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OCSP Usage for Secure Telephone Identity Certificates  
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Abstract

When certificates are used as credentials to attest the assignment or ownership of telephone numbers, some mechanism is required to convey certificate freshness to relying parties. Certificate Revocation Lists (CRLs) are commonly used for this purpose, but for certain classes of certificates, including delegate certificates conveying their scope of authority by-reference in Secure Telephone Identity Revisited (STIR) systems, they may not be aligned with the needs of relying parties. This document specifies the use of the Online Certificate Status Protocol (OCSP) as a means of retrieving real-time status information about such certificates, defining new extensions to compensate for the dynamism of telephone number assignments.

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## 1. Introduction

The STIR problem statement [RFC7340] discusses many attacks on the telephone network that are enabled by impersonation, including various forms of robocalling, voicemail hacking, and swatting. One of the most important components of a system to prevent impersonation is the implementation of credentials which identify the parties who control telephone numbers. The STIR certificates [RFC8226] specification describes a credential system based on [X.509] version 3 certificates in accordance with [RFC5280] for that purpose. Those credentials can then be used by STIR authentication services [RFC8224] to sign PASSporT objects [RFC8225] carried in a SIP [RFC3261] request.

[RFC8226] specifies an extension to X.509 that defines a Telephony Number (TN) Authorization List that may be included by certificate authorities in certificates. This extension provides additional information that relying parties can use when validating transactions with the certificate. When a SIP request, for example, arrives at a terminating administrative domain, the calling number attested by the SIP request can be compared to the TN Authorization List of the certificate that signed the request to determine if the caller is authorized to use that calling number in SIP.

No specific recommendation is made in [RFC8226] for a means of determining the freshness of certificates with a TN Authorization List. Moreover, there is significant dynamism in telephone number assignment, and due to practices like number portability, information about number assignment can suddenly become stale. This problem is especially pronounced when a TN Authorization List extension associates a large block of telephone numbers with a certificate, as relying parties need a way to learn if any one of those telephone numbers has been ported to a different administrative entity. To facilitate this, [RFC8226] Section 10.1 specifies a way that the TN Authorization List can be shared by-reference in a certificate, via a URL in the Authority Information Access extension, so that a more dynamic list can be maintained without continually reissuing the certificate. For very large and/or complex TN Authorization Lists, however, this could require relying parties to redownload the entire list virtually every time they process a call. Moreover, some certificate holders may be reluctant to share the entire list of telephone numbers associated with a certificate in cases where a relying party only needs to know, effectively, whether a single number (the calling party number for a particular call) is in the scope of authority for a certificate or not. This document explores approaches to real-time status information for such certificates, and recommends an approach.

## 2. Terminology

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.

## 3. Overview of Certificate Verification Methods

For traditional certificate status information, there are three common certificate verification mechanisms employed by CAs:

### 1. Certificate Revocation Lists (CRLs) [RFC5280] (and [RFC6818])

2. Online Certificate Status Protocol (OCSP) [RFC6960], and
3. Server-based Certificate Validation Protocol (SCVP) [RFC5055].

Verifiers relying on status information need a way to obtain it - that is, where to locate it. Placing the location of the status information in the certificate makes the certificate larger, but it eases the client workload. The CRL Distribution Point certificate extension includes the location of the CRL and the Authority Information Access certificate extension includes the location of OCSP and/or SCVP servers; both of these extensions are defined in [RFC5280]. In all cases, the status information location is provided in the form of an URI.

CRLs are an attractive solution because they are supported by traditional web PKI environments. CRLs have a reputation of being quite large (10s of MBytes), because CAs maintain and issue one monolithic CRL with all of their revoked certificates, but CRLs do support a variety of mechanisms to scope the size of the CRLs: based on revocation reasons (e.g., key compromise vs CA compromise), user certificates only, and CA certificates only as well as just operationally deciding to keep the CRLs small. However, scoping the CRL introduces other issues (i.e., does the relying party have all of the CRL partitions). In practice, CRLs are widely used in STIR environments, often through a federated approach where a community of trusted CAs pool their CRLs for distribution from a central point.

CAs in the STIR architecture thus have already implemented CRLs, largely for audit purposes rather than real-time status information. The need for these CRLs is not likely to go away, especially for the case of service providers whose certificates are based on Service Provider Codes (SPCs). For delegate STIR certificates ([RFC9060]), however, especially those with TN Authorization Lists based on telephone numbers, OCSP may provide an important optimization. Between the OCSP and SCVP, OCSP is much more widely deployed and this document therefore RECOMMENDS the use of OCSP in high-volume environments (HVE) for validating the freshness of telephone-number based certificates, based on [RFC6960], incorporating some (but not all) of the optimizations of [RFC5019].

Like most PKIX-developed protocols, OCSP is extensible; OCSP supports request extensions (including sending multiple requests at once) and per-request extensions. As the relying party in STIR is validating a PASSporT associated with a telephone call, it is unlikely that the verifier will request authorization checks on multiple telephone numbers in one request, so a per-request extension is what is needed.

OCSF requires an additional round-trip request and response from the verification service to the OCSF responder, and the telephony applications are delay sensitive. Thus, this document also specifies a means to incorporate an OCSF staple into the PASSporT object below (in Section 5).

#### 4. Using OCSF with TN Authorization Lists

Certificates compliant with this specification SHOULD include a URL [RFC3986] pointing to an OCSF service in the Authority Information Access (AIA) certificate extension, via the "id-ad-ocsp" accessMethod specified in [RFC5280]. This can appear in addition to, or as an alternative to, the "id-ad-stirTNList" accessMethod specified in [RFC8226]. It is RECOMMENDED that entities that issue certificates with the Telephone Number Authorization List certificate extension run an OCSF server for this purpose. Baseline OCSF however supports only three possible response values: good, revoked, or unknown. Without some extension, OCSF would not indicate whether the certificate is authorized for a particular telephone number that the verifier is validating.

Consulting OCSF in real time results in a network round-trip delay, which is something to consider because it will add to the call setup time. OCSF server implementations commonly pre-generate responses, and to speed up HTTPS connections, servers often provide OCSF responses for each certificate in their hierarchy. If possible, both of these OCSF concepts should be adopted for use with STIR.

##### 4.1. OCSF Extension Specification

The extension mechanism for OCSF follows X.509 v3 certificate extensions, and thus requires an OID, a criticality flag, and ASN.1 syntax as defined by the OID. The criticality specified here is optional: per [RFC6960] Section 4.4, support for all OCSF extensions is optional. If the OCSF server does not understand the requested extension, it will still provide the baseline validation of the certificate itself. Moreover, in practical STIR deployments, the issuer of the certificate will set the accessLocation for the OCSF AIA extension to point to an OCSF service that supports this extension, so the risk of interoperability failure due to lack of support for this extension is minimal.

The OCSF TNQuery extension is included as one of the request's singleRequestExtensions; it carries the telephone number for which the query is being performed, typically the telephone number in the "orig" field of a PASSporT being validated. The TNQuery extension may also appear in the response's singleExtensions; when an OCSF server includes a telephone number in the response's

singleExtensions, this informs the client that the certificate is still valid for the number that appears in the TNQuery extension field. If the TNQuery is absent from a response to a query containing a TNQuery in its singleRequestExtension, then the server is not able to validate that the number is still in the scope of authority of the certificate.

```
id-pkix-ocsp-stir-tn OBJECT IDENTIFIER ::= { id-pkix-ocsp 10 }
```

```
TNQuery ::= TelephoneNumber
```

The HVE OCSF profile [RFC5019] prohibits the use of per-request extensions. As it is anticipated that STIR will use OCSF in a high-volume environment, many of the optimizations recommended by HVE are desirable for the STIR environment. This document therefore uses the HVE optimizations augmented as follows:

- \* Implementations MUST use SHA-256 as the hashing algorithm for the CertID.issuerNameHash and the CertID.issuerKeyHash values. That is CertID.hashAlgorithm is id-sha256 [RFC4055] and the values are truncated to 160-bits as specified Option 1 in Section 2 of [RFC7093].
- \* Clients MUST include the OCSF TNQuery extension in requests' singleRequestExtensions.
- \* Servers MUST include the OCSF TNQuery extension in responses' singleExtensions.
- \* Servers SHOULD return responses that would otherwise have been "unknown" as "not good" (i.e., return only "good" and "not good" responses).
- \* Clients MUST treat returned "unknown" responses as "not good".
- \* If the server uses ResponderID, it MUST generate the KeyHash using SHA-256 and truncate the value to 160-bits as specified in Option 1 in Section 2 of [RFC7093].
- \* Implementations MUST support ECDSA using P-256 and SHA-256. Note that [RFC6960] requires RSA with SHA-256 be supported.
- \* This removes the requirement to support SHA-1, RSA with SHA-1, or DSA with SHA-1.

OCSF responses MUST be signed using the same algorithm as the certificate being checked.

To facilitate matching the authority key identifier values found in CA certificates with the KeyHash used in the OCSF response, certificates compliant with this specification MUST generate authority key identifiers and subject key identifiers using the SHA-256 and truncate the value to 160-bits as specified in Option 1 in Section 2 of [RFC7093].

Ideally, once a certificate has been acquired by a verifier, some sort of asynchronous mechanism could notify and update the verifier if the scope of the certificate changes so that verifiers could implement a cache. While not all possible categories of verifiers could implement such behavior, some sort of event-driven notification of certificate status is another potential subject of future work. One potential direction is that a future SIP SUBSCRIBE/NOTIFY-based accessMethod for AIA might be defined (which would also be applicable to the method described in the following section) by some future specification.

#### 4.2. Example OCSF Request

OCSF Request: PEM:

```
MIGHMIGEMEEwPzA9MAkGBSsOAwIaBQAeFLdmsxX0LkOSjTdoFXdwRl6mmDfCBBSS
pHUspJ6+gUTrefyKxZWl6xB1cwIEND70z6I/MD0wHwYJKwYBBQUHMAECBBIEEGN0
k6Ihb0QokYQs01/+t0AwGgYJKwYBBQUHMAEKBA0WCzEyMDI1NTUxMjE5
```

#### 4.3. Example OCSF Response

OCSF Response: PEM:



solution is however not optimal for cases where signing certificates are long-lived and cached, so that queries will otherwise be very infrequent. Requiring certificate fetches every time a new telephone number is seen at the verification service would likely incur roughly the same number of round trips as the

[I-D.peterson-stir-certificates-shortlived] mechanism.

There are also variants of the "x5u" approach that sidestep OCSF entirely, by decorating the "x5u" URI with query parameters that incorporate the calling telephone number. As the authentication service necessarily knows the telephone number from the "orig" field, and controls the contents of "x5u", it has the means to decorate the URI appropriately during PASSporT creation. The certificate repository (i.e. HTTP service) receiving a certificate fetch with a decorated URI could then verify that the calling number is currently in the scope of the requested certificate - if it is not, the service could then fail to return a certificate, preventing the verification service from validating. However, like the approach above, this would have implications for certificate fetch frequency similar to short-lived certs, as the decorated URIs would be governed by HTTP caching mechanics.

Thus, the solution proposed here is that the authentication service instead inserts a new PASSporT payload element, "stpl", which has as its value an OCSF staple compliant with the STIR extension defined in Section 4.1. Such staples can either be pre-generated ([RFC6960] Section 2.5) and published regularly to the authentication service, or the authentication service can query for a staple on a per-call basis. Note that OCSF for STIR does furnish a response concerning only a single telephone number, and thus if a certificate can sign for a large number range, one pre-generated staple would need to be furnished to the authentication service for each telephone number that could potentially originate a call. Generating OCSF staples on the fly may however cause a round-trip time delay of its own, which depending on how the authentication service and the certificate authority are connected, could effectively incur the same delay as an OCSF dip from the verification service.

One alternative design would be to carry an OCSF staple at the SIP layer, in a body or header. But the because PASSporT can be used in non-SIP environments, and this OCSF extension is specific to certificates that use the TNAuthList extension, embedding the staple in the PASSporT is a superior choice. While encoding and embedding an OCSF response will increase the size of the PASSporT, that overall increase in SIP message size will ideally be the same as if the response had been placed in a separate header.

Finally, it could be argued that the round-trip delay incurred at the verification service is not actually problematic, as there is a fungible delay on the terminating side during which ringing can be played to the caller without commencing alerting on the end-user called device. But Section 7 also describes the potential privacy implications of revealing to the OCSF responder the verification service that has received a call for a particular calling number. On balance, stapling at the authentication service, especially pre-generated stapling, seems to offer the best all-around solution for using OCSF with STIR.

#### 5.1. OCSF Staple PASSporT Element

The header of a PASSporT with an OCSF staple follows baseline [RFC8225]; no new PASSporT Type is required for transmission of staples.

```
{ "typ":"passport",  
  "alg":"ES256",  
  "x5u":"https://www.example.com/cert.cer" }
```

The payload of the PASSporT contains a new payload claim for "stpl". This is a base64 encoded representation of an OCSF response that the STIR authentication service receives from a CA, either asynchronously (prefetched) or synchronously after querying the CA when a call signed by the certificate in the "x5u" value specified in the header has arrived.

```
{ "orig":{"tn":"12155551212"},
  "dest":{"tn":["12155551214"]},
  "iat":1443208345
  "stpl":"MIIE2QoBAKCCBNiwggTOBgkrBgEFBQcwAQEEggS/MIIIEuzCCASuhgYAwfjELMAKGA1UEBhMCQVUxEzARBgNVBAgTC1NvbWUuU3RhdGUxITAfBgNVBAoTGE1udGVybmV0IFdpZGdpdHMgUHR5IEEx0ZDEVMBMGA1UEAxMMc25tcGxhYnMuY29tMSAwHgYJKoZIhvcNAQkBFhFpbmZvQHNUbXBsYWJzLmNvbRgPMjAyNDZMTcwNTA5MDBaMFQwUjA9MAkGBSsOAwIaBQAQEFldmsxX0LkOSjTdoFXdwRl6mmDFCBBSSpHUSpJ6+gUTrefyKxZWl6xB1cwIENd70z4IAGA8yMDEyMDQxMTE0MDkyMlqhPzA9MB8GCSsGAQUFBzABAgQSBBBjdJOiIW9EKJGELNNf/rdAMBoGCSsGAQUFBzABCgQNFgsxMjAyNTU1MTIxMjANBgkqhkiG9w0BAQUFAAOBgQA5O6EYgsuHsNbtDedkC0RaVvrXW9DX5Fdl8rvhwoSok04WT6/WV2pSIJCdcNwQJ84WwdCV/86uz3/MhM/zq0OBhh+x8g91YD5DLvieiNwNgJ/m1EKPfQJgm2ef7Uh7Q2EDELd4jW79X5NMrw5oe1HSr11DUsiXR3oNu3TDcuJPAKCCAUVwggLxMIIC7TCCA1agAwIBAgIBATANBgkqhkiG9w0BAQUFAADB+MQswCQYDVQQGEwJBVTEtMBEGA1UECBMKU29tZS1TdGF0ZTEhMB8GA1UEChMYSW50ZXJvZmVudGVybmV0IFdpZGdpdHMgUHR5IEEx0ZDEVMBMGA1UEAxMMc25tcGxhYnMuY29tMSAwHgYJKoZIhvcNAQkBFhFpbmZvQHNUbXBsYWJzLmNvbRgPMjAyNDZMTcwNTA5MDBaMFQwUjA9MAkGBSsOAwIaBQAQEFFAAOBjQAwgYkCgYEAAw1ORzpzVfCNgqI8QfIpSFkR2ELmgI546xEzDqa6LgxxV58FqkKPyN5tG12JqHK4fZA3n2/nIHO/niSrwLwaq610Z1N/A5kFP84cqQn7Rhnz/MY7gWdZ9t5Ud4azTdcMANcd10oAwgIONvDrCn9b3F/BLNPaw6PJkKbeBts0eesCAwEAAAN7MHkwCQYDVR0TBAIwADAsBg1ghkgBhvCAQ0EHxYdT3BlblNTTCBHZW51cmF0ZWQgQ2VydG1maWNhdGUwHQYDVR0OBBYEFPLNnaSRszB5cmOew+ATZpapxHGMB8GA1UdIwQYMBAAFPGLNnaSRszB5cmOew+ATZpapxHGMA0GCSqGSIb3DQEBBQUAA4GBAFkdLhSVZUCHeoVaVG4FxU6csLTYrTVxYmGJEUub++zHEiaiwmv3NcJ7i5qnBXLkVctKDevGSQz9hwwynvDAmfPrMfgheeHjPFQoDfbkPV8h08fV61w3d1MPUSVWlkiHs5DSjXgRNJQzNo1IwuBwBEnX+53m89cLagDlxNY1hf8vI"
}
```

## 6. IANA Considerations

### 6.1. TN-HVE OCSP Extension

This document makes use of object identifiers for the TN-HVE OCSP extension in Section 4.1 and the ASN.1 module identifier defined in Appendix A. It therefore requests that the IANA make the following assignments:

TN-OCSP-Module-2016 OID in the SMI Security for PKIX Module Identifier registry: <https://www.iana.org/assignments/smi-numbers/smi-numbers.xhtml#smi-numbers-1.3.6.1.5.5.7.0>

TN-HVE OCSP extension in the SMI Security for PKIX Online Certificate Status Protocol (OCSP) registry: 1.3.6.1.5.5.7.48.1.10.

## 6.2. 'stpl' JSON Web Token Claim

This specification requests that the IANA add one new claim to the JSON Web Token Claims registry as defined in [RFC7519].

Claim Name: "stpl"

Claim Description: OCSP Staple

Change Controller: IESG

Specification Document(s): [RFCThis]

## 7. Privacy Considerations

Querying for real-time status information about certificates can allow parties monitoring communications to gather information about relying parties and the originators of communications. Unfortunately, the TNQuery extension adds a new field that could potentially be monitored by OCSP eavesdroppers: the calling telephone number provides a specific piece of additional data about the originator of communications. Using OCSP over TLS is one potential countermeasure to this threat, as described in [RFC6960] Appendix A.1.

Preventing eavesdropping reduces on potential privacy leak, though of course using OCSP reveals to the OCSP service (likely acting for the certification authority) the verification service where calls from a given telephone number are terminating. Bear in mind that STIR assumes that verification services use HTTPS to acquire certificates (by referencing the "x5u" field of the PASSporT) already, so some connection between the verification service and a certificate repository (likely acting for the certification authority or authentication service) is unavoidable. This OCSP extension further reveals the calling telephone number as it arrives at the verification service to the OCSP service.

One way to mitigate leaking information about relying parties is to use OCSP stapling (see Section 5).

## 8. Security Considerations

This document is entirely about security. For further information on certificate security and practices, see [RFC5280], in particular its Security Considerations. For OCSP-related security considerations see [RFC6960] and [RFC5019].

## 9. Acknowledgments

Stephen Farrell provided key input to the discussions leading to this document. Russ Housley provided some direct assistance and text surrounding the ASN.1 module, and with the OCSF request and staple example.

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## Appendix A. ASN.1 Module

This appendix provides the normative ASN.1 [X.680] definitions for the structures described in this specification using ASN.1, as defined in [X.680] through [X.683].

The modules defined in this document are compatible with the most current ASN.1 specification published in 2015 (see [X.680], [X.681], [X.682], [X.683]). None of the newly defined tokens in the 2008 ASN.1 (DATE, DATE-TIME, DURATION, NOT-A-NUMBER, OID-IRI, RELATIVE-OID-IRI, TIME, TIME-OF-DAY) are currently used in any of the ASN.1 specifications referred to here.

This ASN.1 module imports ASN.1 from [RFC5912] and [RFC8226].

```
TN-OCSP-Module-2023
  { iso(1) identified-organization(3) dod(6) internet(1)
    security(5) mechanisms(5) pkix(7) id-mod(0)
    id-mod-tn-ocsp-module-2023(TBD) }

DEFINITIONS EXPLICIT TAGS ::= BEGIN

IMPORTS

id-ad-ocsp
  FROM PKIX1Explicit-2009 -- From RFC 5912
  { iso(1) identified-organization(3) dod(6) internet(1) security(5)
    mechanisms(5) pkix(7) id-mod(0) id-mod-pkix1-explicit-02(51) }

EXTENSION
  FROM PKIX-CommonTypes-2009 -- From RFC 5912
  { iso(1) identified-organization(3) dod(6) internet(1) security(5)
    mechanisms(5) pkix(7) id-mod(0) id-mod-pkixCommon-02(57) }

TelephoneNumber
  FROM TN-Module-2016 -- From RFC 8226
  { iso(1) identified-organization(3) dod(6) internet(1) security(5)
    mechanisms(5) pkix(7) id-mod(0) id-mod-tn-module(89) }
;

id-pkix-ocsp OBJECT IDENTIFIER ::= id-ad-ocsp

--
-- Telephone Number Query OCSF Extension
--

ext-ocsp-tn-query EXTENSION ::= {
  SYNTAX TNQuery IDENTIFIED BY id-pkix-ocsp-stir-tn }

TNQuery ::= TelephoneNumber

id-pkix-ocsp-stir-tn OBJECT IDENTIFIER ::= { id-pkix-ocsp 10 }

END
```

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