SIPNOC 2019

SHAKEN STI Policy Administrator and Certificate Management

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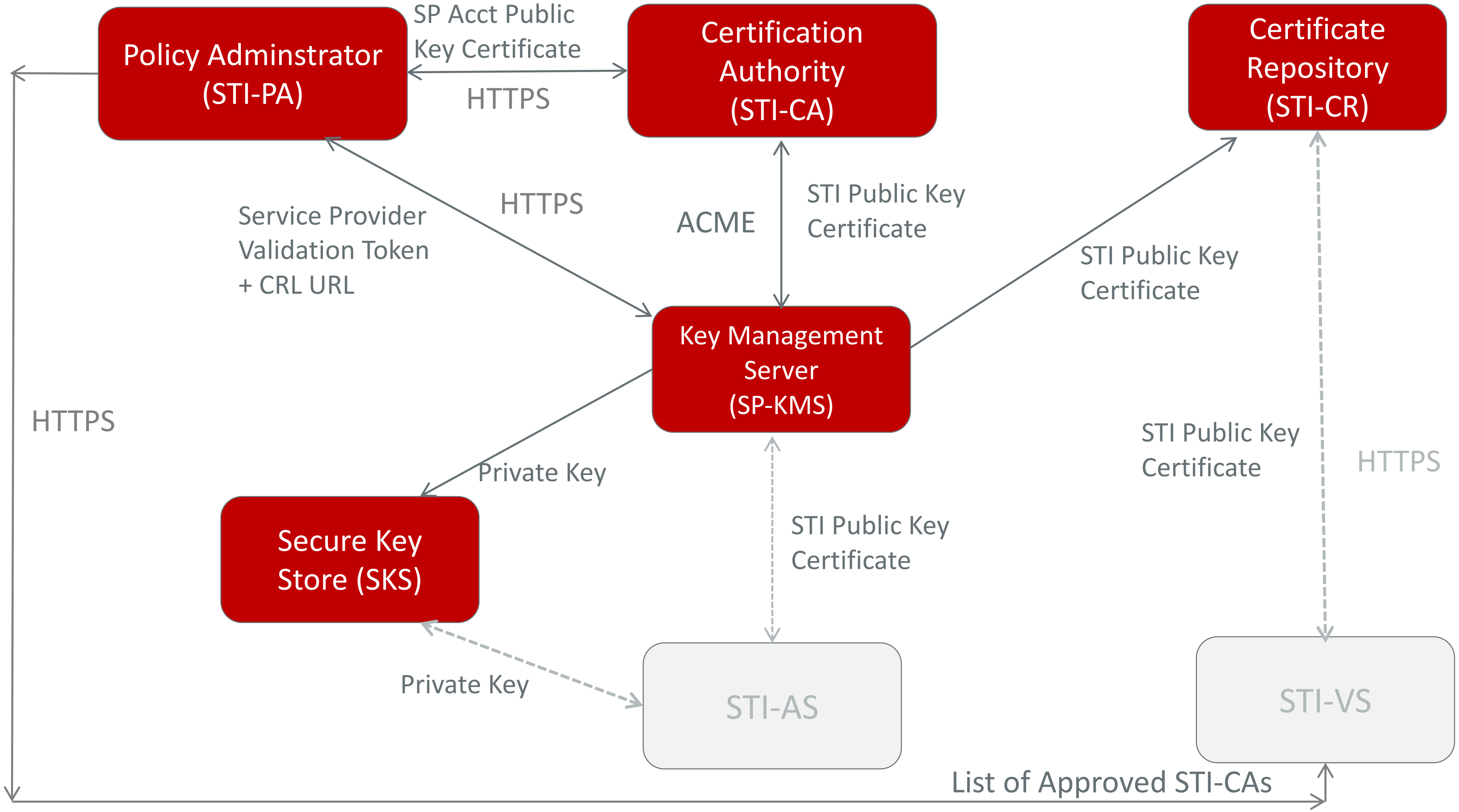
SHAKEN Certificate Management Architecture


Policy Adminstrator (STI-PA)
SP Acct Public Key Certificate
HTTPS
Certification Authority (STI-CA)
Certificate Repository (STI-CR)
Service Provider Validation Token + CRL URL
HTTPS
ACME
STI Public Key Certificate
STI Public Key Certificate
Key Management Server (SP-KMS)
HTTPS
Private Key
Secure Key Store (SKS)
STI Public Key Certificate
STI Public Key Certificate
HTTPS
Private Key
STI-AS
STI-VS
List of Approved STI-CAs

<- - - - - - - - -> Interface used during Session Setup

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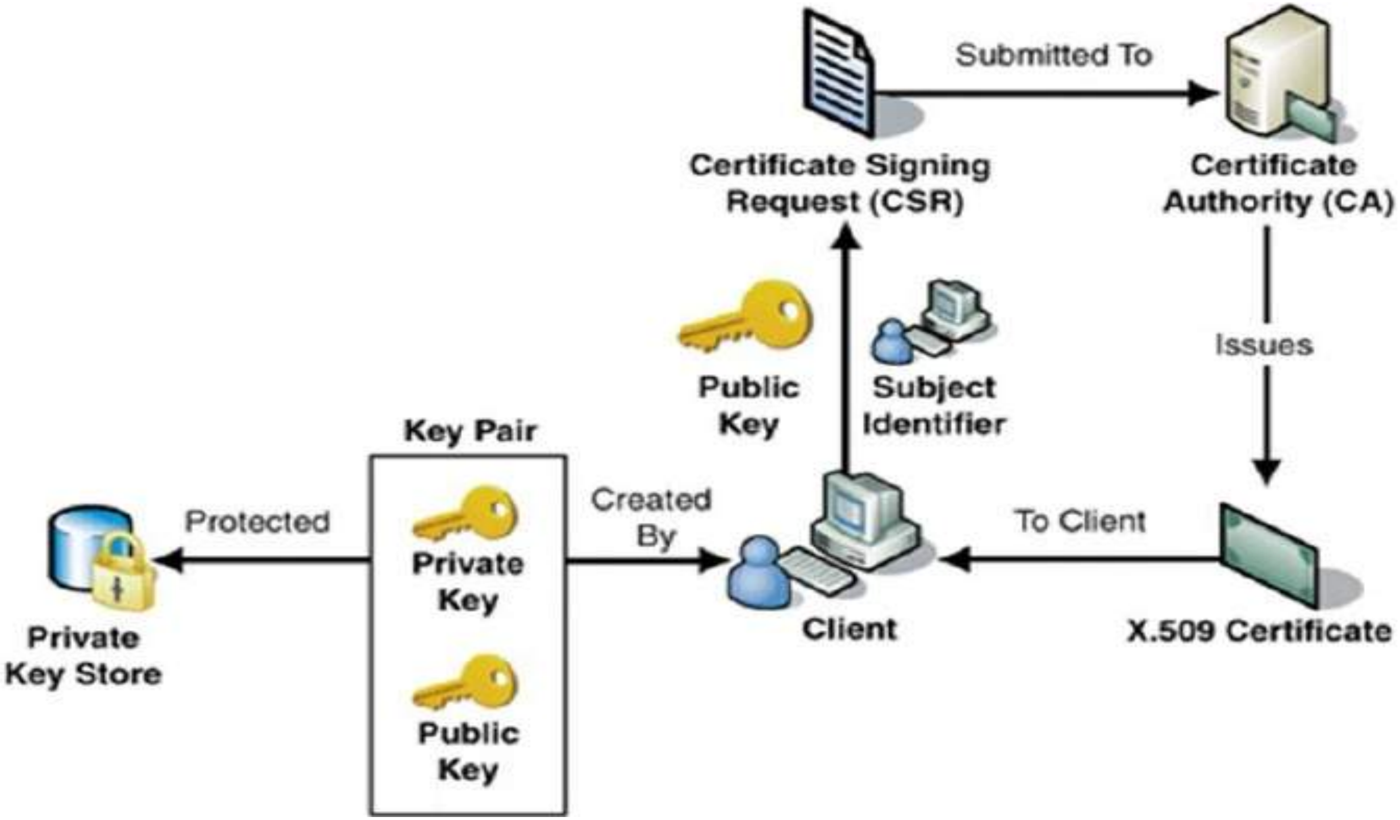
ATIS-1000080/ATIS-1000084

Public Key Certificates

- SHAKEN uses existing widely deployed Public Key Infrastructure principals and techniques (X.509 Certificates) and secure tokens to securely carry telephone identities through the network:
  - Private keys are only visible to the Originating Service Provider
  - Public Keys are available along the call path
  - Public Key certificate:
    - Allows terminating service provider to verify the authenticity of the telephone identity of calling party
    - Includes a new OID including Service Provider Code (OCN)
    - Leverages existing Issuing Distribution Point OID (DistributionPointName field) for indirect CRL model



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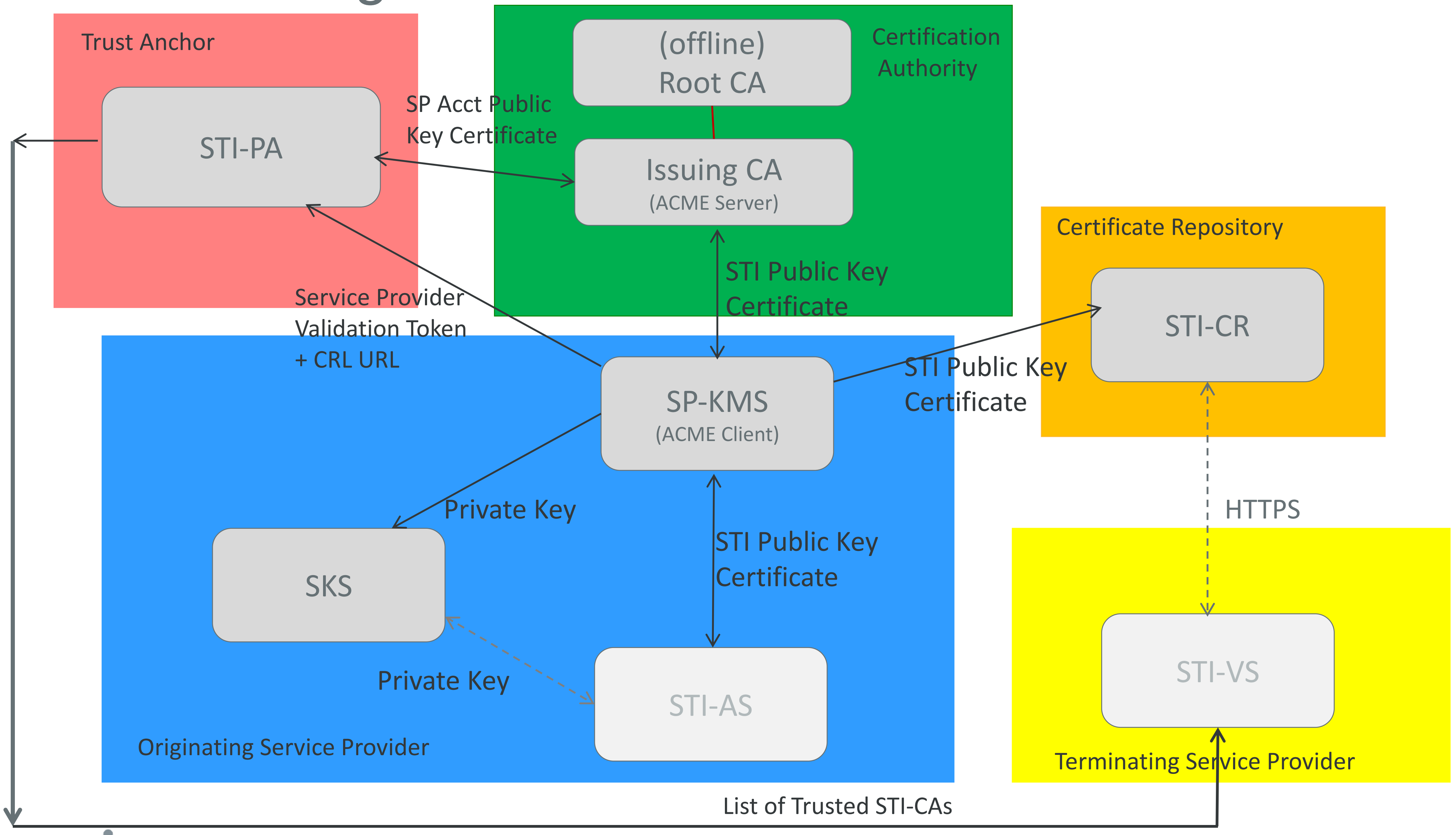
Certificate Management Roles


Trust Anchor
STI-PA
SP Acct Public Key Certificate
(offline) Root CA
Certification Authority
Issuing CA (ACME Server)
Service Provider Validation Token + CRL URL
STI Public Key Certificate
Certificate Repository
STI-CR
SP-KMS (ACME Client)
STI Public Key Certificate
Private Key
HTTPS
SKS
STI Public Key Certificate
Private Key
STI-AS
STI-VS
Originating Service Provider
Terminating Service Provider
List of Trusted STI-CAs

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STI-PA Role: Administration of STI-CAs

STI-PA Policy Management Authority approves STI-CAs

- Develops the Certificate Policy (CP)
- Reviews the Certification Practice Statement (CPS) of the STI-CA to approve an STI-CA
- Applies policies and other criteria as established by the STI-GA including:
  - STI-CA has appropriate expertise
  - STI-CA and Certificate Repository (CR) within the US
- Periodic audits recommended

STI-PA periodically updates list of valid STI-CAs

- Mechanism as specified by ATIS-1000084

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STI-PA Role: Administration of Service Providers

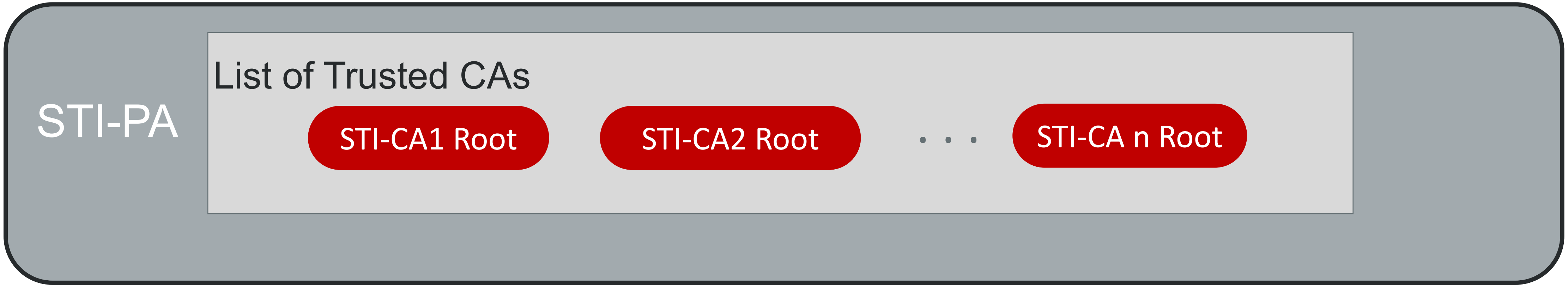
Service Provider Codes

- Existing identifiers (e.g., OCNs) are used as Service Provider Codes:
  - Service Provider codes are allocated and managed by an entity authorized by a National/Regional Regulatory Authority
  - Provide uniqueness & accountability

Service Provider Authorization

- Prior to requesting a certificate, a Service Provider must:
  - Create an account with the STI-PA
  - Create an account with an STI-CA
  - Obtain a service provider code token from the STI-PA (as Trust Anchor) per the procedures outlined in ATIS-1000080.

SHAKEN Trust Authority Model



- STI-PA maintains list of Trusted CAs on behalf of the relying parties in the PKI
- STI-PA serves as the Trust Anchor to the relying parties in the PKI
- Each STI-CA must support Certificate Policy (CP) as established by the STI-PA
- STI-PA reviews Certification Practice Statement (CPS) as provided by the STI-CAs to ensure compliance
- STI-PA also supports the distribution of Certificate Revocation Lists (CRLs)

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STI-Policy Administrator (STI-PA)

Trust Authority Role

- Supports unique requirements of managing PKI infrastructure for STI and Service Providers' interactions with the PKI
  - Serves as the Trust Authority for the PKI by maintaining a list of trusted STI-CAs
  - Serves as a Trust Anchor providing valid service providers with a unique token for authorization to get STI certificates

Certificate Issuance

- Serves no **direct** role in the issuance or validation of certificates:
  - Service Provider Code token mechanism used for authorization
  - Traditional PKI mechanisms for certification path validation are followed during the verification process:
    - STI-PA is NOT in the Certification Path

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STI-Certification Authority (STI-CA)

Roles and responsibilities

Align with those of traditional PKI (RFC 5280)

New x.509 Extension

(TNAuthList, OID 26) added to CSR/certificate to support unique STI identifier requirements (RFC 8226)

Protocol

Interface between STI-CA SP-KMS uses an automated certificate management protocol (ACME) (RFC 8555) (optional)

Uses new Authority Token based “challenge” to support authorization of service providers to obtain certificates (draft-ietf-authority-token & draft-ietf-acme-authority-token-tnauthlist) (protocol optional BUT validation of SPC token is mandatory)

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STI-Certificate Repository (STI-CR)

STI-VS gets STI public key certificate used to sign the Identity header field from the STI-CR during the verification process

- No new functionality or interfaces required
- Follows existing procedures as defined in RFC 5280

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SP-Key Management Server (SP-KMS)

PKI Interface

SP-KMS serves as the Service Provider’s interface to the PKI

ACME client

SP-KMS hosts the ACME client which maintains an account with the ACME server hosted by the STI-CA

Private Key

SP-KMS distributes private key to a Secure Key Store for access by the STI-AS when signing the PASSporT in the Identity header field.

Public Key Certificate

SP-KMS distributes the STI public key certificate to STI-CR

STI-AS Interface

SP-KMS ensures the STI-AS has access to the STI public key certificate URL for inclusion in the PASSporT in the SIP Identity header field

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PKI Model for SHAKEN

Model similar to inter-domain PKI*

- Each STI-CA serves as a root CA operating independently – no cross certificates
- STI-CAs must be approved by the STI-PA and follow Certificate Policy requirements defined by the STI-PA PMA
- STI-PA maintains a Trust List of approved CAs
- Allows each Service Provider to use an STI-CA that satisfies their business needs and meets established corporate security requirements

* see examples in RFC 5217

Use of the X.509 certificates follows standard practices:

- New extension (OID) defined for SHAKEN TNAuthList
- Indirect model for CRLs:
  - STI-PA manages the CRL
  - URL to CRL distributed in the issued certificates in the DistributionPointName field in the certificate
- Certification path validation per procedures defined in RFC 5280.
  - Additional step to verify that root CA is on the Trust List

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Comparison to Enterprise PKI

Similarities

- Single entity (STI-PA) controls who can issue certificates
- CAs issue X.509 v3 certificates
- RFC 5280 certification path validation procedures followed

Differences

- STI-PA as the Trust Authority (Anchor) is not the root CA
- No single Root CA
- List of Trusted CAs provides PKI trust anchor for certificates
- Service Provider selects the CA from which to obtain certificate

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Comparison to WebPKI

Similarities

- List of CAs similar to Trust Anchor Store
- User selects the CA from which to obtain certificates
- No single Root CA
- Hierarchy not imposed

Differences

- Establishes a clear, centralized governance structure with STI-GA and STI-PA
- STI-PA defines clear guidelines by which an STI-CA is added to the Trust List
- Defined procedures for providing Service Providers an updated Trust List
- STI-PA is the single entity authorized to remove an STI-CA from the Trust List
- Defined procedures for who is allowed to obtain certificates from an STI-CA

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Benefits of SHAKEN PKI Model

A single STI-PA is deployed per country/region

- SHAKEN model defines STI-PA as a Trust Authority and NOT as a Root CA
- STI-CAs serve as Root CAs

Service Provider controls which STI-CA to use

- Service Providers can use CAs that meet their business and operational requirements
- STI-PA controls who can serve as an STI-CA and who can obtain certificates – BUT does not control the certificate issuance

Within each STI-CA, a hierarchical, single Root CA model can be established

- Each STI-CA can have an offline root CA with one or more intermediate CAs
- Aligns with model and practices used by existing CAs

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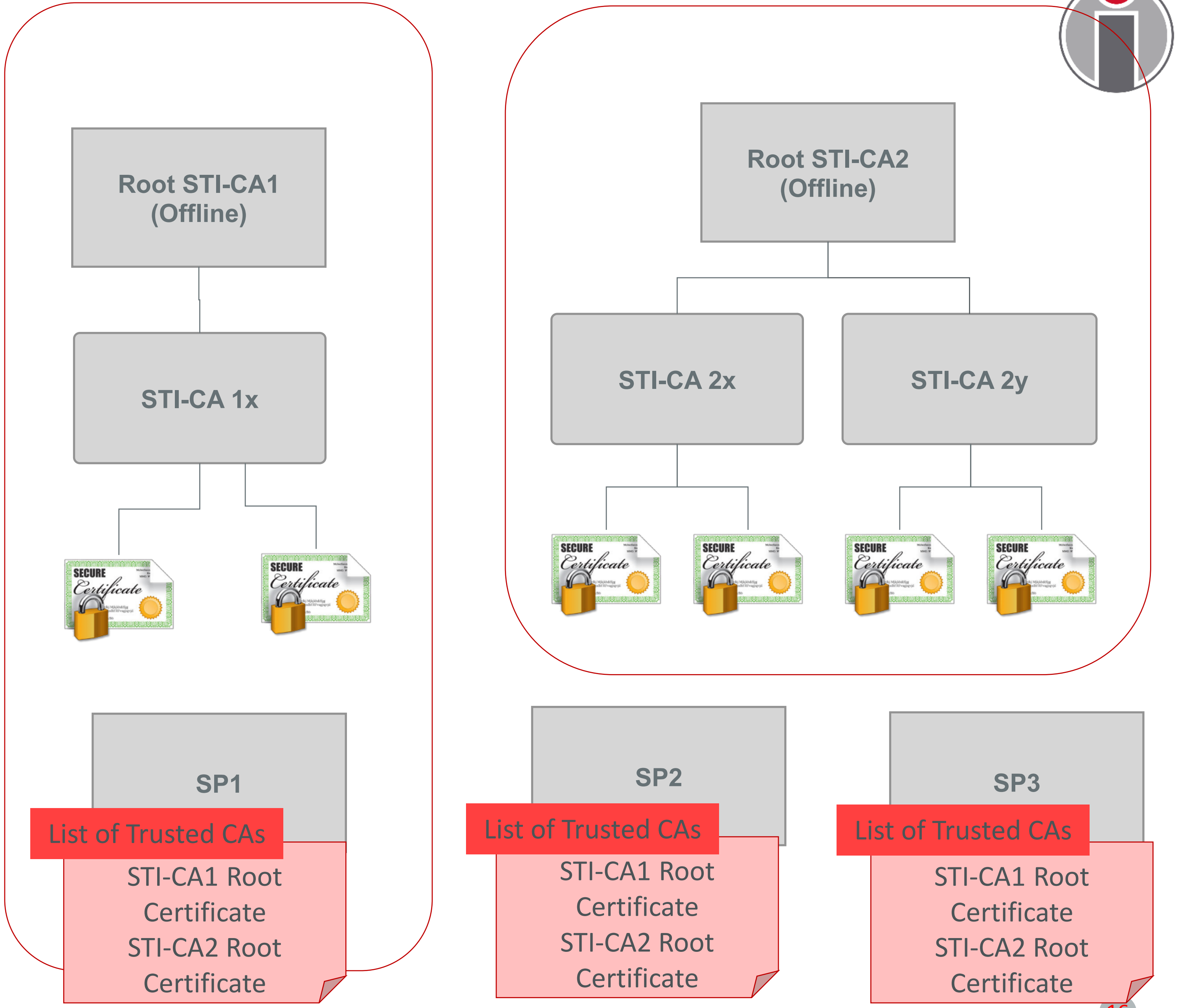
SHAKEN PKI Model

STI-PA

List of Trusted CAs

STI-CA1 Root certificate
STI-CA2 Root certificate



- STI-PA maintains list of Trusted CAs
- Indirect CRL model supported :
  - STI-PA maintains CRL
  - URL is distributed in the certificates
- Local policy determines which STI-CA an SP uses for certificate acquisition
- Certificate is trusted due to trust in Root CA on the list of Trusted CAs

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Policy Administrator Implementation Status

- iconectiv announced as Policy Administrator for the SHAKEN ecosystem in May 2019: https://authenticate.iconectiv.com/
- PMA has produced a CP: https://authenticate.iconectiv.com/documents-authenticate
  - CAs are submitting CPSs, currently under review by PMA.
- PA system testing is wrapping up with Service Providers and CAs

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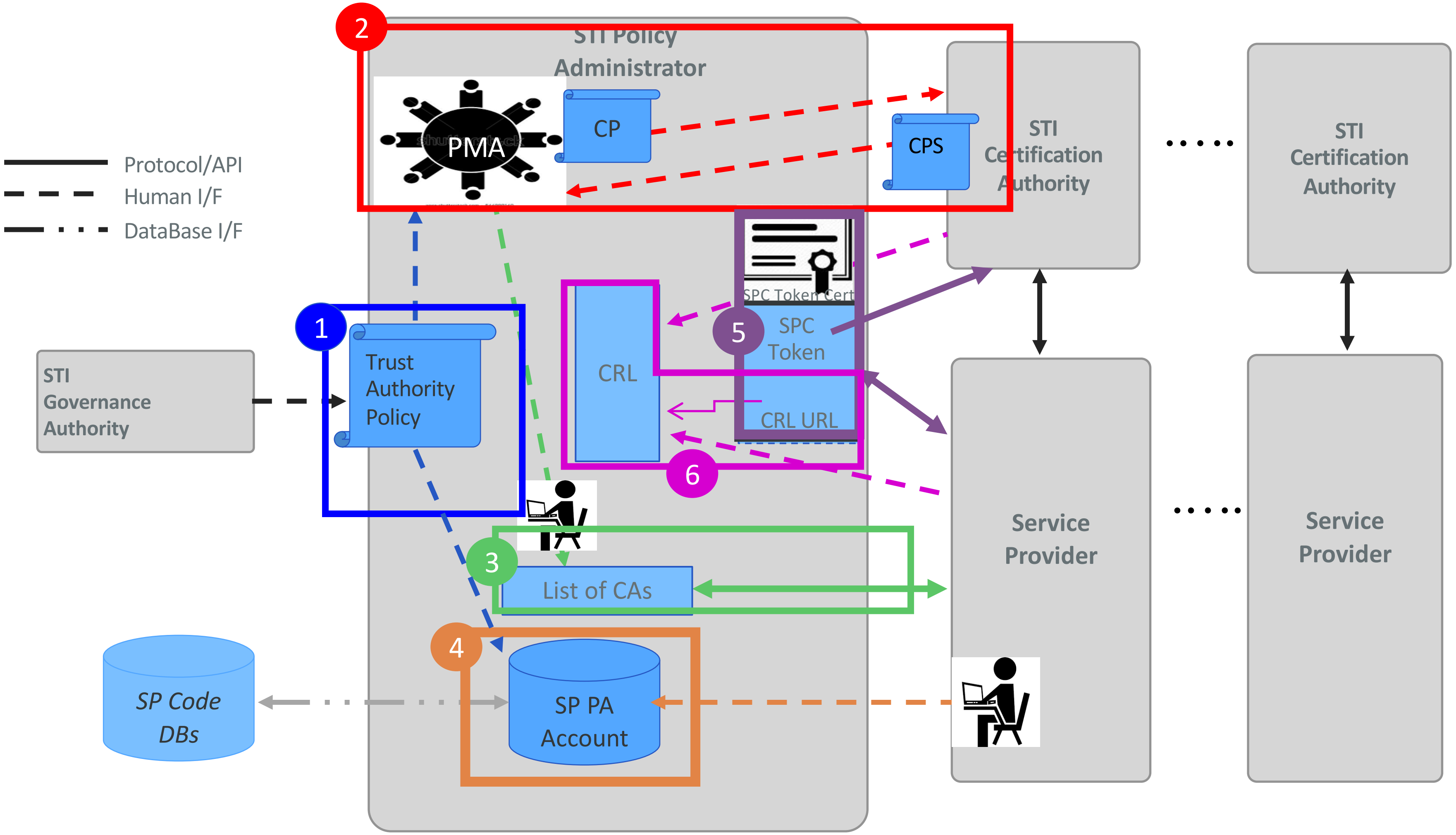
PA functions: Roles & Responsibilities



1 PMA Director & PA Admin

2 PMA & CAs (Portal)

3 PMA, PA Admin (Portal), SP (API)

4 PA Admin & SPs (Portal)

5 CAs & SPs (API)

6 CAs & SPs (Portal), SP (HTTPS)

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PA functions: Administering CAs

- STI-GA provides PMA with policies associated with CA selection (Box 1)
- PMA develops Certificate Policy (Box 2)
- STI-CAs create an account with the STI-PA (portal)
- STI-CA provides CPS to PMA for review/approval (Box 2)
- The PMA director notifies PA admin when a CA has been approved (Box 3)
- The STI-CA's root certificate is added to the list of trusted STI-CAs (Box 3) (portal)
- SPs retrieves the STI-CA trust list from the STI-PA (Box 3) (HTTPS interface)
- SPs and CAs add revoked certificates to the CRL (Box 6) (Portal)

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PA functions: Administration of SPs

- STI-GA has set the policy that OCNs are used as Service Provider Codes, SPs must have numbering resources and must have a Form 499A on file with the FCC (Box 1)*
- Prior to requesting a certificate, a Service Provider must:
  - Create an account with the STI-PA (Box 4) (portal)
  - Create an account with an STI-CA – the fingerprint of the account credentials is input for the token generation**
  - Obtain a service provider code token from the STI-PA (Box 5) (API over HTTPS)
  - STI-PA provides the URL to the CRL in the SPC token request response (Box 5) (API over HTTPS)

* https://www.atis.org/sti-ga/resources/docs/SPC%20Token%20Access%20Policy.pdf

** Not a PA function but a necessary step

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Backup

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STI-GA Role

Regulatory

STI-GA is the conduit for regulatory impacts to the functions associated with the overall deployment of SHAKEN within the telephone network

Policies & Procedures

STI-GA establishes policies and procedures associated with the role and functions of the STI-PA and the overall ecosystem:

- Considers input from ATIS/SIP Forum IPNNI Task Group and industry
- Defines specific criteria for approving STI-CAs (beyond standard CP) such as geographic location of STI-CA and CR, operational experience, etc.
- Defines source of information for uniquely identifying valid Service Providers (i.e., source of Service Provider Code)

STI-PA Selection

STI-GA appoints the STI-PA. The STI-PA operates a Policy Management Authority (PMA) that establishes the Certificate Policies for STI-CAs, incorporating policies as established by the STI-GA

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Certificate Revocation

- Mechanism to support Certificate Revocation added to ATIS-1000080 Errata since not all SPs will support short-lived certificates
- Indirect CRL model is used:
    - STI-PA maintains the Certificate Revocation List (CRL) – entries are in the form specified in RFC 5280
    - A URL to the CRL is included in the response to the request for an SPC token
    - SP includes URL to the CRL in the CSR when requesting certificate issuance in the DistributionPointName field
    - SPs and STI-CAs provide information on any certificates that have been revoked to the STI-PA using an out of band mechanism

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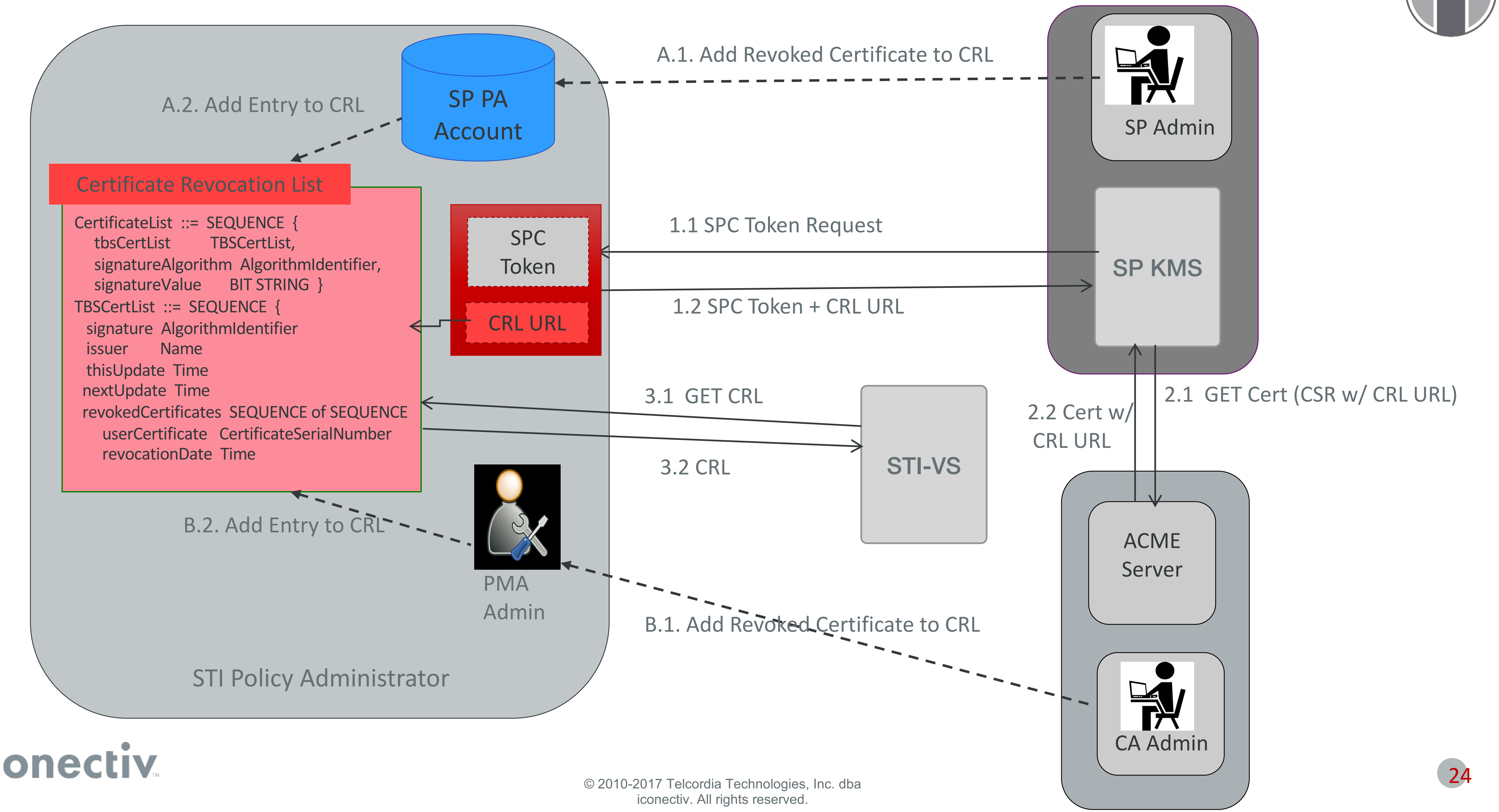
Management and Distribution of Certificate Revocation List



A.1. Add Revoked Certificate to CRL

A.2. Add Entry to CRL

SP PA Account

SP Admin

Certificate Revocation List

```
CertificateList  ::=  SEQUENCE  {
    tbsCertList          TBSCertList,
    signatureAlgorithm  AlgorithmIdentifier,
    signatureValue       BIT STRING  }
TBSCertList  ::=  SEQUENCE  {
  signature  AlgorithmIdentifier
  issuer        Name
  thisUpdate  Time
 nextUpdate  Time
 revokedCertificates  SEQUENCE of SEQUENCE
     userCertificate   CertificateSerialNumber
     revocationDate  Time
```

SPC Token

CRL URL

1.1 SPC Token Request

1.2 SPC Token + CRL URL

SP KMS

3.1 GET CRL

3.2 CRL

STI-VS

2.2 Cert w/ CRL URL

2.1 GET Cert (CSR w/ CRL URL)

ACME Server

B.2. Add Entry to CRL

PMA Admin

B.1. Add Revoked Certificate to CRL

CA Admin

STI Policy Administrator

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ACME Overview

- ACME is a protocol developed in IETF for Automated Certificate Management (Environment).
- ACME defines an extensible framework for automating the issuance and validation procedures for certificates:
  - Allows servers to obtain certificates without manual user interaction
  - Based on a simple JSON over-HTTPS interface
- ACME protocol specifications:
  - Core protocol: RFC 8555
  - Authority Token Based Challenge/Response: draft-ietf-acme-authority-token
  - TNAuthlist (TNs and Service Provider codes) Authority Token Profile: draft-ietf-acme-authority-token-tnauthlist

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ACME Protocol Model

- ACME uses HTTPS as a transport for Javascript Object Notation (JSON) Web Tokens (JWTs) in the form of JSON Web Signature (JWS) objects - effectively a RESTful API:
  - ACME server runs at a Certification Authority (CA) and responds to client's actions if the client is authorized.
  - ACME client uses the protocol to request certificate management actions.
  - ACME client is represented by an "account key pair".
    - ACME client uses the private key to sign all messages to the server.
    - ACME server uses public key to verify the authenticity and integrity of messages from the client.

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ACME Protocol Resource Objects

Account Object

Metadata Associated with Account

Order Object

Information for the Certificate including Certificate Signing Request (CSR)

Authorization Object

Challenges for Identifier validation

Challenge Object

Challenge response to prove Possession of Identifier

Certificate Object

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ACME Protocol SHAKEN Resource Objects

Account Object

Metadata Associated with Account

Order Object

SHAKEN CSR includes TNAuthorizationList & DistributionPointName

Authorization Object

SHAKEN challenge: Authority Token Identifier of type “TNAuthList”

Challenge Object

SHAKEN challenge Response includes Authority Token (“atc”) which includes SPC Token In TNAuthlist

Certificate Object

SHAKEN certificate includes “TNAuthorizationList” & “DistributionPointName”

- In the context of SHAKEN (ATIS-1000080), the TNAuthList contains only one Service Provider Code (SPC).
- DistributionPointName contains the URL to the Certificate Revocation List (CRL) received in response to SPC Token Request.

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ACME Protocol Functions

- ACME uses different URLs (resources) for different management functions:
    - ➢New nonce
    - ➢New Account
    - ➢New Order
    - ➢New Authorization
    - ➢Revoke Certificate
    - ➢Key change
- A single Directory URL is configured in client in order to get the Directory object containing the above URLs.

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ACME Protocol Resource States

- Each resource object has a status field that reflects the state of the object and is used by the client and server to effect changes such as:
  - ACME server sets the status to “valid” in the Authorization object to indicate that the requestor of the certificate has been validated.
    - In the case of challenge/response, ACME client periodically polls (POST-as-GET) the Authorization object to determine if status is “valid”
  - ACME client sets the status to “deactivated” in the Account object to deactivate an account

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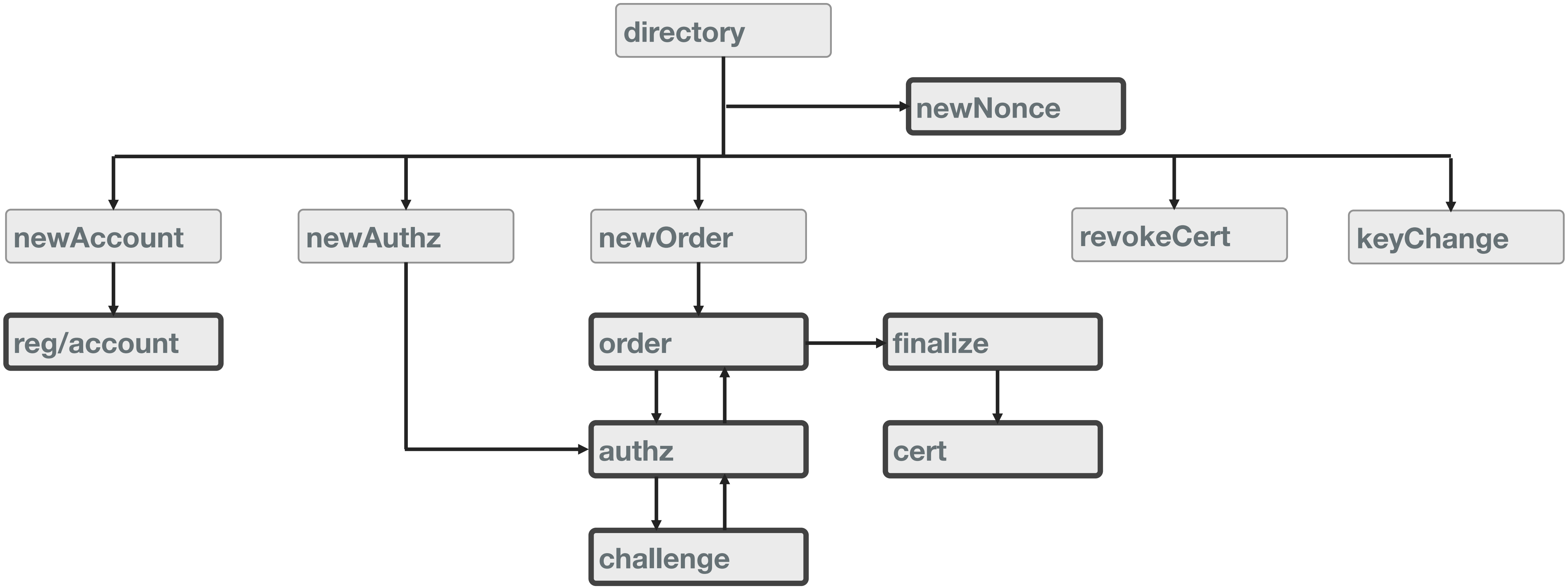
ACME Directory Object



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ACME - high level flow

- ACME high level request flow:

Get a nonce - HEAD newNonce

Create Account - POST newAccount

Submit order for a cert (order) - POST newOrder

Fetch challenges – POST-as-GET authz

Answer challenges – POST-as-GET challenge response

Poll for status – POST-as-GET order

Finalize order – POST order's finalize url

Poll for status – POST-as-GET order

Download certificate – POST-as-GET certificate URL

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ACME - Order object

- ACME Order object represents a client's request for a certificate, and it's lifecycle through to issuance.

status (required, string) - status of the application. "pending", "ready", "processing", "valid","invalid"

expires (optional, string) - timestamp of when the server will no longer consider the application valid

identifiers (required, array of object) – an array of identifier objects that the order pertains to: type (required, string), value (required, string)

notBefore (optional, string) - requested notBefore field in the certificate

notAfter (optional, string) - requested notAfter field in the certificate

error (optional, object) – error that occurred while processing order

authorizations (required, array or string) - requirements client needs to fulfill before granting certificate

finalize (required, string) - URL that a CSR must be POSTed to once all the authorizations have satisfied

certificate (optional, string) - URL for the issued certificate

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ACME - Order example

```
 {
 POST /acme/new-order HTTP/1.1
Host: sti-ca.com
Content-Type: application/jose+json
{
  "protected": base64url({
    "alg": "ES256",
    "kid": "https://sti-ca.com/acme/acct/1",
    "nonce": "5XJ1L3lEkMG7tR6pA00clA",
    "url": "https://sti-ca.com/acme/new-order"
  })
  "payload": base64url({
     ”status": ”pending”,
     "identifiers": [{"type:"TNAuthList","value":"F83n2a...avn27DN3=="}],
    "notBefore": "2016-01-01T00:00:00Z",
    "notAfter": "2016-01-08T00:00:00Z"
  }),
  "signature": "H6ZXtGjTZyUnPeKn...wEA4TklBdh3e454g"
}
   }
```

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ACME - Authorization object

- ACME authorization object represents a server’s authorization for an account to represent an identifier.

status (required, string) - status of the authorization. “pending”, “processing”, “valid”, “invalid”, “revoked” - default value is “pending”.

expires (optional, string) - if present, contains URI for an application resource, if absent, then CA MUST consider authorization valid for all applications

identifier (required, dictionary of string) - The identifier that the account is authorized to represent
 - **type** (required, string) - type of identifier
 - **value** (required, string) - identifier itself

challenges (required, array) - an array of challenges used for authorization

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ACME – Authorization Example

```
HTTP/1.1 200 OK
Content-Type: application/json
Link: <https://sti-ca.com/acme/some-directory>;rel="index"

{
  "status": "pending",

  "identifier": {
    "type": "TNAuthList",
    "value":"F83n2a...avn27DN3=="
  },

  "challenges": [
    {
      "type": "tkauth-01",
      "tkauth-type": "ATC",
      "url": "https://sti-ca.com/authz/1234/0",
      "token": "DGyRejmCefe7v4NfDGDKfA"
    }
  ],
}
```

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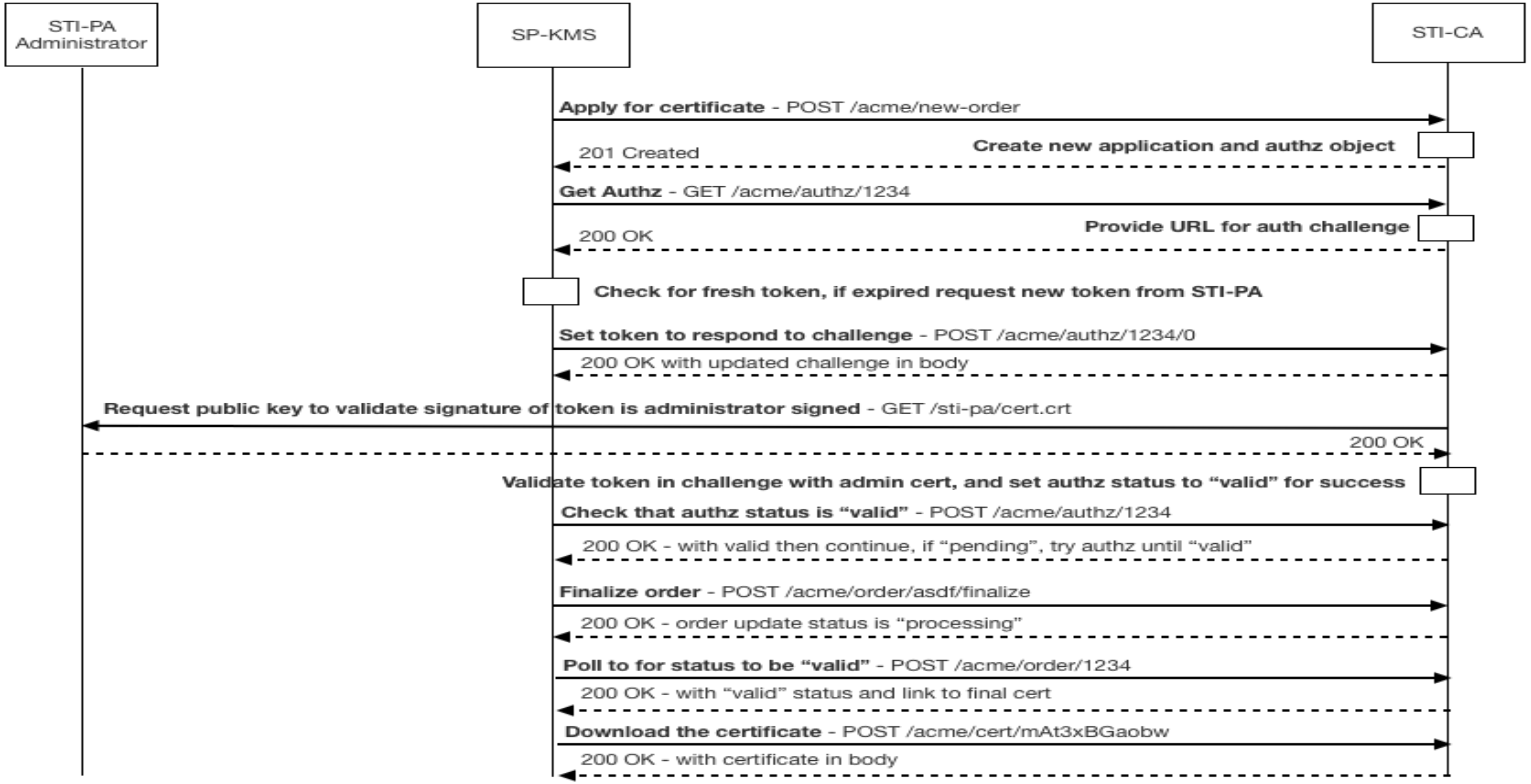
SHAKEN Certificate Management Call Flow



STI-PA Administrator

SP-KMS

STI-CA

Apply for certificate - POST /acme/new-order

Create new application and authz object

201 Created

Get Authz - GET /acme/authz/1234

Provide URL for auth challenge

200 OK

Check for fresh token, if expired request new token from STI-PA

Set token to respond to challenge - POST /acme/authz/1234/0

200 OK with updated challenge in body

Request public key to validate signature of token is administrator signed - GET /sti-pa/cert.crt

200 OK

Validate token in challenge with admin cert, and set authz status to “valid” for success

Check that authz status is “valid” - POST /acme/authz/1234

200 OK - with valid then continue, if “pending”, try authz until “valid”

Finalize order - POST /acme/order/asdf/finalize

200 OK - order update status is “processing”

Poll to for status to be “valid” - POST /acme/order/1234

200 OK - with “valid” status and link to final cert

Download the certificate - POST /acme/cert/mAt3xBGaobw

200 OK - with certificate in body

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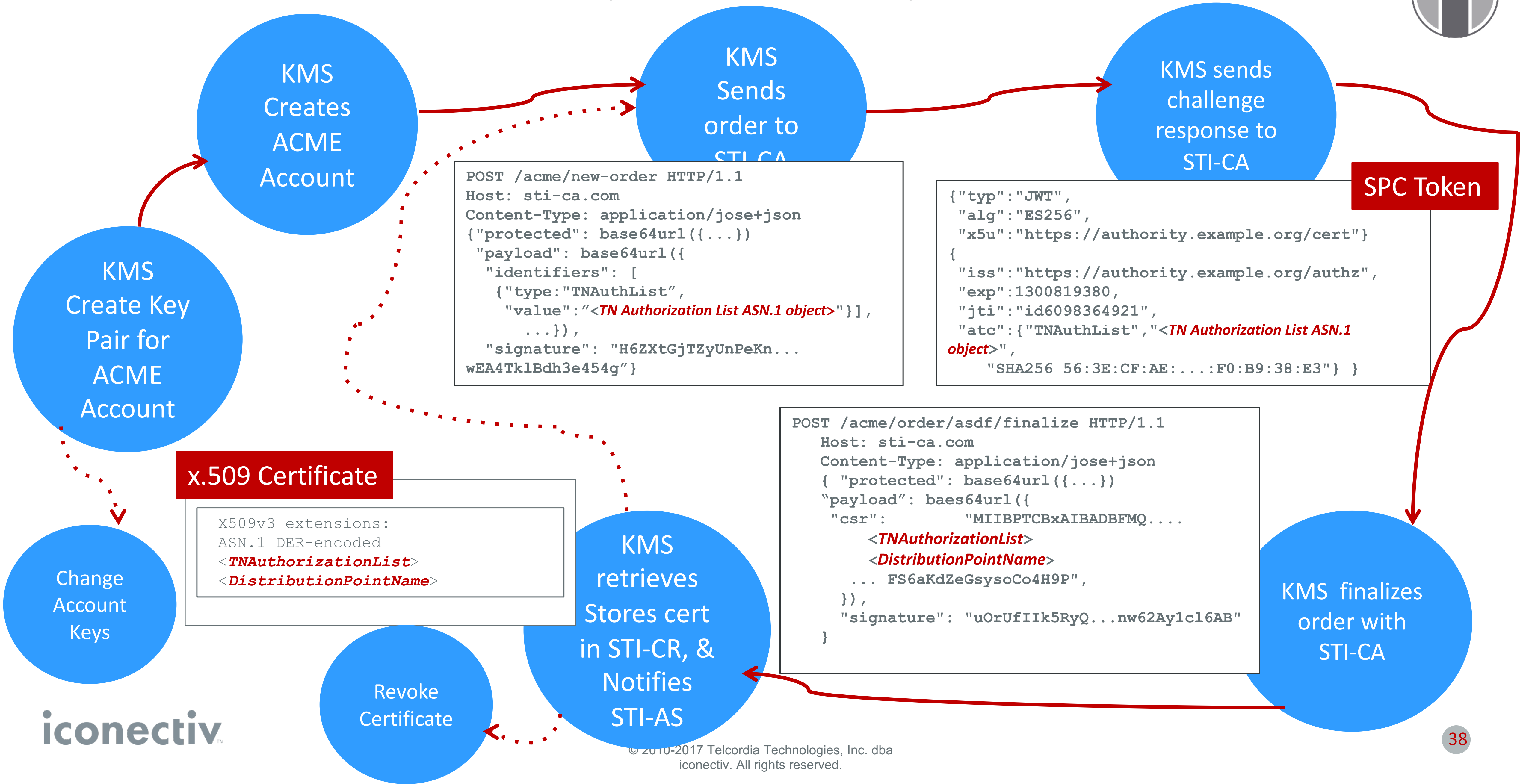
SHAKEN Certificate Acquisition Sequence of Events



KMS Create Key Pair for ACME Account

KMS Creates ACME Account

KMS Sends order to STI-CA

```
POST /acme/new-order HTTP/1.1
Host: sti-ca.com
Content-Type: application/jose+json
{"protected": base64url({...})
 "payload": base64url({
  "identifiers": [
   {"type:"TNAuthList”,
    "value":”<TN Authorization List ASN.1 object>"}],
      ...}),
  "signature": "H6ZXtGjTZyUnPeKn...
wEA4TklBdh3e454g”}
```

KMS sends challenge response to STI-CA

SPC Token

```
{"typ":"JWT",
 "alg":"ES256",
 "x5u":"https://authority.example.org/cert"}
{
 "iss":"https://authority.example.org/authz",
 "exp":1300819380,
 "jti":"id6098364921",
 "atc":{"TNAuthList","<TN Authorization List ASN.1
object>",
    "SHA256 56:3E:CF:AE:...:F0:B9:38:E3"} }
```

KMS finalizes order with STI-CA

```
POST /acme/order/asdf/finalize HTTP/1.1
   Host: sti-ca.com
   Content-Type: application/jose+json
   { "protected": base64url({...})
   “payload”: baes64url({
    "csr":        "MIIBPTCBxAIBADBFMQ....
        <TNAuthorizationList>
        <DistributionPointName>
      ... FS6aKdZeGsysoCo4H9P",
     }),
     "signature": "uOrUfIIk5RyQ...nw62Ay1cl6AB"
   }
```

KMS retrieves Stores cert in STI-CR, & Notifies STI-AS

x.509 Certificate

```
X509v3 extensions:
ASN.1 DER-encoded
<TNAuthorizationList>
<DistributionPointName>
```

Change Account Keys

Revoke Certificate

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