Textual Encodings of PKIX, PKCS, and CMS Structures

Abstract

This document describes and discusses the textual encodings of the Public-Key Infrastructure X.509 (PKIX), Public-Key Cryptography Standards (PKCS), and Cryptographic Message Syntax (CMS). The textual encodings are well-known, are implemented by several applications and libraries, and are widely deployed. This document articulates the de facto rules by which existing implementations operate and defines them so that future implementations can interoperate.

Status of This Memo

This is an Internet Standards Track document.

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1. Introduction

Several security-related standards used on the Internet define ASN.1 data formats that are normally encoded using the Basic Encoding Rules (BER) or Distinguished Encoding Rules (DER) \[X.690\], which are binary, octet-oriented encodings. This document is about the textual encodings of the following formats:

1. Certificates, Certificate Revocation Lists (CRLs), and Subject Public Key Info structures in the Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile \[RFC5280\].
2. PKCS #10: Certification Request Syntax \[RFC2986\].
3. PKCS #7: Cryptographic Message Syntax \[RFC2315\].
4. Cryptographic Message Syntax \[RFC5652\].
5. PKCS #8: Private-Key Information Syntax [RFC5208], renamed to One
Asymmetric Key in Asymmetric Key Package [RFC5958], and Encrypted
Private-Key Information Syntax in the same documents.

6. Attribute Certificates in An Internet Attribute Certificate
Profile for Authorization [RFC5755].

A disadvantage of a binary data format is that it cannot be
interchanged in textual transports, such as email or text documents.
One advantage with text-based encodings is that they are easy to
modify using common text editors; for example, a user may concatenate
several certificates to form a certificate chain with copy-and-paste
operations.

The tradition within the RFC series can be traced back to Privacy-
Enhanced Mail (PEM) [RFC1421], based on a proposal by Marshall Rose
in Message Encapsulation [RFC934]. Originally called "PEM
encapsulation mechanism", "encapsulated PEM message", or (arguably)
"PEM printable encoding", today the format is sometimes referred to
as "PEM encoding". Variations include OpenPGP ASCII armor [RFC4880]
and OpenSSH key file format [RFC4716].

For reasons that basically boil down to non-coordination or
inattention, many PKIX, PKCS, and CMS libraries implement a text-
based encoding that is similar to -- but not identical with -- PEM
encoding. This document specifies the _textual encoding_ format,
articulates the de facto rules that most implementations operate by,
and provides recommendations that will promote interoperability going
forward. This document also provides common nomenclature for syntax
elements, reflecting the evolution of this de facto standard format.
Peter Gutmann’s "X.509 Style Guide" [X.509SG] contains a section
"base64 Encoding" that describes the formats and contains suggestions
similar to what is in this document. All figures are real,
functional examples, with key lengths and inner contents chosen to be
as small as practicable.

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
RFC 2119 [RFC2119].

2. General Considerations

Textual encoding begins with a line comprising "-----BEGIN ", a
label, and "-----", and ends with a line comprising "-----END ", a
label, and "-----". Between these lines, or "encapsulation
boundaries", are base64-encoded data according to Section 4 of
[RFC4648]. (PEM [RFC1421] referred to this data as the "encapsulated
Data before the encapsulation boundaries are permitted, and parsers MUST NOT malfunction when processing such data. Furthermore, parsers SHOULD ignore whitespace and other non-base64 characters and MUST handle different newline conventions.

The type of data encoded is labeled depending on the type label in the "-----BEGIN " line (pre-encapsulation boundary). For example, the line may be "-----BEGIN CERTIFICATE-----" to indicate that the content is a PKIX certificate (see further below). Generators MUST put the same label on the "-----END " line (post-encapsulation boundary) as the corresponding "-----BEGIN " line. Labels are formally case-sensitive, uppercase, and comprised of zero or more characters; they do not contain consecutive spaces or hyphen-minuses, nor do they contain spaces or hyphen-minuses at either end. Parsers MAY disregard the label in the post-encapsulation boundary instead of signaling an error if there is a label mismatch: some extant implementations require the labels to match; others do not.

There is exactly one space character (SP) separating the "BEGIN" or "END" from the label. There are exactly five hyphen-minus (also known as dash) characters ("-") on both ends of the encapsulation boundaries, no more, no less.

The label type implies that the encoded data follows the specified syntax. Parsers MUST handle non-conforming data gracefully. However, not all parsers or generators prior to this document behave consistently. A conforming parser MAY interpret the contents as another label type but ought to be aware of the security implications discussed in the Security Considerations section. The labels described in this document identify container formats that are not specific to any particular cryptographic algorithm, a property consistent with algorithm agility. These formats use the ASN.1 AlgorithmIdentifier structure as described in Section 4.1.1.2 of [RFC5280].

Unlike legacy PEM encoding [RFC1421], OpenPGP ASCII armor, and the OpenSSH key file format, textual encoding does *not* define or permit headers to be encoded alongside the data. Empty space can appear between the pre-encapsulation boundary and the base64, but generators SHOULD NOT emit such any such spacing. (The provision for this empty area is a throwback to PEM, which defined an "encapsulated header portion".)

Implementers need to be aware that extant parsers diverge considerably on the handling of whitespace. In this document, "whitespace" means any character or series of characters that represent horizontal or vertical space in typography. In US-ASCII, whitespace means HT (0x09), VT (0x0B), FF (0x0C), SP (0x20), CR
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(0x0D), and LF (0x0A); "blank" means HT and SP; lines are divided
with CRLF, CR, or LF. The common ABNF production WSP is congruent
with "blank"; a new production W is used for "whitespace". The ABNF
in Section 3 is specific to US-ASCII. As these textual encodings can
be used on many different systems as well as on long-term archival
storage media such as paper or engravings, an implementer ought to
use the spirit rather than the letter of the rules when generating or
parsing these formats in environments that are not strictly limited
to US-ASCII.

Most extant parsers ignore blanks at the ends of lines; blanks at the
beginnings of lines or in the middle of the base64-encoded data are
far less compatible. These observations are codified in Figure 1.
The most lax parser implementations are not line-oriented at all and
will accept any mixture of whitespace outside of the encapsulation
boundaries (see Figure 2). Such lax parsing may run the risk of
accepting text that was not intended to be accepted in the first
place (e.g., because the text was a snippet or sample).

Generators MUST wrap the base64-encoded lines so that each line
consists of exactly 64 characters except for the final line, which
will encode the remainder of the data (within the 64-character line
boundary), and they MUST NOT emit extraneous whitespace. Parsers MAY
handle other line sizes. These requirements are consistent with PEM
[RFC1421].

Files MAY contain multiple textual encoding instances. This is used,
for example, when a file contains several certificates. Whether the
instances are ordered or unordered depends on the context.

3. ABNF

The ABNF [RFC5234] of the textual encoding is:

textualmsg = preeb *WSP eol
*eolWSP
base64text
posteb *WSP [eol]

preeb = "-----BEGIN " label "-----" ; unlike [RFC1421] (A)BNF,
eol is not required (but
posteb = "-----END " label "-----" ; see [RFC1421], Section 4.4)

base64char = ALPHA / DIGIT / "+" / "/"

base64pad = "="

base64line = 1*base64char *WSP eol
base64finl = *base64char (base64pad *WSP eol base64pad /
    *2base64pad) *WSP eol
    ; ...AB< <EOL> = <EOL> is not good, but is valid

base64text = *base64line base64finl
    ; we could also use <encbinbody> from RFC 1421, which requires
    ; 16 groups of 4 chars, which means exactly 64 chars per
    ; line, except the final line, but this is more accurate

labelchar = %x21-2C / %x2E-7E    ; any printable character,
    ; except hyphen-minus

label = [ labelchar *( ["-" / SP] labelchar ) ]       ; empty ok

eol = CRLF / CR / LF

eolWSP = WSP / CR / LF                        ; compare with LWSP

Figure 1: ABNF (Standard)

laxtextualmsg = *W preeb
    laxbase64text
    posteb *W

W = WSP / CR / LF / %x0B / %x0C           ; whitespace

laxbase64text = *(W / base64char) [base64pad *W [base64pad *W]]

    Figure 2: ABNF (Lax)

stricttextualmsg = preeb eol
    strictbase64text
    posteb eol

strictbase64finl = *15(4base64char) (4base64char / 3base64char
    base64pad / 2base64char 2base64pad) eol

base64fullline = 64base64char eol

strictbase64text = *base64fullline strictbase64finl

    Figure 3: ABNF (Strict)

New implementations SHOULD emit the strict format (Figure 3)
specified above. The choice of parsing strategy depends on the
context of use.
4. Guide

For convenience, these figures summarize the structures, encodings, and references in the following sections:

<table>
<thead>
<tr>
<th>Sec.</th>
<th>Label</th>
<th>ASN.1 Type</th>
<th>Reference Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>CERTIFICATE</td>
<td>Certificate</td>
<td>[RFC5280] id-pkix1-e</td>
</tr>
<tr>
<td>6</td>
<td>X509 CRL</td>
<td>CertificateList</td>
<td>[RFC5280] id-pkix1-e</td>
</tr>
<tr>
<td>7</td>
<td>CERTIFICATE REQUEST</td>
<td>CertificationRequest</td>
<td>[RFC2986] id-pkcs10</td>
</tr>
<tr>
<td>8</td>
<td>PKCS7</td>
<td>ContentInfo</td>
<td>[RFC2315] id-pkcs7*</td>
</tr>
<tr>
<td>9</td>
<td>CMS</td>
<td>ContentInfo</td>
<td>[RFC5652] id-cms2004</td>
</tr>
<tr>
<td>10</td>
<td>PRIVATE KEY</td>
<td>PrivateKeyInfo ::=</td>
<td>[RFC5208] id-pkcs8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OneAsymmetricKey</td>
<td>[RFC5958] id-aKPV1</td>
</tr>
<tr>
<td>11</td>
<td>ENCRYPTED PRIVATE KEY</td>
<td>EncryptedPrivateKeyInfo</td>
<td>[RFC5958] id-aKPV1</td>
</tr>
<tr>
<td>12</td>
<td>ATTRIBUTE CERTIFICATE</td>
<td>AttributeCertificate</td>
<td>[RFC5755] id-acv2</td>
</tr>
<tr>
<td>13</td>
<td>PUBLIC KEY</td>
<td>SubjectPublicKeyInfo</td>
<td>[RFC5280] id-pkix1-e</td>
</tr>
</tbody>
</table>

Figure 4: Convenience Guide

*This OID does not actually appear in PKCS #7 v1.5 [RFC2315]. It was defined in the ASN.1 module to PKCS #7 v1.6 [P7v1.6], and has been carried forward through PKCS #12 [RFC7292].

Figure 5: ASN.1 Module Object Identifier Value Assignments
5. Textual Encoding of Certificates

5.1. Encoding

Public-key certificates are encoded using the "CERTIFICATE" label. The encoded data MUST be a BER (DER strongly preferred; see Appendix B) encoded ASN.1 Certificate structure as described in Section 4 of [RFC5280].

-----BEGIN CERTIFICATE-----
MIICLDCCAdKgAwIBAgIBADAKBggqhkjOPQDAjB9MQswCQYDVQQGEwJCRTEPMA0GA1UEChMGR251VExTMSUwIwYDVQQKEwZMZXV2Z4xJTAjBgNVBAMTHEdudVRMUyBjZXJ0aWZpY2F0ZSBhdXR0b3JpdHwKhcNMTIzMjIyMDC0MTUxWjB9MQswCQYDVQQGEwJCRTEPMA0GA1UEChMGR251VExTMSUwIwYDVQQKEwZMZXV2Z4xJTAjBgNVBAMTHEdudVRMUyBjZXJ0aWZpY2F0ZSBhdXR0b3JpdHwWTATBgcqhkjOPQIBggghkjoPQMBBwNCAARS2I0jiuNn14Y2sSALCX3IybsiIjUvxcUpj+oNfzgsvj/Niyv2394BwN4XuQ4RTEiyw87WbwnwGgjbx/t2no0MwQfApaBNVSbRMBAf8EBTADzQH/MA8GA1UdDwEB/wQFAwMHBgAwHYDVR0BBYYEFPCC0gf6YEr+1KLLkQAPLzB9mTigDMAoGCCqGSM49BAMCA0gAMEUCIDuwD1KPyG+hRf8MeyMqOFZD0TbVleF+UsAGQ4enAIoA14oouWwKQa+up8GftXE2C//4mKANBC6It0lgUA0Ipo=
-----END CERTIFICATE-----

Historically, the label "X509 CERTIFICATE" and also less commonly "X.509 CERTIFICATE" have been used. Generators conforming to this document MUST generate "CERTIFICATE" labels and MUST NOT generate "X509 CERTIFICATE" or "X.509 CERTIFICATE" labels. Parsers SHOULD NOT treat "X509 CERTIFICATE" or "X.509 CERTIFICATE" as equivalent to "CERTIFICATE", but a valid exception may be for backwards compatibility (potentially together with a warning).
5.2. Explanatory Text

Many tools are known to emit explanatory text before the BEGIN and after the END lines for PKIX certificates, more than any other type. If emitted, such text SHOULD be related to the certificate, such as providing a textual representation of key data elements in the certificate.

Subject: CN=Atlantis
Issuer: CN=Atlantis
Validity: from 7/9/2012 3:10:38 AM UTC to 7/9/2013 3:10:37 AM UTC

-----BEGIN CERTIFICATE-----
MIIBmTCCAUegAwIBAgIBKjAJBgUrDgMCHQUAMEMxC5APBgNVBAMTB0l0bGFudGlzMB4X
DTEyMDcwOTAzMTAzOTwzMDcwOTAzMTAzN1owEzERMA8GA1UEAxMIQXRsYW50aXMw
XzDBkqkhkiG9w0BAQFAAFLADBlAkeEAw+BXo+miabDHk+yrqcqqNh
Ryn/XtkJIIHvYtHvIX+S1x5ErgMoHehycpxbErZmVR4GCq1S2diN/r2CRtQID
AQABo4GJMIGGMAwGA1UdEwEB/wQCMAAwIAYDVR0ECAQgEBwIEHwECMAwGA1UdEwEB
/wQCMAAwIAYDVR0ECAQgEBwIEHwECAwIBAQAwEigB+Z
-----END CERTIFICATE-----

Figure 7: Certificate Example with Explanatory Text

5.3. File Extension

Although textual encodings of PKIX structures can occur anywhere, many tools are known to offer an option to output this encoding when serializing PKIX structures. To promote interoperability and to separate DER encodings from textual encodings, the extension ".crt" SHOULD be used for the textual encoding of a certificate. Implementations should be aware that in spite of this recommendation, many tools still default to encode certificates in this textual encoding with the extension ".cer".

This section does not disturb the official application/pkix-cert registration [RFC2585] in any way (which states that "each '.cer' file contains exactly one certificate, encoded in DER format"), but merely articulates a widespread, de facto alternative.
Textual Encoding of Certificate Revocation Lists

Certificate Revocation Lists (CRLs) are encoded using the "X509 CRL" label. The encoded data MUST be a BER (DER strongly preferred; see Appendix B) encoded ASN.1 CertificateList structure as described in Section 5 of [RFC5280].

-----BEGIN X509 CRL-----
MIIB9DCCAV8CAQEWcwYJKoZIhvcNAQEFMIIIBCDEXMBUGA1UEChMGMVnYVZ24sIEluYy4xHzaBGA1BMVnYX0IE5ldHdvcmsxRjBERgNVBAxT
PXd3dy52XJpc21nbj5jb20vcmbWcb3NpdG9yeS9SUEEgSW5jb3JwLiBieSBSWYu
LExJQUIuTFREKGMpOTgkH2dAcBGBDAcEGGmmEgTm90IFZhbGlkYXR1ZDEm
MCQGA1UECExMdBG1naXRbRiBCJvBDBbdGFzcyAxIC0gTmV0c2NhcGVxGDAMBgNVBAEw
D1NpbW9uIEpv2Ymc3NvbjEiMCAGCSqGSIb3DQUEJARYC21tb25Aam9zZWZzZ29u
LeM9yZxcNMDYxMjI3MDgwMjAdMw0xLmJjMjA3MDgwMjAwWjEaMFMECCEC4MQWFRoWd
elUNpl1hhTgXDTA2MTIyNzA4MDIxMhMxSwPfoWcWYJo2ZIhvcNAQFVIg4GBAD0z+XJzhkcc
NbrqO1snIKL8nXLqPcHv1I/le1MNo9tlohGQxb5HnFUAy82r6Epor4aHqVyb+5y+neKN9Kn2mPF4iun+a4o26Cj0jPArqJL1p8T0yiy19Xxvyc/ez9A9HiIyP
+3DGMNR+oUmSjKZ0jIhAYMeLXaPHfQW
-----END X509 CRL-----

Figure 8: CRL Example

Historically, the label "CRL" has rarely been used. Today, it is not common and many popular tools do not understand the label. Therefore, this document standardizes "X509 CRL" in order to promote interoperability and backwards-compatibility. Generators conforming to this document MUST generate "X509 CRL" labels and MUST NOT generate "CRL" labels. Parsers SHOULD NOT treat "CRL" as equivalent to "X509 CRL".

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7. Textual Encoding of PKCS #10 Certification Request Syntax

PKCS #10 Certification Requests are encoded using the "CERTIFICATE REQUEST" label. The encoded data MUST be a BER (DER strongly preferred; see Appendix B) encoded ASN.1 CertificationRequest structure as described in [RFC2986].

-----BEGIN CERTIFICATE REQUEST-----
MIIBWDCCAQcCAQAwTjELMAkGA1UEBhMCU0UxJzAlBgNVBAoTHlNpbW9uIExPa3EhIHNhcmRlciBTVElhbGUsIEluYWJsZSBAoIBAga1UEAxMNam9zZWZzc29ubmV0MRMw形成日[320x381]RFC2315]

-----END CERTIFICATE REQUEST-----

Figure 9: PKCS #10 Example

The label "NEW CERTIFICATE REQUEST" is also in wide use. Generators conforming to this document MUST generate "CERTIFICATE REQUEST" labels. Parsers MAY treat "NEW CERTIFICATE REQUEST" as equivalent to "CERTIFICATE REQUEST".

8. Textual Encoding of PKCS #7 Cryptographic Message Syntax

PKCS #7 Cryptographic Message Syntax structures are encoded using the "PKCS7" label. The encoded data MUST be a BER-encoded ASN.1 ContentInfo structure as described in [RFC2315].

-----BEGIN PKCS7-----
MIHjBgsqhkiG9w0BCRAF6CB0zCB0AIBADFHo18CAQCBgYJKoZIhvcNAQgUMMA4EClfrI6dr0gUWAgITdAjiBgsqhkjIGw0BCRAcICTAUBggkqk-iG9w0DBwQIZpCRWtz
u5kEgDCjery8qodQ7EEeromJzVzAurkJ81IrrozB5kgqkhk-iG9w0BBwEmWyRLkoZI
hvcNAQkQAw8wJDAQZhkqk-hkIG9w0DBwQI8tC8xu09nxEwDAIKwYBBQUIAIFIARQ
OsYGYFADAh0RncIw8pBvKEAQUM2Xo8PMHBoYdqEcshGd1CFAZH4=
-----END PKCS7-----

Figure 10: PKCS #7 Example

The label "CERTIFICATE CHAIN" has been in use to denote a degenerate PKCS #7 structure that contains only a list of certificates (see Section 9 of [RFC2315]). Several modern tools do not support this label. Generators MUST NOT generate the "CERTIFICATE CHAIN" label. Parsers SHOULD NOT treat "CERTIFICATE CHAIN" as equivalent to "PKCS7".
PKCS #7 is an old specification that has long been superseded by CMS [RFC5652]. Implementations SHOULD NOT generate PKCS #7 when CMS is an alternative.

9. Textual Encoding of Cryptographic Message Syntax

Cryptographic Message Syntax structures are encoded using the "CMS" label. The encoded data MUST be a BER-encoded ASN.1 ContentInfo structure as described in [RFC5652].

-----BEGIN CMS-----
MIGDBgshqkiG9w0BCRABCaB0MHICAQAwDQYLJKoZIhvcNAQkQAwgwXgYJKoZIhvcNAQcBoFEEEticc87PK0nNK9ENqSxItVloSa000S/ISCzMs1ZIzkgsKk4tsQ0N1nUMdvb05OX15XLPtEtVimwVLwSE0sK1FIvHAqSk3MBkkBAJv0Fx0=
-----END CMS-----

Figure 11: CMS Example

CMS is the IETF successor to PKCS #7. Section 1.1.1 of [RFC5652] describes the changes since PKCS #7 v1.5. Implementations SHOULD generate CMS when it is an alternative, promoting interoperability and forwards-compatibility.

10. One Asymmetric Key and the Textual Encoding of PKCS #8 Private Key Info

Unencrypted PKCS #8 Private Key Information Syntax structures (PrivateKeyInfo), renamed to Asymmetric Key Packages (OneAsymmetricKey), are encoded using the "PRIVATE KEY" label. The encoded data MUST be a BER (DER preferred; see Appendix B) encoded ASN.1 PrivateKeyInfo structure as described in PKCS #8 [RFC5208], or a OneAsymmetricKey structure as described in [RFC5958]. The two are semantically identical and can be distinguished by version number.

-----BEGIN PRIVATE KEY-----
MIGEAgEAMBAGByqGSM49AgEGBSuBBAAKBG0wawIBAQQgVcB/UNPxa1R9zDYAjQIfjojUD1uQnSjrFEEezZPT/92hRANCAAASc7UJtgnF/abqWM60T3XNJEx2Bv5ez9TdwK
HOM6xpM2q+53wsmN/eYLdgtjgBd3DBmHtPi1CkiFICXyaA8z9LkJ
-----END PRIVATE KEY-----

Figure 12: PKCS #8 PrivateKeyInfo (OneAsymmetricKey) Example
11. Textual Encoding of PKCS #8 Encrypted Private Key Info

Encrypted PKCS #8 Private Key Information Syntax structures (EncryptedPrivateKeyInfo), called the same in [RFC5958], are encoded using the "ENCRYPTED PRIVATE KEY" label. The encoded data MUST be a BER (DER preferred; see Appendix B) encoded ASN.1 EncryptedPrivateKeyInfo structure as described in PKCS #8 [RFC5208] and [RFC5958].

-----BEGIN ENCRYPTED PRIVATE KEY-----
MIHNMEAGCSqGSIb3DQEFDATAxMBwGCSqGSIb3DQEDEQAOBAghhICA6T/51QICCAAwFAYIKoZIhvcNAwECBCxDgqI59i9vBIGIY3CAqIaMNBoS15QiiWNJ3IpflnEiEsWZOJIoHyRmKK/cr9qQPlzxmM0TR9s45rG3C1lzTWvb0jYvbG3hu0zyFPraoMkap8eRzWs4wC5S5Ve1+CSjo2sM8v87cy1d+txxr+XOYVDE+eTgMLbrLmsWh3QkCRTfQC7k0N6zUHTV9yGswqMbw==
-----END ENCRYPTED PRIVATE KEY-----

Figure 13: PKCS #8 EncryptedPrivateKeyInfo Example

12. Textual Encoding of Attribute Certificates

Attribute certificates are encoded using the "ATTRIBUTE CERTIFICATE" label. The encoded data MUST be a BER (DER strongly preferred; see Appendix B) encoded ASN.1 AttributeCertificate structure as described in [RFC5755].

-----BEGIN ATTRIBUTE CERTIFICATE-----
MIICKzCCAZQCAQEwogZegQ2QwYmkgYTwgYXAgXzAJBgNVBAYTA1VTMREwDwYDVQQI
DAhOZXgWW9yazEUMBIGA1UEAwgXa80oYMXAgUZIxMBcGCSqGSIb3DQEDEQFADBw
MjE6MgGA1UExwxU2NvdHQqU3RhbGxa9i91bWFpbEFkZHJic3M9c3N0YXxsZzxa
aWMuc3VXaXJlUmVkdQAgARwgdhceMIIGggBgcgcGAMAwIBAgITMREwDwYDVQQI

Figure 14: Attribute Certificate Example
13. Textual Encoding of Subject Public Key Info

Public keys are encoded using the "PUBLIC KEY" label. The encoded data MUST be a BER (DER preferred; see Appendix B) encoded ASN.1 SubjectPublicKeyInfo structure as described in Section 4.1.2.7 of [RFC5280].

```
-----BEGIN PUBLIC KEY-----
MHYwEAYHkoZIzj0CAqYfK44EAAcIDygxixEn1L1wLN/KBYQRVH6ff0MTz0J0VztLe
klchp2hi78cCaMY81FB1ys8J91l7krc+M4aBeCGYFlyjba+hiXttJWPL7yd1E+5UG4U
Nkn3Eos8El2Byi9DVsyf9eejh+8AXgp
-----END PUBLIC KEY-----
```

Figure 15: Subject Public Key Info Example

14. Security Considerations

Data in this format often originates from untrusted sources, thus parsers must be prepared to handle unexpected data without causing security vulnerabilities.

Implementers building implementations that rely on canonical representation or the ability to fingerprint a particular data object need to understand that this document does not define canonical encodings. The first ambiguity is introduced by permitting the text-encoded representation instead of the binary BER or DER encodings, but further ambiguities arise when multiple labels are treated as similar. Variations of whitespace and non-base64 alphabetic characters can create further ambiguities. Data encoding ambiguities also create opportunities for side channels. If canonical encodings are desired, the encoded structure must be decoded and processed into a canonical form (namely, DER encoding).

15. References

15.1. Normative References


15.2. Informative References


Appendix A. Non-conforming Examples

This appendix contains examples for the non-recommended label variants described earlier in this document. As discussed earlier, supporting these is not required and is sometimes discouraged. Still, they can be useful for interoperability testing and for easy reference.

-----BEGIN X509 CERTIFICATE-----
MIIBHDCBxaADAgECigCiczxAJBgcqkhjOIPQMBBAxjAMBgNVBAMUBVBLSVghMB4X
DTE0MDkxNDA2MTU1MFcXDTI0MDkxNDA2MTU1MFowEDEOMAwGA1UEAxQFUEEtJWCEw
WTATBgcgkqjOIPQMBBwNCAATwoQ5r863Qr0PoRIyQ96H7WyKeDPH
Wa0eVAE24bt43wCNc+U5a2761dhGhSSJkVWRgVH5+prLiRznflIq+X4oxAwDjAM
BgNVHRMAf8EAjAAMAKGByqGSM49BAEDRwAwRAIfMdKS5631MnWVi7uaKJzKCs
NnY/OKgBex6MIEAv2AIhAI2GdvfL+mgVhyPZE+JxRxWChmgg5b/9eHdUcmW/jkOH
-----END X509 CERTIFICATE-----

Figure 16: Non-standard 'X509' Certificate Example

-----BEGIN X.509 CERTIFICATE-----
MIIBHDCBxaADAgECigCiczxAJBgcqkhjOIPQMBBAxjAMBgNVBAMUBVBLSVghMB4X
DTE0MDkxNDA2MTU1MFcXDTI0MDkxNDA2MTU1MFowEDEOMAwGA1UEAxQFUEEtJWCEw
WTATBgcgkqjOIPQMBBwNCAATwoQ5r863Qr0PoRIyQ96H7WyKeDPH
Wa0eVAE24bt43wCNc+U5a2761dhGhSSJkVWRgVH5+prLiRznflIq+X4oxAwDjAM
BgNVHRMAf8EAjAAMAKGByqGSM49BAEDRwAwRAIfMdKS5631MnWVi7uaKJzKCs
NnY/OKgBex6MIEAv2AIhAI2GdvfL+mgVhyPZE+JxRxWChmgg5b/9eHdUcmW/jkOH
-----END X.509 CERTIFICATE-----

Figure 17: Non-standard 'X.509' Certificate Example

-----BEGIN NEW CERTIFICATE REQUEST-----
MIIBDCCAQcCAQAwTjELMAkGA1UEBhMCU0UxJzAlBgNVBAoTHlNpbW9uIEpvc2lv
DTE0MDkxNDA2MTU1MFcXDTI0MDkxNDA2MTU1MFowEDEOMAwGA1UEAxQFUEEtJWCEw
WTATBgcgkqjOIPQMBBwNCAATwoQ5r863Qr0PoRIyQ96H7WyKeDPH
Wa0eVAE24bt43wCNc+U5a2761dhGhSSJkVWRgVH5+prLiRznflIq+X4oxAwDjAM
BgNVHRMAf8EAjAAMAKGByqGSM49BAEDRwAwRAIfMdKS5631MnWVi7uaKJzKCs
NnY/OKgBex6MIEAv2AIhAI2GdvfL+mgVhyPZE+JxRxWChmgg5b/9eHdUcmW/jkOH
-----END NEW CERTIFICATE REQUEST-----

Figure 18: Non-standard 'NEW' PKCS #10 Example
-----BEGIN CERTIFICATE CHAIN-----
MIHjBgsqhkjGw0BCRABF6CB0zCB0AIBADFho18CAAQCGwYJKoZIhvcNAQUMMA4E
ClfrI6dr0gUWAgiTJiDAjBgsqhkjGw0BCRADCTAUBggqhkiG9w0DBwQ1ZpECRWtzu
5KEGDCjerX8odQ7EEErOMZjvAurk/j811rozBsgkqhkiG9w0BBwEwYHkoZI
hvcNqAqQAw8wJDAUBggqhkiG9w0DBwQ10tC8c09nxEdAYIKwYBBQUIAQFAIAQ
OsYGYUFdAh0Nc1p4VbKEAQUM2X0s8PMHBoYdqEcsbT0d1CFAZH4=
-----END CERTIFICATE CHAIN-----

Figure 19: Non-standard 'CERTIFICATE CHAIN' Example

Appendix B. DER Expectations

This appendix is informative. Consult the respective standards for the normative rules.

DER is a restricted profile of BER [X.690]; thus, all DER encodings of data values are BER encodings, but just one of the BER encodings is the DER encoding for a data value. Canonical encoding matters when performing cryptographic operations; additionally, canonical encoding has certain efficiency advantages for parsers. There are three principal reasons to encode with DER:

1. A digital signature is (supposed to be) computed over the DER encoding of the semantic content, so providing anything other than the DER encoding is senseless. (In practice, an implementer might choose to have an implementation parse and digest the data as is, but this practice amounts to guesswork.)

2. In practice, cryptographic hashes are computed over the DER encoding for identification.

3. In practice, the content is small. DER always encodes data values in definite-length form (where the length is stated at the beginning of the encoding); thus, a parser can anticipate memory or resource usage up front.
Figure 20 matches the structures in this document with the particular reasons for DER encoding:

<table>
<thead>
<tr>
<th>Sec. Label</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>5  CERTIFICATE</td>
<td>1  2 ~3</td>
</tr>
<tr>
<td>6  X509 CRL</td>
<td>1</td>
</tr>
<tr>
<td>7  CERTIFICATE REQUEST</td>
<td>1 ~3</td>
</tr>
<tr>
<td>8  PKCS7</td>
<td>*</td>
</tr>
<tr>
<td>9  CMS</td>
<td>*</td>
</tr>
<tr>
<td>10 PRIVATE KEY</td>
<td>3</td>
</tr>
<tr>
<td>11 ENCRYPTED PRIVATE KEY</td>
<td>3</td>
</tr>
<tr>
<td>12 ATTRIBUTE CERTIFICATE</td>
<td>1 ~3</td>
</tr>
<tr>
<td>13 PUBLIC KEY</td>
<td>2 3</td>
</tr>
</tbody>
</table>

* Cryptographic Message Syntax is designed for content of any length; indefinite-length encoding enables one-pass processing (streaming) when generating the encoding. Only certain parts -- namely, signed and authenticated attributes -- need to be DER encoded.

- Although not always "small", these encoded structures should not be particularly "large" (e.g., more than 16 kilobytes). The parser ought to be informed of large things up front in any event; this is yet another reason to DER encode these things in the first place.

Acknowledgements

Peter Gutmann suggested to document labels for Attribute Certificates and PKCS #7 messages, and to add examples for the non-standard variants. Dr. Stephen Henson suggested distinguishing when BER versus DER is appropriate or necessary.
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