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Use of Short-Term, Automatically-Renewed (STAR) Certificates to Delegate Authority over Web Sites

draft-sheffer-acme-star-02

Abstract

This memo proposes two mechanisms that work in concert to allow a third party (e.g., a content delivery network) to terminate TLS sessions on behalf of a domain name owner (e.g., a content provider).

The proposed mechanisms are:

1. An extension to the ACME protocol to enable the issuance of short-term and automatically renewed certificates, and
2. A protocol that allows a domain name owner to delegate to a third party control over a certificate that bears one or more names in that domain.

It should be noted that these are in fact independent building blocks that can be used separately to solve completely different problems.

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 November 28, 2017.

Table of Contents

1. Introduction: A Solution for the HTTPS CDN Use Case

A content provider (referred to in this document as Domain Name Owner, DNO) has agreements in place with one or more Content Delivery Networks (CDNs) that are contracted to serve its content over HTTPS. The CDN terminates the HTTPS connection at one of its edge cache servers and needs to present its clients (browsers, set-top-boxes) a certificate whose name matches the authority of the URL that is requested, i.e. that of the DNO. However, many DNOs balk at sharing their long-term private keys with another organization and, equally, CDN providers would rather not have to handle other parties' long-term secrets. This problem has been discussed at the IETF under the LURK (limited use of remote keys) title.

This document proposes a solution to the above problem that involves the use of short-term certificates with a DNO's name on them, and a scheme for handling the naming delegation from the DNO to the CDN. The generated short-term credentials are automatically renewed by an ACME Certification Authority (CA) [I-D.ietf-acme-acme] and routinely rotated by the CDN on its edge cache servers. The DNO can end the delegation at any time by simply instructing the CA to stop the automatic renewal and let the certificate expire shortly thereafter.

Using short-term certificates makes revocation cheap and effective [Topalovic] [I-D.iab-web-pki-problems] in case of key compromise or of termination of the delegation; seamless certificate issuance and renewal enable the level of workflow automation that is expected in today's cloud environments. Also, compared to other keyless-TLS solutions [I-D.cairns-tls-session-key-interface] [I-D.erb-lurk-rsalg], the proposed approach doesn't suffer from scalability issues or increase in connection setup latency, while requiring virtually no changes to existing COTS caching software used by the CDN.

1.1. Cloud Use Case

A similar use case is that of cloud infrastructure components, such as load balancers and Web Application Firewalls (WAF). These components are typically provisioned with the DNO's certificate, and similarly to the CDN use case, many organizations would prefer to

manage the private key only on their own cloud-based or on-premise hosts, often on Hardware Security Modules (HSMs).

Here again, the STAR solution allows the DNO to delegate authority over the domain to the cloud provider, with the ability to revoke this authority at any time.

1.2. Terminology

DNO Domain Name Owner, the owner of a domain that needs to be delegated.
NDC Name Delegation Consumer, the entity to which the domain name is delegated for a limited time. This is often a CDN (in fact, readers may note the similarity 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.

1.3. 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 [RFC2119].

2. Protocol Flow

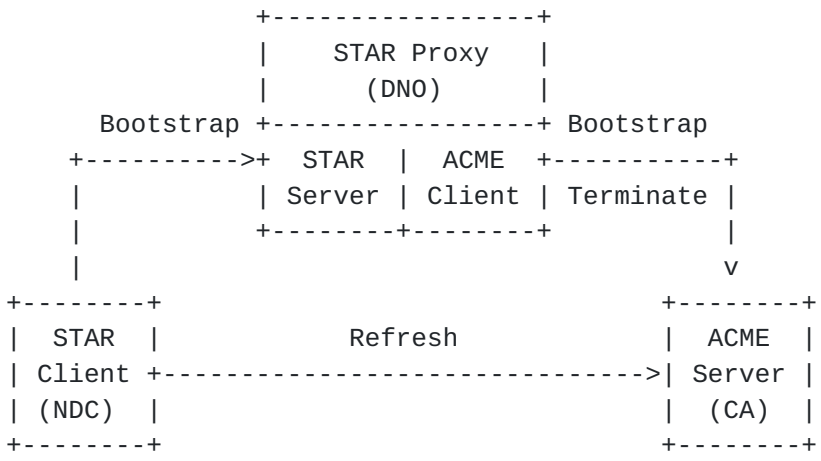
The protocol flow can be split into two: a STAR interface, used by NDC and DNO to agree on the name delegation, and the extended ACME interface, used by DNO to obtain the short-term and automatically renewed certificate from the CA, which is eventually consumed by the NDC. The latter is also used to terminate the delegation, if so needed.

The following subsections describe the preconditions (Section 2.1), and the three main phases of the protocol:

- Bootstrap: the NDC requests from the DNO the delegation of a specific name and in turn DNO asks an ACME CA to create the corresponding short-term and auto-renewed (STAR) certificate (Section 2.2);
- Auto-renewal: the ACME CA periodically re-issues the short-term certificate and posts it to a public URL (Section 2.3);

- Termination: the DNO (indirectly) stops name delegation by explicitly requesting the ACME CA to discontinue the automatic renewal of the certificate (Section 2.4).

This diagram presents the entities involved in the protocol and their interactions during the different phases.



2.1. Preconditions

The protocol assumes the following preconditions are met:

- A mutually authenticated channel between NDC and DNO pre-exists. This is called "STAR channel" and all STAR protocol exchanges between NDC and DNO are run over it. It provides the guarantee that requests and responses are authentic.
- NDC and DNO have agreed on a "CSR template" to use, including at a minimum:

  - Subject name (e.g., "somesite.example.com"),
  - Validity (e.g., 24 to 72 hours),
  - Requested algorithms,
  - Key length,
  - Key usage.

  The NDC is required to use this template for every CSR created under the same delegation.
- DNO has registered through the ACME interface exposed by the Certificate Authority (CA) using the usual ACME registration procedure. In ACME terms, the DNO has an Account on the server and is ready to issue Orders.

2.2. Bootstrap

The NDC (STAR Client) generates a key-pair, wraps it into a Certificate Signing Request (CSR) according to the agreed upon CSR template, and sends it to the DNO (STAR Proxy) over the pre-established STAR channel. The DNO uses the NDC identity provided on the STAR channel to look up the CSR template that applies to the requesting NDC and decides whether or not to accept the request. Assuming everything is in order, it then "forwards" the NDC request to the ACME CA by means of the usual ACME application procedure. Specifically, the DNO, in its role as an ACME client, requests the CA to issue a STAR certificate, i.e., one that:

- Has a short validity (e.g., 24 to 72 hours);
- Is automatically renewed by the CA for a certain period of time;
- Is downloadable from a (highly available) public link without requiring any special authorization.

Other than that, the ACME protocol flows as normal between DNO and CA, in particular DNO is responsible for satisfying the requested ACME challenges until the CA is willing to issue the requested certificate. Per normal ACME processing, the DNO is given back an Order ID for the issued STAR certificate to be used in subsequent interaction with the CA (e.g., if the certificate needs to be terminated.)

Concurrently, a response is sent back to the NDC with an endpoint to poll for completion of the certificate generation process.

The bootstrap phase ends when the DNO obtains the OK from the ACME CA and posts the certificate's URL to the "completion endpoint" where the NDC can retrieve it.

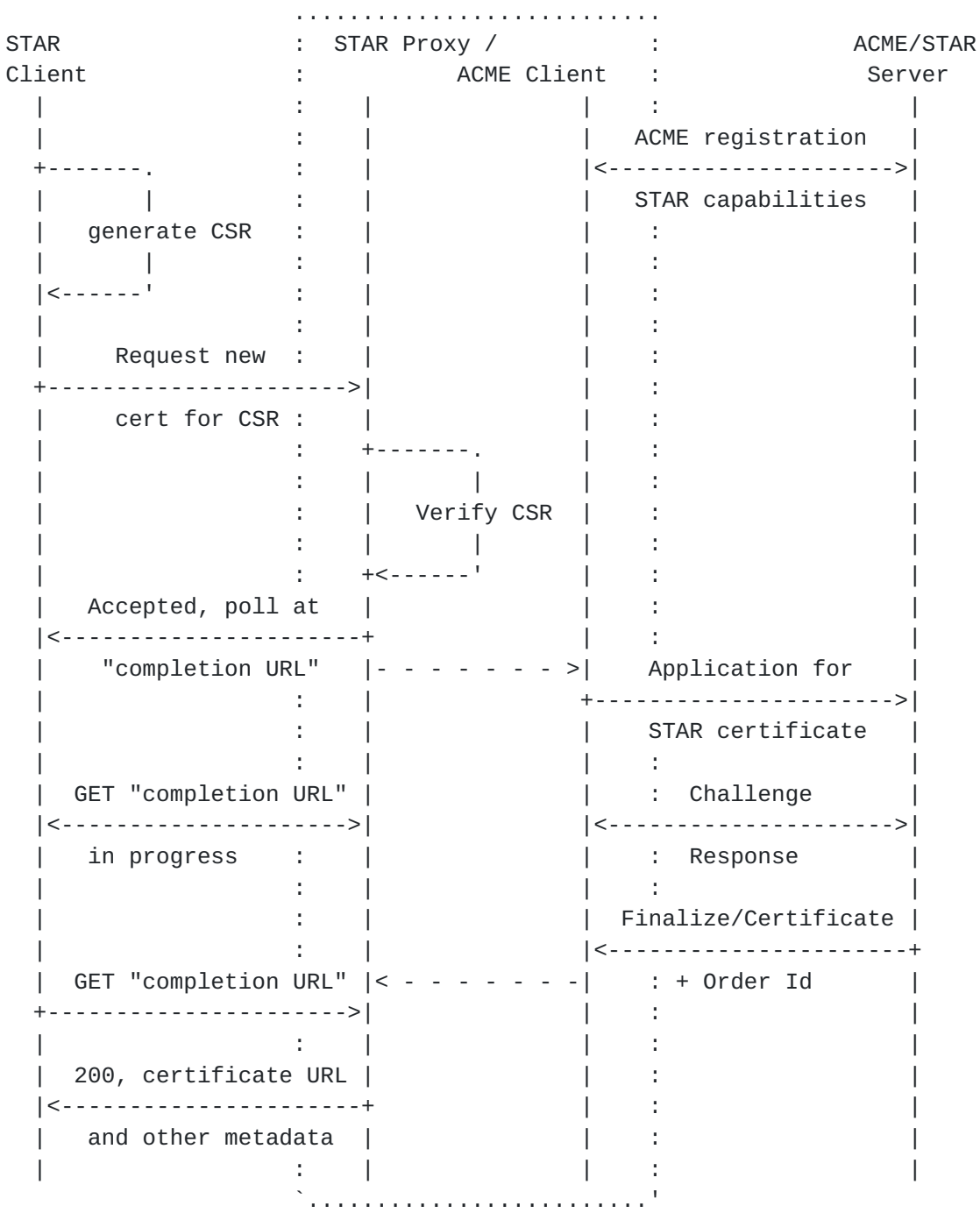


Figure 1: Bootstrap

2.3. Refresh

The CA automatically re-issues the certificate (using the same CSR) before it expires and publishes it to the URL that the NDC has come to know at the end of the bootstrap phase. The NDC downloads and installs it. This process goes on until either:

- DNO terminates the delegation, or
- Automatic renewal expires.

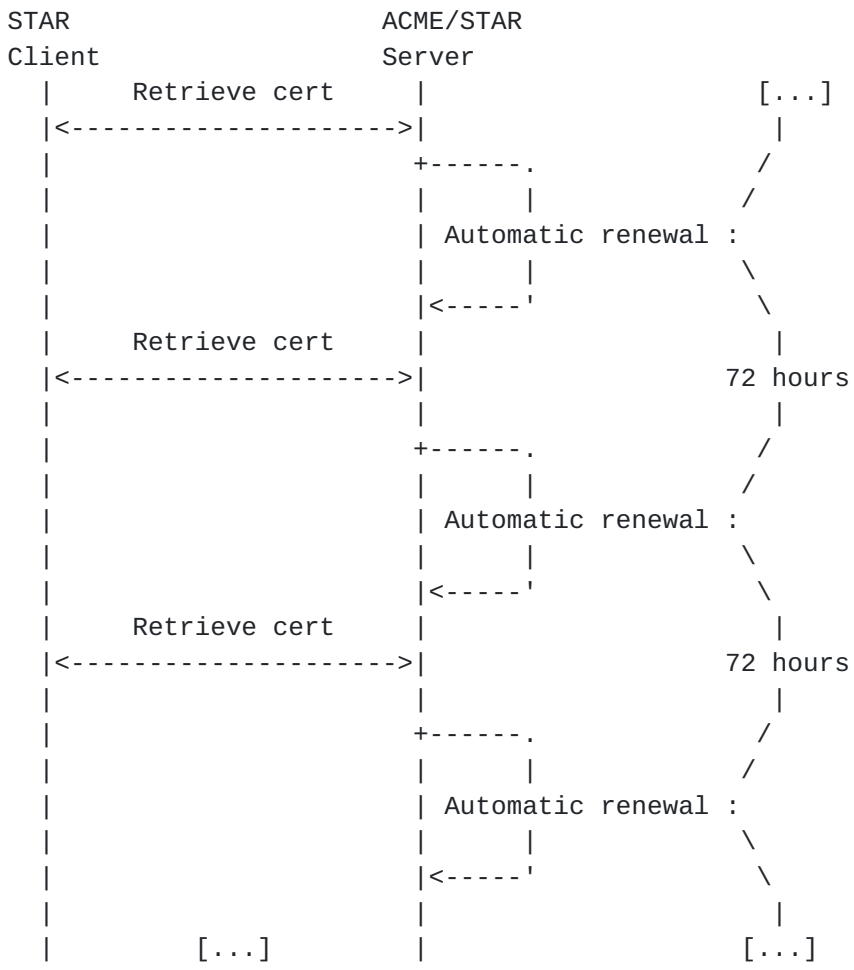


Figure 2: Auto renewal

2.4. Termination

The DNO may request early termination of the STAR certificate by including the Order ID in a certificate termination request to the ACME interface, defined below. After the CA receives and verifies the request, it shall:

- Cancel the automatic renewal process for the STAR certificate;
- Change the certificate publication resource to return an error indicating the termination of the delegation to external clients, including the NDC.

Note that it is not necessary to explicitly revoke the short-term certificate.

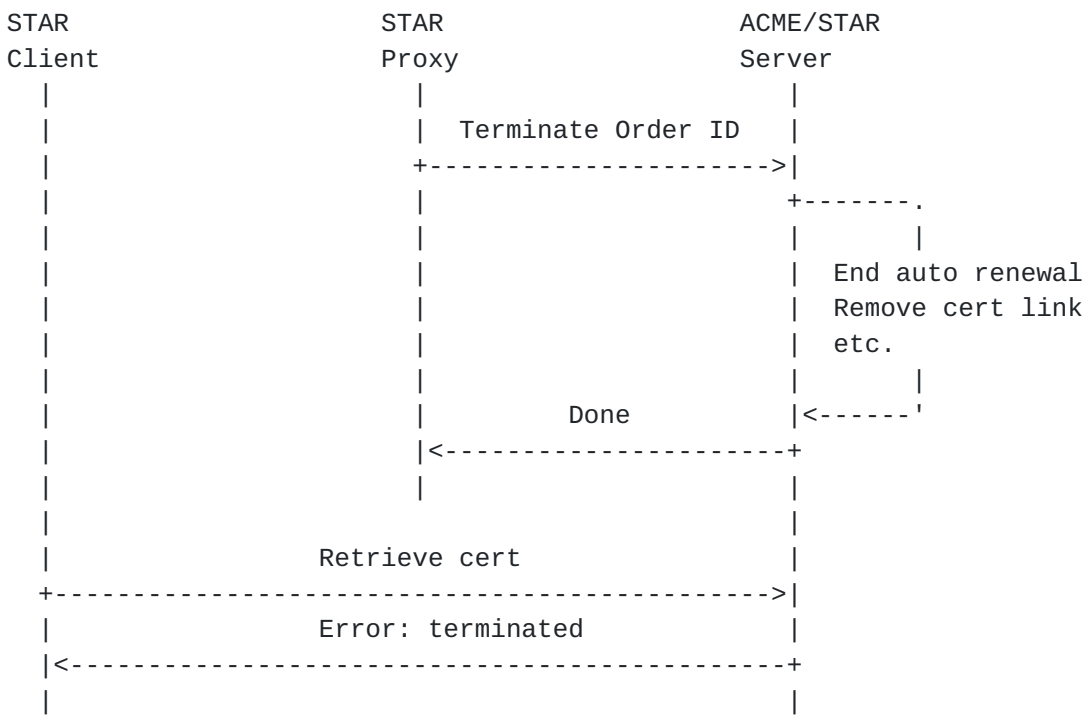


Figure 3: Termination

3. Protocol Details

This section describes the protocol's details. We start with the STAR API between the STAR Client and the STAR Proxy. Then we describe a few extensions to the ACME protocol running between the STAR Proxy and the ACME Server.

3.1. STAR API

This API allows the STAR Client to request a STAR certificate via the STAR Proxy, using a previously agreed-upon CSR template.

The API consists of a single resource, "registration". A new Registration is created with a POST request, and the Registration instance is polled to obtain its details.

3.1.1. Creating a Registration

To create a registration, use:

```
POST /star/registration
Host: star-proxy.example.net
Content-Type: application/json

{
    "csr": "...", // CSR in PEM format
    "lifetime": 365 // requested registration lifetime in days,
                    // between 1 and 1095
}
```

Upon success, the call returns the new Registration resource.

```
HTTP/1.1 201 Created
Location: https://star-proxy.example.net/star/registration/567
```

3.1.2. Polling the Registration

The returned Registration can be polled until the information is available from the ACME server.

```
GET /star/registration/567
Host: star-proxy.example.net
```

In responding to poll requests while the validation is still in progress, the server MUST return a 200 (OK) response and MAY include a Retry-After header field to suggest a polling interval to the client. The Retry-After value MUST be expressed in seconds. If the Retry-After header is present, in order to avoid surprising interactions with heuristic expiration times, a max-age Cache-Control SHOULD also be present and set to a value slightly smaller than the Retry-After value.

```
HTTP/1.1 200 OK
Retry-After: 10
Cache-Control: max-age=9

{
    "status": "pending"
}
```

When the operation is successfully completed, the ACME Proxy returns:

```
HTTP/1.1 200 OK
Expires: Sun, 09 Sep 2018 14:09:00 GMT

{
    "status": "valid", // or "failed"
    "lifetime": 365, // lifetime of the registration in days,
                     //  possibly less than requested
    "certificates": "https://acme-server.example.org/certificates/A51A3"
}
```

The Expires header applies to the Registration resource itself, and may be as small as a few minutes. It is unrelated to the Order's lifetime which is measured in days or longer. The "certificates" attribute contains a URL of the certificate pull endpoint, see Section 3.5.

If the registration fails for any reason, the server returns a "200 OK" response, with the status as "failed" and a "reason" attribute containing a human readable error message.

3.2. ACME Authorization

The DNO MUST restrict the authorizations it requests from the ACME server to only those that cannot be spoofed by a malicious DNC. In most cases the DNC will have strong control of HTTP content under the delegated domain, and therefore HTTPS-based authorization MUST NOT be used. See also Section 6.2.

3.3. Transport Security for the STAR Protocol Leg

Traffic between the STAR Client and the STAR Proxy MUST be protected with HTTPS. For interoperability, all implementations MUST support HTTP Basic Authentication [RFC7617]. However some deployments MAY prefer mutually- authenticated HTTPS or two-legged OAUTH.

3.4. ACME Extensions between Proxy and Server

This protocol extends the ACME protocol, to allow for recurrent orders.

3.4.1. Extending the Order Resource

The Order resource is extended with the following attributes:

```
{
    "recurrent": true,
    "recurrent-total-lifetime": 365, // requested lifetime of the
                                     // recurrent registration, in days
    "recurrent-certificate-validity": 7
       // requested validity of each certificate, in days
}
```

These attributes are included in a POST message when creating the order, as part of the "payload" encoded object. They are returned when the order has been created, and the ACME server MAY adjust them at will, according to its local policy.

3.4.2. Canceling a Recurrent Order

An important property of the recurrent Order is that it can be cancelled by the domain name owner, with no need for certificate revocation. We use the DELETE message to cancel the Order:

```
DELETE /acme/order/1 HTTP/1.1
Host: acme-server.example.org
```

Which returns:

```
HTTP/1.1 202 Deleted
```

The server MUST NOT issue any additional certificates for this Order, beyond the certificate that is available for collection at the time of deletion.

3.4.3. Indicating Support of Recurrent Orders

ACME supports sending arbitrary extensions when creating an Order, and as a result, there is no need to explicitly indicate support of this extension. The Proxy MUST verify that the "recurrent" attribute was understood, as indicated by the "recurrent" attribute included in the created Order. Since the standard ACME protocol does not allow to explicitly cancel a pending Order (the DELETE operation above is an extension), a Proxy that encounters an non-supporting server will probably let the Order expire instead of following through with the authorization process.

3.5. Fetching the Certificates

The certificate is fetched from the certificate endpoint, as per [I-D.ietf-acme-acme], Sec. 7.4.2 "Downloading the Certificate". The server MUST include an Expires header that indicates expiry of the

specific certificate. When the certificate expires, the client MAY assume that a newer certificate is already in place.

A certificate MUST be replaced by its successor at the latest 24 hours before its "Not After" time.

4. CDNI Use Cases

Members of the IETF CDNI (Content Delivery Network Interconnection) working group are interested in delegating authority over web content to CDNs. Their requirements are described in a draft [I-D.fieau-cdni-https-delegation] that compares several solutions. This section discusses two particular requirements in the context of the STAR protocol.

4.1. Multiple Parallel Delegates

In some cases the DNO would like to delegate authority over a web site to multiple CDNs. This could happen if the DNO has agreements in place with different regional CDNs for different geographical regions. STAR enables this use case naturally, since each CDN can authenticate separately to the DNO specifying its CSR, and the DNO is free to allow or deny each certificate request according to its own policy.

4.2. Chained Delegation

In other cases, a content owner (DNO) delegates some domains to a large CDN (CDN1), which in turn delegates to a smaller regional CDN, CDN2. The DNO has a contractual relationship with CDN1, and CDN1 has a similar relationship with CDN2. However DNO may not even know about CDN2.

The STAR protocol does not prevent this use case, although there is no special support for it. CDN1 can forward requests from CDN2 to DNO, and forward responses back to CDN2. Whether such proxying is allowed is governed by policy and contracts between the parties.

5. Operational Considerations

5.1. Certificate Transparency (CT) Logs

TBD: larger logs and how to deal with them.

6. Security Considerations

6.1. STAR Protocol Authentication

The STAR protocol allows its client to obtain certificates bearing the DNO's identity. Therefore strong client authentication is mandatory.

When multiple NDCs may connect to the same DNO, the STAR protocol's authentication must allow the DNO to distinguish between different NDCs. Among other benefits, this allows to DNO to cancel a STAR registration for one of its clients instead of all of them.

6.2. Restricting CDNs to the Delegation Mechanism

Currently there are no standard methods for the DNO to ensure that the CDN cannot issue a certificate through mechanisms other than the one described here, for the URLs under the CDN's control. For example, regardless of the STAR solution, a rogue CDN employee can use the ACME protocol (or proprietary mechanisms used by various CAs) to create a fake certificate for the DNO's content because ACME authorizes its requests using information that may be under the adversary's control.

The best solution currently being worked on would consist of several related configuration steps:

- Make sure that the CDN cannot modify the DNS records for the domain. Typically this would mean that the content owner establishes a CNAME resource record from a subdomain into a CDN-managed domain.
- Restrict certificate issuance for the domain to specific CAs that comply with ACME. This assumes universal deployment of CAA [RFC6844] by CAs, which is not the case yet. We note that the CA/Browser Forum has recently decided to require CAA checking [CAB-CAA].
- Deploy ACME-specific methods to restrict issuance to a specific authorization key which is controlled by the content owner [I-D.landau-acme-caa], and/or to specific ACME authorization methods.

This solution is recommended in general, even if an alternative to the mechanism described here is used.

7. Acknowledgments

This work is partially supported by the European Commission under Horizon 2020 grant agreement no. 688421 Measurement and Architecture for a Middleboxed Internet (MAMI). This support does not imply endorsement.

8. References

8.1. Normative References

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8.2. Informative References

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[Topalovic]
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Appendix A. Document History

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

A.1. draft-sheffer-acme-star-02

- Using a more generic term for the delegation client, NDC.
- Added an additional use case: public cloud services.
- More detail on ACME authorization.

A.2. draft-sheffer-acme-star-01

- A terminology section.
- Some cleanup.

A.3. draft-sheffer-acme-star-00

- Renamed draft to prevent confusion with other work in this space.
- Added an initial STAR protocol: a REST API.
- Discussion of CDNI use cases.

A.4. draft-sheffer-acme-star-lurk-00

- Initial version.

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