
   based encryption such as AESCBC.

According to the OTrP message template, the full request
InstallTARequest is a signed message over the InstallTATBSRequest as
follows.

```
{
    "InstallTARequest": {
        "payload": "<InstallTATBSRequest JSON above>",
        "protected": "<integrity-protected header contents>",
        "header": "<non-integrity-protected header contents>",
        "signature": "<signature contents signed by TAM private key>"
    }
}
```

9.3.1.2. InstallTAResponse Message

The response message for a InstallTARequest contains the following
content.

```
   {
     "InstallTATBSResponse": {
       "ver": "1.0",
       "status": "<operation result>",
       "rid": "<the request ID received>",
       "tid": "<the transaction ID received>",
       "content": ENCRYPTED {
         "reason":"<failure reason detail>", // optional
         "did": "<the device id hash>",
         "dsi": "<Updated TEE state, including all SD owned by
            this TAM>"
       }
     }
   }
```

   In the response message, the following fields MUST be supplied.

   did -   the SHA256 hash of the device TEE certificate. This shows
      the device ID explicitly to the receiving TAM.

   The final message InstallTAResponse looks like the following.

```
   {
       "InstallTAResponse": {
           "payload":"<InstallTATBSResponse JSON above>",
           "protected": {
               "<BASE64URL of signing algorithm>"
           },
           "signature": "<signature contents signed by TEE device
             private key (BASE64URL)>"
       }
   }
```

   When the TEE fails to respond, the OTrP Broker will not provide a
   subsequent response to the TAM. The TAM should treat this as if the
   device has gone offline where a response is never delivered back.

9.3.1.3. Error Conditions

   An error may occur if a request isn't valid or the TEE runs into some
   error. The list of possible errors are as follows. Refer to the
   Error Code List (Section 13.1) for detailed causes and actions.

   ERR_REQUEST_INVALID

   ERR_UNSUPPORTED_MSG_VERSION

ERR_UNSUPPORTED_CRYPTO_ALG

ERR_DEV_STATE_MISMATCH

ERR_SD_NOT_FOUND

ERR_TA_INVALID

ERR_TA_ALREADY_INSTALLED

ERR_TEE_FAIL

ERR_TEE_RESOURCE_FULL

ERR_TAM_NOT_AUTHORIZED

ERR_TAM_NOT_TRUSTED

9.3.2. UpdateTA

This TAM-initiated command can update a TA and its data in an SP's SD
that it manages for the following purposes.

1. Update TA binary

2. Update TA's personalization data

The TAM presents the proof of the SD ownership to a TEE, and includes
related information in its signed message. The entire request is
also encrypted for end-to-end confidentiality.

The TEE processes the command from the TAM to update the TA of an SP
SD. It does the following:

o Validation

   * The TEE validates the TAM message authenticity

   * Decrypt to get request content

   * Look up the SD with the SD name

   * Checks that the TAM owns the SD

   * Checks DSI hash matches that the device state hasn't changed

o TA validation

* Both TA binary and personalization data are optional, but at
  least one of them shall be present in the message

* Decrypt to get the TA binary and any personalization data with
  the "TEE SP AIK private key"

* Check that SP ID is the one that is registered with the SP SD

* Check that the TA signer is either a newly given SP certificate
  or the one in SD.

* If a TA signer is given in the request, add this signer into
  the SD.

o If the above validation passes, continue to do TA update

   * The TEE re-encrypts the TA binary and its personalization data
     with its own method

   * The TEE replaces the existing TA binary and its personalization
     data with the new binary and data.

o Construct a response message. This involves signing a encrypted
   status information for the requesting TAM.

9.3.2.1. UpdateTARequest Message

The request message for UpdateTA has the following JSON format.

```
{
  "UpdateTATBSRequest": {
    "ver": "1.0",
    "rid": "<unique request ID>",
    "tid": "<transaction ID>",
    "tee": "<TEE routing name from the DSI for the SD's target>",
    "nextdsi": true | false,
    "dsihash": "<hash of DSI returned in the prior query>",
    "content": ENCRYPTED {
      "tamid": "<TAM ID previously assigned to the SD>",
      "spid": "<SPID value>",
      "sdname": "<SD name for the domain to be created>",
      "spcert": "<BASE64 encoded SP certificate >", // optional
      "taid": "<TA identifier>"
    },
    "encrypted_ta": {
      "key": "<JWE enveloped data of a 256-bit symmetric key by
              the recipient's TEEspaik public key>",
      "iv": "<hex of 16 random bytes>",
      "alg": "<encryption algoritm. AESCBC by default.",
      "ciphernewtadata": "<Change existing TA binary to this new TA
          binary data(BASE64 encoded and encrypted)>",
      "ciphernewpdata": "<Change the existing data to this new TA
          personalization data(BASE64 encoded and encrypted)>"
          // optional
    }
  }
}
```

In the message,

rid - A unique value to identify this request

tid - A unique value to identify this transaction. It can have the
  same value for the tid in the preceding GetDeviceStateRequest.

tee - TEE ID returned from the previous GetDeviceStateResponse

nextdsi - Indicates whether the up-to-date Device State Information
  (DSI) is to be returned in the response to this request.

dsihash - The BASE64-encoded SHA256 hash value of the DSI data
  returned in the prior TAM operation with this target TEE. This
  value is always included such that a receiving TEE can check
  whether the device state has changed since its last query. It

helps enforce SD update order in the right sequence without
accidentally overwriting an update that was done simultaneously.

content - The "content" is a JSON encrypted message that includes
   actual input for the SD update. The standard JSON content
   encryption key (CEK) is used, and the CEK is encrypted by the
   target TEE's public key.

tamid - SD owner claim by TAM - an SD owned by a TAM will be
   associated with a trusted identifier defined as an attribute in the
   signer TAM certificate.

spid - SP identifier of the TA owner SP

spcert - an optional field to specify the SP certificate that signed
   the TA. This is sent if the SP has a new certificate that hasn't
   been previously registered with the target SD where the TA is to be
   installed.

sdname - the name of the target SD where the TA should be updated

taid - an identifier for the TA application to be updated

encrypted_ta - the message portion contains newly encrypted TA
   binary data and personalization data.

According to the OTrP message template, the full request
UpdateTARequest is a signed message over the UpdateTATBSRequest as
follows.

```
{
    "UpdateTARequest": {
        "payload": "<UpdateTATBSRequest JSON above>",
        "protected": "<integrity-protected header contents>",
        "header": "<non-integrity-protected header contents>",
        "signature": "<signature contents signed by TAM private key>"
    }
}
```

9.3.2.2. UpdateTAResponse Message

The response message for a UpdateTARequest contains the following
content.

```
   {
     "UpdateTATBSResponse": {
       "ver": "1.0",
       "status": "<operation result>",
       "rid": "<the request ID received>",
       "tid": "<the transaction ID received>",
       "content": ENCRYPTED {
         "reason": "<failure reason detail>", // optional
         "did": "<the device id hash>",
         "dsi": "<Updated TEE state, including all SD owned by
           this TAM>"
       }
     }
   }
```

   In the response message, the following fields MUST be supplied.

   did -   the SHA256 hash of the device TEE certificate. This shows
      the device ID explicitly to the receiving TAM.

   The final message UpdateTAResponse looks like the following.

```
   {
       "UpdateTAResponse": {
           "payload":"<UpdateTATBSResponse JSON above>",
           "protected": {
               "<BASE64URL of signing algorithm>"
           },
           "signature": "<signature contents signed by TEE device
             private key (BASE64URL)>"
       }
   }
```

   When the TEE fails to respond, the OTrP Broker will not provide a
   subsequent response to the TAM. The TAM should treat this as if the
   device has gone offline where a response is never delivered back.

9.3.2.3. Error Conditions

   An error may occur if a request isn't valid or the TEE runs into some
   error. The list of possible errors are as follows. Refer to the
   Error Code List (Section 13.1) for detailed causes and actions.

   ERR_REQUEST_INVALID

   ERR_UNSUPPORTED_MSG_VERSION

      ERR_UNSUPPORTED_CRYPTO_ALG

      ERR_DEV_STATE_MISMATCH

      ERR_SD_NOT_FOUND

      ERR_TA_INVALID

      ERR_TA_NOT_FOUND

      ERR_TEE_FAIL

      ERR_TAM_NOT_AUTHORIZED

      ERR_TAM_NOT_TRUSTED

9.3.3. DeleteTA

   This operation defines OTrP messages that allow a TAM to instruct a
   TEE to delete a TA for an SP in a given SD. A TEE will delete a TA
   from an SD and also TA data in the TEE. A Client Application cannot
   directly access TEE or OTrP Broker to delete a TA.

9.3.3.1. DeleteTARequest Message

   The request message for DeleteTA has the following JSON format.

```
   {
     "DeleteTATBSRequest": {
       "ver": "1.0",
       "rid": "<unique request ID>",
       "tid": "<transaction ID>",
       "tee": "<TEE routing name from the DSI for the SD's target>",
       "nextdsi": true | false,
       "dsihash": "<hash of DSI returned in the prior query>",
       "content": ENCRYPTED {
         "tamid": "<TAM ID previously assigned to the SD>",
         "sdname": "<SD name of the TA>",
         "taid": "<the identifier of the TA to be deleted from the
                   specified SD>"
       }
     }
   }
```

   In the message,

   rid - A unique value to identify this request

tid - A unique value to identify this transaction. It can have the
   same value for the tid in the preceding GetDeviceStateRequest.

tee - The TEE ID returned from the previous GetDeviceStateResponse

nextdsi - Indicates whether the up-to-date Device State Information
   (DSI) is to be returned in the response to this request.

dsihash - The BASE64-encoded SHA256 hash value of the DSI data
   returned in the prior TAM operation with this target TEE. This
   value is always included such that a receiving TEE can check
   whether the device state has changed since its last query. It
   helps enforce SD update order in the right sequence without
   accidentally overwriting an update that was done simultaneously.

content - The "content" is a JSON encrypted message that includes
   actual input for the SD update. The standard JSON content
   encryption key (CEK) is used, and the CEK is encrypted by the
   target TEE's public key.

tamid - SD owner claim by TAM - an SD owned by a TAM will be
   associated with a trusted identifier defined as an attribute in the
   signer TAM certificate.

sdname - the name of the target SD where the TA is installed

taid - an identifier for the TA application to be deleted

According to the OTrP message template, the full request
DeleteTARequest is a signed message over the DeleteTATBSRequest as
follows.


```
{
    "DeleteTARequest": {
        "payload": "<DeleteTATBSRequest JSON above>",
        "protected": "<integrity-protected header contents>",
        "header": "<non-integrity-protected header contents>",
        "signature": "<signature contents signed by TAM
            private key>"
    }
}
```

9.3.3.2. Request Processing Requirements at a TEE

A TEE processes a command from a TAM to delete a TA of an SP SD. It
does the following:

1. Validate the JSON request message

    *   The TEE validates TAM message authenticity

    *   Decrypt to get request content

    *   Look up the SD and the TA with the given SD name and TA ID

    *   Checks that the TAM owns the SD, and TA is installed in the SD

    *   Checks that the DSI hash matches and the the device state
        hasn't changed

2. Deletion action

    *   If all the above validation points pass, the TEE deletes the
        TA from the SD

    *   The TEE SHOULD also delete all personalization data for the TA

3. Construct DeleteTAResponse message.

If a request is illegitimate or the signature doesn't pass, a
"status" property in the response will indicate the error code and
cause.

9.3.3.3. DeleteTAResponse Message

The response message for a DeleteTARequest contains the following
content.

```
  {
    "DeleteTATBSResponse": {
      "ver": "1.0",
      "status": "<operation result>",
      "rid": "<the request ID received>",
      "tid": "<the transaction ID received>",
      "content": ENCRYPTED {
        "reason": "<failure reason detail>", // optional
        "did": "<the device id hash>",
        "dsi": "<Updated TEE state, including all SD owned by
          this TAM>"
      }
    }
  }
```

In the response message, the following fields MUST be supplied.

did -   the SHA256 hash of the device TEE certificate. This shows
   the device ID explicitly to the receiving TAM.

The final message DeleteTAResponse looks like the following.

```
  {
      "DeleteTAResponse": {
          "payload": "<DeleteTATBSResponse JSON above>",
          "protected": {
              "<BASE64URL of signing algorithm>"
          },
          "signature": "<signature contents signed by TEE device
              private key (BASE64URL)>"
      }
  }
```

When the TEE fails to respond, the OTrP Broker will not provide a
subsequent response to the TAM. The TAM should treat this as if the
device has gone offline where a response is never delivered back.

9.3.3.4. Error Conditions

An error may occur if a request isn't valid or the TEE runs into some
error. The list of possible errors are as follows. Refer to the
Error Code List (Section 13.1) for detailed causes and actions.

ERR_REQUEST_INVALID

ERR_UNSUPPORTED_MSG_VERSION

ERR_UNSUPPORTED_CRYPTO_ALG

ERR_DEV_STATE_MISMATCH

ERR_SD_NOT_FOUND

ERR_TA_NOT_FOUND

ERR_TEE_FAIL

ERR_TAM_NOT_AUTHORIZED

ERR_TAM_NOT_TRUSTED

10. Response Messages a TAM May Expect

A TAM expects some feedback from a remote device when a request
message is delivered to a device. The following three types of
responses SHOULD be supplied.

Type 1:   Expect a valid TEE-generated response message

   A valid TEE signed response may contain errors detected by a TEE,
   e.g. a TAM is trusted but some TAM-supplied data is missing, for
   example, SP ID doesn't exist. TEE MUST be able to sign and
   encrypt.

   If a TEE isn't able to sign a response, the TEE returns an error
   to the OTrP Broker without giving any other internal information.
   The OTrP Broker will be generating the response.

Type 2:   The OTrP Broker generated error message when TEE fails.
   OTrP Broker errors will be defined in this document.

   A Type 2 message has the following format.

```
  {
    "OTrPBrokerError": {
        "ver": "1.0",
        "rid": "",
        "tid": "",
        "errcode": "ERR_AGENT_TEE_UNKNOWN | ERR_AGENT_TEE_BUSY"
    }
  }
```

Type 3:   OTrP Broker itself isn't reachable or fails. A Client
   Application is responsible to handle error and respond the TAM in
   its own way. This is out of scope for this specification.

11. Basic Protocol Profile

This section describes a baseline for interoperability among the
protocol entities, mainly, the TAM and TEE.

A TEE MUST support RSA algorithms. It is optional to support ECC
algorithms. A TAM SHOULD use a RSA certificate for TAM message
signing. It may use an ECC certificate if it detects that the TEE
supports ECC according to the field "supportedsigalgs" in a TEE
response.

A TAM MUST support both RSA 2048-bit algorithm and ECC P-256
algorithms. With this, a TEE and TFW certificate can be either RSA
or ECC type.

JSON signing algorithms

o RSA PKCS#1 with SHA256 signing : "RS256"

o ECDSA with SHA256 signing : "ES256"

JSON asymmetric encryption algorithms (describes key-exchange or key-
agreement algorithm for sharing symmetric key with TEE):

o RSA PKCS#1 : "RSA1_5"

o ECDH using TEE ECC P-256 key and ephemeral ECC key generated by
   TAM : "ECDH-ES+A128W"

JSON symmetric encryption algorithms (describes symmetric algorithm
for encrypting body of data, using symmetric key transferred to TEE
using asymmetric encryption):

o Authenticated encryption AES 128 CBC with SHA256 :
   {"enc":"A128CBC-HS256"}

12. Attestation Implementation Consideration

It is important to know that the state of a device is appropriate
before trusting that a device is what it says it is. The attestation
scheme for OTrP must also be able to cope with different TEEs,
including those that are OTrP compliant and those that use another
mechanism. In the initial version, only one active TEE is assumed.

It is out of scope how the TAM and the device implement the trust
hierarchy verification. However, it is helpful to understand what
each system provider should do in order to properly implement an OTrP
trust hierarchy.

In this section, we provide some implementation reference
consideration.

12.1. OTrP Trusted Firmware

12.1.1. Attestation signer

It is proposed that attestation for OTrP is based on the TFW layer,
and that further attestation is not performed within the TEE itself
during Security Domain operations. The rationale is that the device
boot process will be defined to start with a secure bootloader
protected with a harden key in eFUSE. The process releases
attestation signing capabilities into the TFW once a trust boot has
been established. In this way the release of the attestation signer
can be considered the first "platform configuration metric", using
Trust Computing Group (TCG) terminology.

12.1.2. TFW Initial Requirements

R1 The TFW must be possible for verification during boot

R2 The TFW must allow a public / private key pair to be generated
    during device manufacture

R3 The public key and certificate must be possible to store securely

R4 The private key must be possible to store encrypted at rest

R5 The private key must only be visible to the TFW when it is
    decrypted

R6 The TFW must be able to read a list of root and intermediate
    certificates that it can use to check certificate chains with.
    The list must be stored such that it cannot be tampered with

R7 Need to allow a TEE to access its unique TEE specific private key

12.2. TEE Loading

During boot, the TFW is required to start all of the root TEEs.
Before loading them, the TFW must first determine whether the code
sign signature of the TEE is valid. If TEE integrity is confirmed,
the TEE may be started. The TFW must then be able to receive the
identity certificate from the TEE (if that TEE is OTrP compliant).
The identity certificate and keys will need to be baked into the TEE
image, and therefore also covered by the code signer hash during the
manufacturing process. The private key for the identity certificate
must be securely protected. The private key for a TEE identity must

never be released no matter how the public key and certificate are
released to the TFW.

Once the TFW has successfully booted a TEE and retrieved the identity
certificate, the TFW will commit this to the platform configuration
register (PCR) set, for later use during attestation. At minimum,
the following data must be committed to the PCR for each TEE:

1. Public key and certificate for the TEE

2. TEE identifier that can be used later by a TAM to identify this
    TEE

12.3. Attestation Hierarchy

The attestation hierarchy and seed required for TAM protocol
operation must be built into the device at manufacture. Additional
TEEs can be added post-manufacture using the scheme proposed, but it
is outside of the current scope of this document to detail that.

It should be noted that the attestation scheme described is based on
signatures. The only decryption that may take place is through the
use of a bootloader key.

12.3.1. Attestation Hierarchy Establishment: Manufacture

During manufacture the following steps are required:

1. A device-specific TFW key pair and certificate are burnt into the
    device. This key pair will be used for signing operations
    performed by the TFW.

2. TEE images are loaded and include a TEE instance-specific key
    pair and certificate. The key pair and certificate are included
    in the image and covered by the code signing hash.

3. The process for TEE images is repeated for any subordinate TEEs,
    which are additional TEEs after the root TEE that some devices
    have.

12.3.2. Attestation Hierarchy Establishment: Device Boot

During device boot the following steps are required:

1. The boot module releases the TFW private key by decrypting it
    with the bootloader key.

2. The TFW verifies the code-signing signature of the active TEE and
    places its TEE public key into a signing buffer, along with its
    identifier for later access. For a non-OTrP TEE, the TFW leaves
    the TEE public key field blank.

3. The TFW signs the signing buffer with the TFW private key.

4. Each active TEE performs the same operation as the TFW, building
    up their own signed buffer containing subordinate TEE
    information.

12.3.3. Attestation Hierarchy Establishment: TAM

Before a TAM can begin operation in the marketplace to support
devices of a given TEE, it must obtain a TAM certificate from a CA
that is registered in the trust store of devices with that TEE. In
this way, the TEE can check the intermediate and root CA and verify
that it trusts this TAM to perform operations on the TEE.

13. IANA Considerations

There are two IANA requests: a media type and list of error codes.

This section first requests that IANA assign a media type:
application/otrp+json.

Type name: application

Subtype name: otrp+json

Required parameters: none

Optional parameters: none

Encoding considerations: Same as encoding considerations of
   application/json as specified in Section 11 of [RFC7159]

Security considerations: See Section 12 of [RFC7159] and Section 14
   of this document

Interoperability considerations: Same as interoperability
   considerations of application/json as specified in [RFC7159]

Published specification: [TEEPArch]

Applications that use this media type: OTrP implementations

Fragment identifier considerations: N/A

Additional information:

    Deprecated alias names for this type: N/A

    Magic number(s): N/A

    File extension(s): N/A

    Macintosh file type code(s): N/A

  Person to contact for further information: teep@ietf.org

  Intended usage: COMMON

  Restrictions on usage: none

  Author: See the "Authors' Addresses" section of this document

  Change controller: IETF

  The error code listed in the next section will be registered.

13.1. Error Code List

  This section lists error codes that could be reported by a TA or TEE
  in a device in responding to a TAM request, and a separate list that
  OTrP Broker may return when the TEE fails to respond.

13.1.1. TEE Signed Error Code List

  ERR_DEV_STATE_MISMATCH - A TEE will return this error code if the
    DSI hash value from TAM doesn't match the has value of the device's
    current DSI.

  ERR_SD_ALREADY_EXISTS - This error will occur if an SD to be created
    already exists in the TEE.

  ERR_SD_NOT_EMPTY - This is reported if a target SD isn't empty.

  ERR_SDNAME_ALREADY_USED A TEE will return this error code if the new
    SD name already exists in the TEE.

  ERR_REQUEST_INVALID - This error will occur if the TEE meets any of
    the following conditions with a request message: (1) The request
    from a TAM has an invalid message structure; mandatory information
    is absent in the message. undefined member or structure is
    included. (2) TEE fails to verify signature of the message or
    fails to decrypt its contents.

ERR_SPCERT_INVALID - If a new SP certificate for the SD to be
   updated is not valid, then the TEE will return this error code.

ERR_TA_ALREADY_INSTALLED - While installing a TA, a TEE will return
   this error if the TA has already been installed in the SD.

ERR_TA_INVALID - This error will occur when a TEE meets any of
   following conditions while checking validity of TA: (1) The TA
   binary has a format that the TEE can't recognize. (2) The TEE fails
   to decrypt the encoding of the TA binary and personalization data.
   (3) If an SP isn't registered with the SP SD where the TA will be
   installed.

ERR_TA_NOT_FOUND - This error will occur when the target TA doesn't
   exist in the SD.

ERR_TEE_FAIL - If the TEE fails to process a request because of an
   internal error, it will return this error code.

ERR_TEE_RESOURCE_FULL - This error is reported when a device
   resource isn't available anymore such as storage space is full.

ERR_TFW_NOT_TRUSTED - A TEE is responsible for determining that the
   underlying device firmware is trustworthy. If the TEE determines
   the TFW is not trustworthy, then this error will occur.

ERR_TAM_NOT_TRUSTED - Before processing a request, a TEE needs to
   make sure whether the sender TAM is trustworthy by checking the
   validity of the TAM certificate, etc. If the TEE finds that the
   TAM is not trustworthy, then it will return this error code.

ERR_UNSUPPORTED_CRYPTO_ALG - This error will occur if a TEE receives
   a request message encoded with cryptographic algorithms that the
   TEE doesn't support.

ERR_UNSUPPORTED_MSG_VERSION - This error will occur if a TEE
   receives a message version that the TEE can't deal with.

14. Security Consideration

14.1. Cryptographic Strength

The strength of the cryptographic algorithms, using the measure of
'bits of security' defined in NIST SP800-57 allowed for OTrP is:

o At a minimum, 112 bits of security. The limiting factor for this
   is the RSA-2048 algorithm, which is indicated as providing 112
   bits of symmetric key strength in SP800-57. It is important that

      RSA is supported in order to enhance the interoperability of the
      protocol.

   o The option exists to choose algorithms providing 128 bits of
      security. This requires using TEE devices that support ECC P256.

   The available algorithms and key sizes specified in this document are
   based on industry standards. Over time the recommended or allowed
   cryptographic algorithms may change. It is important that the OTrP
   allows for crypto-agility. In this specification, TAM and TEE can
   negotiate an agreed upon algorithm where both include their supported
   algorithm in OTrP message.

14.2. Message Security

   OTrP messages between the TAM and TEE are protected by message
   security using JWS and JWE. The 'Basic protocol profile' section of
   this document describes the algorithms used for this. All OTrP TEE
   devices and OTrP TAMs must meet the requirements of the basic
   profile. In the future additional 'profiles' can be added.

   PKI is used to ensure that the TEE will only communicate with a
   trusted TAM, and to ensure that the TAM will only communicate with a
   trusted TEE.

14.3. TEE Attestation

   It is important that the TAM can trust that it is talking to a
   trusted TEE. This is achieved through attestation. The TEE has a
   private key and certificate built into it at manufacture, which is
   used to sign data supplied by the TAM. This allows the TAM to verify
   that the TEE is trusted.

   It is also important that the TFW (trusted firmware) can be checked.
   The TFW has a private key and certificate built into it at
   manufacture, which allows the TEE to check that that the TFW is
   trusted.

   The GetDeviceState message therefore allows the TAM to check that it
   trusts the TEE, and the TEE at this point will check whether it
   trusts the TFW.

14.4. TA Protection

   A TA will be delivered in an encrypted form. This encryption is an
   additional layer within the message encryption described in the
   Section 11 of this document. The TA binary is encrypted for each
   target device with the device's TEE SP AIK public key. A TAM can

either do this encryption itself or provide the TEE SP AIK public key
to an SP such that the SP encrypts the encrypted TA for distribution
to the TEE.

The encryption algorithm can use a random AES 256 key "taek" with a
16 byte random IV, and the "taek" is encrypted by the "TEE SP AIK
public key". The following encrypted TA data structure is expected
by a TEE:

```
"encrypted_ta_bin": {
  "key": "<JWE enveloped data of a 256-bit symmetric key by
          the recipient's TEEspaik public key>",
  "iv": <hex of 16 random bytes>",
  "alg": "AESCBC",
  "cipherdata": "<BASE64 encoded encrypted TA binary data>"
}
```

14.5. TA Personalization Data

An SP or TAM can supply personalization data for a TA to initialize
for a device. Such data is passed through an InstallTA command from
a TAM. The personalization data itself is (or can be) opaque to the
TAM. The data can be from the SP without being revealed to the TAM.
The data is sent in an encrypted manner in a request to a device such
that only the device can decrypt. A device's TEE SP AIK public key
for an SP is used to encrypt the data. Here JWE enveloping is used
to carry all encryption key parameters along with encrypted data.

```
"encrypted_ta_data": { // "TA personalization data"
    "key": "<JWE enveloped data of a 256-bit symmetric key by
              the recipient's TEEspaik public key>",
    "iv": "<hex of 16 random bytes>",
    "alg": "AESCBC",
    "cipherdata": "<BASE64 encoded encrypted TA personalization
                    data>"
  }
```

14.6. TA Trust Check at TEE

A TA binary is signed by a TA signer certificate. This TA signing
certificate/private key belongs to the SP, and may be self-signed
(i.e., it need not participate in a trust hierarchy). It is the
responsibility of the TAM to only allow verified TAs from trusted SPs
into the system. Delivery of that TA to the TEE is then the
responsibility of the TEE, using the security mechanisms provided by
the OTrP.

We allow a way for an (untrusted) application to check the
trustworthiness of a TA. OTrP Broker has a function to allow a
Client Application to query the information about a TA.

An application in the Rich O/S may perform verification of the TA by
verifying the signature of the TA. The GetTAInformation function is
available to return the TEE supplied TA signer and TAM signer
information to the application. An application can do additional
trust checks on the certificate returned for this TA. It might trust
the TAM, or require additional SP signer trust chaining.

14.7. One TA Multiple SP Case

A TA for multiple SPs must have a different identifier per SP. A TA
will be installed in a different SD for each respective SP.

14.8. OTrP Broker Trust Model

An OTrP Broker could be malware in the vulnerable REE. A Client
Application will connect its TAM provider for required TA
installation. It gets command messages from the TAM, and passes the
message to the OTrP Broker.

The OTrP is a conduit for enabling the TAM to communicate with the
device's TEE to manage SDs and TAs. All TAM messages are signed and
sensitive data is encrypted such that the OTrP Broker cannot modify
or capture sensitive data.

14.9. OCSP Stapling Data for TAM Signed Messages

The GetDeviceStateRequest message from a TAM to a TEE shall include
OCSP stapling data for the TAM's signer certificate and for
intermediate CA certificates up to the root certificate so that the
TEE can verify the signer certificate's revocation status.

A certificate revocation status check on a TA signer certificate is
OPTIONAL by a TEE. A TAM is responsible for vetting a TA and the SP
before it distributes them to devices. A TEE will trust a TA signer
certificate's validation status done by a TAM when it trusts the TAM.

14.10. Data Protection at TAM and TEE

The TEE implementation provides protection of data on the device. It
is the responsibility of the TAM to protect data on its servers.

14.11. Privacy Consideration

Devices are issued with a unique TEE certificate to attest the
device's validity. This uniqueness also creates a privacy and
tracking risk that must be mitigated.

The TEE will only release the TEE certificate to a trusted TAM (it
must verify the TAM certificate before proceeding). OTrP is designed
such that only a TAM can obtain the TEE device certificate and
firmware certificate - the GetDeviceState message requires signature
checks to validate the TAM is trusted, and OTrP delivers the device's
certificate(s) encrypted such that only that TAM can decrypt the
response. A Client Application will never see the device
certificate.

An SP-specific TEE SP AIK (TEE SP Anonymous Key) is generated by the
protocol for Client Applications. This provides a way for the Client
Application to validate some data that the TEE may send without
requiring the TEE device certificate to be released to the client
device rich O/S , and to optionally allow an SP to encrypt a TA for a
target device without the SP needing to be supplied with the TEE
device certificate.

14.12. Threat Mitigation

A rogue application may perform excessive TA loading. An OTrP Broker
implementation should protect against excessive calls.

Rogue applications might request excessive SD creation. The TAM is
responsible to ensure this is properly guarded against.

Rogue OTrP Broker could replay or send TAM messages out of sequence:
e.g., a TAM sends update1 and update2. The OTrP Broker replays
update2 and update1 again, creating an unexpected result that a
client wants. "dsihash" is used to mitigate this. The TEE MUST store
DSI state and check that the DSI state matches before it does another
update.

Concurrent calls from a TAM to a TEE MUST be handled properly by a
TEE. If multiple concurrent TAM operations take place, these could
fail due to the "dsihash" being modified by another concurrent
operation. The TEE is responsible for resolve any locking such that
one application cannot lock other applications from using the TEE,
except for a short term duration of the TAM operation taking place.
For example, an OTrP operation that starts but never completes (e.g.
loss of connectivity) must not prevent subsequent OTrP messages from
being executed.

14.13. Compromised CA

A root CA for TAM certificates might get compromised. Some TEE trust
anchor update mechanism is expected from device OEMs. A compromised
intermediate CA is covered by OCSP stapling and OCSP validation check
in the protocol. A TEE should validate certificate revocation about
a TAM certificate chain.

If the root CA of some TEE device certificates is compromised, these
devices might be rejected by a TAM, which is a decision of the TAM
implementation and policy choice. Any intermediate CA for TEE device
certificates SHOULD be validated by TAM with a Certificate Revocation
List (CRL) or Online Certificate Status Protocol (OCSP) method.

14.14. Compromised TAM

The TEE SHOULD use validation of the supplied TAM certificates and
OCSP stapled data to validate that the TAM is trustworthy.

Since PKI is used, the integrity of the clock within the TEE
determines the ability of the TEE to reject an expired TAM
certificate, or revoked TAM certificate. Since OCSP stapling
includes signature generation time, certificate validity dates are
compared to the current time.

14.15. Certificate Renewal

TFW and TEE device certificates are expected to be long lived, longer
than the lifetime of a device. A TAM certificate usually has a
moderate lifetime of 2 to 5 years. A TAM should get renewed or
rekeyed certificates. The root CA certificates for a TAM, which are
embedded into the trust anchor store in a device, should have long
lifetimes that don't require device trust anchor update. On the
other hand, it is imperative that OEMs or device providers plan for
support of trust anchor update in their shipped devices.

15. Acknowledgements

We thank Alin Mutu for his contribution to many discussion that
helped to design the trust flow mechanisms, and the creation of the
flow diagrams. We also thank the following people (in alphabetical
order) for their input and review: Sangsu Baek, Rob Coombs, Dapeng
Liu, Dave Thaler, and Pengfei Zhao.

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Appendix A. Sample Messages

A.1. Sample Security Domain Management Messages

A.1.1. Sample GetDeviceState

A.1.1.1. Sample GetDeviceStateRequest

   The TAM builds a "GetDeviceStateTBSRequest" message.

```
 {
     "GetDeviceStateTBSRequest": {
        "ver": "1.0",
        "rid": "8C6F9DBB-FC39-435c-BC89-4D3614DA2F0B",
        "tid": "4F454A7F-002D-4157-884E-B0DD1A06A8AE",
        "ocspdat": "c2FtcGxlIG9jc3BkYXQgQjY0IGVuY29kZWQgQVNOMQ==",
        "icaocspdat": "c2FtcGxlIGljYW9jc3BkYXQgQjY0IGVuY29kZWQgQVNOMQ==",
        "supportedsigalgs": "RS256"
     }
 }
```

   The TAM signs "GetDeviceStateTBSRequest", creating
   "GetDeviceStateRequest"

```
{
  "GetDeviceStateRequest": {
    "payload":"
    ewoJIkdldERldmljZVN0YXRlVEJTUmVxdWVzdCI6IHsKCQkidmVyIjogIjEuMCIsCgkJ
    InJpZCI6IHs4QzZGOURCQi1GQzM5LTQzNWMtQkM4OS00RDM2MTREQTJGMEJ9LAoJCSJ0
    aWQiOiAiezRGNDU0QTdGLTAwMkQtNDE1Ny04ODRFLUIwREQxQTA2QThBRX0iLAoJCSJv
    Y3NwZGF0IjogImMyRnRjR3hsSUc5amMzQmtZWFFnUWpZMElHVnVZMjlrWldRZ1FWTk9N
    UT09IiwKCQkiaWNhb2NzcGRhdCI6ICJjMkZ0Y0d4bElHbGpZVzlqYzNCa1lYUWdRalkw
    SUdWdVkyOWtaV1FnUVZOT01RPT0iLAoJCSJzdXBwb3J0ZWRzaWdhbGdzIjogIlJTMjU2
    IgoJfQp9",
    "protected": "eyJhbGciOiJSUzI1NiJ9",
    "header": {
      "x5c": ["ZXhhbXBsZSBBU04xIHNpZ25lciBjZXJ0aWZpY2F0ZQ==",
              "ZXhhbXBsZSBBU04xIENBIGNlcnRpZmljYXRl"]
    },
    "signature":"c2FtcGxlIHNpZ25hdHVyZQ"
  }
}
```

A.1.1.2. Sample GetDeviceStateResponse

   The TAM sends "GetDeviceStateRequest" to the OTrP Broker

The OTrP Broker obtains "dsi" from each TEE. (In this example there
is a single TEE.)

The TEE obtains signed "fwdata" from firmware.

The TEE builds "dsi" - summarizing device state of the TEE.

```
    {
      "dsi": {
        "tfwdata": {
          "tbs": "ezRGNDU0QTdGLTAwMkQtNDE1Ny04ODRFLUIwREQxQTA2QThBRX0=",
          "cert": "ZXhhbXBsZSBGVyBjZXJ0aWZpY2F0ZQ==",
          "sigalg": "RS256",
          "sig": "c2FtcGxlIEZXIHNpZ25hdHVyZQ=="
        },
        "tee": {
          "name": "Primary TEE",
          "ver": "1.0",
          "cert": "c2FtcGxlIFRFRSBjZXJ0aWZpY2F0ZQ==",
          "cacert": [
            "c2FtcGxlIENBIGNlcnRpZmljYXRlIDE=",
            "c2FtcGxlIENBIGNlcnRpZmljYXRlIDI="
          ],
          "sdlist": {
            "cnt": "1",
            "sd": [
            {
              "name": "default.acmebank.com",
              "spid": "acmebank.com",
              "talist": [
                {
                  "taid": "acmebank.secure.banking",
                  "taname": "Acme secure banking app"
                },
                {
                  "taid": "acmebank.loyalty.rewards",
                  "taname": "Acme loyalty rewards app"
                }
              ]
            }
            ]
          },
          "teeaiklist": [
            {
              "spaik": "c2FtcGxlIEFTTjEgZW5jb2RlZCBQS0NTMSBwdWJsaWNrZXk=",
              "spaiktype": "RSA",
              "spid": "acmebank.com"
            }
          ]
          }
      }
    }
```

The TEE encrypts "dsi", and embeds it into a
"GetDeviceTEEStateTBSResponse" message.

```
{
  "GetDeviceTEEStateTBSResponse": {
    "ver": "1.0",
    "status": "pass",
    "rid": "{8C6F9DBB-FC39-435c-BC89-4D3614DA2F0B}",
    "tid": "{4F454A7F-002D-4157-884E-B0DD1A06A8AE}",
    "signerreq":"false",
    "edsi": {
      "protected": "eyJlbmMiOiJBMTI4Q0JDLUhTMjU2In0K",
      "recipients": [
        {
          "header": {
          "alg": "RSA1_5"
        },
        "encrypted_key":
        "
        QUVTMTI4IChDRUspIGtleSwgZW5jcnlwdGVkIHdpdGGgVFNNIFJTQSBwdWJsaWMg
        a2V5LCB1c2luZyBSU0ExXzUgcGFkZGluZw"
        }
      ],
      "iv": "ySGmfZ69YlcEilNr5_SGbA",
      "ciphertext":
      "
      c2FtcGxlIGRzaSBkYXRhIGVuY3J5cHRlZCB3aXRoIEFFUzEyOCBrZXkgZnJvbSByZW
      NpcGllbnRzLmVuY3J5cHRlZF9rZXk",
      "tag": "c2FtcGxlIGF1dGhlbnRpY2F0aW9uIHRhZw"
    }
  }
}
```

   The TEE signs "GetDeviceTEEStateTBSResponse" and returns it to the
   OTrP Broker. The OTrP Broker encodes "GetDeviceTEEStateResponse"
   into an array to form "GetDeviceStateResponse".

```
{
  "GetDeviceStateResponse": [
    {
      "GetDeviceTEEStateResponse": {
        "payload":
        "
```
        ewogICJHZXREZXZpY2VURUVTdGF0ZVRCU1Jlc3BvbnNlIjogewogICAgInZlciI6
        ICIxLjAiLAogICAgInN0YXR1cyI6ICJwYXNzIiwKICAgICJyaWQiOiAiezhDNkY5
        REJCLUZDMzktNDM1Yy1CQzg5LTREEMzYxNERBMkYwQn0iLAogICAgInRpZCI6ICJ7
        NEY0NTRBN0YtMDAyRC00MTU3LTg4NEUtQjBERDFBMDZBOEFFfSIsCgkic2lnbmVy
        cmVxIjoiZmFsc2UiLAogICAgImVkc2kiOiB7CiAgICAgICJwcm90ZWN0ZWQiOiAi
        ZXlKbGJtTWlPaUpCTVRJNFEwSkRMVWhUTWpVMkluMEsiLAogICAgICAicmVjaXBp
        ZW50cyI6IFsKICAgICAgICB7CiAgICAgICAgICAiaGVhZGVyIjogewogICAgICAg
        ICAgImFsZyI6ICJSU0ExXzUiCiAgICAgICAgfSwKICAgICAgICAiZW5jcnlwdGVk
        X2tleSI6CiAgICAgICAgIgogICAgICAgIFFVlRNVEk0SUNoRFJVc3BJR3RseVZN3
        Z1pXNWpbmx3ZEdWa0lZHBkR2dnVkOTklGSlRRU0J3ZFdKc2FXTWcKICAgICAg
        ICBhMlY1TENMWMybHVaeUJTVTBFeFh6VWdjR0ZyWkdsdVp3IgogICAgICAgIH0K
        ICAgICAgXSwKICAgICAgIml2Ijog InlTR21mWjY5WWxjRWlsTnI1X1NHYkEiLAog
        ICAgICAiY2lwaGVydGV4dCI6CiAgICAgICIKICAgICAgYzJGdGNHeGxJR1J6YVNC
        a1lYUmhJR1Z1WTNKNWNNIUmxaQ0IzYVhSb0lFRkZVekV5T0NclpYa2dabkp2YlNC
        eVpXXiAgICAgIE5wY0dsbGJuUnpMbVZ1WTNKNWNNIUmxaRjlyWlhrIiwKICAgICAg
        InRhZyI6ICJjMkZ0Y0d4bElHRjFkR2hsYm5ScFkyRjBhVzl1SUhSaFp3IgogICAg
        fQogIH0KfQ",
```
        "protected": "eyJhbGciOiJSUzI1NiJ9",
        "signature": "c2FtcGxlIHNpZ25hdHVyZQ"
      }
    }
  ]
}
```

The TEE returns "GetDeviceStateResponse" back to the OTrP Broker,
which returns message back to the TAM.

A.1.2. **Sample CreateSD**

A.1.2.1. **Sample CreateSDRequest**

```
{
  "CreateSDTBSRequest": {
    "ver":"1.0",
    "rid":"req-01",
    "tid":"tran-01",
    "tee":"SecuriTEE",
    "nextdsi":"false",
    "dsihash":"Iu-c0-fGrpMmzbbtiWI1U8u7wMJE7IK8wkJpsVuf2js",
    "content":{
      "spid":"bank.com",
      "sdname":"sd.bank.com",
      "spcert":"MIIDFjCCAn-
      gAwIBAgIJAIk0Tat0tquDMA0GCSqGSIb3DQEBBQUAMGwxCzAJBgNVBAYTAkTAMQ4wD
      AYDVQQIDAVTZW91bDESMBAGA1UEBwwJR3Vyby1kb25nMRAwDgYDVQQKDAdTb2xhY2l
      hMRAwDgYDVQQLDAdTb2xhY2lhMRUwEwYDVQQDDAxTb2xhLWNpYS5jb20wHhcNMTUwN
      zAyMDg1MTU3WhcNMjAwNjMwMDg1MTU3WjBsMQswCQYDVQQGEwJLUjEOMAwGA1UECAw
      FU2VvdWwxEjAQBgNVBAcMCUd1cm8tZG9uZzEQMA4GA1UECgwHU29sYWNpYTEQMA4GA
      1UECwwHU29sYWNpYTEVMBMGA1UEAwwMU29sYS1jaWEuY29tMIGfMA0GCSqGSIb3DQE
      BAQUAA4GNADCBiQKBgQDYWLrFf2OFMEciwSYsyhaLY4kslaWcXA0hCWJRaFzt5mU-
      lpSJ4jeu92inBbsXcI8PfRbaItsgW1TD1Wg4gQH4MX_YtaBoOepE--
      3JoZZyPyCWS3AaLYWrDmqFXdbzaO1i8GxB7zz0gWw55bZ9jyzcl5gQzWSqMRpx_dca
      d2SP2wIDAQABo4G_MIG8MIGGBgNVHSMEfzB9oXCkbjBsMQswCQYDVQQGEwJLUjEOMA
      wGA1UECAwFU2VvdWwxEjAQBgNVBAcMCUd1cm8tZG9uZzEQMA4GA1UECgwHU29sYWNp
      YTEQMA4GA1UECwwHU29sYWNpYTEVMBMGA1UEAwwMU29sYS1jaWEuY29tggkAiTRNq3
      S2q4MwCQYDVR0TBAIwADAOBgNVHQ8BAf8EBAMCBsAwFgYDVR0lAQH_BAwwCgYIKwYB
      BQUHAwMwDQYJKoZIhvcNAQEFBQADgYEAEFMhRwEQ-
      LDa9O7P1N0mcLORpo6fW3QuJfuXbRQRQGoXddXMKazI4VjbGaXhey7Bzvk6TZYDa-
      GRiZby1J47UPaDQR3UiDzVvXwCOU6S5yUhNJsW_BeMViYj4lssX28iPpNwLUCVm1QV
      THILI6afLCRWXXclc1L5KGY290OwIdQ",
      "tamid":"TAM_x.acme.com",
      "did":"zAHkb0-SQh9U_OT8mR5dB-tygcqpUJ9_x07pIiw8WoM"
    }
  }
}
```

   Below is a sample message after the content is encrypted and encoded

```
{
  "CreateSDRequest": {
  "payload":"
  eyJDcmVhdGVTRFRCU1JlcXVlc3QiOnsidmVyIjoiMS4wIiwicmlkIjoicmVxLTAxIiwidG
  lkIjoidHJhbi0wMSIsInRlZSI6IlNlY3VyaVRFRSIsIm5leHRkc2kiOiJmYWxzZSIsImRz
  aWhhc2giOiIyMmVmOWNkM2U3YzZhZTkzMjZj2ZWQ4OTYyMzU1M2NiYmJjMGMyNDRlYz
  gyYmNjMjQyNjliMTViOWZkYTNiIiwiY29udGVudCI6eyJwcm90ZWN0ZWQiOiJlLUtBbkdW
  dVktS0FuVHJpZ0p4Qk1USRRMEpETFVoVE4qVTI0b0NkZlEiLCJyZWNpcGllbnRzIjpbey
  JoZWFkZXIiOnsiYWxnIjoiUlNBMV81In0sImVuY3J5cHRlZF9rZXkiOiJTUzE2NTl4Q2FJ
  c1dUeUlsVTZPLUVsZZU4UUhvT1pCPekxVRGptVG9vanBwWE54VjpBakRMcWtaSTdEUzhOVG
  FIWHcxczFvZjgydVhsM0d6NlVWMkRoZDJ3R2l6Y2VEGtXc1RwZDg4QVYwaWpEYTNXa3lk
  ```

      dEpSVmlPOGdkSlEtV29NSUVJRUxzVGthblZCb25wQkF4ZHE0ckVMbl9TZlliaFg4Zm9ub2
      gxUVUifV0sIml2IjoiQXhZOERDdERhR2xzYkdsamIzUm9aUSIsImNpcGhlcnRleHQiOiI1
      bmVWZXdndm55UXprR3hZeWw5QlFrZTJVNjVaOHp4ND9lb3NzM3FETy0xY2FfNEpiFY3NLcj
      ZhNjF5QzBUb0doYnJOQWJXbVRSemMwSXB5bTF0ZjdGemp4UlhBaTZBYnVSM2gzSUpRS1Bj
      UUVvRUlkZ2tWX0aZTM2eTBkVDBpRFBMclg0QzFkb0dmMEdvaWViRC1yVUg1VUtEY3BsTW
      9lTjZvUnFyd0dnNUhxLTJXM3B4MUlzY0h4SktRZm11dkYxMTJ4ajBmZFNZX0N2WFE1NTJr
      TVRDUW1ZbzRPaGF2R0ZvaG9TZVVnaGGZSVG1LYWp3OThkTzdhREdrUEpRUlBtYVVHWllEMW
      JXd01nMXFRV3RPd19EZlIyZDNzTzVUN0pQMDJDUFprVXBiQ3dZYVcybW9HN1c2Zlc2U3V5
      Q2lppd2ppQWmZSQmIzSktTVTFTd1kxYXZvdW02OWctaDB6by12TGZvbHRrWFV2LVdPTXZTY0
      JzR25NRzZYZmMzbXlTWnJ1WTNRR09wVVRzdjFCQ0JqSTJpdjjwb2U2aXFCcVpxQVBxbzdi
      ajYwVlJGQzZPTlNLZExGQTIyU3pqRHo1dmtnTXNEaHkwSzlEeVhYTlZ6MkNLTXJvQjNiUE
      xFZF9abTZuVWlkTFN5cVJ5cXJxTmVnN1lmQng3aV93X0dzRW9rX1VYZXd6RGtineHp6RjZj
      XzZ6S0s3UFktVnVmYUo0Z2dHZmlpOHEwMm9RZ1VEZTB2Vm1FWDc0c2VQX2RxakVpZVVOYm
      xBZE9sS2dBWlFGdEs4dy1xVUMzSzVVGTjRoUG9yeDc2b3lPVUpOQTVFZVV2Qy1jR2tMcTNQ
      UG1GRmQyaUtOTElCTEJzVWl6c1h3RERvZVA5SmktWGt5ZEQtREN1SHdpcno0OEdNNWVLSj
      Q5WVdqRUtFQko2T01NNUNmZHZ4cDNmVG1uUTdfTXcwZ3FZVDRiOUJSSnBfWjA3TTctNUpE
      emg0czhyU3dsQzFXU3V2RmhRWlJCcXXJtX2RaUlRIb0VaZldXc1VCSWVNWWdxNG1zb0JqTj
      NXSzhnRWYwZGI5a3Z6UG9LYmpJRy10UUE2R2l1X3pHaFFVfLXFBV1lLemVKMDZ6djRIWlBO
      dHktQXRyTGF0WGhtUTdOQlVrX0hvbjdOUWxhU1g1ZHVNVmN4bGs1ZHVrWFZNMDgxa09wYV
      kzbDliQVffYVhTM0FNaFFTTVVsT3dnTDZJazFPYVpaTGFMLUE3ejlITnlESmFEWTVhakZK
      TWFDV1lfOG94YlNoQUktNXA2MmNuT0xzV0dNWWNKTlBGVTZpcWlMR19oc3JfNlNKMURhbD
      VtQ0YycnBJLUItMlhuckxZR01ZS0NEZ2V2dGFnbi1DVUV6RURwR3ozQ2VLcWdQU0Vqd3BK
      N0M3NXduYTlCSmtTUkpOdDNla3hoWElrcnNEazpRHVVpMSDdQYzFZHdRTXhxdWpzNmxJSV
      EycjM1NWEtVkotWHdPcFpfY3RPdW96LTA4WHdYQ3RkTEliSFFVTG40RjlMRTRtanU0dUxS
      bjNsc043WWZ1S3dCVmVEZDJ6R3NBY0s5SVlDa3hOaDk3d0luYW1iMDZqSXVoWF5QkhWRU
      9nTkhici1rMDY1bW9Ovk5lVVUyMm5OdVNKS0ZxVnIxT0dKNGVfNXkzYkNwTmxTeEFFPV1Bn
      RnJzU0Flc2JJOWw4eVJtVTAwenJYdGc4OWt5SjlCcXN2eXA1RE8wX2FtS1JyMXB1MVJVWF
      lFZzB2ampKS1FSdDDVZbXRUNFJzaWpqdGRDWDg3UUxJaUdSY0hDdlJzUzZSdDJESmNYR1ht
      UGQyc0ZmNUZyNnJnMkFzX3BmUHN3cnF1WlAxbVFLc3RPMFVkTXpqbW2N1NHVxVXlHUD
      lWWU54cHVnWVdNSjRYb1dRelJtWGNTUEJ4VEtnenenFPS2s3UnRzWWVMNXl4LVM4NjV0cHVz
      dTA0bXpzYUJRZ21od1ZFVXBRdWNrcG1YWkNLNHlJUXktaHNFQUlJSmVxdFFB3dVAySXF0X2
      I5dlk0bzExeEdzeXhzdmp2RnNKN0VVZU1MaGE2R2dSanBSbnU5RWIzRnlJZ0U5M0VVNEEw
      T0lUMWlOSGNRYWc0eWtOc3dPdXkxQbjZIZ21zQ05ESlgwewkc2RlFDMTZRdjBSQ25SVTdfV2
      VvblhSTUZwUzZRZ1JiSk45R1NMckxN5bklJSWxUcDBxNHBaS05zM0tqQ2tMUzJrb3Bhd2Y0
      WF9BUllmTko3a0s5eW5BR0dCcktuUWJNRWVxUEFmMDBKMLYtVXpuU1JMZmQ4SGs3Y2JEdk
      5RQlhHQW9BR0RwVUc0RXFwMlVyQ2o3dEtyUURVSRlh4RTVsOFNHY2czQ1RmN2Zoazdx
      VEFBVjVsWEFnOUtOUDF1c1ZRZk1fUlBleHFNTG9WQVVKV2syQkF6WF9uSEhkVVVhaSVBIOG
      hLeDctdEFRV0dTWUd0R2FmanJZZzI2c082TzloQWZVd3BpSV90MzF6SkZORDU0OTZURHBz
      QmNnd2dMLU1UcVhCRUJ2NEhvQld5SG1DVjVFMUwiLCJ0YWciOiJkbXleWZJVlNJUi1Ren
      ExOEgybFRIeEMxbl9HZEtrdnZNMDJUcHdsYzQwIn19fQ",
      "protected":"e-KAnGFsZ-KAnTrigJxSUzI1NuKAnX0",   //RSAwithSHA256
      "header": {
        "kid":"e9bc097a-ce51-4036-9562-d2ade882db0d",
          "signer":"
          MIIC3zCCAkigAwIBAgIJAJf2fFkE1BYOMA0GCSqGSIb3DQEBBQUAMFoxCzAJBgNVBA
          YTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxpZm9ybmlhMSEw
          HwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGQwHhcNMTUwNzAyMDkwMTE4Wh
          cNMjAwNjMwMDkwMTE4WjBaMQswCQYDVQQGEwJVUzETMBEGA1UECAwKQ2FsaWZvcm5p

```
        YTETMBEGA1UEBwwKQ2FsaWZvcm5pYTEhMB8GA1UECgwYSW50ZXJuZXQgV2lkZ2l0cy
        BQdHkgTHRkMIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQC8ZtxM1bYickpgSVG-
        meHInI3f_chlMBdL8l7daOEztSs_a6GLqmvSu-
        AoDpTsfEd4EazdMBp5fmgLRGdCYMcI6bgpO94h5CCnlj8xFKPq7qGixdwGUA6b_ZI3
        c4cZ8eu73VMNrrn_z3WTZlExlpT9XVj-
        ivhfJ4a6T20EtMM5qwIDAQABo4GsMIGpMHQGA1UdIwRtMGuhXqRcMFoxCzAJBgNVBA
        YTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxpZm9ybmlhMSEw
        HwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGSCCQCX9nxZBNQWDjAJBgNVHR
        MEAjAAMA4GA1UdDwEB_wQEAwIGwDAWBgNVHSUBAf8EDDAKBggrBgEFBQcDAzANBgkq
        hkiG9w0BAQUFAAOBgQAGkz9QpoxghZUWT4ivem4cIckfxzTBBiPHCjrrjB2X8Ktn8G
        SZ1MdyIZV8fwdEmD90IvtMHgtzK-
        9wo6Aibj_rVIpxGb7trP82uzc2X8VwYnQbuqQyzofQvcwZHLYplvi95pZ5fVrJvnYA
        UBFyfrdT5GjqL1nqH3a_Y3QPscuCjg"
          },
        "signature":"nuQUsCTEBLeaRzuwd7q1iPIYEJ2eJfurO5sT5Y-
        N03zFRcv1jvrqMHtx_pw0Y9YWjmpoWfpfelhwGEko9SgeeBnznmkZbp7kjS6MmX4CKz
        9OApe3-VI7yL9Yp0WNdRh3425eYfuapCy3lcXFln5JBAUnU_OzUg3RWxcU_yGnFsw"
      }
    }
```

A.1.2.2. Sample CreateSDResponse

```
{
  "CreateSDTBSResponse": {
    "ver":"1.0",
    "status":"pass",
    "rid":"req-01",
    "tid":"tran-01",
    "content":{
      "did":"zAHkb0-SQh9U_OT8mR5dB-tygcqpUJ9_x07pIiw8WoM",
      "sdname":"sd.bank.com",
      "teespaik":"AQABjY9KiwH3hkMmSAAN6CLXot525U85WNlWKAQz5TOdfe_CM8h-
      X6_EHX1gOXoyRXaBiKMqWb0YZLCABTw1ytdXy2kWa525imRho8Vqn6HDGsJDZPDru9
      GnZR8pZX5ge_dWXB_uljMvDttc5iAWEJ8ZgcpLGtBTGLZnQoQbjtn1lIE",
    }
  }
}
```

   Below is the response message after the content is encrypted and
   encoded.

```
{
  "CreateSDResponse": {
    "payload":"
    eyJDcmVhdGVTRFRCU1Jlc3BvbnNlIjp7InZlciI6IjEuMCIsInN0YXR1cyI6InBhc3Mi
    LCJyaWQiOiJyZXEtMDEiLCJ0aWQiOiJ0cmFuLTAxIiwiY29udGVudCI6eyJwcm90ZWN0
    ZWQiOiJlLUtBbkdWktS0FuVHJpZ0p4Qk1USTRRMEpETFVoTE1qVTI0b0NkZlEiLCJy
    ZWNpcGllbnRzIjpbeyJoZWFkZXIiOnsiYWxnIjoiUlNBMV81In0sImVuY3J5cHRlZF9r
```

        ZXkiOiJOX0I4R3pldUlfN2hwd0wwTFpHSTkxVWVBbmxJRkJfcndmZU1yZERrWnFGak1s
        VVhjdlI0XzhhOGhyeFI4SXR3aEtFZnVfRWVLRDBQb0dqQ2pCSHcxdG1ULUN6eWhsbW5v
        Slk3LXllWnZzRkRpc2VNTkd0eGE0OGZJYUs2VWx5NUZMYXBCZVc5T1I5bmktOU9GQV9j
        aFVuWWl3b2Q4ZTJFa0Vpd0JEZ11EzMk0ifV0sIml2IjoiQXhZOERDdERhR2xzYmdsamIz
        Um9aUSIsImNpcGhlcnRleHQiOiJsalh6Wk5JTmR1WjFaMXJHVElkTjBiVUp1RDRVV2xT
        QVptLWd6YnJJINFVDYy1jMEFQenMtMWdWSFk4NTRUR3VMYkdyRmVHcDFqM2Fsb1lacWZp
        ZnE4aEt3Ty16RFlBN2tmVFhBZHp6czM4em9xeG4zbHoyM2w1RUlGUWhrOHBBWTRYTHRW
        M3ZBQWlNYnlrQ1Q3VS1CWDdWcjBacVNhYWZTQVZ4OFBLQ1RIU3hHN3hHVko0NkxxRzJS
        RE54WXQ4RC1SQ3lZUi1zRTM0MUFKZldEc2FLaGRRbzJXcjNVN1hTOWFqaXJtWjdqqTlJ4
        cVRodHJBRWlIY1ctOEJMdVFHWEZ1YUhLMTZrenJKUGl4d0VXbzJ4cmw4cmkwc3ZRRcHpl
        Z2M3MEt2Z0I0NUVaNHZiNXR0YlUya25hN185QU1Wcm4wlUJaQ1Bnb280MWlFb#lhuNVJn
        TXY2c2V2Y1JPQ2xHMnpWSjFoRkVLYjk2akEiLCJ0YWciOiIzOTZISTk4Uk1NQnR0eDlo
        ZUtsODROOaVZLd0lJSzI0UEt2Z1RGYzFrbEJzIn19fQ",
        "protected": "e-KAnGFsZ-KAnTrigJxSUzI1NuKAnX0",
        "header": {
            "kid":"e9bc097a-ce51-4036-9562-d2ade882db0d",
            "signer":"
                MIIC3zCCAkigAwIBAgIJAJf2fFkE1BYOMA0GCSqGSIb3DQEBBQUAMFoxCzAJ
                BgNVBAYTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxp
                Zm9ybmlhMSEwHwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGQwHhcN
                MTUwNzAyMDkwMTE4WhcNMjAwNjMwMDkwMTE4WjBaMQswCQYDVQQGEwJVUzET
                MBEGA1UECAwKQ2FsaWZvcm5pYTETMBEGA1UEBwwKQ2FsaWZvcm5pYTEhMB8G
                A1UECgwYSW50ZXJuZXQgV2lkZ2l0cyBQdHkgTHRkMIGfMA0GCSqGSIb3DQEB
                AQUAA4GNADCBiQKBgQC8ZtxM1bYickpgSVG-
                meHInI3f_chlMBdL8l7daOEztSs_a6GLqmvSu-
                AoDpTsfEd4EazdMBp5fmgLRGdCYMcI6bgpO94h5CCnlj8xFKPq7qGixdwGUA
                6b_ZI3c4cZ8eu73VMNrrn_z3WTZlExlpT9XVj-
                ivhfJ4a6T20EtMM5qwIDAQABo4GsMIGpMHQGA1UdIwRtMGuhXqRcMFoxCzAJ
                BgNVBAYTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxp
                Zm9ybmlhMSEwHwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGSCCQCX
                9nxZBNQWDjAJBgNVHRMEAjAAMA4GA1UdDwEB_wQEAwIGwDAWBgNVHSUBAf8E
                DDAKBggrBgEFBQcDAzANBgkqhkiG9w0BAQUFAAOBgQAGkz9QpoxghZUWT4iv
                em4cIckfxzTBBiPHCjrrjB2X8Ktn8GSZ1MdyIZV8fwdEmD90IvtMHgtzK-
                9wo6Aibj_rVIpxGb7trP82uzc2X8VwYnQbuqQyzofQvcwZHLYplvi95pZ5fV
                rJvnYAUBFyfrdT5GjqL1nqH3a_Y3QPscuCjg"
        },
        "signature":"jnJtaB0vFFwrE-qKOR3Pu9pf2gNoI1s67GgPCTq0U-
        qrz97svKpuh32WgCP2MWCoQPEswsEX-nxhIx_siTe4zIPO1nBYn-
        R7b25rQaF87O8uAOOnBN5Yl2Jk3laIbs-
        hGE32aRZDhrVoyEdSvIFrT6AQqD20bIAZGqTR-zA-900"
    }
}

A.1.3. **Sample UpdateSD**

A.1.3.1. **Sample UpdateSDRequest**

```
{
  "UpdateSDTBSRequest": {
    "ver": "1.0",
    "rid": "1222DA7D-8993-41A4-AC02-8A2807B31A3A",
    "tid": "4F454A7F-002D-4157-884E-B0DD1A06A8AE",
    "tee": "Primary TEE ABC",
    "nextdsi": "false",
    "dsihash":
    "
    IsOvwpzDk8Onw4bCrsKTJsONwrbDrcKJYjVTw4vCu8OAw4JEw6zCgsK8w4JCacKxW8Kf
    w5o7",
    "content": { // NEEDS to BE ENCRYPTED
      "tamid": "id1.TAMxyz.com",
      "spid": "com.acmebank.spid1",
      "sdname": "com.acmebank.sdname1",
      "changes": {
        "newsdname": "com.acmebank.sdname2",
        "newspid": "com.acquirer.spid1",
        "spcert":
        "MIIDFjCCAn-
        gAwIBAgIJAIk0Tat0tquDMA0GCSqGSIb3DQEBBQUAMGwxCzAJBgNVBAYTAkTAMQ4
        wDAYDVQQIDAVTZW91bDESMBAGA1UEBwwJR3Vyby1kb25nMRAwDgYDVQQKDAdTb2x
        hY2lhMRAwDgYDVQQLDAdTb2xhY2lhMRUwEwYDVQQDDAxTb2xhLWNpYS5jb20wHhc
        NMTUwNzAyMDg1MTU3WhcNMjAwNjMwMDg1MTU3WjBsMQswCQYDVQQGEwJLUjEOMAw
        GA1UECAwFU2VvdWwxEjAQBgNVBAcMCUd1cm8tZG9uZzEQMA4GA1UECgwHU29sYWN
        pYTEQMA4GA1UECwwHU29sYWNpYTEVMBMGA1UEAwwMU29sYS1jaWEuY29tMIGfMA0
        GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQDYWLrFf2OFMEciwSYsyhaLY4kslaWcXA0
        hCWJRaFzt5mU-
        lpSJ4jeu92inBbsXcI8PfRbaItsgW1TD1Wg4gQH4MX_YtaBoOepE--
        3JoZZyPyCWS3AaLYWrDmqFXdbzaO1i8GxB7zz0gWw55bZ9jyzcl5gQzWSqMRpx_d
        cad2SP2wIDAQABo4G_MIG8MIGGBgNVHSMEfzB9oXCkbjBsMQswCQYDVQQGEwJLUj
        EOMAwGA1UECAwFU2VvdWwxEjAQBgNVBAcMCUd1cm8tZG9uZzEQMA4GA1UECgwHU2
        9sYWNpYTEQMA4GA1UECwwHU29sYWNpYTEVMBMGA1UEAwwMU29sYS1jaWEuY29tgg
        kAiTRNq3S2q4MwCQYDVR0TBAIwADAOBgNVHQ8BAf8EBAMCBsAwFgYDVR0lAQH_BA
        wwCgYIKwYBBQUHAwMwDQYJKoZIhvcNAQEFBQADgYEAEFMhRwEQ-
        LDa9O7P1N0mcLORpo6fW3QuJfuXbRQRQGoXddXMKazI4VjbGaXhey7Bzvk6TZYDa
        -
        GRiZby1J47UPaDQR3UiDzVvXwCOU6S5yUhNJsW_BeMViYj4lssX28iPpNwLUCVm1
        QVTHILI6afLCRWXXclc1L5KGY290OwIdQ",
        "renewteespaik": "0"
      }
    }
  }
}
```

A.1.3.2. **Sample UpdateSDResponse**

```
{
  "UpdateSDTBSResponse": {
    "ver": "1.0",
    "status": "pass",
    "rid": "1222DA7D-8993-41A4-AC02-8A2807B31A3A",
    "tid": "4F454A7F-002D-4157-884E-B0DD1A06A8AE",
    "content": {
      "did": "MTZENTE5Qzc0Qzk0NkUxMzYxNzk0NjY4NTc3OTY4NTI=",
      "teespaik":
      "AQABjY9KiwH3hkMmSAAN6CLXot525U85WNlWKAQz5TOdfe_CM8h-
      X6_EHX1gOXoyRXaBiKMqWb0YZLCABTw1ytdXy2kWa525imRho8Vqn6HDGsJDZPDru9
      GnZR8pZX5ge_dWXB_uljMvDttc5iAWEJ8ZgcpLGtBTGLZnQoQbjtn1lIE",
      "teespaiktype": "RSA"
    }
  }
}
```

A.1.4. **Sample DeleteSD**

A.1.4.1. **Sample DeleteSDRequest**

The TAM builds message - including data to be encrypted.

```
{
    "DeleteSDTBSRequest": {
      "ver": "1.0",
      "rid": "{712551F5-DFB3-43f0-9A63-663440B91D49}",
      "tid": "{4F454A7F-002D-4157-884E-B0DD1A06A8AE}",
      "tee": "Primary TEE",
      "nextdsi": "false",
      "dsihash": "AAECAwQFBgcICQoLDA0ODwABAgMEBQYHCAkKCwwNDg8=",
      "content": ENCRYPTED {
        "tamid": "TAM1.com",
        "sdname": "default.acmebank.com",
        "deleteta": "1"
      }
    }
  }
```

The TAM encrypts the "content".

```
{
  "DeleteSDTBSRequest": {
    "ver": "1.0",
    "rid": "{712551F5-DFB3-43f0-9A63-663440B91D49}",
    "tid": "{4F454A7F-002D-4157-884E-B0DD1A06A8AE}",
    "tee": "Primary TEE",
    "nextdsi": "false",
    "dsihash": "AAECAwQFBgcICQoLDA0ODwABAgMEBQYHCAkKCwwNDg8=",
    "content": {
    "protected": "eyJlbmMiOiJBMTI4Q0JDLUhTMjU2In0",
    "recipients": [
      {
        "header": {
          "alg": "RSA1_5"
        },
      "encrypted_key":
      "
      QUVTMTI4IChDRUspIGtleSwgZW5jcnlwdGVkIHdpdGggVFNNIFJTQSBwdWJsaWMga2
      V5LCB1c2luZyBSU0ExXzUgcGFkZGluZw"
      }
    ],
    "iv": "rWO5DVmQX9ogelMLBIogIA",
    "ciphertext":
    "
    c2FtcGxlIGRzaSBkYXRhIGVuY3J5cHRlZCB3aXRoIEFFUzEyOCBrZXkgZnJvbSByZWNp
    cGllbnRzLmVuY3J5cHRlZF9rZXk",
    "tag": "c2FtcGxlIGF1dGhlbnRpY2F0aW9uIHRhZw"
    }
  }
}
```

    The TAM signs the "DeleteSDTBSRequest" to form a "DeleteSDRequest"

```
  {
    "DeleteSDRequest": {
      "payload":"
```
```
      ewoJIkRlbGV0ZVNEVEJTUmVxdWVzdCI6IHsKCQkidmVyIjogIjEuMCIsCgkJInJp
      ZCI6ICJ7NzEyNTUxRjUtREZCMy00M2YwLTlBNjMtNjYzNDQwQjkxRDQ5fSIsCgkJ
      InRpZCI6ICJ7NEY0NTRBN0YtMDAyRC00MTU3LTg4NEUtQjBERDFBMDZBOEFFfSIs
      CgkJInRlZSI6ICJQcmltYXJ5IFRFRSIsCgkJIm5leHRkc2kiOiAiZmFsc2UiLAoJ
      CSJkc2loYXNoIjogIkFBRUNBd1FGQmdjSUNRb0xEQTBPRHdBQkFnTUVCUVlIQ0Fr
      S0N3d05EZzg9IiwKCQkiY29udGVudCI6IHsKCQkJInByb3RlY3RlZCI6ICJleUps
      Ym1NaU9pSkJNVEk0UTBKREExVaFNalUySW4wIiwKCQkJInJlY2lwaWVudHMiOiBb
      ewoJCQkJImhlYWRlciI6IHsKCQkJCQkiYWxnIjogIlJTQTFfNSIKCQkJCX0sCgkJ
      CQkiZW5jcnlwdGVkX2tleSI6ICJRVVZUVRJNElDaERSVXNwSUd0bGVTd2daVz5q
      Y25sd2RHVmtJSGRZZnZ1ZGTk5JRkpUVUNd2RXSnnhV01nYTJWNUxDQjFjMmx1
      WnlCU1UwRXhYyelVnY0dGa1pHHVadyIKCQkJfV0sCgkJCSJpdiI6ICJyV081RFZt
      UVg5b2dlbE1MQklvZ0lBIiwKCQkJImNpcGhlcnRleHQiOiAiYzJGdGNHeGJR1J6
      YVNa1lYmhJR1Z1WTNNNWNIUmaQ0IzYVhSb0lFUkZWekV5T0NclpYa2dabkp2
      YlNCZVpXnBjR2xsYm5SekxtVnZbM0o1Y0hSpGOXJaWGSsLAoJCQkidGFnIjog
      ImMyRnRjR3hsSUdGMWRHaGibJJwWTJGMGFXOXVJSFJoWnciCgkJfQoJfQp9",
```
```
      "protected":"eyJhbGciOiJSUzI1NiJ9",
      "header": {
        "x5c": ["ZXhhbXBsZSBBU04xIHNpZ25lciBjZXJ0aWZpY2F0ZQ==",
                "ZXhhbXBsZSBBU04xIENBIGNlcnRpZmljYXRl"]
      },
      "signature":"c2FtcGxlIHNpZ25hdHVyZQ"
    }
  }
```

The TEE creates a "DeleteSDTBSResponse" to respond to the
"DeleteSDRequest" message from the TAM, including data to be
encrypted.

```
  {
     "DeleteSDTBSResponse": {
       "ver": "1.0",
       "status": "pass",
       "rid": "{712551F5-DFB3-43f0-9A63-663440B91D49}",
       "tid": "{4F454A7F-002D-4157-884E-B0DD1A06A8AE}",
       "content": ENCRYPTED {
         "did": "MTZENTE5Qzc0Qzk0NkUxMzYxNzk0NjY4NTc3OTY4NTI=",
       }
     }
  }
```

The TEE encrypts the "content" for the TAM.

```
     {
      "DeleteSDTBSResponse": {
       "ver": "1.0",
       "status": "pass",
       "rid": "{712551F5-DFB3-43f0-9A63-663440B91D49}",
       "tid": "{4F454A7F-002D-4157-884E-B0DD1A06A8AE}",
        "content": {
        "protected": "eyJlbmMiOiJBMTI4Q0JDLUhTMjU2In0K",
        "recipients": [
          {
            "header": {
            "alg": "RSA1_5"
          },
            "encrypted_key":
            "
            QUVTMTI4IChDRUspIGtleSwgZW5jcnlwdGVkIHdpdGggVFNNIFJTQSBwdWJsaWMg
            a2V5LCB1c2luZyBSU0ExXzUgcGFkZGluZw"
          }
        ],
        "iv": "ySGmfZ69YlcEilNr5_SGbA",
        "ciphertext":
        "
        c2FtcGxlIGRzaSBkYXRhIGVuY3J5cHRlZCB3aXRoIEFFUzEyOCBrZXkgZnJvbSByZW
        NpcGllbnRzLmVuY3J5cHRlZF9rZXk",
        "tag": "c2FtcGxlIGF1dGhlbnRpY2F0aW9uIHRhZw"
        }
       }
     }
```

     The TEE signs "DeleteSDTBSResponse" to form a "DeleteSDResponse"

```
{
  "DeleteSDResponse": {
    "payload":"
```
    ewoJIkRlbGV0ZVNEVEJTUmVzcG9uc2UiOiB7CgkJInZlciI6ICIxLjAiLAoJCSJz
    dGF0dXMiOiAicGFzcyIsCgkJInJpZCI6ICJ7NzEyNTUxRjUtREZCMy00M2YwLTlB
    NjMtNjYzNDQwQjkxRDQ5fSIsCgkJInRpZCI6ICJ7NEY0NTRBN0YtMDAyRC00MTU3
    LTg4NEUtQjBERDFBMDZBOEFFfSIsCgkJImNvbnRlbnQiOiB7CgkJCSJwcm90ZWN0
    ZWQiOiAiZXlKbGGJtTWlPaUpCCTVRJNFEwSkRMVWhUWpVMkluMEsiLAoJCQkicmVj
    aXBpZW50cyI6IFt7CgkJCQkiaGVhZGVyIjogewoJCQkJCSJhbGciOiAiUlNBMV81
    IgoJCQkJfSwKCQkJCSJlbmNyeXB0ZWRfa2V5IjogIlFVVlRNVEk0SUNoRFJVc3BJ
    R3RsZVN3Z1pYTWpbmx3ZEda0lIZHBkR2dnVkZTTklGSlRRU0J3ZFdKc2FXTWdh
    MlY1TENCWMybHVaUJTVTBFeFh6VWdjR0ZyWkdsdVp3IgoJCQl9XSwKCQkJIml2
    IjogInlTR21mWjY5WWxjRWlsTnI1X1NHYkEiLAoJCQkiY2lwaGVydGV4dCI6ICJj
    MkZ0Y0d4bElHUnphU0JrWVhSaElHVnVZM0o1Y0hSbFpDQjNhWFFvvSUVGRlV6RXlP
    Q0JyYWlhrZ1puSnziU0J5WldOcGNNhbGxiblJ6TG1WdVkzSjVjSFJsWkY5clpYayIs
    CgkJCSJ0YWciOiAiYzJGdGNHeGxJR0YxZEdobGJuUnBZMkYwaVc5dUlIUmhadyIK
    CQl9Cgl9Cn0",
```
    "protected":"eyJhbGciOiJSUzI1NiJ9",
    "signature":"c2FtcGxlIHNpZ25hdHVyZQ"
  }
}
```

The TEE returns "DeleteSDResponse" back to the OTrP Broker, which
returns the message back to the TAM.

A.2. Sample TA Management Messages

A.2.1. Sample InstallTA

A.2.1.1. Sample InstallTARequest

```
{
  "InstallTATBSRequest": {
    "ver": "1.0",
    "rid": "24BEB059-0AED-42A6-A381-817DFB7A1207",
    "tid": "4F454A7F-002D-4157-884E-B0DD1A06A8AE",
    "tee": "Primary TEE ABC",
    "nextdsi": "true",
    "dsihash":
    "
    IsOvwpzDk8Onw4bCrsKTJsONwrbDrcKJYjVTw4vCu8OAw4JEw6zCgsK8w4JCacKxW8Kf
    w5o7",
    "content": {
      "tamid": "id1.TAMxyz.com",
      "spid": "com.acmebank.spid1",
      "sdname": "com.acmebank.sdname1",
      "taid": "com.acmebank.taid.banking"
    },
    "encrypted_ta": {
      "key":
      "mLBjodcE4j36y64nC/nEs694P3XrLAOokjisXIGfs0H7lOEmT5FtaNDYEMcg9RnE
      ftlJGHO7N0lgcNcjoXBmeuY9VI8xzrsZM9gzH6VBKtVONSx0aw5IAFkNcyPZwDdZ
      MLwhvrzPJ9Fg+bZtrCoJz18PUz+5aNl/dj8+NM85LCXXcBlZF74btJer1Mw6ffzT
      /grPiEQTeJ1nEm9F3tyRsvcTInsnPJ3dEXv7sJXMrhRKAeZsqKzGX4eiZ3rEY+FQ
      6nXULC8cAj5XTKpQ/EkZ/iGgS0zcXR7KUJv3wFEmtBtPD/+ze08NILLmxM8olQFj
      //Lq0gGtq8vPC8r0oOfmbQ==",
      "iv": "4F5472504973426F726E496E32303135",
      "alg": "AESCBC",
      "ciphertadata":
      "......0x/5KGCXWfg1Vrjm7zPVZqtYZ2EovBow+7EmfOJ1tbk......=",
      "cipherpdata": "0x/5KGCXWfg1Vrjm7zPVZqtYZ2EovBow+7EmfOJ1tbk="
    }
  }
}
```

A.2.1.2. **Sample InstallTAResponse**

   A sample to-be-signed response of InstallTA looks as follows.

```
{
  "InstallTATBSResponse": {
    "ver": "1.0",
    "status": "pass",
    "rid": "24BEB059-0AED-42A6-A381-817DFB7A1207",
    "tid": "4F454A7F-002D-4157-884E-B0DD1A06A8AE",
    "content": {
      "did": "MTZENTE5Qzc0Qzk0NkUxMzYxNzk0NjY4NTc3OTY4NTI=",
      "dsi": {
        "tfwdata": {
```

```
              "tbs": "ezRGNDU0QTdGLTAwMkQtNDE1Ny04ODRFLUIwREQxQTA2QThBRX0="
              "cert": "ZXhhbXBsZSBGVyBjZXJ0aWZpY2F0ZQ==",
              "sigalg": "UlMyNTY=",
              "sig": "c2FtcGxlIEZXIHNpZ25hdHVyZQ=="
            },
            "tee": {
              "name": "Primary TEE",
              "ver": "1.0",
              "cert": "c2FtcGxlIFRFRSBjZXJ0aWZpY2F0ZQ==",
              "cacert": [
                "c2FtcGxlIENBIGNlcnRpZmljYXRlIDE=",
                "c2FtcGxlIENBIGNlcnRpZmljYXRlIDI="
              ],
              "sdlist": {
                "cnt": "1",
                "sd": [
                  {
                    "name": "com.acmebank.sdname1",
                    "spid": "com.acmebank.spid1",
                    "talist": [
                        {
                        "taid": "com.acmebank.taid.banking",
                        "taname": "Acme secure banking app"
                        },
                        {
                        "taid": "acom.acmebank.taid.loyalty.rewards",
                        "taname": "Acme loyalty rewards app"
                        }
                    ]
                  }
                ]
              },
              "teeaiklist": [
                {
                  "spaik":
                    "c2FtcGxlIEFTTjEgZW5jb2RlZCBQS0NTMSBwdWJsaWNrZXk=",
                  "spaiktype": "RSA"
                  "spid": "acmebank.com"
                }
              ]
            }
          }
        }
      }
    }
  }
```

A.2.2. **Sample UpdateTA**

A.2.2.1. **Sample UpdateTARequest**

```
{
  "UpdateTATBSRequest": {
    "ver": "1.0",
    "rid": "req-2",
    "tid": "tran-01",
    "tee": "SecuriTEE",
                "nextdsi": " false",
    "dsihash": "gwjul_9MZks3pqUSN1-eL1aViwGXNAxk0AIKW79dn4U",
    "content": {
      "tamid": "TAM1.acme.com",
      "spid": "bank.com",
      "sdname": "sd.bank.com",
      "taid": "sd.bank.com.ta"
    },
    "encrypted_ta": {
      "key":
      "
      XzmAn_RDVk3IozMwNWhiB6fmZlIs1YUvMKlQAv_UDoZ1fvGGsRGo9bT0A440aYMgLt
      GilKypoJjCgijdaHgamaJgRSc4Je2otpnEEagsahvDNoarMCC5nGQdkRxW7Vo2NKgL
      A892HGeHkJVshYm1cUlFQ-BhiJ4NAykFwlqC_oc",
      "iv": "AxY8DCtDaGlsbGljb3RoZQ",
      "alg": "AESCBC",
      "ciphernewtadata":
      "KHqOxGn7ib1F_14PG4_UX9DBjOcWkiAZhVE-U-
      67NsKryHGokeWr2spRWfdU2KWaaNncHoYGwEtbCH7XyNbOFh28nzwUmstep4nHWbAl
      XZYTNkENcABPpuw_G3I3HADo"
    }
  }
}
```

```
{
  "UpdateTARequest": {
    "payload" :
    "
    eyJVcGRhdGVUQVRCU1JlcXVlc3QiOnsidmVyIjoiMS4wIiwicmlkIjoicmVxLTIiLCJ0
    aWQiOiJ0cmFuLTAxIiwidGVlIjoiU2VjdXJpVEVFIiwibmV4dGRzaSI6ImZhbHNlIiwi
    ZHNpaGFzaCI6Imd3anVsXzlNWmtzM3BxVVNOMS1lTDFhVml3R1hOQXhrMEFJS1c3OWRu
    NFUiLCJjb250ZW50Ijp7InByb3RlY3RlZCI6ImV5SmxibU1pT2lKQk1USRRMEpETFVo
    VE1qVTJJbjAiLCJyZWNpcGllbnRzIjpbeyJoZWFkZXIiOnsiYWxnIjoiUlNBMV81In0s
    ImVuY3J5cHRlZF9rZXkiOiJYem1Bbl9SRFZrM0lvek13TldoaUI2Zm1abElzMVlVdk1L
    bFFBdl9VRG9aMWZ2R0dzUkdvOWJUMEE0NDBhWU1nTHRHaWxLeXBvSmpDZ2lqZGFIZ2Ft
    YUpnUlNjNEplMm90cG5FRWFnc2FodkROb2FyTUNDNW5HUWRrUnhXN1ZvMk5LZ0xBODky
    SEdlSGtKVnNoWW0xY1VsRlEtQmhpSjROQXlrRndscUNfb2MifV0sIml2IjoiQXhZOERD
    dERhR2xzYkdsamIzUm9aUSIsImNpcGhlcnRleHQiOiJIYTcwVXRZVEtWQmtXRFJuMi0w
    ```

        SF9IdkZtazl5SGtoVV91bk1OLWc1T3BqLWF1NGFUb2lxWklMYzVzYTdENnZZSjF6eW04
        QW1JOEJIVXFqc2l5Z0tOcC1HdURJUjFzRXc0a2NhMVQ5ZENuU0RydHhSUFhESVdrZmt3
        azZlR1NQWiIsInRhZyI6Im9UN01UTE41eWtBTFBoTDR0aUh6T1pPTGVeU9xZ0NWaEM5
        MXpkcldMU0UifSwiZW5jcnlwdGVkX3RhIjp7ImtleSI6Ilh6bUFuX1JEVmszSW96TXdO
        V2hpQjZmbVpsSXMxWVV2TUttsUUF2X1VEb1oxZnZHR3NSR285YlQwQTQ0MGFZTWdMdEdp
        bEt5cG9KakNnaWpkYUhnYW1hSmdSU2M0SmUyb3RwbkVFYWdzYWh2RE5vYXJNQ0M1bkdR
        ZGtSeFc3Vm8yTktnTEE4OTJIR2VIa0pwWc2hZbTFjVWxGUS1CaGlKNE5BeWtGd2xxQ19v
        YyIsIml2IjoiQXhZOERDdERhR2xzZsamIzUm9aUSIsImFsZyI6IkFFU0NCQyIsImNp
        cGhlcm5ld3RhZGF0YSI6IktTcU94R243aWIxRl8xNFBHNF9VWDlEQmpPY1draUFaZFZF
        LVUtNjdOc0tyeUhhHb2tlV3Iyc3BSV2ZkVTJLV2FhTm5jSG9ZR3dFdGJDSDdDYeU5iT0Zo
        MjhuendVbXN0ZXA0bkhYYkFsWFpZVE5rRU5jQUJQcHV3X0czSTNIQURvIn19fQ",
        "protected": " eyJhbGciOiJSUzI1NiJ9",
        "header": {
          "kid":"e9bc097a-ce51-4036-9562-d2ade882db0d",
          "signer":"
          MIIC3zCCAkigAwIBAgIJAJf2fFkE1BYOMA0GCSqGSIb3DQEBBQUAMFoxCzAJBgNVBA
          YTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxpZm9ybmlhMSEw
          HwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGQwHhcNMTUwNzAyMDkwMTE4Wh
          cNMjAwNjMwMDkwMTE4WjBaMQswCQYDVQQGEwJVUzETMBEGA1UECAwKQ2FsaWZvcm5p
          YTETMBEGA1UEBwwKQ2FsaWZvcm5pYTEhMB8GA1UECgwYSW50ZXJuZXQgV2lkZ2l0cy
          BQdHkgTHRkMIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQC8ZtxM1bYickpgSVG-
          meHInI3f_chlMBdL8l7daOEztSs_a6GLqmvSu-
          AoDpTsfEd4EazdMBp5fmgLRGdCYMcI6bgpO94h5CCnlj8xFKPq7qGixdwGUA6b_ZI3
          c4cZ8eu73VMNrrn_z3WTZlExlpT9XVj-
          ivhfJ4a6T20EtMM5qwIDAQABo4GsMIGpMHQGA1UdIwRtMGuhXqRcMFoxCzAJBgNVBA
          YTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxpZm9ybmlhMSEw
          HwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGSCCQCX9nxZBNQWDjAJBgNVHR
          MEAjAAMA4GA1UdDwEB_wQEAwIGwDAWBgNVHSUBAf8EDDAKBggrBgEFBQcDAzANBgkq
          hkiG9w0BAQUFAAOBgQAGkz9QpoxghZUWT4ivem4cIckfxzTBBiPHCjrrjB2X8Ktn8G
          SZ1MdyIZV8fwdEmD90IvtMHgtzK-
          9wo6Aibj_rVIpxGb7trP82uzc2X8VwYnQbuqQyzofQvcwZHLYplvi95pZ5fVrJvnYA
          UBFyfrdT5GjqL1nqH3a_Y3QPscuCjg"
        },
        "signature":"inB1K6G3EAhF-
        FbID83UI25R5Ao8MI4qfrbrmf0UQhjM3O7_g3l6XxN_JkHrGQaZr-
        myOkGPVM8BzbUZW5GqxNZwFXwMeaoCjDKc4Apv4WZkD1qKJxkg1k5jaUCfJz1Jmw_XtX
        6MHhrLh9ov03S9PtuT1VAQ0FVUB3qFIvjSnNU"
      }
}

. **Sample UpdateTAResponse**

```
{
  "UpdateTATBSResponse": {
    "ver": "1.0",
    "status": "pass",
      "rid": "req-2",
      "tid": "tran-01",
      "content": {
      "did": "zAHkb0-SQh9U_OT8mR5dB-tygcqpUJ9_x07pIiw8WoM"
    }
  }
}
```

```
{
  "UpdateTAResponse":{
    "payload":"
    eyJVcGRhdGVUQVRCU1Jlc3BvbnNlIjp7InZlciI6IjEuMCIsInN0YXR1cyI6InBhc3Mi
    LCJyaWQiOiJyZXEtMiIsInRpZCI6InRyYW4tMDEiLCJjb250ZW50Ijp7InByb3RlY3Rl
    ZCI6ImV5SmxibU1pT2lKQk1USTRRRMEpETFVoVE1qVTJJbjAiLCJyZWNpcGllbnRzIjpb
    eyJoZWFkZXIiOnsiYWxnIjoiUlNBMV81In0sImVuY3J5cHRlZF9rZXkiOiJFaGUxLUJB
    UUdJLTNEMFNHdXFGY01MZDJtd0gxQm1uRnddYQWx1M1FxUFVXZ1RRVm55SUowNFc2MnBK
    YWVSREFkeTU0R0FSVjBrVzQ0RGw0MkdUUlhqbE1EZ3BYdXdFLWloc1JVV0tNNldCZ2N3
    VXVGQTRUR3gwU0I1NTZCdl92dnBBNaFdfMXh2c2FHdFBaQmwxTnZjbXNibzBhY3FobXlu
    bzBDTmF5SVAtX1UifV0sIml2IjoiQXhZOERDdERhR2xzYWRsamIzUm9aUSIsImNpcGhl
    cnRleHQiOiJwc2o2dGtaaGJXM0lmVElMeE9GMU5HdFUtcTFmeVBidV9KWk9jbklycWGwIw
    eTNPOHN6OTItaWpWR1ZyRW5WbG1sY1FYeWFNZTNyX1JGdEkwV3B4UmodyIsInRhZyI6
    Ik0zb2dNNk11MVJYMUMybEZvaG5rTkN5b25qNjd2TDNqd2RrZXhFdUlpaTgifX19",
    "protected":"eyJhbGciOiJSUzI1NiJ9",
    "header": {
      "kid":"e9bc097a-ce51-4036-9562-d2ade882db0d",
      "signer":"
      MIIC3zCCAkigAwIBAgIJAJf2fFkE1BYOMA0GCSqGSIb3DQEBBQUAMFoxCzAJBgNVBA
      YTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxpZm9ybmlhMSEw
      HwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGQwHhcNMTUwNzAyMDkwMTE4Wh
      cNMjAwNjMwMDkwMTE4WjBaMQswCQYDVQQGEwJVUzETMBEGA1UECAwKQ2FsaWZvcm5p
      YTETMBEGA1UEBwwKQ2FsaWZvcm5pYTEhMB8GA1UECgwYSW50ZXJuZXQgV2lkZ2l0cy
      BQdHkgTHRkMIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQC8ZtxM1bYickpgSVG-
      meHInI3f_chlMBdL8l7daOEztSs_a6GLqmvSu-
      AoDpTsfEd4EazdMBp5fmgLRGdCYMcI6bgpO94h5CCnlj8xFKPq7qGixdwGUA6b_ZI3
      c4cZ8eu73VMNrrn_z3WTZlExlpT9XVj-
      ivhfJ4a6T20EtMM5qwIDAQABo4GsMIGpMHQGA1UdIwRtMGuhXqRcMFoxCzAJBgNVBA
      YTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxpZm9ybmlhMSEw
      HwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGSCCQCX9nxZBNQWDjAJBgNVHR
      MEAjAAMA4GA1UdDwEB_wQEAwIGwDAWBgNVHSUBAf8EDDAKBggrBgEFBQcDAzANBgkq
      hkiG9w0BAQUFAAOBgQAGkz9QpoxghZUWT4ivem4cIckfxzTBBiPHCjrrjB2X8Ktn8G
      SZ1MdyIZV8fwdEmD90IvtMHgtzK-
      9wo6Aibj_rVIpxGb7trP82uzc2X8VwYnQbuqQyzofQvcwZHLYplvi95pZ5fVrJvnYA
      UBFyfrdT5GjqL1nqH3a_Y3QPscuCjg"
    },
    "signature":"
    Twajmt_BBLIMcNrDsjqr8lI7O7lEQxXZNhlUOtFkOMMqf37wOPKtp_99LoS82CVmdpCo
    PLaws8zzh-SNIQ42-
    9GYO8_9BaEGCiCwyl8YgWP9fWNfNv2gR2fl2DK4uknkYu1EMBW4YfP81n_pGpb4Gm-
    nMk14grVZygwAPej3ZZk"
  }
}
```

A.2.3. Sample DeleteTA

A.2.3.1. Sample DeleteTARequest

```
{
  "DeleteTATBSRequest": {
    "ver": "1.0",
    "rid": "req-2",
    "tid": "tran-01",
    "tee": "SecuriTEE",
    "nextdsi": "false",
    "dsihash": "gwjul_9MZks3pqUSN1-eL1aViwGXNAxk0AIKW79dn4U",
    "content": {
      "tamid": "TAM1.acme.com",
      "sdname": "sd.bank.com",
      "taid": "sd.bank.com.ta"
    }
  }
}
```

```
{
  "DeleteTARequest": {
    "payload":
    "
    eyJEZWxldGVUQVRCU1JlcXVlc3QiOnsidmVyIjoiMS4wIiwicmlkIjoicVxLTIiLCJ0
    aWQiOiJ0cmFuLTAxIiwidGVlIjoiU2VjdXJpVEFIiwibmV4dGRzaSI6ImZhbHNlIiwi
    ZHNpaGFzaCI6Imd3anVsXzlNWmtzM3BxVVNOMS1lTDFhVml3R1hOQXhrMEFJS1c3OWRu
    NFUiLCJjb250ZW50Ijp7InByb3RlY3RlZCI6eyJlbmMiOiJBMTI4Q0JDLUhTMjU2In0s
    InJlY2lwaWVudHMiOlt7ImhlYWRlciI6eyJhbGciOiJSU0ExXzUifSwiZW5jcnlwdGVk
    X2tleSI6ImtyaGs0d2dpY0RlX3d0VQyTW4tSUJsdUtv0JkeXpNY2p1cVlBenBPYnRS
    TG9MZzQ0QkFFLN2tRVWE1YTg0TEVJRGEzaHNtWDIxdldNZFJLczN4MTJsOUh5VFdfLUNS
    WmZtcUx2bEh1LV9MSVdvc1ZyRTZVMlJqUnRdllVOWliUkVLczkzRDRHWm4xVHFuZG9n
    d0tXRF9jdG1nWG1sbzZZVXpCWDZhR1dZMCJ9XSwiaXYiOiJBEFk4REN0RGFHbHNiR2xq
    YjNSb1pRIiwiY2lwaGVydGV4dCI6IkhhNzBVdFlUS1ZCa1dEUm4yeLTBIX1BGa19yQnpQ
    dGJHdzhSNktlMXotdklNeFBSY0Nxa1puZmwyTjRjUTZPSTZCSHZJUUFoM2Jic0l0dHlR
    bXhDTE5Nbm8wejBrYm9TdkIyVXlxWExpeGVZIiwidGFnIjoidEtUbFRLdlR2LTRtVVlG
    Y1dYWnZMMVlhQnRGNloxVlNxOTMzVmI2UEpmcyJ9fX0",
    "protected" : "eyJhbGciOiJSUzI1NiJ9",
    "header":     {
      "kid":"e9bc097a-ce51-4036-9562-d2ade882db0d",
      "signer":"
      MIIC3zCCAkigAwIBAgIJAJf2fFkE1BYOMA0GCSqGSIb3DQEBBQUAMFoxCzAJBgNVBA
      YTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxpZm9ybmlhMSEw
      HwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGQwHhcNMTUwNzAyMDkwMTE4Wh
      cNMjAwNjMwMDkwMTE4WjBaMQswCQYDVQQGEwJVUzETMBEGA1UECAwKQ2FsaWZvcm5p
      YTETMBEGA1UEBwwKQ2FsaWZvcm5pYTEhMB8GA1UECgwYSW50ZXJuZXQgV2lkZ2l0cy
      BQdHkgTHRkMIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQC8ZtxM1bYickpgSVG-
      meHInI3f_chlMBdL8l7daOEztSs_a6GLqmvSu-
      AoDpTsfEd4EazdMBp5fmgLRGdCYMcI6bgpO94h5CCnlj8xFKPq7qGixdwGUA6b_ZI3
      c4cZ8eu73VMNrrn_z3WTZlExlpT9XVj-
      ivhfJ4a6T20EtMM5qwIDAQABo4GsMIGpMHQGA1UdIwRtMGuhXqRcMFoxCzAJBgNVBA
      YTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxpZm9ybmlhMSEw
      HwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGSCCQCX9nxZBNQWDjAJBgNVHR
      MEAjAAMA4GA1UdDwEB_wQEAwIGwDAWBgNVHSUBAf8EDDAKBggrBgEFBQcDAzANBgkq
      hkiG9w0BAQUFAAOBgQAGkz9QpoxghZUWT4ivem4cIckfxzTBBiPHCjrrjB2X8Ktn8G
      SZ1MdyIZV8fwdEmD90IvtMHgtzK-
      9wo6Aibj_rVIpxGb7trP82uzc2X8VwYnQbuqQyzofQvcwZHLYplvi95pZ5fVrJvnYA
      UBFyfrdT5GjqL1nqH3a_Y3QPscuCjg"
    },
    "signature" :
    "
    BZS0_Ab6pqvGNXe5lqT4Sc3jakyWQeiK9KlVSnimwWnjCCyMtyB9bwvlbILZba3IJiFe
    _3F9bIQpSytGS0f2TQrPTKC7pSjwDw-3kH7HkHcPPJd-
    PpMMfQvRx7AIV8vBqO9MijIC62iN0V2se5z2v8VFjGSoRGgq225w7FvrnWE"
  }
}
```

A.2.3.2. Sample DeleteTAResponse

```
   {
     "DeleteTATBSResponse": {
       "ver": "1.0",
       "status": "pass",
           "rid": "req-2",
           "tid": "tran-01",
           "content": {
         "did": "zAHkb0-SQh9U_OT8mR5dB-tygcqpUJ9_x07pIiw8WoM"
       }
     }
   }
```

```
{
  "DeleteTAResponse":{
    "payload":"
    ew0KCSJEZWxldGVUQVRCU1Jlc3BvbnNlIjogew0KCQkidmVyIjogIjEuMCIsDQoJCSJz
    dGF0dXMiOiAicGFzcyIsDQoJCSJyaWQiOiAicmVxLTIiLA0KCQkidGlkIjogInRyYW4t
    MDEiLA0KCQkiY29udGVudCI6IHsNCgkJCSJwcm90ZWN0ZWQiOnsiZW5jIjoiQTEyOENC
    Qy1IUzI1NiJ9LA0KCQkJInJlY2lwaWVudHMiOlsNCgkJCQl7DQoJCQkJCSJoZWFkZXIi
    OnsiYWxnIjoiUlNBMV81In0sDQoJCQkJCSJlbmNyeXB0ZWRfa2V5IjoiTXdtU1ZHaWU2
    eHpfQmxTaFlmTFRKRHhKT3oyNWhvYy1HZ2NEM2o5OWFyM2E4X2lYY182ZE44bFRTb1dD
    X19wZEFhaEMyWk5SakdIcTBCCZ2JDYTRKalk0eXRkMVBVWDB6M1psbXXl1YnRXM291eEpY
    el9PMzg1WGM4S3hySndjbElyZGx2WUY2OVZmeERLQkVzUHJCdzlVenVIa1VmSU4xWlFU
    bWZ0QmVaSlJnIg0KCQkJCX0NCgkJCJCV0sDQoJCQkiaXYiOiJBeFk4REN0RGFHHbHNiR2xq
    YjNSb1pRIiwNCgkJCSJjaXBoZXJ0ZXh0IjoiamhQTlV5ZkFTel9rVV9GbEM2LUtCME01
    WDBHNE5MbHc0LWt0bERyajZTWlUteUp6eUFUbC1oY0ZBWWMwLXJMVEF4cF93N1d1WER0
    Y3N3SzJSSzRjWciLA0KCQkJInRhZyI6IlBBeGo5N25oT29qVTNIREhxSll4MGZMNWpt
    b0xkTlJkTHRTAMIzUTdrYXciDQoJCX0NCgl9DQp9",
    "protected": "eyJhbGciOiJSUzI1NiJ9",
    "header": {
      "kid":"e9bc097a-ce51-4036-9562-d2ade882db0d",
      "signer":"
      MIIC3zCCAkigAwIBAgIJAJf2fFkE1BYOMA0GCSqGSIb3DQEBBQUAMFoxCzAJ
      BgNVBAYTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxp
      Zm9ybmlhMSEwHwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGQwHhcN
      MTUwNzAyMDkwMTE4WhcNMjAwNjMwMDkwMTE4WjBaMQswCQYDVQQGEwJVUzET
      MBEGA1UECAwKQ2FsaWZvcm5pYTETMBEGA1UEBwwKQ2FsaWZvcm5pYTEhMB8G
      A1UECgwYSW50ZXJuZXQgV2lkZ2l0cyBQdHkgTHRkMIGfMA0GCSqGSIb3DQEB
      AQUAA4GNADCBiQKBgQC8ZtxM1bYickpgSVG-
      meHInI3f_chlMBdL8l7daOEztSs_a6GLqmvSu-
      AoDpTsfEd4EazdMBp5fmgLRGdCYMcI6bgpO94h5CCnlj8xFKPq7qGixdwGUA
      6b_ZI3c4cZ8eu73VMNrrn_z3WTZlExlpT9XVj-
      ivhfJ4a6T20EtMM5qwIDAQABo4GsMIGpMHQGA1UdIwRtMGuhXqRcMFoxCzAJ
      BgNVBAYTAlVTMRMwEQYDVQQIDApDYWxpZm9ybmlhMRMwEQYDVQQHDApDYWxp
      Zm9ybmlhMSEwHwYDVQQKDBhJbnRlcm5ldCBXaWRnaXRzIFB0eSBMdGSCCQCX
      9nxZBNQWDjAJBgNVHRMEAjAAMA4GA1UdDwEB_wQEAwIGwDAWBgNVHSUBAf8E
      DDAKBggrBgEFBQcDAzANBgkqhkiG9w0BAQUFAAOBgQAGkz9QpoxghZUWT4iv
      em4cIckfxzTBBiPHCjrrjB2X8Ktn8GSZ1MdyIZV8fwdEmD90IvtMHgtzK-
      9wo6Aibj_rVIpxGb7trP82uzc2X8VwYnQbuqQyzofQvcwZHLYplvi95pZ5fV
      rJvnYAUBFyfrdT5GjqL1nqH3a_Y3QPscuCjg"
    },
    "signature":"
    DfoBOetNelKsnAe_m4Z9K5UbihgWNYZsp5jVybiI05sOagDzv6R4do9npaAlAvpNK8HJ
    CxD6D22J8GDUExlIhSR1aDuDCQm6QzmjdkFdxAz5TRYl6zpPCZqgSToN_g1TZxqxEv6V
    Ob5fies4g6MHvCH-Il_-KbHq5YpwGxEEFdg"
  }
}
```

A.3. **Example OTrP Broker Option**

The most popular TEE devices today are Android powered devices. In
an Android device, an OTrP Broker can be a bound service with a
service registration ID that a Client Application can use. This
option allows a Client Application not to depend on any OTrP Broker
SDK or provider.

An OTrP Broker is responsible to detect and work with more than one
TEE if a device has more than one. In this version, there is only
one active TEE such that an OTrP Broker only needs to handle the
active TEE.

Appendix B. **Contributors**

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