Open Trust Protocol (OTrP)

Technical and RFC Draft

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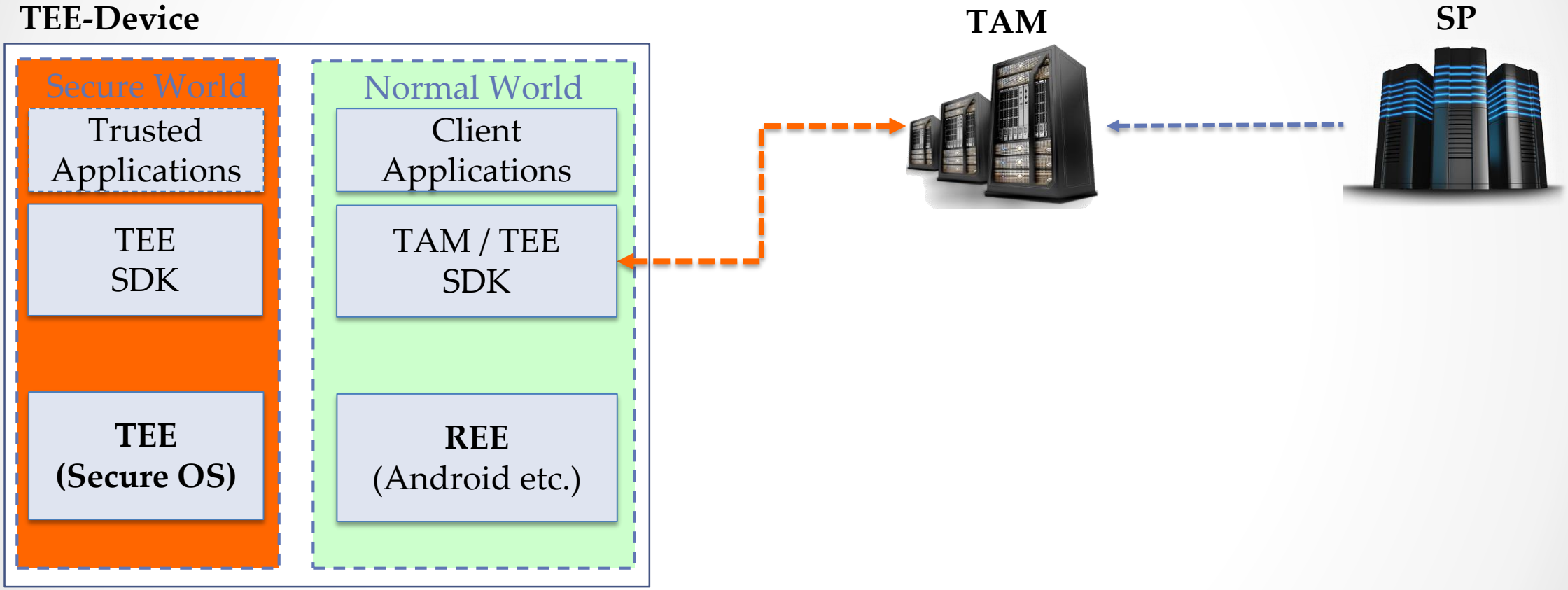
OTrP Spec History

- Joint effort from Open Trust Protocol Alliance founding member companies
  - ARM, Intercede, Solacia, Symantec
- A message protocol to define trust hierarchy and Trusted Application (TA) management over the air by SP via TSM
  - Basing on standard PKI
  - Trust establishment from end-to-end
    - FW → TEE → TA → TSM / SP
  - Allow different TEE and TSM with trust selection
- Open standards
  - RFC Draft: July 8, 2016, 96-th IETF
    - https://tools.ietf.org/html/draft-pei-opentrustprotocol-01
  - Global Platform submission consideration

Background Context

- Challenges and Proposals

Trusted Execution Environment and TAs

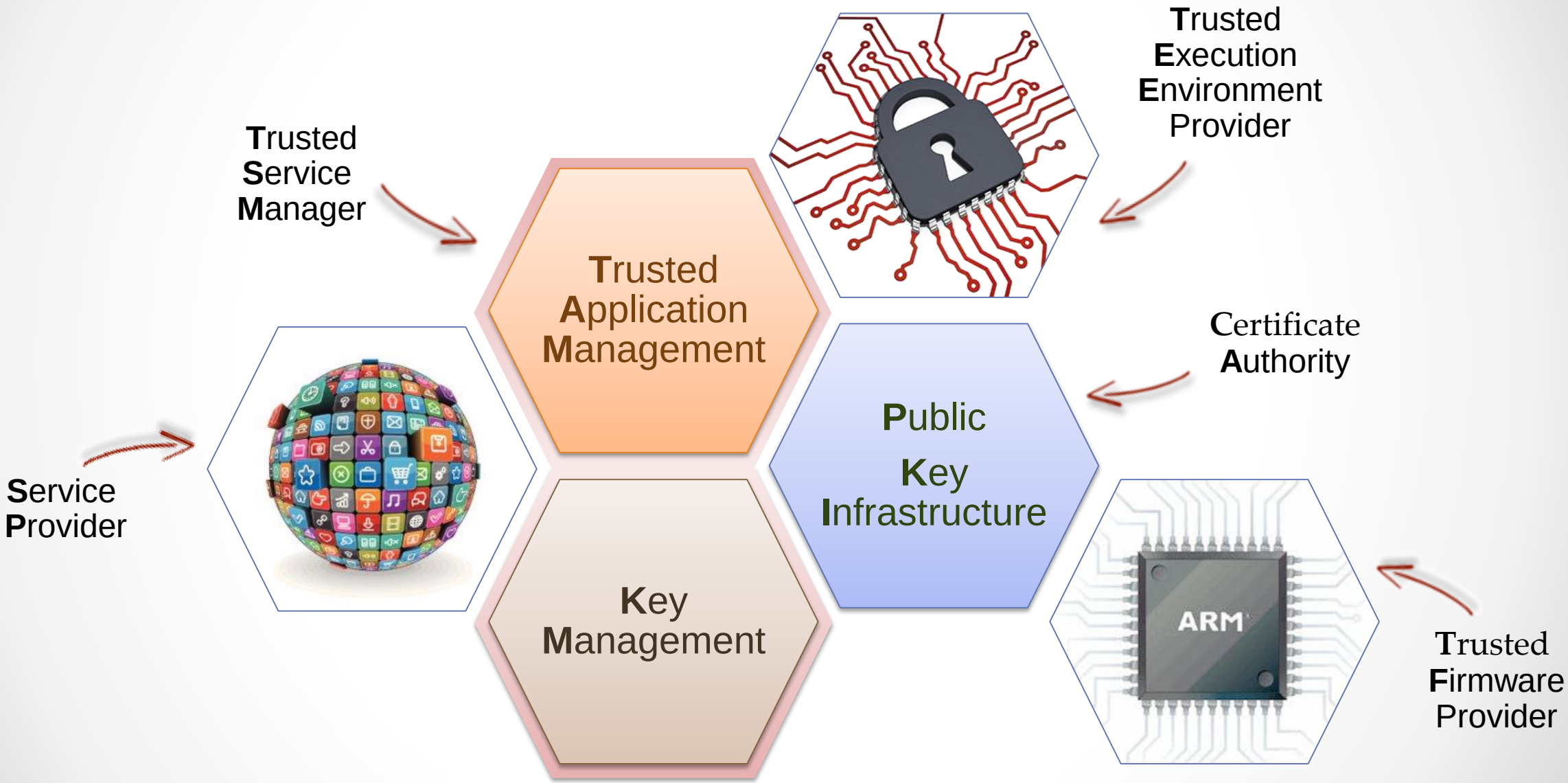


The Challenge

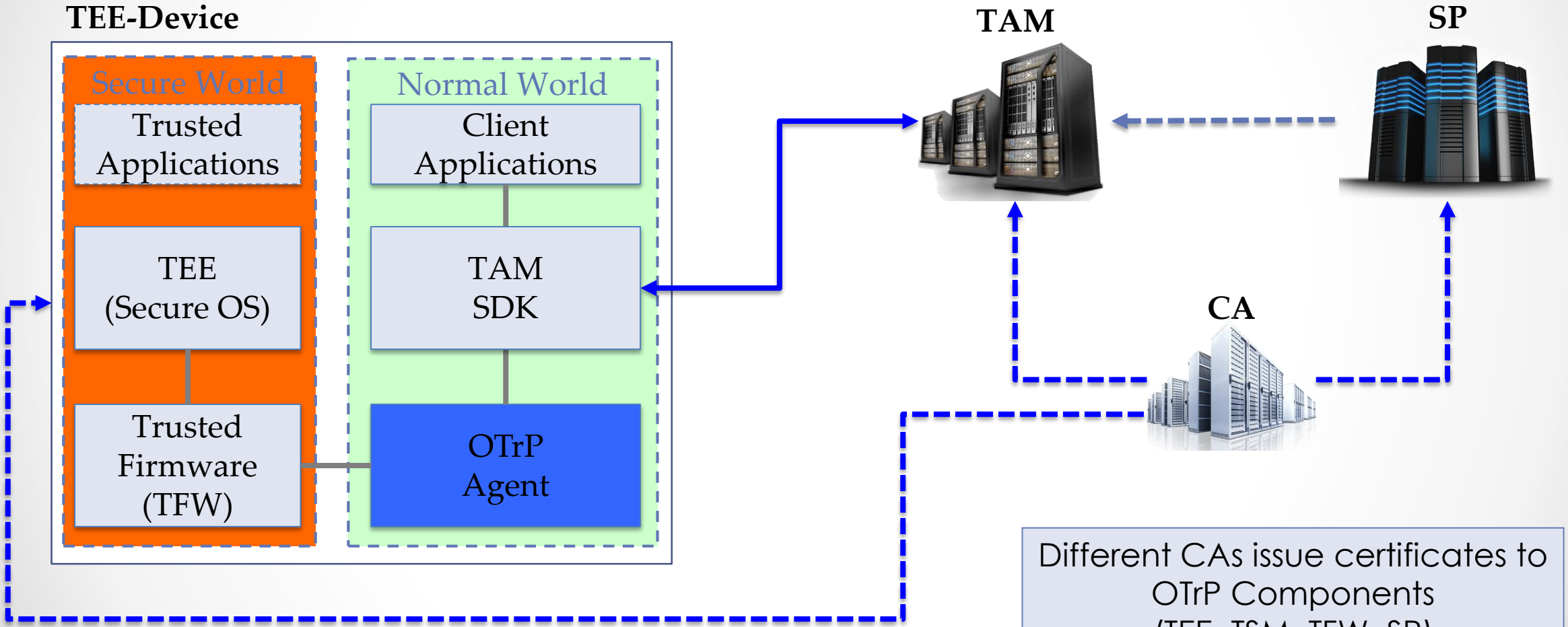
How to access hardware security when fragmentation is growing?

- Adoption gap for service providers: gap between devices with hardware security and a wish to push keys/Trusted Apps to devices with different TEEs and vendors
- Fragmentation is growing – IOT will accelerate that fragmentation
- Lack of standards to manage TAs
  - Devices have hardware based Trusted Execution Environments (TEE) but they do not have a standard way of managing those security domains/TAs
  - e.g. how to install / delete a Trusted App?

Open Trust Ecosystem



Solution: Open Trust Protocol



OTrP Design Goals

- Simplify trusted provisioning of connected devices
- Designed to work with *any* "hardware secure environment"
  - Starting with TrustZone based TEE with wide potential in Mobile and IOT
- Creating a free specification for industry use
- Focus on re-use of existing schemes (CA and PKI) and ease of implementation (keeping message protocol high level)

Benefits of OTrP

Built-in Trust and Privacy

- Device Trusted Firmware and TEE identity information is never exposed to Client Applications
- Device generated key for runtime anonymous attestation

Interoperability & Easy Adoption

- Reduce cost of research and development through royalty-free, open standards-based specifications, technical collaboration and solution component integration

Scalability

- Flexible model that relies on independent certification and managed trust

No "Vendor Lock"

- Open ecosystem that offers broader vendor choice for flexible, best-in-class solution deployment

Innovation

- Service Providers can focus on added-value and best use of hardware security capabilities

OTrP RFC Spec

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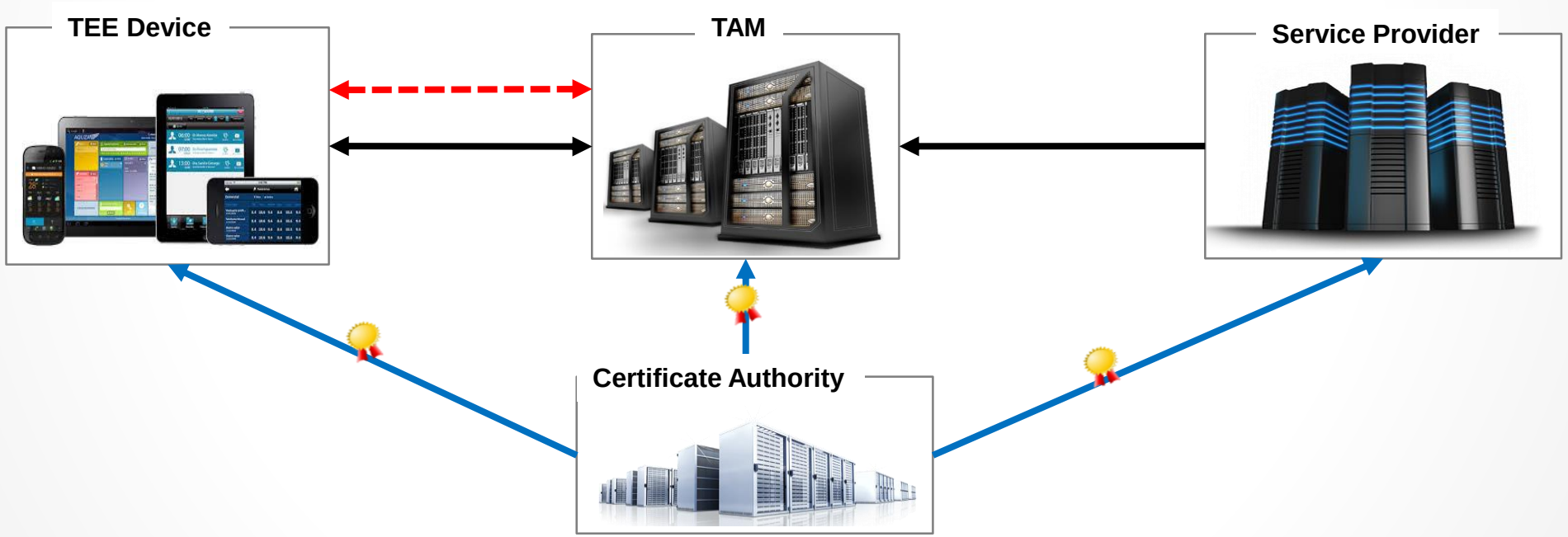
Basic Concept

- Open and Secure framework for Over-The-Air management of Secure Keys and Trusted Application (TA)
- Based on the standard PKI (Public Key Infrastructure)
  - ✓ PKI trust anchors embedded in end-points and configured in services
- Attestation between TAM and TEE-device with Key pair and Certificate for remote integrity check
- Cryptography based authentication with certified asymmetric device keys



Technical Spec Content

- **Define trust relationship of entities**
- **Define JSON messages for trust and remote TA management** between a TSM and TEE
  - Messages for device attestation (device integrity check) by a TSM and a device to trust a TSM
  - Messages for Security domain management and TA management
  - Network communication among entities are left to implementations
- **Define an OTrP Agent in REE (Rich Execution Environment)**
  - Necessary component from REE of a device to relay message exchanges between a TSM and TEE
- Use standard PKI artifacts and algorithms
- Use standard JSON messages and JSON security RFCs

Entity Key Architecture and Trust Model

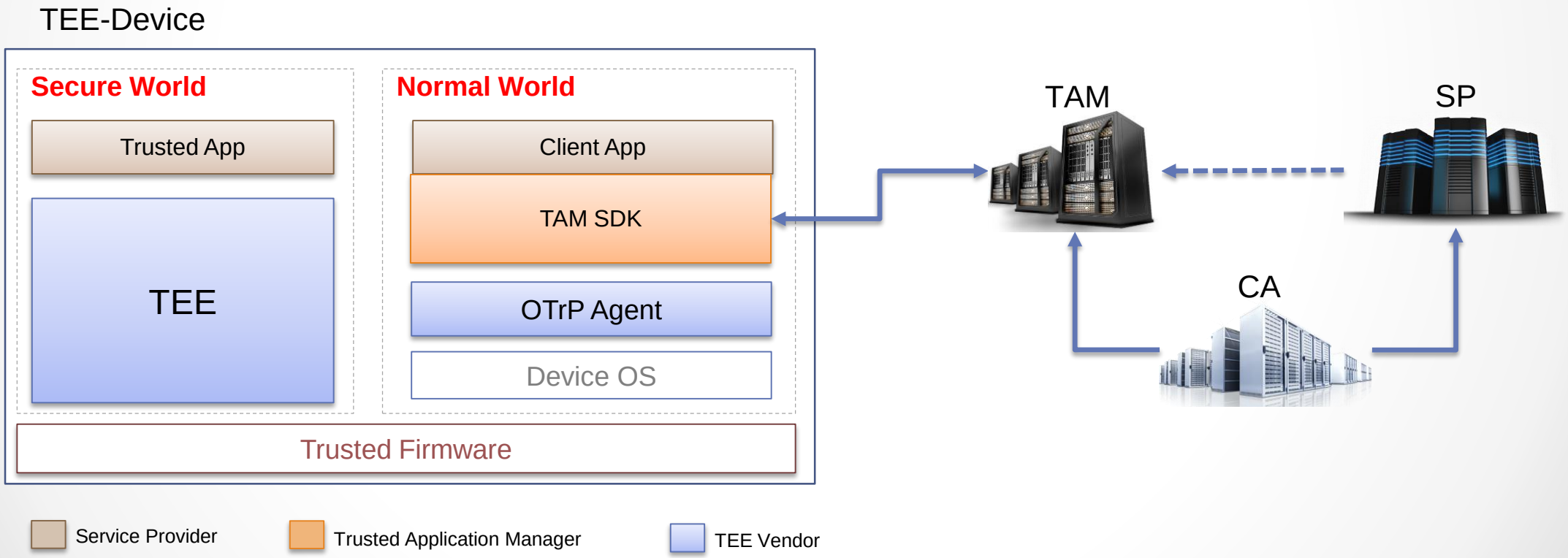
	Certificate Authority	Service Provider	TAM	Device TEE	
Keys	 **CA Certificate**	 SP Key pair and Certificate	 TAM Key pair and Certificate	 **TEE Key pair and Certificate**	 **TFW Key pair and Certificate**
Derived Keys		**SP Anonymous Public Key** 		 **SP Anonymous Key (SP AIK)**	
Trust Anchors			 **Trust Anchors:** trusted Root CA list of TEE Cert	 **Trust Anchors:** trusted Roots of TAM / TFW	
Usage	**** Key pair and Certificate:*** *used to issue certificate*	**** Key pair and Certificate:*** *used to sign a TA*	**** Key pair and Certificate:*** *sign OTrP requests to be verified by TEE*	**** Key pair and Certificate:*** *device attestation to remote TAM and SP.* **** SP AIK*** *to encrypt TA binary data*	**** Key pair and Certificate:*** *evidence of secure boot and trustworthy firmware*

Key Usage

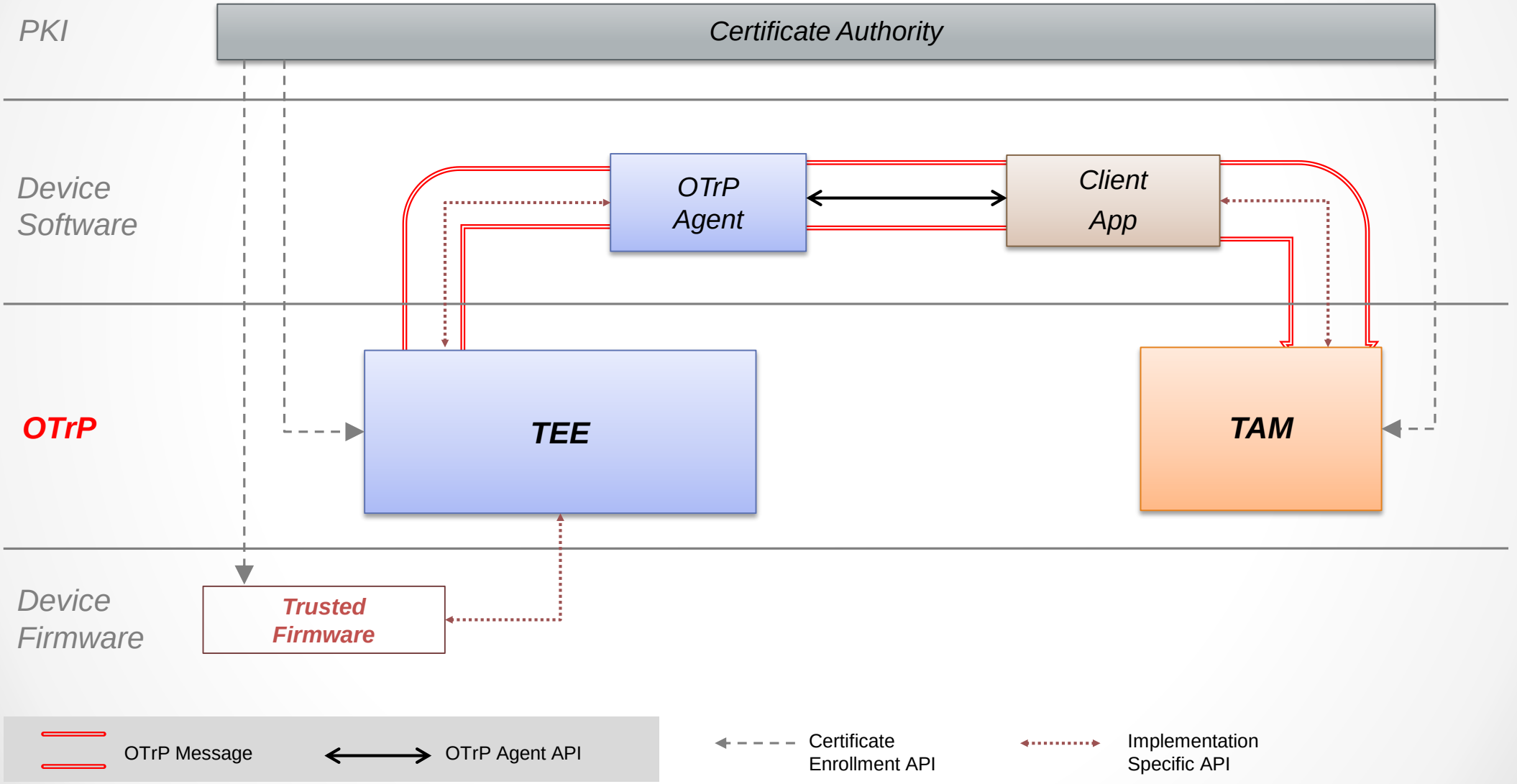
*** AIK: Attestation Identity Key, TFW: Trusted Firmware**

OTrP System Architecture

- CA issues certificates to all OTrP Components (TEE, TAM, TFW, SP)
- TAM vendor provides the SDK to communicate with TAM from Client Application
- TAM communicates with OTrP Agent to relay the OTrP message between TAM and TEE

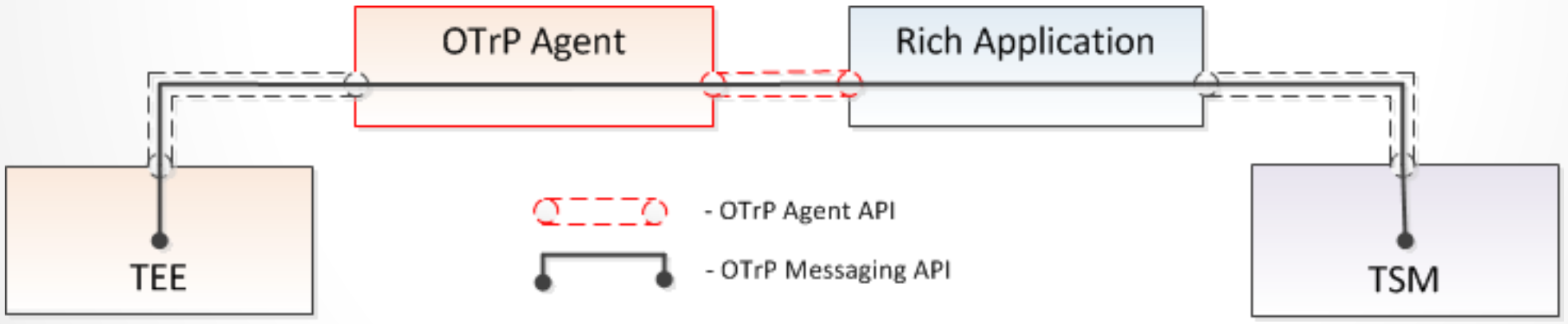


OTrP Spec Scope



OTrP Agent

- Responsible for routing OTrP Messages to the appropriate TEE
- Most commonly developed and distributed by TEE vendor
- Implements an interface as a service, SDK, etc.



OTrP Agent API

```
interface IOTrPAgentService {
    String processMessage(String tsmInMsg) throws OTrPAgentException;
    String getTAInformation(String spid, String taid, byte[] nonce);
}

public class OTrPAgentException extends Throwable {
    private int errCode;
}
```

OTrP Operations and Messages

✓ Remote Device Attestation

Command	Descriptions
GetDeviceState	• Retrieve information of TEE device state including SD and TA associated to a TAM

✓ Security Domain Management

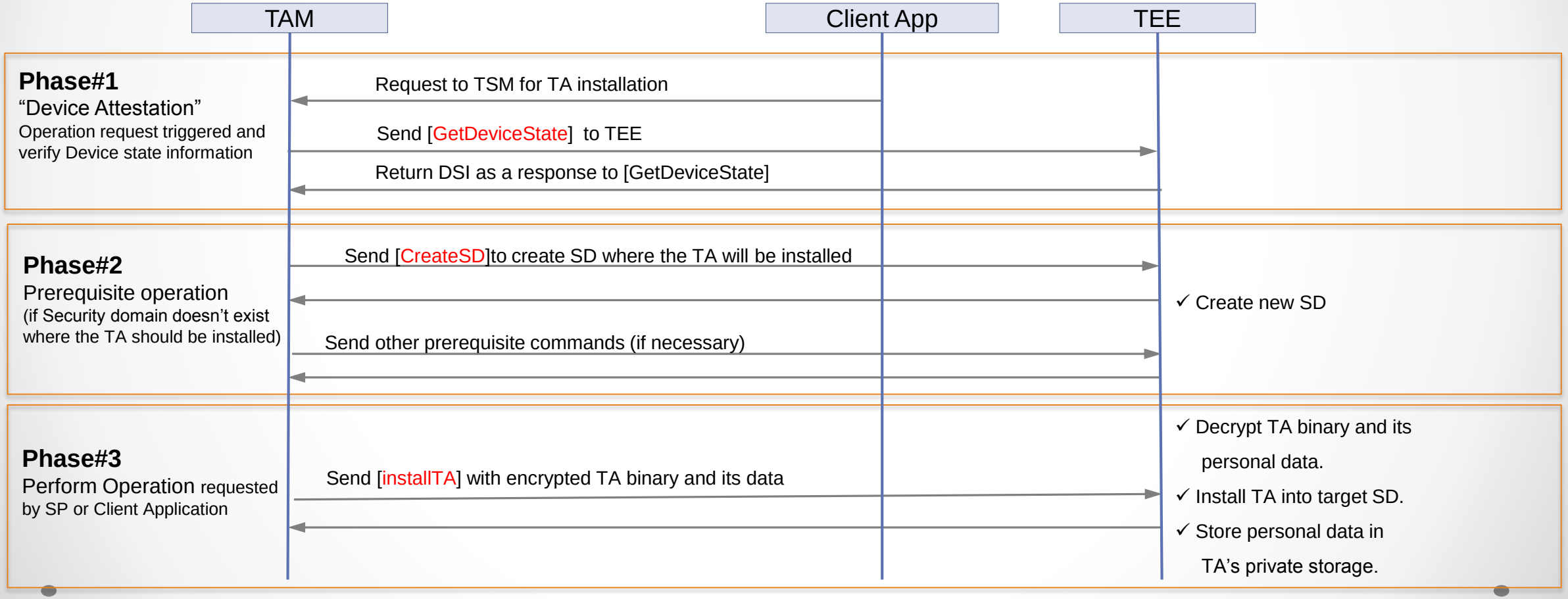
Command	Descriptions
CreateSD	• Create SD in the TEE associated to a TAM
UpdateSD	• Update sub-SD within SD or SP related information
DeleteSD	• Delete SD or SD related information in the TEE associated to a TAM

✓ Trusted Application Management

Command	Descriptions
InstallTA	• Install TA in the SD associated to a TAM
UpdateTA	• Update TA in the SD associated to a TAM
DeleteTA	• Delete TA in the SD associated to a TAM

Protocol Flow

- Security of the Operation Protocol is enhanced by applying the following three Measures:
  - ✓ Verifies validity of Message Sender's Certificate
  - ✓ Verifies signature of Message Sender to check immutability
  - ✓ Encrypted to guard against exposure of Sensitive data



JSON Message Security and Crypto Algorithms

- Use JSON signing and encryption RFCs
  - RFC 7515, JSON Web Signature (JWS)
  - RFC 7516, JSON Web Encryption (JWE)
  - RFC 7517, JSON Web Key (JWK)
  - RFC 7518, JSON Web Algorithms (JWA)
- Supported encryption algorithms
  - A128CBC-HS256
  - A256CBC-HS512
- Supported signing algorithms
  - RS256 (RSA 2048-bit key)
  - ES256 (ECC P-256)
- Examples
  - {"alg":"RS256"}
  - {"alg":"ES256"}
  - {"enc":"A128CBC-HS256"}

OTrP JSON Message Format and Convention

```
{
   “<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>"
   }
}
```

For example:

- CreateSDRequest
- CreateSDResponse

OTrP JSON Sample Message: GetDeviceState

```
{
  "GetDeviceStateTBSRequest": {
     "ver": "1.0",
      "rid": "<Unique request ID>",
      "tid": "<transaction ID>",
      "ocspdat": "<OCSP stapling data of TSM certificate>",
      "icaocspdat": "<OCSP stapling data for TSM CA certificates>",
      "supportedsigalgs": "<comma separated signing algorithms>"
   }
}
```

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

OTrP Sample Message: CreateSD Request

```
{
   "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>",
        "tsmid": "<An identifiable attribute of the TSM certificate>",
        "did": "<SHA256 hash of the TEE cert>"
     }
   }
 }
```

OTrP Sample Message: CreateSD Response

```
{
  "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 SD owned by this TSM>"
     }
  }
}
```

Thank you!

Q&A

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