The SODP (Secure Object Delivery Protocol) Server Interfaces: NSA’s Profile for Delivery of Certificates, CRLs, and Symmetric Keys to Clients

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Abstract

This document specifies protocol interfaces profiled by the US NSA (United States National Security Agency) for NSS (National Security System) servers that provide public key certificates, CRLs (Certificate Revocation Lists), and symmetric keys to NSS clients. Servers that support these interfaces are referred to as SODP (Secure Object Delivery Protocol) servers. The intended audience for this profile comprises developers of client devices that will obtain key management services from NSA-operated SODP servers. Interfaces supported by SODP servers include: EST (Enrollment over Secure Transport) and its extensions as well as CMC (Certificate Management over CMS (Cryptographic Message Syntax)).

This profile applies to the capabilities, configuration, and operation of all components of US National Security Systems (SP 800-59). It is also appropriate for other US Government systems that process high-value information. It is made publicly available for use by developers and operators of these and any other system deployments.

Status of this Memo

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1. Introduction

This document specifies protocol interfaces profiled by the US NSA (United States National Security Agency) for NSS (National Security System) servers that provide public key certificates, CRLs (Certificate Revocation Lists), and symmetric keys to NSS clients. Servers that support these interfaces are referred to as SODP (Secure Object Delivery Protocol) servers. The purpose of this document is to indicate options from, and requirements additional to, the base specifications listed in Section 1.1 that are necessary for client interoperability with NSA-operated SODP servers. Clients are always devices, and need not implement all of the interfaces specified herein; clients are free to choose which interfaces to implement based on their operational requirements. Interfaces supported by SODP servers include:

- EST (Enrollment over Secure Transport) [RFC7030] and its extensions [RFC8295], and
- CMC (Certificate Management over CMS (Cryptographic Message Syntax)) [RFC5274][RFC6402] for both Simple PKI (Public Key Infrastructure) requests and responses (i.e., PKCS#10 requests and PKCS#7 responses) and Full PKI requests and responses.

This profile applies to the capabilities, configuration, and operation of all components of US National Security Systems [SP 800-59]. It is also appropriate for other US Government systems that process high-value information. It is made publicly available for use by developers and operators of these and any other system deployments.

This profile conforms to the existing requirements of NSA’s Commercial National Security Algorithms. As operational needs evolve over time, this profile will be updated to incorporate new commercial algorithms and protocols as they are developed and approved for use.

1.1. Documents to be Familiar With
Familiarity with following specifications is assumed:

- EST [RFC7030] and EST extensions [RFC8295];
- PKI-related specifications [RFC2986], [RFC3739], [RFC5274], [RFC5280], [RFC5912], [RFC5913], [RFC5916], [RFC5917], [RFC6010], and [RFC6402];
- Key-format-related specifications [RFC5915], [RFC5958], [RFC5959], [RFC6031], [RFC6032], [RFC6160], [RFC6161], [RFC6162], [RFC7191], [RFC7192], [RFC7292], and [RFC7906];
- CMS-related (Cryptographic Message Syntax) RFCs [RFC5652], [RFC5915], and [RFC7192];
- CNSA-related (Commercial National Security Algorithm) drafts [RFC8603], [ID.cnsa-smime-profile], [ID.cnsa-cmc-profile], and [ID.cnsa-tls-profile]. The profile defined herein does not support RSA-based algorithms.

The requirements from RFCs apply throughout this profile and are generally not repeated here. This document is purposely written without [RFC2119] language.

1.2. Document Organization

The document is organized as follows:

- The remainder of this section describes the operational environment used by clients to retrieve secure objects.
- Section 2 specifies the version of ASN.1 (Abstract Syntax Notation One) version used.
- Section 3 specifies SODP’s EST interface.
- Section 4 specifies SODP’s CMC interfaces; one section each for Simple PKI requests/responses and Full PKI requests/responses.
- Sections 5–9 respectively specify TA, CA, and EE certificates as well as CRL.

1.3. Environment

The environment is Client-Server-based from which clients obtain secure "objects" or "packages". Objects/packages vary based on the SOA (Source of Authority) but all objects are "secured" minimally through the use of one or more digital signatures and zero or more layers of encryption, as profiled in this document. An SOA is the authority for the creation of objects that the client will recognize as valid. An SOA can delegate its authority to other actors; delegation occurs through the issuance of certificates. An object or package is the generic term for certificates, certificate status information, and keys (both asymmetric and symmetric). All of the objects except for the certificates and certificate status information are directly encapsulated in and protected by CMS content...
types. CMS content types that provide security are referred to as CMS-protecting content types. All others are simply referred to as CMS content types. All secured objects are distributed either as CMS packages or as part of a CMS package.

In the following example depicted in Figure 1, there are two SOAs: one for symmetric keys, as depicted by the KTA (Key Trust Anchor), and one for public key certificates, as depicted by the PKI TA (Trust Anchor). The KTA is responsible for the creation and distribution of symmetric keys. The KTA delegates the creation and distribution responsibilities to separate entities through the issuance of certificates to a KSA (Key Source Authority) and a KDA (Key Distribution Authority). The KSA generates the keys, digitally signs the keys, and encrypts the key for the end client using CMS content types for each step. The KDA distributes the KSA-generated and protected key to the client; the key may also be signed by the KDA.

The resulting CMS package is provided to the client through the EST extension’s /symmetrickey service. The PKI TA is responsible for the creation, distribution, and management of public key certificates. The PKI TA delegates these responsibilities to CAs (Certification Authorities) and CAs in turn are responsible for creating, distributing, and managing EEs (End-Entities) certificates; CAs distribute PKI-related information through the /cacerts, /crls, /eecerts, /fulcmc, /simpleenroll, /simplereenroll, /csrattrs EST and EST extension services.
2. Abstract Syntax Notation One

Implementations of this specification use the ‘02/’08 ASN.1 (Abstract Syntax Notation One) version; ‘02/’08 ASN.1 modules can be found in [RFC5911], [RFC5912], and [RFC6268] (use RFC 6268 for the CMS syntax) while other specifications already include the ‘02/’08 ASN.1 along with the ‘88 ASN.1. See Section 1.1 of [RFC6268] for a discussion about the differences between the ‘02 and ‘08 ASN.1 versions.

3. EST Interface

EST [RFC7030] and EST extensions [RFC8295] client options are specified in this section.

3.1. Hypertext Transfer Protocol Layer

Clients that receive redirection responses (3xx status codes) will terminate the connection ([RFC7030], Section 3.2.1).

Clients include an HTTP Accept header with each HTTP GET request to indicate the PAL Package Type supported ([RFC8295], Section 2.1.1).

3.2. Transport Layer Security

TLS implementations are configured as specified in [ID.cnsa-tls-profile]; the notable exception is that RSA-based algorithms are not used.

3.3. Eligibility

At the EST interface, servers enroll only clients that they have an established relationship with. To accomplish this, client owners/operators interact in person with the human acting as the RA (Registration Authority) to ensure the information included in the transmitted certificate request, which is sometimes called a CSR (Certificate Signing Request), is associated with a client. The mechanism by which the owner/operator interact with the RA as well as the information provided is beyond the scope of this document. The information exchanged by the owner/operator might be something as
simple as the subject name included in the to-be sent CSR or a copy of an entire certificate that will be used to verify the certificate request.

3.4. Authentication

Mutual authentication occurs via "Certificate TLS Authentication" ([RFC7030], Section 2.1). Clients provide their certificate to servers in the TLS Certificate message, which is sent in response to the server’s TLS Certificate Request message. Clients reject all server attempts to authenticate that do not validate back to a TA.

3.5. Authorization

Clients always use an explicit TA database ([RFC7030], Section 3.6.1). At a minimum, clients support two TAs; one for the PKI and one for symmetric keys.

Clients check that the server’s certificate includes the id-kp-cmcRA EKU (Extended Key Usage) value ([RFC6402], Section 2.10).

Clients that support processing the CMS Content Constraints extension ([RFC6010]) ensure returned CMS content is from an SOA or is from an entity authorized by an SOA for that CMS content; see Section 6.0 for SOA certificates.

3.6. EST and EST Extensions

This section profiles SODP’s EST [RFC7030] and EST Extensions [RFC8295] interfaces.

3.6.1. /pal

The PAL (Package Availability List) is limited to 32 entries, where the 32nd PAL entry links to an additional PAL (i.e., is PAL Package Type 0001).

The PAL is XML [XML].

3.6.2. /cacerts

The CA certificates located in the explicit TA database are distributed to the client when it is registered. This TA distribution mechanism is out-of-scope.

CA certificates provided through this service are as specified in Sections 5 and 6 of this document.
3.6.3. /simpleenroll

CSRs follow the specifications in Section 5.1 of [ID.cnsa-cmc-profile], with two exceptions. First, the Change Subject Name and the POP Link Witness V2 attributes, which are CMC-specific requirements do not apply. Second, RSA-based algorithms are not used.

Client requests include the tls-unique value in the challenge-password attribute, as specified in [RFC7030], or the id-aa-estIdentityLinking attribute, as specified in [RFC7894].

Client certificates provided through this service are as specified in Section 7 of this document.

The HTTP content-type of "text/plain" ([RFC2046], Section 4.1) is used to return human readable errors.

3.6.4. /simplereenroll

There are no additional requirements for requests beyond those specified in Sections 3.4 and 3.6.3 of this document.

The HTTP content-type of "text/plain" ([RFC2046], Section 4.1) is used to return human readable errors.

3.6.5. /fullcmc

Requests are as specified in [ID.cnsa-cmc-profile] with the notable exception that RSA-based algorithms are not supported.

Additional attributes for returned CMS packages can be found in [RFC7906].

Certificates provided through this service are as specified in Section 7 of this document.

3.6.6. /serverkeygen

PKCS#12 [RFC7292], sometimes referred to as "PFX" (Personal inFormation eXchange), "P12", and "PKCS#12" files, are used to provide server-generated asymmetric private keys and the associated certificate to clients. This interface is a one-way interface as the RA requests these from the server.

PFXs [RFC7292] are exchanged using both password privacy mode and integrity password mode. The PRF algorithm for both the PBES2 and PBMAC1 is HMAC-SHA-384 and the PBES2 encryption scheme is AES-256.
The HTTP content-type of "text/plain" ([RFC2046], Section 4.1) is used to return human readable errors.

/serverkeygen/return is not supported at this time.

3.6.7. /csratts

Clients use this service to retrieve partially filled PKIRequests: PKIRequests with no public key or proof-of-possession signature, i.e., their values are set to zero length either a zero length BIT STRING or OCTET STRING. The pKCS7PDU attribute, defined in [RFC2985], includes the partially filled PKIRequest as the only element in the CsrAttrs sequence. Even though the CsrAttrs syntax is defined as a set, there is only ever exactly one instance of values present.

3.6.8. /crls

CRLs provided through this service are as specified in Section 9 of this document.

3.6.9. /symmetrickeys

Clients that claim to support SODP-interoperation will be able to process the following messages from a SODP server: additional encryption and origin authentication ([RFC8295], Section 5); server-provided Symmetric Key Content Type [RFC6032] encapsulated in an Encrypted Key Content Type using the EnvelopedData choice [RFC6033] with a SOA certificate that includes the CMS Content Constraints extension (see Section 7.1).

Client-supported algorithms to decrypt the server-returned symmetric key are as follows:

- Message Digest: See Section 5 of [ID.cnsa-smime-profile].
- Digital Signature Algorithm: See Section 6.1 of [ID.cnsa-smime-profile].
- Key Agreement: See Section 7.1 of [ID.cnsa-smime-profile].
- Key Wrap: AES-256 Key Wrap with Padding [RFC6033] is used. AES-128 Key Wrap with Padding is not used.
- Content Encryption: AES-256 Key Wrap with Padding [RFC6033] is used. AES-128 Key Wrap with Padding is not used.

/serverkeygen/return is not used at this time.

3.6.10. /eecerts, /firmware, /tamp

/eecerts, /firmware, /tamp are not used at this time.
4. CMC Interface

CMC [RFC5274][RFC6402] clients options are specified in this section.

4.1. RFC 5273 Transport Protocols

Clients use only the HTTPS-based transport; the TLS implementation and configuration is as specified in [ID.cnsa-tls-profile]; the notable exception is that RSA-based algorithms are not supported.

Clients that receive HTTP redirection responses (3xx status codes) will terminate the connection ([RFC7030], Section 3.2.1).

4.2. Eligibility

At the CMC interface, servers enroll only clients that they have an established relationship with. To accomplish this, client owners/operators interact in person with the human acting as the RA (Registration Authority) to ensure the information included in the transmitted certificate request, which is sometimes called a CSR (Certificate Signing Request), is associated with a client. The mechanism by which the owner/operator interact with the RA as well as the information provided is beyond the scope of this document. The information exchanged by the owner/operator might be something as simple as the subject name included in the to-be sent CSR or a copy of an entire certificate that will be used to verify the certificate request.

4.3. Authentication

Mutual authentication occurs via client and server signing of CMC protocol elements, as required by [ID.cnsa-cmc-profile]. All such signatures must be validated against an installed TA; any that fail validation are rejected.

4.4. Authorization

Clients support the simultaneous presence of as many TAs as are required for all of the functions of the client, and only these TAs.

Clients check that the server’s certificate includes the id-kp-cmcRA EKU (Extended Key Usage) value [RFC6402], Section 2.10.

Clients that support processing the CMS Content Constraints extension [RFC6010] ensure returned CMS content is from an SOA or is from an entity authorized by an SOA for that CMS content; see Section 6.0 for SOA certificates.
4.5. Simple PKI Requests/Responses

CSRs follow the specifications in Section 5.1 of [ID.cnsa-cmc-profile], with two exceptions. First, the Change Subject Name and the POP Link Witness V2 attributes, which are CMC-specific requirements do not apply. Second, RSA-based algorithms are not used.

Certificates provided through this service are as specified in Section 7 of this document.

4.6. Full PKI Requests/Responses

Requests are as specified in [ID.cnsa-cmc-profile] with the notable exception that RSA-based algorithms are not used.

Additional attributes for returned CMC packages can be found in [RFC7906].

Certificates provided through this service are as specified in Section 7 of this document.

5. Trust Anchor Profile

Clients are free to store the TA in format of their choosing; however, servers provide TA information in the form of self-signed CA certificates. This section documents requirements for self-signed certificates in addition to those specified in [RFC8603], which in turn specifies requirements in addition to those in [RFC5280].

RSA-based algorithms are not used.

Issuer and subject names are composed of only the following naming attributes: country name, domain component, organization name, organizational unit name, common name, state or province name, distinguished name qualifier, and serial number.

In the Subject Key Identifier extension, the keyIdentifier is the 64 low-order bits of the subject’s subjectPublicKey field.

In the Key Usage extension, the nonRepudiation bit is never set.

6. Non-Self-Signed Certification Authority Certificate Profile

This section documents requirements for non-self signed CA certificates in addition to those specified in [RFC8603], which in turn specifies requirements in addition to those in [RFC5280].
RSA-based algorithms are not used.

Subject names are composed of only the following naming attributes: country name, domain component, organization name, organizational unit name, common name, state or province name, distinguished name qualifier, and serial number.

In the Authority Key Identifier extension, the keyIdentifier choice is always used. The keyIdentifier is the 64 low-order bits of the issuer’s subjectPublicKey field.

In the Subject Key Identifier extension, the keyIdentifier is the 64 low-order bits of the subject’s subjectPublicKey field.

In the Key Usage extension, the nonRepudiation bit is never set.

The Certificate Policies extension is always included and policyQualifiers are never used.

Non-self-signed CA certificates can also include the following:

- Name Constraints: permittedSubtrees constraints are applied and excludedSubstree constraints are not. Of the GeneralName choices, issuers support the following: rfc822Name, dNSName, uniformResourceIdentifier, and iPAдресs (both IPv4 and IPv6) as well as hardwareModuleName, which is defined in [RFC4108]. Note that rfc822Name, dNSName, and uniformResourceIdentifier are defined as IA5 strings and the character sets allowed is not uniform amongst these three name forms.

- CRL Distribution Points: A distributionPoint is always the fullName choice; the uniformResourceIdentifier GeneralName choice is always included but others can also be used as long as the first element in the sequence of CRLDistributionPoints is the uniformResourceIdentifier choice; the reasons and CRLIssuer fields are never populated. This extension is never marked critical.

- Authority Information Access: Only one instance of AccessDescription is included. accessMethod is id-caIssuers and accessLocation’s GeneralName is always the uniformResourceIdentifier choice.

- Extended Key Usage: EST servers and RAs include the id-kp-cmcRA EKU and the CAs include the id-kp-cmcCA, which are both specified in [RFC6402].

Issuers include the Authority Clearance Constraints extension.
criticality is determined by the issuer and a securityCategories is never included. Only one instance of Clearance is generated in the AuthorityClearanceConstraints sequence.

Issuers include a critical CMS Content Constraints extension [RFC6010] in CA certificates used to issue SOA certificates. The content types included depend on the packages the SOA sources, but include key packages (i.e., Encrypted Key Packages, Symmetric Key Packages, and Asymmetric Key Packages).

7. End-Entity Certificate Profile

This section documents requirements for EE signature and key establishment certificates in addition to those listed in [RFC8603], which in turn specifies requirements in addition to those in [RFC5280].

RSA-based algorithms are not used.

Subject names are composed of the following naming attributes: country name, domain component, organization name, organizational unit name, common name, state or province name, distinguished name qualifier, and serial number.

In the Authority Key Identifier extension, the keyIdentifier choice is always used. The keyIdentifier is the 64 low-order bits of the issuer's subjectPublicKey field.

In the Subject Key Identifier extension, the keyIdentifier is the 64 low-order bits of the subject’s subjectPublicKey field.

In the Key Usage extension, signature certificates only assert digitalSignature and key establishment certificates only assert keyAgreement.

The Certificate Policies extension is always included and policyQualifiers are never used.

When included, the non-critical CRL Distribution Point extension’s distributionPoint is always identified by the fullName choice; the uniformResourceIdentifier GeneralName choice is always included but others can also be used as long as the first element in the sequence of distribution points is the URI choice and it is an HTTP/HTTPS scheme; the reasons and cRLIssuer fields are never populated.
The following subsections provide additional requirements for the different types of EE certificates.

7.1. Source of Authority Certificate Profile

This section specifies the format for SOA certificates, i.e., certificates issued to those entities that are authorized to create, digitally sign, encrypt, and distribute key packages; these certificates are issued by non-PKI TAs.

The Subject Alternative Name extension is always included. The following choices are supported: rfc822Name, dnsName, ediPartyName, uniformResourceIdentifier, or ipAddress (both IPv4 and IPv6). This extension is never critical.

A critical CMS Content Constraints extension [RFC6010] is included in SOA signature certificates. The content types included depend on the packages the SOA sources (e.g., Encrypted Key Packages, Symmetric Key Packages, Asymmetric Key Packages).

7.2. Client Certificate Profile

This section specifies the format for certificates issued to clients.

A non-critical Subject Directory Attributes extension is always included with the following attributes:

- Device Owner [RFC5916]
- Clearance Sponsor [RFC5917]
- Clearance [RFC5913]

The following extensions are also included at the discretion of the CA:

- The Authority Information Access extension with only one instance of the accessMethod id-caIssuers and the accessLocation’s GeneralName using the uniformResourceIdentifier choice.

- A non-critical Subject Alternative Name extension that includes the hardwareModuleName form [RFC4108], rfc822Name, or uniformResourceIdentifier.

- A critical Subject Alternative Name extension that includes: dNSName, rfc822Name, ediPartyName, uniformResourceIdentifier, or ipAddress (both IPv4 and IPv6).

8. Relying Party Applications
This section documents requirements for RPs (Relying Parties) in addition to those listed in [RFC8603], which in turn specifies requirements in addition to those in [RFC5280].

RSA-based algorithms are not supported.

RPs support the Authority Key Identifier and the Subject Key Identifier extensions.

RPs should support the following extensions: CRL Distribution Points, Authority Information Access, Subject Directory Attribute, Authority Clearance Constraints, and CMS Content Constraints extensions.

Within the Subject Directory Attribute extension, RPs should support the Clearance Sponsor, Clearance, and Device Owner attributes.

RPs support the id-kp-cmcRA and id-kp-cmcCA EKUs.

Failure to support extensions in this section might limit the suitability of a device for certain applications.

9. CRL Profile

This section documents requirements for CRLs in addition to those listed in [RFC8603], which in turn specifies requirements in addition to those in [RFC5280].

RSA-based algorithms are not used.

Two types of CRLs are produced: complete base CRLs and partitioned base CRLs.

crlEntryExtensions are never included and the reasons and cRLIssuer fields are never populated.

All CRLs include the following CRL extensions:

- The Authority Key Identifier extension: The keyIdentifier is the 64 low-order bits of the issuer’s subjectPublicKey field.

- As per [RFC5280], the CRL Number extension.

The only other extension included in partitioned base CRLs is the Issuing Distribution Point extension. The distributionPoint is always identified by the fullName choice; the uniformResourceIdentifier GeneralName choice is always included but others can also be used as long as the first element in the sequence of distribution points is the uniformResourceIdentifier choice and the
scheme is an HTTP/HTTPS scheme; all other fields are omitted.

10. IANA Considerations

None.

11. Security Considerations

This entire document is about security. This document profiles the use of many protocols and services: EST, CMC, and PKCS#10/#7/#12 as well as certificates, CRLs, and their extensions [RFC5280]. These have been referred to throughout this document and those specifications should be consulted for security considerations related to implemented protocol and services.

12. References

12.1. Normative References


[ RFC7191 ] Housley, R., "Cryptographic Message Syntax (CMS) Key


12.2. Informative References


None.

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