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ARM

An ACME Profile for Generating Delegated STAR Certificates

Abstract

This memo proposes a profile of the ACME protocol that allows the owner of an identifier (e.g., a domain name) to delegate to a third party access to a certificate associated with said identifier. A primary use case is that of a CDN (the third party) terminating TLS sessions on behalf of a content provider (the owner of a domain name). The presented mechanism allows the owner of the identifier to retain control over the delegation and revoke it at any time by cancelling the associated STAR certificate renewal with the ACME CA. Another key property of this mechanism is it does not require any modification to the deployed TLS ecosystem.

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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This Internet-Draft will expire on 26 February 2021.

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1. Introduction

This document is a companion document to [RFC8739]. To avoid duplication, we give here a bare-bones description of the motivation for this solution. For more details and further use cases, please refer to the introductory sections of [RFC8739].

An Identifier Owner (IdO), that we can associate in the primary use case to a content provider (also referred to as Domain Name Owner, DNO), has agreements in place with one or more NDC (Name Delegation Consumer) to use and attest its identity. In the primary use case, we consider a CDN provider contracted to serve the IdO content over HTTPS. The CDN terminates the HTTPS connection at one of its edge cache servers and needs to present its clients (browsers, mobile apps, set-top-boxes) a certificate whose name matches the authority of the URL that is requested, i.e., that of the IdO. Understandably, most IdOs balk at sharing their long-term private keys with another organization and, equally, delegates would rather not have to handle other parties' long-term secrets.

Other relevant use cases are discussed in Section 4.

This document describes a profile of the ACME protocol [RFC8555] that allows the NDC to request the IdO, acting as a profiled ACME server, a certificate for a delegated identity - i.e., one belonging to the IdO. The IdO then uses the ACME protocol (with the extensions described in [RFC8739]) to request issuance of a STAR certificate for the same delegated identity. The generated short-term certificate is automatically renewed by the ACME Certification Authority (CA), periodically fetched by the NDC and used to terminate HTTPS connections in lieu of the IdO. The IdO can end the delegation at any time by simply instructing the CA to stop the automatic renewal and letting the certificate expire shortly thereafter.

In case the delegated identity is a domain name, this document also provides a way for the NDC to inform the IdO about the CNAME mappings that need to be installed in the IdO's DNS zone to enable the aliasing of the delegated name, thus allowing the complete name delegation workflow to be handled using a single interface.

While the primary use case we address is delegation of STAR certificates, the mechanism proposed here accommodates any certificate managed with the ACME protocol. See Section 2.4 for details.

1.1. Terminology

IdO Identifier Owner, the owner of an identifier (e.g., a domain name) that needs to be delegated.

DNO Domain Name Owner, a specific kind of IdO whose identifier is a domain name

NDC Name Delegation Consumer, the entity to which the domain name is delegated for a limited time. This is a CDN in the primary use case (in fact, readers may note the symmetry of the two acronyms).

CDN Content Delivery Network, a widely distributed network that serves the domain's web content to a wide audience at high performance.

STAR Short-Term, Automatically Renewed X.509 certificates.

ACME The IETF Automated Certificate Management Environment, a certificate management protocol.

CA A Certificate Authority that implements the ACME protocol.

1.2. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2. Protocol Flow

This section presents the protocol flow. For completeness, we include the ACME profile proposed in this draft as well as the extended ACME protocol described in [RFC8739].

2.1. Preconditions

The protocol assumes the following preconditions are met:

* The IdO exposes an ACME server interface to the NDC(s) comprising the account management interface;
* The NDC has registered an ACME account with the IdO;
* NDC and IdO have agreed on a "CSR template" to use, including at a minimum: subject name (e.g., somesite.example.com), requested algorithms and key length, key usage, extensions (e.g., TNAuthList). The NDC is required to use this template for every CSR created under the same delegation;

* IdO has registered an ACME account with the Certificate Authority (CA)

Note that even if the IdO implements the ACME server role, it is not acting as a CA: in fact, from the point of view of the certificate issuance process, the IdO only works as a "policing" forwarder of the NDC's key-pair and is responsible for completing the identity verification process towards the ACME CA.

2.2. Overview

The interaction between the NDC and the IdO is governed by the profiled ACME workflow detailed in Section 2.3. The interaction between the IdO and the CA is ruled by ACME STAR [RFC8739] as well as any other ACME extension that applies (e.g., [I-D.ietf-acme-authority-token-tnauthlist] for STIR).

The outline of the combined protocol is as follow (Figure 1):

* NDC sends an order Order1 for the delegated identifier to IdO;
* IdO creates an Order1 resource in state ready with a finalize URL;
* NDC immediately sends a finalize request (which includes the CSR) to the IdO;
* IdO verifies the CSR according to the agreed upon CSR template;
* If the CSR verification fails, Order1 is moved to an invalid state and everything stops;
* If the CSR verification is successful, IdO moves Order1 to state processing, and sends a new Order2 (using its own account) for the delegated identifier to the ACME STAR CA;
* If the ACME STAR protocol fails, Order2 moves to invalid and the same state is reflected in the NDC Order;
* If the ACME STAR run is successful (i.e., Order2 is valid), IdO copies the star-certificate URL from Order2 to Order1 and moves its state to valid.

The NDC can now download, install and use the short-term certificate bearing the name delegated by the IdO. This can continue until the STAR certificate expires or the IdO decides to cancel the automatic renewal process with the ACME STAR CA.

Note that, because the identity validation is suppressed, the NDC sends the finalize request, including the CSR, to the IdO immediately after Order1 has been acknowledged. The IdO must buffer a (valid) CSR until the Validation phase completes successfully.

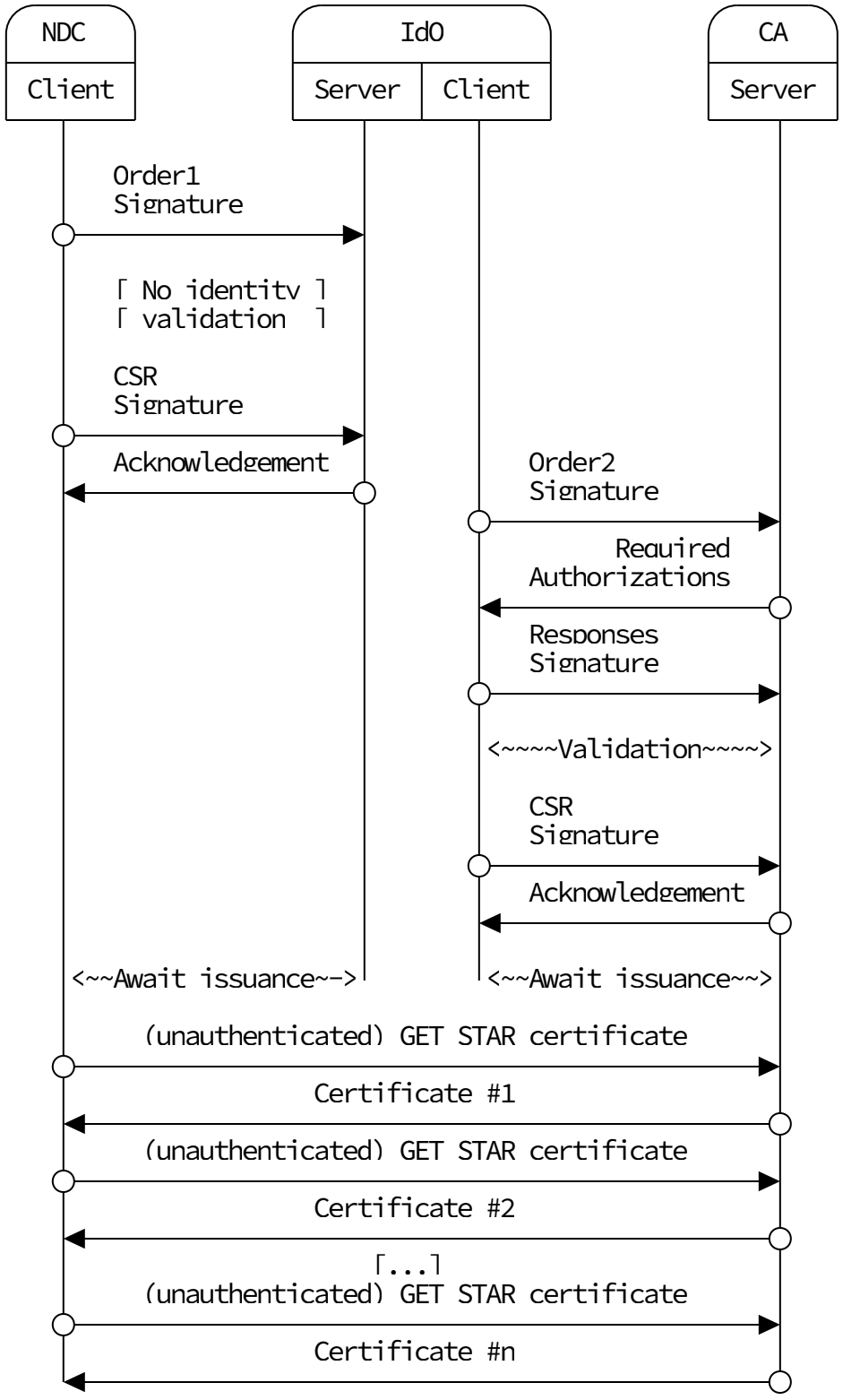


Figure 1: End to end STAR delegation flow

2.3. Delegated Identity Profile

This section defines a profile of the ACME protocol, to be used between the NDC and IdO.

2.3.1. Delegation Configuration

An NDC identifies itself to the IdO as an ACME account. The IdO can delegate multiple names through each NDC, and these configurations are described through delegation objects associated with the NDC's Account object on the IdO. A delegation configuration object contains the CSR template (see Section 3) that applies to that delegation. Its structure is as follows:

*csr-template (required, object): CSR template as defined in Section 3.

An example delegation object is shown in Figure 2.

```
{
  "csr-template": {
    "keyTypes": [
      {
        "PublicKeyType": "ecPublicKey",
        "Curve": "secp521r1",
        "SignatureType": "ecdsa-with-SHA256"
      }
    ],
    "subject": {
      "country": "CA",
      "stateOrProvince": "**",
      "locality": "**",
      "commonName": "**"
    },
    "extensions": {
      "subjectAltName": {
        "DNS": [
          "abc.ndc.dno.example"
        ]
      },
      "keyUsage": [
        "digitalSignature"
      ],
      "extendedKeyUsage": [
        "serverAuth"
      ]
    }
  }
}
```

Figure 2: Example Delegation Configuration object

In order to list all the delegation configuration objects that are associated with the NDC account, a new (read-only) delegations attribute is added to the Account object. The value of this attribute is an array of URLs each pointing to a delegation configuration object as shown in Figure 3.

```
{
  "status": "valid",
  "contact": [
    "mailto:delegation-admin@ido.example"
  ],
  "termsOfServiceAgreed": true,
  "orders": "https://example.com/acme/orders/rzGoeA",
  "delegations": [
    "https://acme.dno.example/acme/acct/ndc/delegations/1",
    "https://acme.dno.example/acme/acct/ndc/delegations/2"
  ]
}
```

Figure 3: Example Account object with delegations

In order to indicate which specific delegation applies to the requested certificate a new delegation attribute is added to the Order object on the NDC-IdO side (see Section 2.3.2). The value of this attribute is the URL pointing to the delegation configuration object that is to be used for this certificate request.

2.3.2. Order Object on the NDC-IdO side

The Order object created by the NDC:

- MUST contain a delegation attribute indicating the configuration used for this request;
- MUST contain identifiers with the new delegated field set to true;
- MUST NOT contain the notBefore and notAfter fields;
- MUST contain an auto-renewal object and inside it, the fields listed in Section 3.1.1 of [RFC8739];
- In case the identifier type is dns, it MAY contain a cname field with the alias of the identifier in the NDC domain. This field is used by the IdO to create the DNS aliasing needed to redirect the resolvers to the delegated entity.

```
POST /acme/new-order HTTP/1.1
Host: acme.dno.example
Content-Type: application/jose+json

{
  "protected": base64url({
    "alg": "ES256",
    "kid": "https://acme.dno.example/acme/acct/evOfKhNU60wg",
    "nonce": "5XJ1L3lEkMG7tR6pA00clA",
    "url": "https://acme.dno.example/acme/new-order"
  }),
  "payload": base64url({
    "identifiers": [
      {
        "type": "dns",
        "value": "abc.ndc.dno.example.",
        "delegated": true,
        "cname": "abc.ndc.example."
      }
    ],
    "auto-renewal": {
      "end-date": "2020-04-20T00:00:00Z",
      "lifetime": 345600,          // 4 days
      "allow-certificate-get": true
    },
    "delegation":
      "https://acme.dno.example/acme/acct/ndc/delegations/2"
  }),
  "signature": "H6ZXtGjTZyUnPeKn...wEA4TklBdh3e454g"
}
```

The Order object that is created on the IdO:

- *MUST start in the ready state;
- *MUST contain an authorizations array with zero elements;
- *MUST NOT contain the notBefore and notAfter fields;
- *MUST contain the indicated delegation configuration.

```
{
  "status": "ready",
  "expires": "2019-05-01T00:00:00Z",

  "identifiers": [
   {
     "type": "dns",
     "value": "abc.ndc.dno.example.",
     "delegated": true,
     "cname": "abc.ndc.example."
   }
  ],

  "auto-renewal": {
    "end-date": "2020-04-20T00:00:00Z",
    "lifetime": 345600,
    "allow-certificate-get": true
  },

  "delegation":
    "https://acme.dno.example/acme/acct/ndc/delegations/2",

  "authorizations": [],

  "finalize": "https://acme.dno.example/acme/order/TO8rfgo/finalize"
}
```

The IdO MUST copy the auto-renewal object from the NDC request into the related STAR request to the ACME CA.

When the validation of the identifiers has been successfully completed and the certificate has been issued by the CA, the IdO:

- *MUST move its Order resource status to valid;
- *MUST copy the star-certificate field from the STAR Order;

The latter indirectly includes (via the NotBefore and NotAfter HTTP headers) the renewal timers needed by the NDC to inform its certificate reload logic.

```
{
  "status": "valid",
  "expires": "2019-05-01T00:00:00Z",

  "identifiers": [
   {
     "type": "dns",
     "value": "abc.ndc.dno.example.",
     "delegated": true,
     "cname": "abc.ndc.example."
   }
  ],

  "auto-renewal": {
    "end-date": "2020-04-20T00:00:00Z",
    "lifetime": 345600,
    "allow-certificate-get": true
  },

  "delegation":
    "https://acme.dno.example/acme/acct/ndc/delegations/2",

  "authorizations": [],

  "finalize": "https://acme.dno.example/acme/order/TO8rfgo/finalize",

  "star-certificate": "https://acme.ca.example/acme/order/yTr23sSDg9"
}
```

If an identifier attribute of type dns was included, the IdO MUST validate the specified CNAME at this point in the flow. At the minimum, the IdO MUST verify that both DNS names are syntactically valid, to prevent a malicious NDC from injecting arbitrary data into a DNS zone file.

Following this validation, the IdO can add the CNAME records to its zone:

```
abc.ndc.dno.example. CNAME abc.ndc.example.
```

2.3.3. Order Object on the IdO-CA side

When sending the Order to the ACME CA, the IdO SHOULD strip the delegated and cname attributes sent by the NDC (Section 2.3.2). The IdO MUST add the necessary STAR extensions to the Order. In addition, to allow the NDC to download the certificate using unauthenticated GET, the IdO MUST add the auto-renewal object and inside it, include the allow-certificate-get attribute and set it to true.

2.3.4. Capability Discovery

In order to help a client to discover support for this profile, the directory object of an ACME server MUST contain the following attribute in the meta field:

- delegation-enabled: boolean flag indicating support for the profile specified in this memo. An ACME server that supports this delegation profile MUST include this key, and MUST set it to true.

The delegation-enabled flag may be specified regardless of the existence or setting of the auto-renewal flag.

2.3.5. On Cancellation

It is worth noting that cancellation of the ACME STAR certificate is a prerogative of the IdO. The NDC does not own the relevant account key on the ACME CA, therefore it can't issue a cancellation request for the STAR cert. Potentially, since it holds the STAR certificate's private key, it could request the revocation of a single STAR certificate. However, STAR explicitly disables the revokeCert interface.

2.4. Delegation of Non-STAR Certificates

The mechanism defined here can be used to delegate regular ACME certificates whose expiry is not "short term".

To allow delegation of non-STAR certificates, this document allows use of allow-certificate-get directly in the Order object and independently of the auto-renewal object, so that the NDC can fetch the certificate without having to authenticate into the ACME server.

The following differences exist between STAR and non-STAR certificate delegation:

- With STAR certificates, the star-certificate field is copied by the IdO; with non-STAR certificates, the certificate field is copied.
- The auto-renewal object is not used (either in the request or response) for non-STAR certificates. The field allow-certificate-get MUST be included in the order object, and its value MUST be true.
- The notBefore and notAfter order fields are omitted only in STAR certificates.

When delegating a non-STAR certificate, standard certificate revocation still applies. The ACME certificate revocation endpoint is explicitly unavailable for STAR certificates but it is available

for all other certificates. We note that according to Sec. 7.6 of [RFC8555], the revocation endpoint can be used with either the account keypair, or the certificate keypair. In other words, the NDC would be able to revoke the certificate. The authors believe that this is a very minor security risk.

2.5. Proxy Behavior

There are cases where the ACME Delegation flow should be proxied, such as the use case described in Section 4.1.2. This section describes the behavior of such proxies.

An ACME Delegation server can decide, on a per-identity case, whether to act as a proxy into another ACME Delegation server, or to behave as an IdO and obtain a certificate directly. The determining factor is whether the server can successfully be authorized by the ACME Server for the identity associated with the certificate request.

The identities supported by each server and the disposition for each of them are preconfigured.

Following is the proxy's behavior for each of the messages exchanged in the ACME Delegation process:

* New-order request:
  - The complete identifiers object MUST be copied as-is.
  - Similarly, the auto-renewal object MUST be copied as-is.
* New-order response:
  - The status, expires, authorizations, identifiers and auto-renewal attributes/objects MUST be copied as-is.
  - The finalize URL is rewritten, so that the finalize request will be made to the proxy.
  - Similarly, the Location header is rewritten.
* Get Order response:
  - The status, expires, authorizations, identifiers and auto-renewal attributes/objects MUST be copied as-is.
  - Similarly, the star-certificate URL MUST be copied as-is.
  - The finalize URL is rewritten, so that the finalize request will be made to the proxy.
  - The Location header must be rewritten.
* Finalize request:
  - The CSR MUST be copied as-is.
* Finalize response:
  - Both the Location header and the finalize URLs are rewritten.

We note that all the above messages are authenticated, and therefore each proxy must be able to authenticate any subordinate server.

3. CSR Template

The CSR template is used to express and constrain the shape of the CSR that the NDC uses to request the certificate. The CSR is used for every certificate created under the same delegation. Its validation by the IdO is a critical element in the security of the whole delegation mechanism.

Instead of defining every possible CSR attribute, this document takes a minimalist approach by declaring only the minimum attribute set and deferring the registration of further, more specific, attributes to future documents.

3.1. Template Syntax

The template is a JSON document. Each field denotes one of:

* A mandatory field, where the template specifies the literal value of that field. This is denoted by a literal string, such as client1.ndc.dno.example.com.
* A mandatory field, where the content of the field is defined by the client. This is denoted by **.
* An optional field, where the client decides whether the field is included in the CSR and what its value is. This is denoted by *.

The NDC MUST NOT include in the CSR any fields that are not specified in the template, and in particular MUST NOT add any extensions unless those were previously negotiated out of band with the IdO.

The mapping between X.509 CSR fields and the template will be defined in a future revision of this document.

When the CSR is received by the IdO, it MUST verify that the CSR is consistent with the template that the IdO sent earlier. The IdO MAY enforce additional constraints, e.g. by restricting field lengths.

3.2. Example

The CSR template in Figure 4 represents one possible CSR template governing the delegation exchanges provided in the rest of this document.

```
{
  "keyTypes": [
    {
      "PublicKeyType": "RSA",
      "PublicKeyLength": 4096,
      "SignatureType": "sha256WithRSAEncryption"
    }
  ],
  "subject": {
    "country": "CA",
    "stateOrProvince": "**",
    "locality": "**",
    "commonName": "**"
  },
  "extensions": {
    "subjectAltName": {
      "DNS": [
        "client1.ndc.dno.example"
      ],
      "IP": [
        "1.2.3.4",
        "13::17"
      ]
    },
    "keyUsage": [
      "digitalSignature"
    ],
    "extendedKeyUsage": [
      "serverAuth",
      "timeStamping"
    ]
  }
}
```

Figure 4: Example CSR template

The template syntax is defined in Appendix B.

4. Further Use Cases

4.1. CDNI

[I-D.ietf-cdni-interfaces-https-delegation] discusses several solutions addressing different delegation requirements for the CDNI (CDN Interconnection) environment. This section discusses two of the stated requirements in the context of the STAR delegation workflow.

4.1.1. Multiple Parallel Delegates

In some cases the content owner (IdO) would like to delegate authority over a web site to multiple NDCs (CDNs). This could happen if the IdO has agreements in place with different regional CDNs for different geographical regions, or if a "backup" CDN is used to handle overflow traffic by temporarily altering some of the CNAME mappings in place. The STAR delegation flow enables this use case naturally, since each CDN can authenticate separately to the IdO (via its own separate account) specifying its CSR, and the IdO is free to allow or deny each certificate request according to its own policy.

4.1.2. Chained Delegation

In other cases, a content owner (IdO) delegates some domains to a large CDN (uCDN), which in turn delegates to a smaller regional CDN, dCDN. The DNO has a contractual relationship with uCDN, and uCDN has a similar relationship with dCDN. However IdO may not even know about dCDN.

If needed, the STAR protocol can be chained to support this use case: uCDN could forward requests from dCDN to DNO, and forward responses back to dCDN. Whether such proxying is allowed is governed by policy and contracts between the parties.

A mechanism is necessary at the interface between uCDN and dCDN by which the uCDN can advertise:

* The namespace that is made available to the dCDN to mint its delegated names;
* The policy for creating the key material (allowed algorithms, minimum key lengths, key usage, etc.) that the dCDN needs to satisfy.

Note that such mechanism is provided by the CSR template.

4.1.2.1. Two-Level Delegation in CDNI

A User Agent (browser or set-top-box) wants to fetch the video resource at the following URI: https://video.cp.example/movie. Redirection between Content Provider, upstream, and downstream CDNs is arranged as a CNAME-based aliasing chain as illustrated in Figure 5.

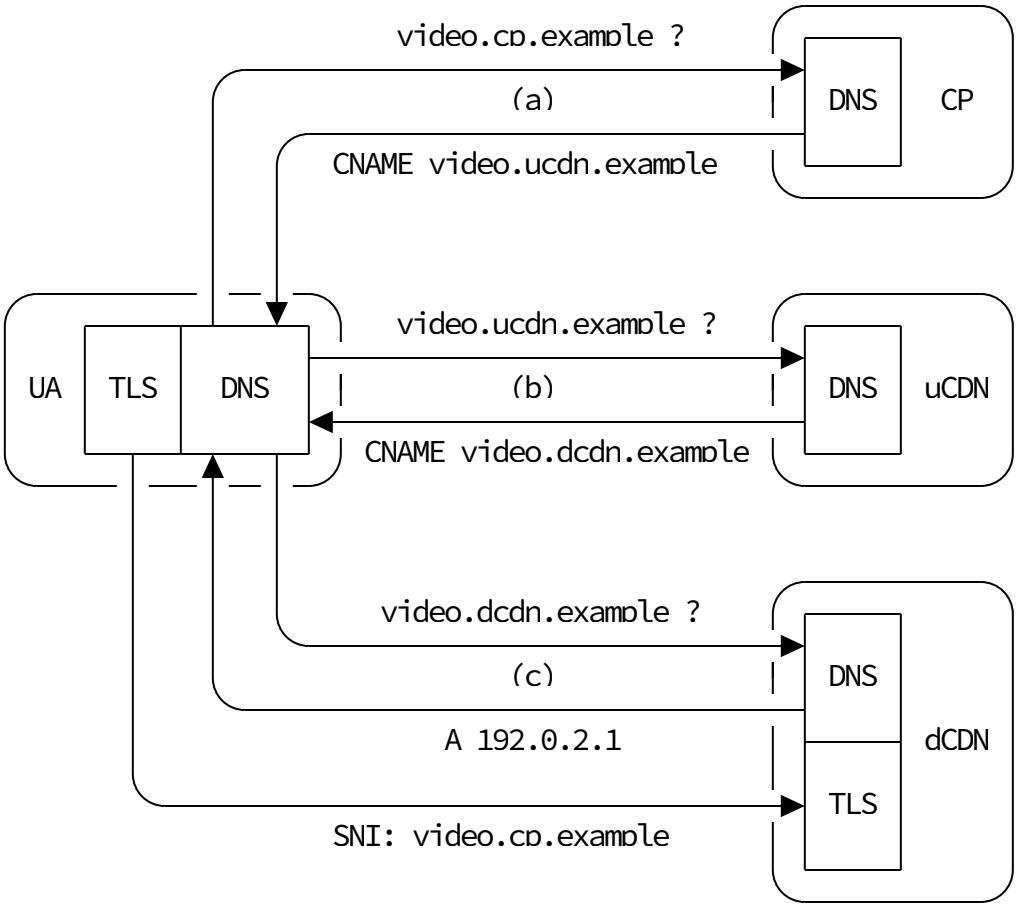


Figure 5: DNS Redirection

Unlike HTTP based redirection, where the original URL is supplanted by the one found in the Location header of the 302 response, DNS redirection is completely transparent to the User Agent. As a result, the TLS connection to the dCDN edge is done with an SNI equal to the host in the original URI - in the example, video.cp.example. So, in order to successfully complete the handshake, the landing dCDN node has to be configured with a certificate whose SAN matches video.cp.example, i.e., a Content Provider's name.

Figure 6 illustrates the cascaded delegation flow that allows dCDN to obtain a STAR certificate that bears a name belonging to the Content Provider with a private key that is only known to the dCDN.

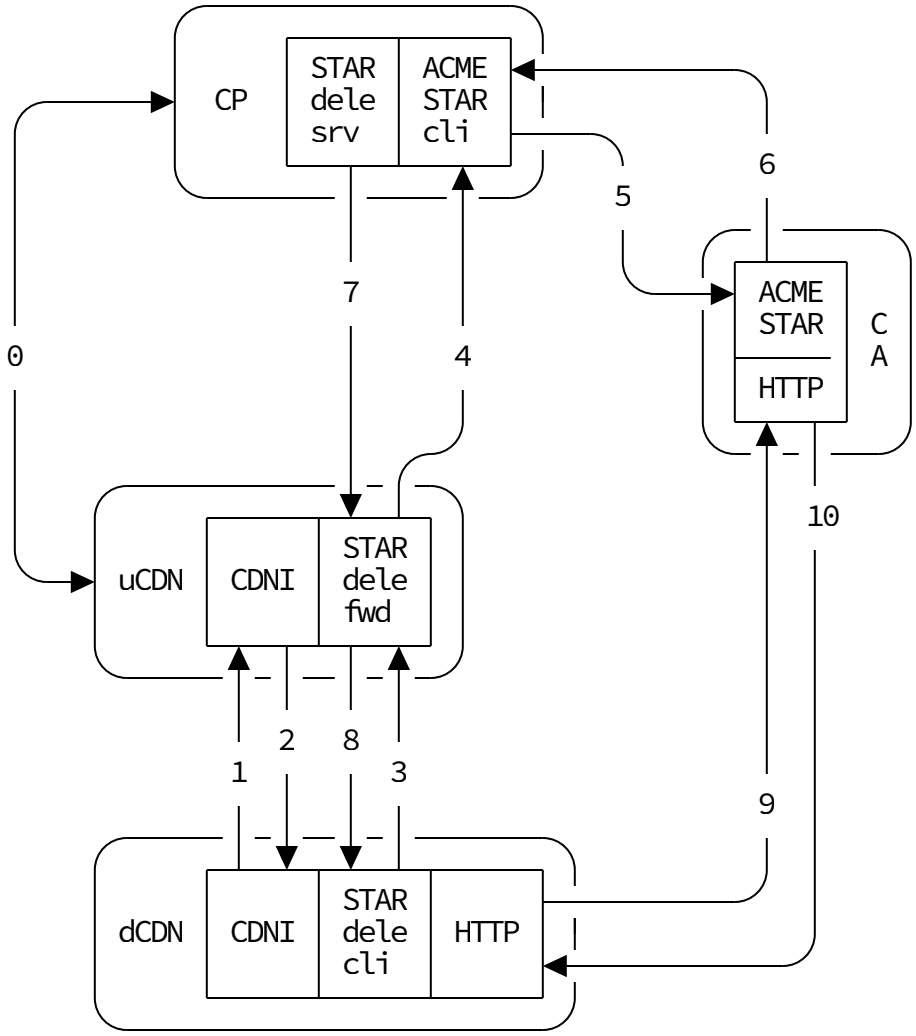


Figure 6: Two levels delegation in CDNI

TBD bootstrap, see https://github.com/yaronf/I-D/issues/47

1. dCDN requests CDNI path metadata to uCDN;
2. uCDN replies with, among other CDNI things, the STAR delegation configuration, which includes the delegated Content Provider's name;
3. dCDN creates a key-pair and the CSR with the delegated name. It then places an order for the delegated name to uCDN;
4. uCDN forwards the received order to the Content Provider (CP);
5. CP creates an order for a STAR certificate and sends it to the ACME CA. The order also requests unauthenticated access to the certificate resource;
6. After all authorizations complete successfully, the STAR certificate is issued;
7. CP notifies uCDN that the STAR cert is available at the order's star-certificate URL;

8. uCDN forwards the information to dCDN. At this point the ACME signalling is complete;
9. dCDN requests the STAR cert using unauthenticated GET from the ACME CA;
10. the CA returns the certificate. Now dCDN is fully configured to handle HTTPS traffic in-lieu of the Content Provider.

Note that 9. and 10. repeat until the delegation expires or is terminated.

4.2. STIR

As a second use case, we consider the delegation of credentials in the STIR ecosystem [I-D.ietf-stir-cert-delegation].

In the STIR delegated mode, a service provider SP2 - the NDC - needs to sign PASSPorT's [RFC8225] for telephone numbers (e.g., TN=+123) belonging to another service provider, SP1 - the IdO. In order to do that, SP2 needs a STIR certificate, and private key, that includes TN=+123 in the TNAuthList [RFC8226] cert extension.

In details (Figure 7):

1. SP1 and SP2 agree on the configuration of the delegation - in particular, the CSR template that applies;
2. SP2 generates a private/public key-pair and sends a CSR to SP1 requesting creation of a certificate with: SP1 name, SP2 public key, and a TNAuthList extension with the list of TNs that SP1 delegates to SP2. (Note that the CSR sent by SP2 to SP1 needs to be validated against the CSR template agreed upon in step 1.);
3. SP1 sends an Order for the CSR to the ACME STAR CA;
4. Subsequently, after the required TNAuthList authorizations are successfully completed, the ACME STAR CA moves the Order to a "valid" state; at the same time the star-certificate endpoint is populated.
5. The Order contents are forwarded from SP1 to SP2 by means of the paired "delegation" Order.
6. SP2 dereferences the star-certificate URL in the Order to fetch the rolling STAR certificate bearing the delegated identifiers.

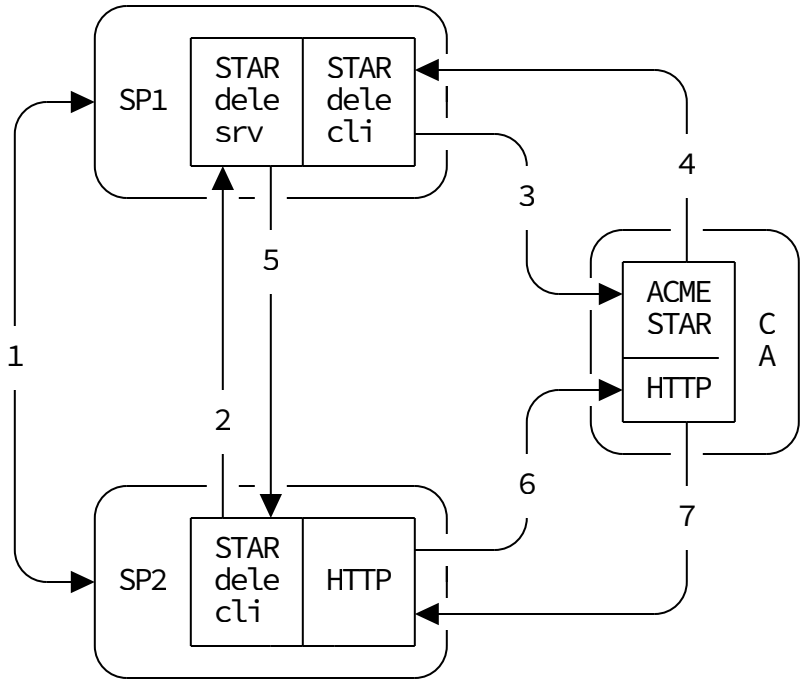


Figure 7: Delegation in STIR

As shown, the STAR delegation profile described in this document applies straightforwardly, the only extra requirement being the ability to instruct the NDC about the allowed TNAuthList values. This can be achieved by a simple extension to the CSR template.

5. IANA Considerations

[[RFC Editor: please replace XXXX below by the RFC number.]]

5.1. New Fields in the "meta" Object within a Directory Object

This document adds the following entries to the ACME Directory Metadata Fields:

Field Name	Field Type	Reference
delegation-enabled	boolean	RFC XXXX

Table 1

5.2. New Fields in the Order Object

This document adds the following entries to the ACME Order Object Fields:

Field Name	Field Type	Configurable	Reference
allow-certificate-get	boolean	true	RFC XXXX
delegation	string	true	RFC XXXX

Table 2

Note that the delegation field is only meaningful in interactions with ACME servers that have delegation-enabled set to true in their meta Object.

5.3. New Fields in the Account Object

This document adds the following entries to the ACME Account Object Fields:

Field Name	Field Type	Requests	Reference
delegations	array of strings	none	RFC XXXX

Table 3

Note that the delegations field is only reported by ACME servers that have delegation-enabled set to true in their meta Object.

5.4. New Fields for Identifiers

This document adds the following entries to each element of the ACME identifiers array of objects:

Field Name	Field Type
delegated	boolean
cname	string

Table 4

We note that [RFC8555] does not define a registry for these objects.

5.5. CSR Template Extensions

IANA is requested to establish a registry "STAR Delegation CSR Template Extensions", with "Expert Review" as its registration procedure.

Each extension registered must specify:

*An extension name
*An extension syntax, as a JSON Schema snippet that defines a type
*Mapping into an X.509 certificate extension.

The initial contents of this registry are the extensions defined by the JSON Schema document in Appendix B.

Extension Name	Type	Mapping to X.509
keyUsage	See Appendix B	[RFC5280], Sec. 4.2.1.3
extendedKeyUsage	See Appendix B	[RFC5280], Sec. 4.2.1.12

Extension Name	Type	Mapping to X.509
subjectAltName	See Appendix B	[RFC5280], Sec. 4.2.1.6 (only for the supported name formats)

Table 5

6. Security Considerations

6.1. Trust Model

The ACME trust model needs to be extended to include the trust relationship between NDC and IdO. Note that once this trust link is established, it potentially becomes recursive. Therefore, there has to be a trust relationship between each of the nodes in the delegation chain; for example, in case of cascading CDNs this is contractually defined. Note that using standard [RFC6125] identity verification there are no mechanisms available to the IdO to restrict the use of the delegated name once the name has been handed over to the first NDC.

6.2. Delegation Security Goal

Delegation introduces a new security goal: only an NDC that has been authorised by the IdO, either directly or transitively, can obtain a cert with an IdO identity.

From a security point of view, the delegation process has two separate parts:

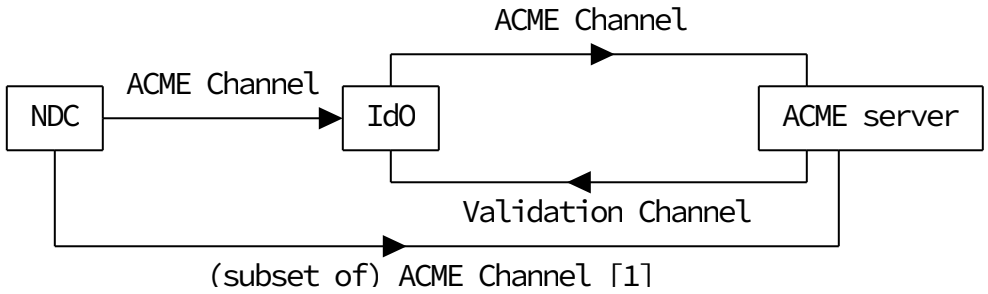
1. Enabling a specific third party (the intended NDC) to submit requests for delegated certificates;
2. Making sure that any request for a delegated certificate matches the intended "shape" in terms of delegated identities as well as any other certificate metadata, e.g., key length, x.509 extensions, etc.

The first part is covered by the NDC's ACME account that is administered by the IdO, whose security relies on the correct handling of the associated key pair. When a compromise of the private key is detected, the delegate MUST use the account deactivation procedures defined in Section 7.3.6 of [RFC8555].

The second part is covered by the act of checking an NDC's certificate request against the intended CSR template. The steps of shaping the CSR template correctly, selecting the right CSR template to check against the presented CSR, and making sure that the presented CSR matches the selected CSR template are all security relevant.

6.3. New ACME Channels

Using the model established in Section 10.1 of [RFC8555], we can decompose the interactions of the basic delegation workflow as shown in Figure 8.



[1] Unauthenticated certificate fetch and non-STAR certificate revocation.

Figure 8: Delegation Channels Topology

The considerations regarding the security of the ACME Channel and Validation Channel discussed in [RFC8555] apply verbatim to the IdO/ACME server leg. The same can be said for the ACME channel on the NDC/IdO leg. A slightly different set of considerations apply to the ACME Channel between NDC and ACME server, which consists of a subset of the ACME interface comprising two API endpoints: the unauthenticated certificate retrieval and, potentially, non-STAR revocation via certificate private key. No specific security considerations apply to the former, but the privacy considerations in Section 6.3 of [RFC8739] do. With regards to the latter, it should be noted that there is currently no means for an IdO to disable authorising revocation based on certificate private keys. So, in theory, an NDC could use the revocation API directly with the ACME server, therefore bypassing the IdO. The NDC SHOULD NOT directly use the revocation interface exposed by the ACME server unless failing to do so would compromise the overall security, for example if the certificate private key is compromised and the IdO is not currently reachable.

All other security considerations from [RFC8555] and [RFC8739] apply as-is to the delegation topology.

6.4. Restricting CDNs to the Delegation Mechanism

When a web site is delegated to a CDN, the CDN can in principle modify the web site at will, create and remove pages. This means that a malicious or breached CDN can pass the ACME (as well as

common non-ACME) HTTPS-based validation challenges and generate a certificate for the site. This is true regardless of whether the CNAME mechanisms defined in the current document is used or not.

In some cases, this is the desired behavior: the domain owner trusts the CDN to have full control of the cryptographic credentials for the site. The current document however assumes that the domain owner only wants to delegate restricted control, and wishes to retain the capability to cancel the CDN's credentials at a short notice.

Following is the proposed solution where the IdO wishes to ensure that a rogue CDN cannot issue unauthorized certificates:

* The domain owner makes sure that the CDN cannot modify the DNS records for the domain. The domain owner should ensure it is the only entity authorized to modify the DNS zone. Typically, it establishes a CNAME resource record from a subdomain into a CDN-managed domain.
* The domain owner uses a CAA record [RFC6844] to restrict certificate issuance for the domain to specific CAs that comply with ACME and are known to implement [RFC8657].
* The domain owner uses the ACME-specific CAA mechanism [RFC8657] to restrict issuance to a specific account key which is controlled by it, and MUST require "dns-01" as the sole validation method.

We note that the above solution may need to be tweaked depending on the exact capabilities and authorisation flows supported by the selected CAs.

7. Acknowledgments

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8. References

8.1. Normative References

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Appendix A. Document History

[[Note to RFC Editor: please remove before publication.]]

A.1. draft-ietf-acme-star-delegation-04

- Delegation of non-STAR certificates.
- More IANA clarity, specifically on certificate extensions.
- Add delegation configuration object and extend account and order objects accordingly.
- A lot more depth on Security Considerations.

A.2. draft-ietf-acme-star-delegation-03

- Consistency with the latest changes in the base ACME STAR document, e.g. star-delegation-enabled capability renamed and moved.
- Proxy use cases (recursive delegation) and the definition of proxy behavior.
- More detailed analysis of the CDNI and STIR use cases, including sequence diagrams.

A.3. draft-ietf-acme-star-delegation-02

- Security considerations: review by Ryan Sleevi.

*CSR template simplified: instead of being a JSON Schema document itself, it is now a simple JSON document which validates to a JSON Schema.

A.4. draft-ietf-acme-star-delegation-01

*Refinement of the CDNI use case.
*Addition of the CSR template (partial, more work required).
*Further security considerations (work in progress).

A.5. draft-ietf-acme-star-delegation-00

*Republished as a working group draft.

A.6. draft-sheffer-acme-star-delegation-01

*Added security considerations about disallowing CDNs from issuing certificates for a delegated domain.

A.7. draft-sheffer-acme-star-delegation-00

*Initial version, some text extracted from draft-sheffer-acme-star-requests-02

Appendix B. CSR Template Schema

Following is a JSON Schema definition of the CSR template. The syntax used is that of draft 7 of JSON Schema, which may not be the latest version of the corresponding Internet Draft [I-D.handrews-json-schema] at the time of publication.

While the CSR template must follow the syntax defined here, neither the IdO nor the NDC are expected to validate it at run-time.

```
{
  "title": "JSON Schema for the STAR Delegation CSR template",
  "$schema": "http://json-schema.org/draft-07/schema#",
  "$id": "http://ietf.org/acme/drafts/star-delegation/csr-template",
  "$def": {
    "distinguished-name": {
      "$id": "#distinguished-name",
      "type": "object",
      "properties": {
        "country": {
          "type": "string"
        },
        "stateOrProvince": {
          "type": "string"
        },
        "locality": {
          "type": "string"
        },
        "organization": {
          "type": "string"
        },
        "organizationalUnit": {
          "type": "string"
        },
        "emailAddress": {
          "type": "string"
        },
        "commonName": {
          "type": "string"
        }
      },
      "additionalProperties": false
    },
    "rsaKeyType": {
      "$id": "#rsaKeyType",
      "type": "object",
      "properties": {
        "PublicKeyType": {
          "type": "string",
          "const": "RSA"
        },
        "PublicKeyLength": {
          "type": "integer"
        },
        "SignatureType": {
          "type": "string",
          "enum": [
            "sha256WithRSAEncryption"
          ]
```

```
      }
    },
    "additionalProperties": false
  },
  "ecKeyTYpe": {
    "$id": "#ecKeyType",
    "type": "object",
    "properties": {
      "PublicKeyType": {
        "type": "string",
        "const": "ecPublicKey"
      },
      "Curve": {
        "type": "string",
        "enum": [
          "secp521r1"
        ]
      },
      "SignatureType": {
        "type": "string",
        "enum": [
          "ecdsa-with-SHA256"
        ]
      }
    },
    "additionalProperties": false
  }
},
"type": "object",
"properties": {
  "keyTypes": {
    "type": "array",
    "items": {
      "oneOf": [
        {
          "$ref": "#rsaKeyType"
        },
        {
          "$ref": "#ecKeyType"
        }
      ]
    }
  },
  "subject": {
    "$ref": "#distinguished-name"
  },
  "extensions": {
    "type": "object",
    "properties": {
```

```
"keyUsage": {
  "type": "array",
  "items": {
    "type": "string",
    "enum": [
      "digitalSignature",
      "nonRepudiation",
      "keyEncipherment",
      "dataEncipherment",
      "keyAgreement",
      "keyCertSign",
      "cRLSign",
      "encipherOnly",
      "decipherOnly"
    ]
  }
},
"extendedKeyUsage": {
  "type": "array",
  "items": {
    "type": "string",
    "enum": [
      "serverAuth",
      "clientAuth",
      "codeSigning",
      "emailProtection",
      "timeStamping",
      "OCSPSigning"
    ]
  }
},
"subjectAltName": {
  "type": "object",
  "properties": {
    "DNS": {
      "type": "array",
      "items": {
        "type": "string",
        "format": "hostname"
      }
    },
    "IP": {
      "type": "array",
      "items": {
        "oneOf": [
          {
            "type": "string",
            "format": "ipv4"
          },
```

```
                {
                  "type": "string",
                  "format": "ipv6"
                }
              ]
            }
          },
          "Email": {
            "type": "array",
            "items": {
              "type": "string",
              "format": "email"
            }
          }
        },
        "additionalProperties": false
      }
    },
    "additionalProperties": false
  }
},
"additionalProperties": false
}
```

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