SHAKEN - Certificate Framework Administration using ACME/OAuth

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Auth framework

- **STI-PA**: Provide private/public key
  - **STI-CA**: retrieve certificate
  - **ACME**: validate JWT using certificate in x5u
  - **SP-KMS**: Generate JWT with x5u of public key
ACME - Registration object

- ACME Registration resource represents an account

- **key** (required, dictionary) - public key encoded as JSON WebKey
- **status** (required, string) - status of the registration. “valid”, “deactivated”, “revoked” - deactivated represents user invoked deactivation vs. revoked is administrator invoked deactivation.
- **contact** (optional, array of string) - An array of URIs the ACME server can use to contact the clients about authorization issues (e.g. being revoked)
- **terms-of-service-agreed** (optional, boolean) - true indicates agreement
- **applications** (required, string) - URI from which a list of authorization submitted by this account can be fetched

Example Registration object:
```json
{
    "contact": [
        "mailto:cert-admin@example.com",
        "tel:+12025551212"
    ],
    "terms-of-service-agreed": true,
    "applications": "https://example.com/acme/reg/1/apps"
}
```

Example response to applications URL:
```json
{
    "applications": [
        "https://example.com/acme/reg/1/apps/1",
        "https://example.com/acme/reg/1/apps/2",
        /* 47 more URLs not shown for example brevity */
        "https://example.com/acme/reg/1/apps/50"
    ]
}
```
ACME - Application object

• ACME Application object represents a client’s request for a certificate, and it’s lifecycle through to issuance.

• **status** (required, string) - status of the application. “pending”, “valid”, “invalid”
  **expires** (optional, string) - timestamp of when the server will no longer consider the application valid
  **csr** (required, string) - CSR encoding for the requested certificate
  **notBefore** (optional, string) - requested notBefore field in the certificate
  **notAfter** (optional, string) - requested notAfter field in the certificate
  **requirements** (required, array) - requirements client needs to fulfill before granting certificate
  **certificate** (optional, string) - URL for the certificate issued for this application
ACME - Application object

Example Application object:
{
    "status": "pending",
    "expires": "2015-03-01T14:09:00Z",
    "csr": "jcRf4uXra7FGYW5ZMewvV...rhlnznwy8YbpMGqwidEXfE",
    "notBefore": "2016-01-01T00:00:00Z",
    "notAfter": "2016-01-08T00:00:00Z",

    "requirements": [
        {
            "type": "authorization",
            "status": "valid",
            "url": "https://example.com/acme/authz/1234"
        }
    ]

    "certificate": "https://example.com/acme/cert/1234"
}

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

- **type** (required, string) - “authorization” or “out-of-band”
- **status** (required, string) - “pending”, “valid”, “invalid”
- **url** (required for “authorization”, string) - URL of the authorization resource
ACME - Authorization object

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

  - **identifier** (required, dictionary of string) - The identifier that the account is authorized to represent
    - **type** (required, string) - type of identifier (e.g. “dns” or “spid”)
    - **value** (required, string) - identifier itself
  
  - **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

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

```json
{
  "status": "valid",
  "expires": "2015-03-01T14:09:00Z",

  "identifier": {
    "type": "dns",
    "value": "example.org"
  },

  "challenges": [
    {
      "type": "http-01",
      "status": "valid",
      "validated": "2014-12-01T12:05:00Z",
      "keyAuthorization": "SXQe-2XODaDxNR...vb29HhjjLPSggwiE"
    }
  ]
}
```
ACME - high level flow

• ACME high level request flow:

  • **Get a nonce** - HEAD new-nonce

  • **Register/Account** - POST new-reg

  • **Apply for a cert (app/order)** - POST new-app

  • **Fetch challenges** - GET authz

  • **Answer challenges** - POST challenge

  • **Poll for status** - GET authz

  • **Check for new cert** - GET cert
Process New SPID and add account
Provide SP account access through secure means

Request CA token - GET /sti-pa/account/:id/token

Establish account with Administrator with secure credentials

Receive token with store with TTL, periodically refresh on demand use for all authz challenges

Request nonce - HEAD /acme/new-nonce

Registration request - POST /acme/new-reg

Create registration
SHAKEN ACME flow

- Step 1 - Request nonce

```http
HEAD /acme/new-nonce HTTP/1.1
Host: sti-ca.com

HTTP/1.1 200 OK
Replay-Nonce: oFvn1FPlwHrlYs2jTaXbA
Cache-Control: no-store
```

- Step 2 - Registration Request - likely done per SP-KMS node

```http
POST /acme/new-reg HTTP/1.1
Host: sti-ca.com
Content-Type: application/jose+json

{
    "protected": base64url({
        "alg": "ES256",
        "jwk": {...},
        "nonce": "6S8IqOGY7eL2lsGoTZYifg",
        "url": "https://sti-ca.com/acme/new-reg"
    }),
    "payload": base64url({
        "terms-of-service-agreed": true,
        "contact": ["mailto:cert-admin-sp-kms01@sp.com",
                     "tel:+12155551212"
                     ],
    }),
    "signature": "RZPOnYoPs1PhjszF...-nh6X1qtOFPB519I"
}
```

Example jwk public key - EC256

```json
{
    "kty": "EC",
    "crv": "P-256",
    "x": "f83OJ3D2xF1Bg8vub9tLe1gHMzV76e8Tus9uPHvRVEU",
    "y": "X_FEzRu9m36HLN_tue659LNpXW6pCyStikYjKIWI5a0",
    "kid": "Public key used in JWS spec Appendix A.3 example"
}
```
SHAKEN flow

- Step 3 - If registration exists return 200 OK response, otherwise if registration is created return 201

```plaintext
HTTP/1.1 201 Created
Content-Type: application/json
Replay-Nonce: D8s4D2mLs8Vn-goWuPQeKA
Location: https://sti-ca.com/acme/reg/asdf
Link: <https://sti-ca.com/acme/some-directory>;rel="directory"

{
    "key": { /* JWK from JWS header */ },
    "status": "valid",
    "contact": [
        "mailto:cert-admin-sp-kms01@sp.com",
        "tel:+12155551212"
    ]
}
```
SHAKEN flow

• Step 3a - if key is compromised, a key-change can be initiated

POST /acme/key-change HTTP/1.1
Host: sti-ca.com
Content-Type: application/jose+json

{
  "protected": base64url({
    "alg": "ES256",
    "jwk": /* old key */,
    "nonce": "K60BWPrMQG9SDxBDS_xtSw",
    "url": "https://sti-ca.com/acme/key-change"
  }),
  "payload": base64url({
    "protected": base64url({
      "alg": "ES256",
      "jwk": /* new key */,
    }),
    "payload": base64url({
      "account": "https://sti-ca.com/acme/reg/asdf",
      "newKey": /* new key */
    })
  })
  "signature": "Xe8B94RD30Azj2ea...8BmZIRtcSKPSd8gU"
}),
"signature": "5TWiqIYQfIDfALQv...x9C2mg8JGPx15bI4"}
SHAKEN flow

- Step 4 - apply for new certificate with a CSR

```
POST /acme/new-app HTTP/1.1
Host: sti-ca.com
Content-Type: application/jose+json

{
  "protected": base64url({
    "alg": "ES256",
    "kid": "https://sti-ca.com/acme/reg/asdf",
    "nonce": "5XJ1L3lEkMG7tR6pA00c1A",
    "url": "https://sti-ca.com/acme/new-app"
  })

  "payload": base64url({
    "csr": "5jNudRx6Ye4HzKEqT5...FS6aKdZeGsysoCo4H9P",
    "notBefore": "2016-01-01T00:00:00Z",
    "notAfter": "2016-01-08T00:00:00Z"
  } ),
  "signature": "H6ZXtGjTzyUnPeKn...wEA4TklBdh3e454g"
}
```
SHAKEN flow

- Step 5 - server provides required challenge authorization with URL, client must respond with authorization before “expires” time

HTTP/1.1 201 Created
Replay-Nonce: MYAuvOpaoIiywTezizk5vw
Location: https://sti-ca.com/acme/app/asdf

{
    "status": "pending",
    "expires": "2015-03-01T14:09:00Z",

    "csr": "jcRf4uXra7FGYW5ZMewvV...rhlnznwy8YbpMGqwidEXfE",
    "notBefore": "2016-01-01T00:00:00Z",
    "notAfter": "2016-01-08T00:00:00Z",

    "requirements": [
        {
            "type": "authorization",
            "status": "valid",
            "url": "https://sti-ca.com/acme/authz/1234"
        }
    ]
}

SHAKEN flow

- Step 6 - get authorization

GET /acme/authz/1234 HTTP/1.1
Host: sti-ca.com

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

{
    "status": "pending",
    "identifier": {
        "type": "spid",
        "value": "123"
    },
    "challenges": [
        {
            "type": "token",
            "url": "https://sti-ca.com/authz/asdf/0"
        }
    ]
}
SHAKEN flow

- Step 7 - respond to the challenge

POST /acme/authz/asdf/0 HTTP/1.1
Host: sti-ca.com
Content-Type: application/jose+json

{
  "protected": base64url(
    "alg": "ES256",
    "kid": "https://sti-ca.com/acme/reg/asdf",
    "nonce": "Q_s3MWoqT05TrdkM2MTDcw",
    "url": "https://sti-ca.com/acme/authz/asdf/0"
  ),
  "payload": base64url(
    "type": "token",
    "keyAuthorization": "IlirfxKKXA...vb29HhjjLPSggwiE"
  ),
  "signature": "9cbg5JO1Gf5YLjjz...SpkUfcdPai9uVYYQ"
}
SHAKEN flow

- Step 8 - check on status of authorization

GET /acme/authz/asdf HTTP/1.1
Host: sti-ca.com

HTTP/1.1 200 OK

{ "status": "valid",
  "expires": "2015-03-01T14:09:00Z",

  "identifier": {
    "type": "spid",
    "value": "123"
  },

  "challenges": [
    {
      "type": "token",
      "status": "valid",
      "validated": "2014-12-01T12:05:00Z"
    }
  ]
}
SHAKEN flow

- Step 9 - download the certificate

GET /acme/cert/asdf HTTP/1.1
Host: sti-ca.com
Accept: application/pkix-cert

HTTP/1.1 200 OK
Content-Type: application/pkix-cert
Link: <https://sti-ca.com/acme/ca-cert>;rel="up";title="issuer"
Link: <https://sti-ca.com/acme/revoke-cert>;rel="revoke"
Link: <https://sti-ca.com/acme/app/asdf>;rel="author"
Link: <https://sti-ca.com/acme/sct/asdf>;rel="ct-sct"
Link: <https://sti-ca.com/acme/some-directory>;rel="directory"

-----BEGIN CERTIFICATE-----
[End-entity certificate contents]
-----END CERTIFICATE-----

-----BEGIN CERTIFICATE-----
[Issuer certificate contents]
-----END CERTIFICATE-----

-----BEGIN CERTIFICATE-----
[Other certificate contents]
-----END CERTIFICATE-----