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A Protocol for Dynamic Trusted Execution Environment Enablement
draft-liu-opentrustprotocol-usecase-01

Abstract

This document describes features of a open trust protocol and related use cases. With the Open Trust Protocol, see https://tools.ietf.org/html/draft-pei-opentrustprotocol-03, we have been trying to develop this application layer security protocol that allows the management of credentials and the update of such applications.

Status of This Memo

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

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1. Acronyms

CA	Certificate Authority
OTrP	Open Trust Protocol
REE	Rich Execution Environment
SD	Security Domain
SP	Service Provider
SBM	Secure Boot Module
TA	Trusted Application
TEE	Trusted Execution Environment
TFW	Trusted Firmware
TSM	Trusted Service Manager

2. Introduction

Chips used on smart phones, tablets, and many consumer appliances today have built-in support for a so-called Trusted Execution Environment (TEE). The TEE is a security concept that separates normal operating systems, like Linux, from code that requires higher security protection, like security-related code. The underlying idea of this sandboxing approach is to have smaller code that is better reviewed and test and to provide it with more rights. They run on the so-called Secure World (in comparison to the Linux operating system that would run in the Normal World).

TEEs have been on the market for a while and have been successfully used for a number of applications, such as payment. However, the technology hasn’t reached its full potential since ordinary developers who could make use of such functionality have a hard time getting access to it, and to write applications for it .

The industry has been working on an application layer security protocol that allows to configure security credentials and software running on a Trusted Execution Environment (TEE) for sometime. Today, TEEs are, for example, found home routers, set-top boxes, smart phones, tablets, wearables, etc. Unfortunately, there have been mostly proprietary protocols used in this environment.

This document describes features of a open trust protocol and related use cases.

3. Terminology

Client Application: An application running on a rich OS, such as an Android, Windows, or iOS application, provided by a SP.

Device: A physical piece of hardware that hosts symmetric key cryptographic modules

OTrP Agent: An application running in the rich OS allowing communication with the TSM and the TEE.

Rich Application: Alternative name of "Client Application". In this document we may use these two terms interchangably.

Rich Execution Environment (REE) An environment that is provided and governed by a rich OS, potentially in conjunction with other supporting operating systems and hypervisors; it is outside of the TEE. This environment and applications running on it are considered un-trusted.

Secure Boot Module (SBM): A firmware in a device that delivers secure boot functionality. It is also referred as Trusted Firmware (TFW) in this document.

Service Provider (SP): An entity that wishes to supply Trusted Applications to remote devices. A Service Provider requires the help of a TSM in order to provision the Trusted Applications to the devices.

Trust Anchor: A root certificate that a module strusts. It is usually embedded in one validating module, and used to validate the trust of a remote entity’s certificate.

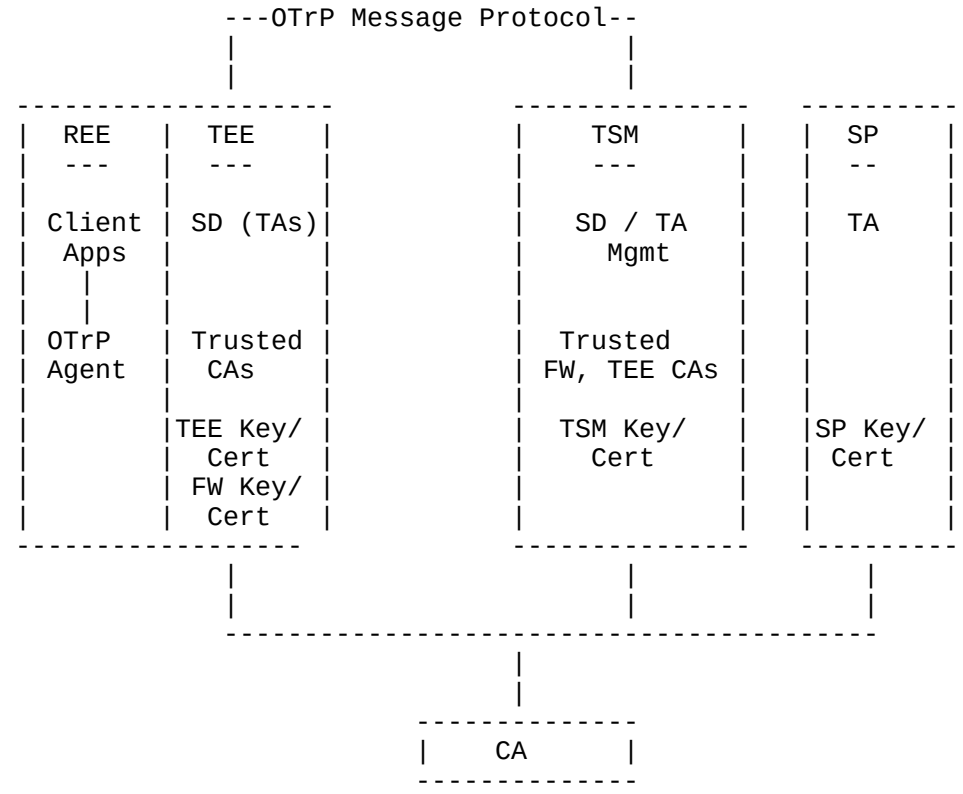
Trusted Application (TA): Application that runs in TEE.

Trusted Execution Environment (TEE): An execution environment that runs alongside but isolated from an REE. A TEE has security capabilities and meets certain security-related requirements: It protects TEE assets from general software attacks, defines rigid safeguards as to data and functions that a program can access, and resists a set of defined threats. There are multiple technologies that can be used to implement a TEE, and the level of security achieved varies accordingly.

4. Scenario and usecase of OtrP

OTrP Message is an open interoperable protocol that allows trustworthy TSM to manage security domains and contents running in different Trusted Execution Environment (TEE) of various devices.

Figure 1: OTrP System Diagram



TEE is usually used to solve the following security issues.In theory, in order to solve the above security issues, TEE which can exist in the corresponding TA to complete the corresponding security features.In conjunction with the description in Figure 1, the SP is responsible for developing the appropriate security application and becoming the end user of the OTrP protocol.

o The use of open environments: In general, some new kind device will be equipped with open environment to provide the operating system. This has the advantage that users can add applications at any time, and there is little need to worry about their impact on the stability and security of the device. However, the open environment makes the device face more and more foreign attacks. Device manufacturers want to take advantage of this operating system, but need to effectively control the behavior of the software running on the device.

- Verification: The traditional user authentication method requires a username and password. At present, this approach is increasingly considered safe, after all, consumers will use a less confidential password or re-use the existing password, and hackers are increasingly able to invade the consumer's account. Because an application or service provider typically stores personal verification and sensitive information on its own server, such hacking is the headline of the news, causing consumers to fear and shaken business confidence. Therefore, there is a need for a more sophisticated validation mechanism to ensure that the openers of the application enjoy the necessary flexibility while protecting the consumer.

- Privacy: The device stores more and more personal information (such as contact information, photos, photos and video clips), and even sensitive data (including credentials, passwords, medical data, etc.). In order to prevent this information from being exposed to loss, theft, malware or other negative events, we need adequate security to store, process and distribute such personal data.

- Content protection: Today, more and more devices with high-definition (HD) video playback and video streaming, mobile TV playback and host 3D games and other functions. They can even become content gateway devices, and to replace the traditional set-top boxes or game consoles. In this case, the playback function of the device becomes less important, and the security requirements are more and more prominent. Therefore, not only to protect the mobile device on the full HD or ultra-high-definition content, but also to protect the device to send the content to the TV through the channel.

- Enterprise Data Access: Enterprise IT professionals often exercise caution when opening access to their internal network, fearing that the device will carry malware, the device will be stolen, or when used outside the company, there will be attacks from the internal network The As a result, IT departments often establish green lists and red lists of equipment based on the security performance of the device. They are also concerned about the characteristics of these devices always open and the implementation of password protection and device lockout functions in shutdown mode.

- Financial risk: Financial transactions through networking devices, especially mobile devices, are becoming increasingly common. These transactions include booking, remote payments, near-field payments and financial electronic transactions. Moreover, the use of mobile devices in the retail outlets shopping has become

increasingly common. Moreover, mobile devices become a point-of-sale terminal, especially mobile point of sale, and this use case is now growing.

OTrP can be more efficient than the traditional OTA model, which can also reduce management overhead.The following two scenarios are used to explain why OTrP is required instead of OTA:

- Use Case 1 - Security vulnerability fixes:Imagining a fingerprint application stored in TEE appear an error, OTrP can help to fix this by several programers in one small team, but OTA may need to update the whole application by several teams in a company.

- Use Case 2 - Personalization data update: In IoT,there are lots of scenes that only need to update the personalized data without having to update the entire application like OTA.

Based on current research, this document provides an example of the application in the payment and IoT industry.

4.1. Use Case 1 - Payment

Payment technology(Especially mobile payments) is growing rapidly, in which the payment system continues to expand their trusted payment applications through existing technology and new technologies.

The TEE-based identity authentication application has a strong need for using otrp. The types of TA involved mainly include the following two kinds.

- Identification:Personal identification password and biometric.Because TEE can provides larger amount of memory and data transfer, TEE can store a trusted application that is used to complete a personal password acquisition or biological identification.For the development of the relevant TA of SP, the use of OTrP can easily send the latest trusted application to the device. At the same time, because TA and REE applications are independent of each other, REE side of the corresponding application only need to make little changes because of the OTrP.

- Security interface:Mobile payment is inseparable from the security interaction between end users and consumer devices. For example, the user needs to confirm the sensitive information displayed on the screen and enter the sensitive information (such as a password) through the keyboard.A TA such as keyboard in tee is needed.When designing a keyboard in tee, you should consider how to make a timely update when an application has a vulnerability to

ensure that user sensitive data is not compromised.In this case, it is necessary to use OTrP

4.2. Use Case 2 - IoT

In the field of Internet of Things, the purpose of TA is to use TEE to perform the functions of storing and managing sensitive data (eg, encryption keys) and performing sensitive operations (eg, authentication or encryption) in a secure environment in devices

In the smart home industry, a lot of security equipment are used TEE program to protect users of sensitive data, such as smart door locks. Some smart door locks even use biometrics, which makes this application in smart home very similar to the payment industry. Similarly, security products also need a secure and trusted remote update protocol to update the TA program in the device.

In the automotive (and bike) sharing industry, smart door locks use TEE technology to protect users' identity information. Operators who share automotive products need to remotely update trusted applications in smart locks.

Some high-value consumer electronics devices also have the need to use TEE and complete TA remote updates.For example, UAV devices use TEE to store sensitive operational instructions to prevent hackers from controlling the UAV's takeoff or landing by tampering with GPS location information.The manufacturer of the UAV needs to consider the easy management of the safety instructions in the UAV. For example, when the geographical location information of the prohibited flight area is changed, the equipment manufacturer should be able to update all the Corresponding information stored in the device .

In the automotive (and bike) sharing industry, smart door locks use TEE technology to protect users' identity information. Operators who share automotive products need to remotely update trusted applications in smart locks.

5. The functional requirements generated by the scenario and usecase

OTrP need to consider the requirements of OEM, SP, CA, TEE manufacturers, it will be helpfull to analysis the scenario and usecase to improve the functions of OTrP and solve the problems encountered in the deployment process.

The following lists the scenarios that OTrP users have already submitted. This section will continue to update according to the actual deployment of OTrP.

5.1. Use Case 1 - Resource-constrained interaction and multicast

In draft-pei-opentrustprotocol-03,OTrP is defined with a protocol which relies on IETF-defined end-to-end security mechanisms, namely JSON Web Encryption (JWE), JSON Web Signature (JWS), and JSON Web Key(JWK). Using JSON makes OTrP easier to accept by the developer, but in the case of limited resources, the use of Json is not a good choice, especially Json need to do some of the contents of the base64 transcoding.

As mentioned earlier, in the shared automotive industry, smart door locks have the requirement to use OTrP. In this scenario, the update of TA in the smart door locks is facing with the problem of communication bandwidth limitation and multicast demand. software and firmware updates often comprise quite a large amount of data. Therefore, it can overload a LLN that is otherwise typically used to deal with only small amounts of data, on an infrequent base. Rather than sending software and firmware updates as unicast messages to each individual device, multicasting such updated data to a larger group of devices at once displays a number of benefits.Binary solutions will be a better choice in the scenario such as low-power and lossy networks (LLNs),Low Power Personal Area Network(LWPAN)and Low Power Wide Area Network (LWAN).

As descrypted above, public key infrastructure (PKI) is used to do identiy authentication and securely exchange data over network. But, this is not a good choice for resource-constrained devices, especailly for IoT, to manage certificates and process TLS protocols, which need much memory and processing time.

5.2. Use Case 2 - TA and SD management owned by OEM and SP

There are three permission settings to manage TA and SD in TEE:

- The OEM wants to ensure that no service provider can talk to the TEE without the OEM’s prior approval. Once approved, the Service Provider is allowed to create security domains and install trusted apps. The OEM doesn’t require to be involved in that phase.

- The OEM wants to ensure that no service provider can talk to the TEE without the OEM’s prior approval. Once approved, the Service Provider is allowed to perform lifecycle management of trusted apps within a particular security domain but cannot create any new security domains without the OEM being involved and agreeing to it.

- The OEM and Service provider both want to be involved in every transaction with the TEE, and only when they both agree should the TEE accept the OTrP message and perform the action.

The first kind of permission setting can give SP manufacturers greater management authority, which can be very convenient management of SD and TA, but the security between SDs which set up by different vendors will not be able to be protected.

The second permission setting can give SP manufacturers a certain degree of control, TA can be easily issued to SD by SP. But at the same time, how to protect the security of TAM platform and TEE terminal should be considered.

The third permission setting can guarantee the management right of the OEM to the terminal, and avoid the terminal security risk caused by the insecurity of the TA program to a certain extent. However, in this authority set, the service provider to maintain the convenience of TA will be significantly reduced.

5.3. Use Case 3 - Batch mode

In draft-pei-opentrustprotocol-03, the following steps have to be done for deploying TA to device: establish trust between TEE and TSM, create Security Domain, and finally install TA in the device. This procedure will take at least three back and forth between TSM server and the device. While there are huge amount of IoT devices, this mechanism will make the burden of TSM server raise considerably.

In order to reduce the burden of TSM server, this procedure can be simplified by batch mode: TSM server will sign every command which runs in the device, pack them together in a command package, and send this package to a batch of devices. This one-time communication can significantly reduce the burden of TSM server. To make this happen, the DSI of these devices should be the same. DSI information can be organized by manufacture or by device model.

5.4. Use Case 4 - personalization data management

In many scenes, TAM only need to manage TA and SD personalization data, without having to update the entire TA or SD. Therefore, personalization data management function is required.The detail functions involved are as follows:

- Service provider key management(SD personalization data management). For example: In the field of IoT,a hotel(Service provider)an use this function to update a pair of keys to the lock of the door and the IoT device of customer.

- o TUI management(TA personalization data management).For example:In the field of financial, a bank can use this function to update the keyboard(Or other Trusted User Interfaces) of E-banking.

- o Other business data management.For example:In the field of payment,a company can use this function to update the QR code stored in TEE which is used for payment.

6. IANA Considerations

This memo includes no request to IANA.

7. Security Considerations

TBD.

8. References

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The Open Trust Protocol (OTrP)
draft-pei-opentrustprotocol-06.txt

Abstract

This document specifies the Open Trust Protocol (OTrP), a protocol to install, update, and delete applications in a Trusted Execution Environment (TEE) and to manage their security configuration.

TEEs are used in environments where security services should be isolated from a regular operating system (often called rich OS). This form of compartmentlization grants a smaller codebase access to security sensitive services and restricts communication from the rich OS to those security services via mediated access.

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1. Introduction

The Trusted Execution Environment (TEE) concept has been designed and used to increase security by separating a regular operating system, also referred as a Rich Execution Environment (REE), from security-sensitive applications. In an TEE ecosystem, a Trusted Application Manager (TAM) is used to manage keys and the Trusted Applications (TA) that run in a device. Different device vendors may use different TEE implementations. Different application providers may use different TAM providers. There arises a need of an open interoperable protocol that establishes trust between different devices and TAM providers, and management capability for a trustworthy TAM to manage Security Domains and applications running in different TEEs of various devices.

The Open Trust Protocol (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 assumes that an applicable device is equipped with a TEE and is pre-provisioned with a device-unique public/private key pair, which is securely stored. This key pair is referred as the 'root of trust'. An entity that uses such a device to run Trusted Applications (TAs) is known as a Service Provider (SP).

A Security Domain is defined as the TEE representation of a Service Provider, which is a logical space that contains the SP's TAs. Each Security Domain requires the management operations of TAs in the form of installation, update and deletion.

The protocol builds on the following properties of the system:

1. The SP needs to determine security-relevant information of a device before provisioning information to a TEE. Examples include the verification of the device 'root of trust', the type of firmware installed, and the type of TEE included in a device.

2. A TEE in a device needs to determine whether an SP or a TAM is trustworthy or authorized to manage applications in the TEE.

3. Secure Boot must be able to ensure a TEE is genuine.

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.

A TA binary and personalization data 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 considers the first case where TA binary and personalization data are encrypted by recipient's public key that TAM has to be involved. The second case will 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. The same terms may be defined differently in other documents.

Client Application: An application running on a rich OS, such as an Android, Windows, or iOS application, typically provided by an SP.

Device: A physical piece of hardware that hosts a TEE along with a rich OS.

OTrP Agent: An application running in the rich OS allowing communication with the TAM and the TEE.

Rich Application: Alternative name of "Client Application". In this document we may use these two terms interchangably.

Rich Execution Environment (REE) An environment that is provided and governed by a standard OS, potentially in conjunction with other supporting operating systems and hypervisors; it is outside of the TEE. This environment and applications running on it are considered un-trusted.

Secure Boot Module (SBM): A firmware in a device that delivers secure boot functionality. It is generally signed and can be verified whether it can be trusted. We also call it a Trusted Firmware (TFW).

Service Provider (SP): An entity that wishes to supply Trusted Applications to remote devices. A Service Provider requires the help of a TAM in order to provision the Trusted Applications to the devices.

Trust Anchor: A root certificate that can be used to validate its children certificates. It is usually embedded in a device or configured by a TAM for validating the trust of a remote entity’s certificate.

Trusted Application (TA): An Application that runs in a TEE.

Trusted Execution Environment (TEE): An execution environment that runs alongside of, but is isolated from, an REE. A TEE has security capabilities and meets certain security-related requirements. It protects TEE assets from general software attacks, defines rigid safeguards as to data and functions that a program can access, and resists a set of defined threats. It should have at least the following three properties: (a) A unique security identity that cannot be cloned; (b) Assuance that only authorized code can run in the TEE; (c) Memory that cannot be read by code outside of TEE. There are multiple technologies that can be used to implement a TEE, and the level of security achieved varies accordingly.

3.2. Abbreviations

CA	Certificate Authority
OTrP	Open Trust Protocol
REE	Rich Execution Environment
SD	Security Domain
SP	Service Provider
SBM	Secure Boot Module
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 following are the main components in this OTrP system.

TAM: The TAM is responsible for originating and coordinating lifecycle management activity on a particular TEE.

A TAM manages device trust check on behalf of Service Providers. A TAM may be used by one SP or many SPs. A TAM also provides

Security Domain management and TA management in a device, in particularly, over-the-air update to keep TAs up-to-date and clean up when a version should be removed.

Certificate Authority (CA): Mutual trust between a device and a TAM as well as an SP is based on certificates. A device embeds a list of root certificates, called Trust Anchors, from trusted Certificate Authorities that a TAM will be validated against. A TAM will remotely attest a device by checking whether a device comes with a certificate from a trusted CA.

TEE: The TEE in a device is responsible for protecting applications from attack, enabling the application to perform secure operations.

REE: The REE is responsible for enabling off device communications to be established between the TEE and TAM. OTrP does not require the device OS to be secure.

OTrP Agent: An application in the REE that can relay messages between a Client Application and TEE. Its implementation can be TEE specific as to how it can interact with a TEE in a device.

Secure Boot: Secure boot (for the purposes of OTrP) must enable authenticity checking of TEEs by the TAM.

The OTrP establishes appropriate trust anchors to enable TEEs and TAMs to communicate in a trusted way when performing lifecycle management transactions.

4.2. Trusted Anchors in TEE

The TEE in each device comes with a trust store that contains a whitelist of the TAM’s root CA certificates, which are called Trust Anchors. A TAM will be trusted to manage Security Domains and TAs in a device only if the TAM’s certificate is chained to one of the root CA certificates in this trust store.

Such a list is typically embedded in the TEE of a device, and the list update should be generally enabled.

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 the TEE.

4.3. Trusted 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.

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

Table 1: Key and Certificate Types

1. TFW key pair and certificate: A key pair and certificate for evidence of secure boot and trustworthy firmware in a device.

   Location: Device secure storage

   Supported Key Type: RSA and ECC

Issuer: OEM CA

Trust Implication: A white list 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 white list 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 white list 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 Agent application in the REE that can relay messages between a Client Application and TEE

Figure 1: Protocol Scope and Entity Relationship

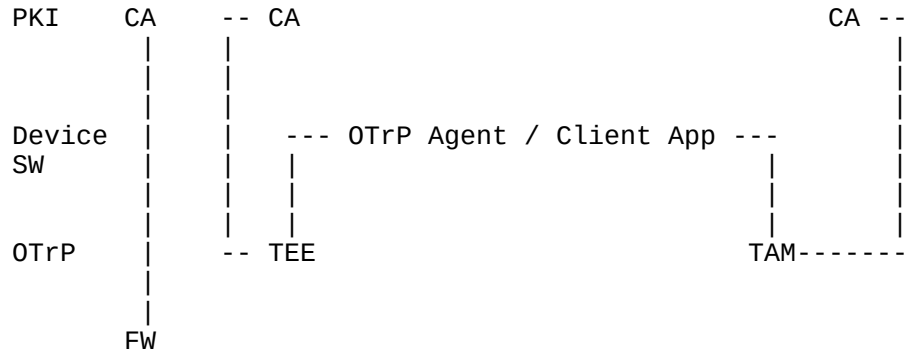
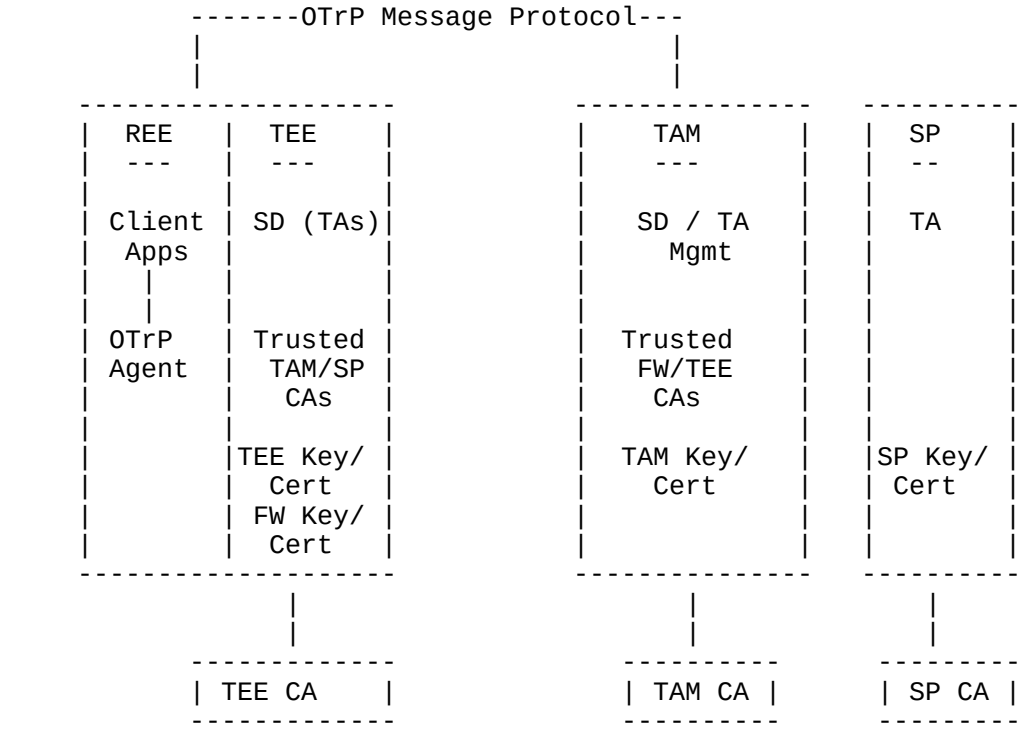


Figure 2: OTrP System Diagram



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.

It should be noted that network communication capability is generally not available in today's TEE powered devices. The networking functionality is handled by a rich Client Application with a remote internet services; the Client Applications uses a local TEE interface such as inter-process or a secure shared memory approach to interfact with TA inside a TEE for message exchanges. Consequenly, a TAM generally communicates with a Client Application about how it gets

OTrP Messages that originates from TEE inside a device. Similarly, a TA or TEE generally gets OTrP messages from a TAM via some Client Application, not direct to the internet.

It is imperative to have an interoperable interface to communicate with differnet TEEs in differnent devices that a Client Application needs to run and access a TA inside a TEE. This is the role of an OTrP Agent, which is a software component to bridge communication between a TAM and a TEE. The OTrP Agent 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 Secure Boot Public Key and eFuse Key (eFuse key is unique per device)

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 applications. 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.

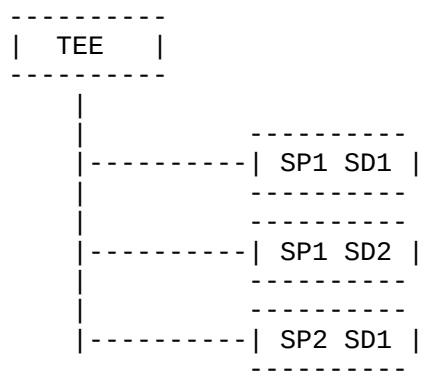
One common choice of the identifier value is the TAM’s service URL. A CA can verify the domain ownership of the URL with the TAM in the certificate enrollment process.

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.



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 Agent

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 Agent comes to meed this need. An OTrP Agent 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 Agent.

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

6.1. Role of OTrP Agent

An OTrP Agent 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 Agent for some TA query functions.

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

OTrP Agent only needs to return an OTrP Agent 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 Agent 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 Agent Implementation Consideration

A Provider should consider methods of distribution, scope and concurrency on device and runtime options when implementing an OTrP Agent. 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 Agent Distribution

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

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

6.3.2. Number of OTrP Agent

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

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

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

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

6.4. OTrP Agent Interfaces for Client Applications

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

If a failure is occured during calling OTrP Agent, 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 Agent 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 agent not being able to communicate with the TEE, a OTrPAgentException 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 Agent 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’tknow 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 Agent call ProcessOTrPMessage. The communication between a Client Application and an OTrP Agent is up to the implementation of the OTrP Agent.

4. The OTrP Agent routes the message to the active TEE. Multiple TEE case: it is up to OTrP Agent 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 Agent 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 Agent 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 Agent to query the TA.

3. The OTrP Agent 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 Agent 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 ommitted 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:

- 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.

- 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.

- 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 Agent 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 Agent 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 Agent 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 Agent 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 revocaton 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. Collect Firmware signed data

* This is a capability in ARM architecture that allows a TEE to query Firmware to get FW signed data.

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. A TAM trusts the TEE and the TFW trust status check carried out by the TEE.

```
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.

- RSA with SHA256
- ECDSA with SHA 256

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

- RS256
- 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.

ERR_AGENT_TEE_FAIL The TEE failed to respond to a TAM request. The OTrP Agent will construct an error message in responding to the TAM's request. The error message will not be signed.

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 Agent.

9.1.7. TAM Processing Requirements

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

- Parse to get list of GetDeviceTEEStateResponse JSON objects
- Parse the JSON "payload" property and decrypt the JSON element "edsi". The decrypted message contains the TEE signer certificate.
- Validate the GetDeviceTEEStateResponse JSON signature. The signer certificate is extracted from the decrypted message in the last step.
- Extract TEE information and check it against its TEE acceptance policy.
- Extract the TFW signed element, and check the signer and data integration against its TFW policy.
- 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:

- TAM as the owner. The owner identifier is a registered unique TAM ID that is stored in the TAM certificate.
- 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 accidently 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 Agent 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 Agent if the OTrP Agent is able to detect such error from TEE. In this case, a general error response message should be returned by the OTrP Agent, assuming OTrP Agent 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)>"
  }
}
```

A response message type "status" will be returned when the TEE fails to respond. The OTrP Agent is responsible to create this message.

```
{
  "status": {
     "result": "fail",
     "error-code": "ERR_AGENT_TEE_FAIL",
     "error-message": "TEE fails to respond"
  }
}
```

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 15.1) for detailed causes and actions.

ERR_AGENT_TEE_BUSY

ERR_AGENT_TEE_FAIL

ERR_AGENT_TEE_UNKNOWN

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 accidently 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 Agent 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)>"
  }
}
```

A response message type "status" will be returned when the TEE fails to respond. The OTrP Agent is responsible to create this message.

```
{
  "status": {
     "result": "fail",
     "error-code": "ERR_AGENT_TEE_FAIL",
     "error-message": "<TEE fails to respond message>"
  }
}
```

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 15.1) for detailed causes and actions.

ERR_AGENT_TEE_BUSY

ERR_AGENT_TEE_FAIL

ERR_AGENT_TEE_UNKNOWN

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 accidently 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 Agent 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)>"
  }
}
```

A response message type "status" will be returned when the TEE fails to respond. The OTrP Agent is responsible to create this message.

```
{
  "status": {
     "result": "fail",
     "error-code": "ERR_AGENT_TEE_FAIL",
     "error-message": "TEE fails to respond"
  }
}
```

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 15.1) for detailed causes and actions.

ERR_AGENT_TEE_BUSY

ERR_AGENT_TEE_FAIL

ERR_AGENT_TEE_UNKNOWN

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.

- InstallTA - provision a TA by TAM
- UpdateTA - update a TA by TAM
- 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:

- The target SD information: SP ID and SD name
- Encrypted TA binary data. TA data is encrypted with the TEE SP AIK.
- 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:

- 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
- 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 accidently 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)>"
    }
}
```

A response message type "status" will be returned when the TEE fails to respond. The OTrP Agent is responsible to create this message.

```
{
  "status": {
     "result": "fail",
     "error-code": "ERR_AGENT_TEE_FAIL",
     "error-message": "TEE fails to respond"
  }
}
```

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 15.1) for detailed causes and actions.

ERR_AGENT_TEE_BUSY

ERR_AGENT_TEE_FAIL

ERR_AGENT_TEE_UNKNOWN

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:

- 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
- 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.
- 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.
- 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 accidently 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)>"
    }
}
```

A response message type "status" will be returned when the TEE fails to respond. The OTrP Agent is responsible to create this message.

```
{
  "status": {
     "result": "fail",
     "error-code": "ERR_AGENT_TEE_FAIL",
     "error-message": "TEE fails to respond"
  }
}
```

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 15.1) for detailed causes and actions.

ERR_AGENT_TEE_BUSY

ERR_AGENT_TEE_FAIL

ERR_AGENT_TEE_UNKNOWN

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 Agent 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 accidently 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)>"
    }
}
```

A response message type "status" will be returned when the TEE fails to respond. The OTrP Agent is responsible to create this message.

```
{
  "status": {
     "result": "fail",
     "error-code": "ERR_AGENT_TEE_FAIL",
     "error-message": "TEE fails to respond"
  }
}
```

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 15.1) for detailed causes and actions.

ERR_AGENT_TEE_BUSY

ERR_AGENT_TEE_FAIL

ERR_AGENT_TEE_UNKNOWN

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 Agent without giving any other internal information. The OTrP Agent will be generating the response.

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

A Type 2 message has the following format.

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

Type 3: OTrP Agent 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

- RSA PKCS#1 with SHA256 signing : "RS256"
- ECDSA with SHA256 signing : "ES256"

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

- RSA PKCS#1 : "RSA1_5"

- 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):

- 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 Secure Boot Module

12.1.1. Attestation signer

It is proposed that attestation for OTrP is based on the SBM secure boot 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 boot approach that, using eFuse, only releases attestation signing capabilities into the SBM once a secure 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. SBM Initial Requirements

R1 The SBM must be possible to load securely into the secure boot flow

R2 The SBM 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 SBM when it is decrypted

R6 The SBM 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 SBM is required to start all of the root TEEs. Before loading them, the SBM must first determine whether the code sign signature of the TEE is valid. If TEE integrity is confirmed, the TEE may be started. The SBM 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 SBM.

Once the SBM has successfully booted a TEE and retrieved the identity certificate, the SBM 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 encryption that takes place is with eFuse to release the SBM signing key and later during the protocol lifecycle management interchange with the TAM.

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, encrypted by eFuse. This key pair will be used for signing operations performed by the SBM.

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. Secure boot releases the TFW private key by decrypting it with eFuse

2. The SBM 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 SBM leaves the TEE public key field blank.

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

4. Each active TEE performs the same operation as the SBM, 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.

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15. IANA Considerations

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

15.1. 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 Agent may return when the TEE fails to respond.

15.1.1. 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.

15.1.2. OTrP Agent Error Code List

ERR_AGENT_TEE_UNKNOWN - This error will occur if the receiver TEE is not supposed to receive the request. That will be determined by checking the TEE name or device id in the request message.

ERR_AGENT_TEE_BUSY - The device TEE is busy. The request can be generally sent again to retry.

ERR_AGENT_TEE_FAIL - The TEE fails to respond to a TAM request. The OTrP Agent will construct an error message in responding to the TAM's request.

16. Security Consideration

16.1. Cryptographic Strength

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

- 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.

- 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.

16.2. 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.

16.3. 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.

16.4. 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>"
}
```

16.5. 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>"
  }
```

16.6. 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 Agent has a function to allow an 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.

16.7. 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.

16.8. OTrP Agent Trust Model

An OTrP Agent could be malware in the vulnerable Rich OS. 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 Agent.

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 Agent cannot modify or capture sensitive data.

16.9. 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.

16.10. 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.

16.11. 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.

16.12. Threat Mitigation

A rogue application may perform excessive TA loading. An OTrP Agent 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 Agent could replay or send TAM messages out of sequence: e.g., a TAM sends update1 and update2. The OTrP Agent 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.

16.13. Compromised CA

A root CA for TAM certificates might get compromised. Some TEE trust anchor update mechanism is expected from device OEM. 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.

16.14. 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.

16.15. 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.

17. References

17.1. Normative References

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17.2. Informative References

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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 Agent

The OTrP Agent 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 Agent. The OTrP Agent encodes "GetDeviceTEEStateResponse" into an array to form "GetDeviceStateResponse".

```
{
  "GetDeviceStateResponse": [
    {
      "GetDeviceTEEStateResponse": {
        "payload":
        "
        ewogICJHZXREZXZpY2VURUVTdGF0ZVRCU1Jlc3BvbnNlIjogewogICAgInZlciI6
        ICIxLjAiLAogICAgInN0YXR1cyI6ICJwYXNzIiwKICAgICJyaWQiOiAiezhDNkY5
        REJCLUZDMzktNDM1Yy1CQzg5LTREMzYxNERBMkYwQn0iLAogICAgInRpZCI6ICJ7
        NEY0NTRBN0YtMDAyRC00MTU3LTg4NEUtQjBERDFBMDZBOEFFfSIsCgkic2lnbmVy
        cmVxIjoiZmFsc2UiLAogICAgImVkc2kiOiB7CiAgICAgICJwcm90ZWN0ZWQiOiAi
        ZXlKbGJtTWlPaUpCTVRJNFEwSkRMVWhUTWpVMkluMEsiLAogICAgICAicmVjaXBp
        ZW50cyI6IFsKICAgICAgICB7CiAgICAgICAgICAiaGVhZGVyIjogewogICAgICAg
        ICAgImFsZyI6ICJSU0ExXzUiCiAgICAgICAgfSwKICAgICAgICAiZW5jcnlwdGVk
        X2tleSI6CiAgICAgICAgIgogICAgICAgIFFVVlRNVEk0SUNoRFJVc3BJR3RsZVN3
        Z1pXNWpjbmx3ZEdWa0lIZHBkR2dnVkZOTklGSlRRU0J3ZFdKc2FXTWcKICAgICAg
        ICBhMlY1TENCMWMybHVaeUJTVTBFeFh6VWdjR0ZrWkdsdVp3IgogICAgICAgIH0K
        ICAgICAgXSwKICAgICAgIml2IjogInlTR21mWjY5WWxjRWlsTnI1X1NHYkEiLAog
        ICAgICAiY2lwaGVydGV4dCI6CiAgICAgICIKICAgICAgYzJGdGNHeGxJR1J6YVNC
        a1lYUmhJR1Z1WTNKNWNIUmxaQ0IzYVhSb0lFRkZVekV5T0NCclpYa2dabkp2YlNC
        eVpXCiAgICAgICAgIE5wY0dsbGJuUnpMbVZ1WTNKNWNIUmxaRjlyWlhrIiwKICAgICAg
        InRhZyI6ICJjMkZ0Y0d4bElHRjFkR2hsYm5ScFkyRjBhVzl1SUhSaFp3IgogICAg
        fQogIH0KfQ",
        "protected": "eyJhbGciOiJSUzI1NiJ9",
        "signature": "c2FtcGxlIHNpZ25hdHVyZQ"
      }
    }
  ]
}
```


The TEE returns "GetDeviceStateResponse" back to the OTrP Agent, 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
  aWhhc2giOiIyMmVmOWNkM2U3YzZhZTkzMjZjZGI2ZWQ4OTYyMzU1M2NiYmJjMGMyNDRlYz
  gyYmNjMjQyNjliMTViOWZkYTNiIiwiY29udGVudCI6eyJwcm90ZWN0ZWQiOiJlLUtBbkdW
  dVktS0FuVHJpZ0p4Qk1USTRRMEpETFVoVE1qVTI0b0NkZlEiLCJyZWNpcGllbnRzIjpbey
  JoZWFkZXIiOnsiYWxnIjoiUlNBMV81In0sImVuY3J5cHRlZF9rZXkiOiJTUzE2NTl4Q2FJ
  c1dUeUlsVTZPLUVsZzU4UUhvT1pCekxVRGptVG9vanBaWE54TVpBakRMcWtaSTdEUzhOVG
  FIWHcxczFvZjgydVhsM0d6NlVWMkRoZDJ3R2l6Y2VEdGtXc1RwZDg4QVYwaWpEYTNXa3lk
```

dEpSVmlPOGdkSlEtV29NSUVJRUxzVGthblZCb25wQkF4ZHE0ckVMbl9TZlliaFg4Zm9ub2
gxUVUifV0sIml2IjoiQXhZOERDdERhR2xzYkdsamIzUm9aUSIsImNpcGhlcnRleHQiOiI1
bmVWZXdndm55UXprR3hZeWw5QlFrZTJVNjVaOHp4NDdlb3NzM3FETy0xY2FfNEpFY3NLcj
ZhNjF5QzBUb0doYnJOQWJXbVRSemMwSXB5bTF0ZjdGemp4UlhBaTZBYnVSM2gzSUpRS1Bj
UUVvRUlkZ2tWX0NaZTM2eTBkVDBpRFBMclg0QzFkb0dmMEdvaWViRC1yVUg1VUtEY3BsTW
9lTjZvUnFyd0dnNUhxLTJXM3B4MUlzY0h4SktRZm11dkYxMTJ4ajBmZFNZX0N2WFE1NTJr
TVRDUW1ZbzRPaGF2R0ZvaG9TZVVnaGZSVG1LYWp3OThkTzdhREdrUEpRUlBtYVVHWllEMW
JXd01nMXFRV3RPd19EZlIyZDNzTzVUN0pQMDJDUFprVXBiQ3dZYVcybW9HN1c2Zlc2U3V5
Q2lpd2pQWmZSQmIzSktTVTFTd1kxYXZvdW02OWctaDB6by12TGZvbHRrWFV2LVdPTXZTY0
JzR25NRzZYZnMzbXlTWnJ1WTNRR09wVVRzdjFCQ0JqSTJpdjkwb2U2aXFCcVpxQVBxbzdi
ajYwVlJGQzZPTlNLZExGQTIyU3pqRHo1dmtnTXNEaHkwSzlDeVhYN1Z6MkNLTXJvQjNiUE
xFZF9abTZuVWlkTFN5cVJ5cXJxTmVnN1lmQng3aV93X0dzRW9rX1VYZXd6RGtneHp6RjZj
XzZ6S0s3UFktVnVmYUo0Z2dHZmlpOHEwMm9RZ1VEZTB2Vm1FWDc0c2VQX2RxakVpZVVOYm
xBZE9sS2dBWlFGdEs4dy1xVUMzSzVGTjRoUG9yeDc2b3lPVUpOQTVFZVV2Qy1jR2tMcTNQ
UG1GRmQyaUtOTElCTEJzVWl6c1h3RERvZVA5SmktWGt5ZEQtREN1SHdpcno0OEdNNWVLSj
Q5WVdqRUtFQko2T01NNUNmZHZ4cDNmVG1uUTdfTXcwZ3FZVDRiOUJJSnBfWjA3TTctNUpE
emg0czhyU3dsQzFXU3V2RmhRWlJCcXJtX2RaUlRIb0VaZldXc1VCSWVNWWdxNG1zb0JqTj
NXSzhnRWYwZGI5a3Z6UG9LYmpJRy10UUE2R2l1X3pHaFVfLXFBV1lLemVKMDZ6djRIWlBO
dHktQXRyTGF0WGhtUTdOQlVrX0hvbjdOUWxhU1g1ZHVNVmN4bGs1ZHVrWFZNMDgxa09wYV
kzbDliQVFfYVhTM0FNaFFTTVVsT3dnTDZJazFPYVpaTGFMLUE3ejlITnlESmFEWTVhakZK
TWFDV1lfOG94YlNoQUktNXA2MmNuT0xzV0dNWWNKTlBGVTZpcWlMR19oc3JfNlNKMURhbD
VtQ0YycnBJLUItMlhuckxZR01ZS0NEZ2V2dGFnbi1DVUV6RURwR3ozQ2VLcWdQU0Vqd3BK
N0M3NXduYTlCSmtTUkpOdDNla3hoWElrcnNEazRHVVpMSDdQYzFYZHdRTXhxdWpzNmxJSV
EycjM1NWEtVkotWHdPcFpfY3RPdW96LTA4WHdYQ3RkTEliSFFVTG40RjlMRTRtanU0dUxS
bjNSc043WWZ1S3dCVmVEZDJ6R3NBY0s5SVlDa3hOaDk3dDluYW1iMDZqSXVoWXF5QkhWRU
9nTkhici1rMDY1bW9OVk5lVVUyMm5OdVNKS0ZxVnIxT0dKNGVfNXkzYkNwTmxTeEFPV1Bn
RnJzU0Flc2JJOWw4eVJtVTAwenJYdGc4OWt5SjlCcXN2eXA1RE8wX2FtS1JyMXB1MVJVWF
lFZzB2ampKS1FSdDVZbXRUNFJzaWpqdGRDWDg3UUxJaUdSY0hDdlJzUzZSdDJESmNYR1ht
UGQyc0ZmNUZyNnJnMkFzX3BmUHN3cnF1WlAxbVFLc3RPMFVkTXpqMTlyb2N1NHVxVXlHUD
lWWU54cHVnWVdNSjRYb1dRelJtWGNTUEJ4VEtnenFPS2s3UnRzWWVMNXl4LVM4NjV0cHVz
dTA0bXpzYUJRZ21od1ZFVXBRdWNrcG1YWkNLNHlJUXktaHNFQUlJSmVxdFB3dVAySXF0X2
I5dlk0bzExeXdzeXhzdmp2RnNKN0VVZU1MaGE2R2dSanBSbnU5RWIzRnlJZ0U5M0VVNEEw
T0lUMWlOSGNRYWc0eWtOc3dPdkxQbjZIZ21zQ05ESlgwekc2RlFDMTZRdjBSQ25SVTdfV2
VvblhSTUZwUzZRZ1JiSk45R1NMckN5bklJSWxUcDBxNHBaS05zM0tqQ2tMUzJrb3Bhd2Y0
WF9BUllmTko3a0s5eW5BR0dCcktnUWJNRWVxUEFmMDBKMlYtVXpuU1JMZmQ4SGs3Y2JEdk
5RQlhHQW9BR0ViaGRwVUc0RXFwMlVyQko3dEtyUUVSRlh4RTVsOFNHY2czQ1RmN2Zoazdx
VEFBVjVsWEFnOUtOUDF1c1ZRZk1fUlBleHFNTG9WQVVKV2syQkF6WF9uSEhkVVhaSVBIOG
hLeDctdEFRV0dTWUd0R2FmanZJZzI2c082TzloQWZVd3BpSV90MzF6SkZORDU0OTZURHBz
QmNnd2dMLU1UcVhCRUJ2NEhvQld5SG1DVjVFMUwiLCJ0YWciOiJkbXlEeWZJVlNJUi1Ren
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
    ZWQiOiJlLUtBbkdWdVktS0FuVHJpZ0p4Qk1USTRRMEpETFVoVE1qVTI0b0NkZlEiLCJy
    ZWNpcGllbnRzIjpbeyJoZWFkZXIiOnsiYWxnIjoiUlNBMV81In0sImVuY3J5cHRlZF9r
```

```
    ZXkiOiJOX0I4R3pldUlfN2hwd0wwTFpHSTkxVWVBbmxJRkJfcndmZU1yZERrWnFGak1s
    VVhjdlI0XzhhOGhyeFI4SXR3aEtFZnVfRWVLRDBQb0dqQ2pCSHcxdG1ULUN6eWhsbW5v
    Slk3LXllWnZzRkRpc2VNTkd0eGE0OGZJYUs2VWx5NUZMYXBCZVc5T1I5bmktOU9GQV9j
    aFVuWWl3b2Q4ZTJFa0Vpd0JEZ1EzMk0ifV0sIml2IjoiQXhZOERDdERhR2xzYkdsamIz
    Um9aUSIsImNpcGhlcnRleHQiOiJsalh6Wk5JTmR1WjFaMXJHVElkTjBiVUp1RDRVV2xT
    QVptLWd6YnJINFVDYy1jMEFQenMtMWdWSFk4NTRUR3VMYkdyRmVHcDFqM2Fsb1lacWZp
    ZnE4aEt3Ty16RFlBN2tmVFhBZHp6czM4em9xeG4zbHoyM2w1RUlGUWhrOHBRWTRYTHRW
    M3ZBQWlNYnlrQ1Q3VS1CWDdWcjBacVNhYWZTQVZ4OFBLQ1RIU3hHN3hHVko0NkxxRzJS
    RE54WXQ4RC1SQ3lZUi1zRTM0MUFKZldEc2FLaGRRbzJXcjNVN1hTOWFqaXJtWjdqTlJ4
    cVRodHJBRWlIY1ctOEJMdVFHWEZ1YUhLMTZrenJKUGl4d0VXbzJ4cmw4cmkwc3ZRcHpl
    Z2M3MEt2Z0I0NUVaNHZiNXR0YlUya25hN185QU1Wcm4wLUJaQ1Bnb280MWlFblhuNVJn
    TXY2c2V2Y1JPQ2xHMnpWSjFoRkVLYjk2akEiLCJ0YWciOiIzOTZISTk4Uk1NQnR0eDlo
    ZUtsODROaVZLd0lJSzI0UEt2Z1RGYzFrbEJzIn19fQ",
    "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
    Ym1NaU9pSkJNVEk0UTBKRExVaFRNalUySW4wIiwKCQkJInJlY2lwaWVudHMiOiBb
    ewoJCQkJImhlYWRlciI6IHsKCQkJCQkiYWxnIjogIlJTQTFfNSIKCQkJCX0sCgkJ
    CQkiZW5jcnlwdGVkX2tleSI6ICJRVVZUTVRJNElDaERSVXNwSUd0bGVTd2daVzVq
    Y25sd2RHVmtJSGRwZEdnZ1ZGTk5JRkpUUVNCd2RXSnNhV01nYTJWNUxDQjFjMmx1
    WnlCU1UwRXhYelVnY0dGa1pHbHVadyIKCQkJfV0sCgkJCSJpdiI6ICJyV081RFZt
    UVg5b2dlbE1MQklvZ0lBIiwKCQkJImNpcGhlcnRleHQiOiAiYzJGdGNHeGxJR1J6
    YVNCa1lYUmhJR1Z1WTNKNWNIUmxaQ0IzYVhSb0lFRkZVekV5T0NCclpYa2dabkp2
    YlNCeVpXTnBjR2xsYm5SekxtVnVZM0o1Y0hSbFpGOXJaWGsiLAoJCQkidGFnIjog
    ImMyRnRjR3hsSUdGMWRHaGxiblJwWTJGMGFXOXVJSFJoWnciCgkJfQoJfQp9",
    "protected":"eyJhbGciOiJSUzI1NiJ9",
    "header": {
      "x5c": ["ZXhhbXBsZSBBU04xIHNpZ25lciBjZXJ0aWZpY2F0ZQ==",
              "ZXhhbXBsZSBBU04xIENBIGNlcnRpZmljYXRl"]
    },
    "signature":"c2FtcGxlIHNpZ25hdHVyZQ"
  }
}
```

A.1.4.2. Sample DeleteSDResponse

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
    ZWQiOiAiZXlKbGJtTWlPaUpCTVRJNFEwSkRMVWhUTWpVMkluMEsiLAoJCQkicmVj
    aXBpZW50cyI6IFt7CgkJCQkiaGVhZGVyIjogewoJCQkJSJhbGciOiAiUlNBMV81
    IgoJCQkJfSwKCQkJSJlbmNyeXB0ZWRfa2V5IjogIlFVVlRNVEk0SUNoRFJVc3BJ
    R3RsZVN3Z1pXNWpjbmx3ZEdWa0lIZHBkR2dnVkZOTklGSlRRU0J3ZFdKc2FXTWdh
    MlY1TENCMWMybHVaeUJTVTBFeFh6VWdjR0ZrWkdsdVp3IgoJCQl9XSwKCQkJIml2
    IjogInlTR21mWjY5WWxjRWlsTnI1X1NHYkEiLAoJCQkiY2lwaGVydGV4dCI6ICJj
    MkZ0Y0d4bElHUnphU0JrWVhSaElHVnVZM0o1Y0hSbFpDQjNhWFJvSUVGRlV6RXlP
    Q0JyWlhrZ1puSnZiU0J5WldOcGNHbGxiblJ6TG1WdVkzSjVjSFJsWkY5clpYayIs
    CgkJCSJ0YWciOiAiYzJGdGNHeGxJR0YxZEdobGJuUnBZMkYwYVc5dUlIUmhadyIK
    CQl9Cgl9Cn0",
    "protected":"eyJhbGciOiJSUzI1NiJ9",
    "signature":"c2FtcGxlIHNpZ25hdHVyZQ"
  }
}
```


The TEE returns "DeleteSDResponse" back to the OTrP Agent, 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
    NFUiLCJjb250ZW50Ijp7InByb3RlY3RlZCI6ImV5SmxibU1pT2lKQk1USTRRMEpETFVo
    VE1qVTJJbjAiLCJyZWNpcGllbnRzIjpbeyJoZWFkZXIiOnsiYWxnIjoiUlNBMV81In0s
    ImVuY3J5cHRlZF9rZXkiOiJYem1Bbl9SRFZrM0lvek13TldoaUI2Zm1abElzMVlVdk1L
    bFFBdl9VRG9aMWZ2R0dzUkdvOWJUMEE0NDBhWU1nTHRHaWxLeXBvSmpDZ2lqZGFIZ2Ft
    YUpnUlNjNEplMm90cG5FRWFnc2FodkROb2FyTUNDNW5HUWRrUnhXN1ZvMk5LZ0xBODky
    SEdlSGtKVnNoWW0xY1VsRlEtQmhpSjROQXlrRndscUNfb2MifV0sIml2IjoiQXhZOERD
    dERhR2xzYkdsamIzUm9aUSIsImNpcGhlcnRleHQiOiJIYTcwVXRZVEtWQmtXRFJuMi0w
```

```
    SF9IdkZtazl5SGtoVV91bk1OLWc1T3BqLWF1NGFUb2lxWklMYzVzYTdENnZZSjF6eW04
    QW1JOEJIVXFqc2l5Z0tOcC1HdURJUjFzRXc0a2NhMVQ5ZENuU0RydHhSUFhESVdrZmt3
    azZlR1NQWiIsInRhZyI6Im9UN01UTE41eWtBTFBoTDR0aUh6T1pPTGVFeU9xZ0NWaEM5
    MXpkcldMU0UifSwiZW5jcnlwdGVkX3RhIjp7ImtleSI6Ilh6bUFuX1JEVmszSW96TXdO
    V2hpQjZmbVpsSXMxWVV2TUtsUUF2X1VEb1oxZnZHR3NSR285YlQwQTQ0MGFZTWdMdEdp
    bEt5cG9KakNnaWpkYUhnYW1hSmdSU2M0SmUyb3RwbkVFYWdzYWh2RE5vYXJNQ0M1bkdR
    ZGtSeFc3Vm8yTktnTEE4OTJIR2VIa0pWc2hZbTFjVWxGUS1CaGlKNE5BeWtGd2xxQ19v
    YyIsIml2IjoiQXhZOERDdERhR2xzYkdsamIzUm9aUSIsImFsZyI6IkFFU0NCQyIsImNp
    cGhlcm5ld3RhZGF0YSI6IktIcU94R243aWIxRl8xNFBHNF9VWDlEQmpPY1draUFaaFZF
    LVUtNjdOc0tyeUhHb2tlV3Iyc3BSV2ZkVTJLV2FhTm5jSG9ZR3dFdGJDSDdYeU5iT0Zo
    MjhuendVbXN0ZXA0bkhXYkFsWFpZVE5rRU5jQUJQcHV3X0czSTNIQURvIn19fQ",
    "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"
  }
}
```


A.2.2.2. 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
    ZCI6ImV5SmxibU1pT2lKQk1USTRRMEpETFVoVE1qVTJJbjAiLCJyZWNpcGllbnRzIjpb
    eyJoZWFkZXIiOnsiYWxnIjoiUlNBMV81In0sImVuY3J5cHRlZF9rZXkiOiJFaGUxLUJB
    UUdJLTNEMFNHdXFGY01MZDJtd0gxQm1uRndYQWx1M1FxUFVXZ1RRVm55SUowNFc2MnBK
    YWVSREFkeTU0R0FSVjBrVzQ0RGw0MkdUUlhqbE1EZ3BYdXdFLWloc1JVV0tNNldCZ2N3
    VXVGQTRUR3gwU0I1NTZCdl92dnBNaFdfMXh2c2FHdFBaQmwxTnZjbXNibzBhY3FobXlu
    bzBDTmF5SVAtX1UifV0sIml2IjoiQXhZOERDdERhR2xzYkdsamIzUm9aUSIsImNpcGhl
    cnRleHQiOiJwc2o2dGtyaGJXM0lmVElMeE9GMU5HdFUtcTFmeVBidV9KWk9jbklycWIw
    eTNPOHN6OTItaWpWR1ZyRW5WbG1sY1FYeWFNZTNyX1JGdEkwV3B4UmRodyIsInRhZyI6
    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":
    "
    eyJEZWxldGVUQVRCU1JlcXVlc3QiOnsidmVyIjoiMS4wIiwicmlkIjoicmVxLTIiLCJ0
    aWQiOiJ0cmFuLTAxIiwidGVlIjoiU2VjdXJpVEVFIiwibmV4dGRzaSI6ImZhbHNlIiwi
    ZHNpaGFzaCI6Imd3anVsXzlNWmtzM3BxVVNOMS1lTDFhVml3R1hOQXhrMEFJS1c3OWRu
    NFUiLCJjb250ZW50Ijp7InByb3RlY3RlZCI6eyJlbmMiOiJBMTI4Q0JDLUhTMjU2In0s
    InJlY2lwaWVudHMiOlt7ImhlYWRlciI6eyJhbGciOiJSU0ExXzUifSwiZW5jcnlwdGVk
    X2tleSI6ImtyaGs0d2dpY0RlX3d0VXQyTW4tSUJsdUtvX0JkeXpNY2p1cVlBenBPYnRS
    TG9MZzQ0QkFLN2tRVWE1YTg0TEVJRGEzaHNtWDIxdldNZFJLczN4MTJsOUh5VFdfLUNS
    WmZtcUx2bEh1LV9MSVdvc1ZyRTZVMlJqUnRndllVOWliUkVLczkzRDRHWm4xVHFuZG9n
    d0tXRF9jdG1nWG1sbzZZVXpCWDZhR1dZMCJ9XSwiaXYiOiJBeFk4REN0RGFHbHNiR2xq
    YjNSb1pRIiwiY2lwaGVydGV4dCI6IkhhNzBVdFlUS1ZCa1dEUm4yLTBIX1BGa19yQnpQ
    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
    X19wZEFhaEMyWk5SakdIcTBCZ2JDYTRKalk0eXRkMVBVWDB6M1psbXl1YnRXM291eEpY
    el9PMzg1WGM4S3hySndjbElyZGx2WUY2OVZmeERLQkVzUHJCdzlVenVIa1VmSU4xWlFU
    bWZ0QmVaSlJnIg0KCQkJCX0NCgkJCV0sDQoJCQkiaXYiOiJBeFk4REN0RGFHbHNiR2xq
    YjNSb1pRIiwNCgkJCSJjaXBoZXJ0ZXh0IjoiamhQTlV5ZkFTel9rVV9GbEM2LUtCME01
    WDBHNE5MbHc0LWt0bERyajZTWlUteUp6eUFUbC1oY0ZBWWMwLXJMVEF4cF93N1d1WER0
    Y3N3SzJSSzRjcWciLA0KCQkJInRhZyI6IlBBeGo5N25oT29qVTNIREhxSll4MGZMNWpt
    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 Agent Option

The most popular TEE devices today are Android powered devices. In an Android device, an OTrP Agent 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 Agent SDK or provider.

An OTrP Agent 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 Agent only needs to handle the active TEE.

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