



PKCS #11 Cryptographic Token Interface Current Mechanisms Specification Version 3.0

Candidate OASIS Standard 01

27 March 2020

This stage:

<https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/cos01/pkcs11-curr-v3.0-cos01.docx> (Authoritative)
<https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/cos01/pkcs11-curr-v3.0-cos01.html>
<https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/cos01/pkcs11-curr-v3.0-cos01.pdf>

Previous stage:

<https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/cs01/pkcs11-curr-v3.0-cs01.docx> (Authoritative)
<https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/cs01/pkcs11-curr-v3.0-cs01.html>
<https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/cs01/pkcs11-curr-v3.0-cs01.pdf>

Latest stage:

<https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/pkcs11-curr-v3.0.docx> (Authoritative)
<https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/pkcs11-curr-v3.0.html>
<https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/pkcs11-curr-v3.0.pdf>

Technical Committee:

OASIS PKCS 11 TC

Chairs:

Tony Cox (tony.cox@cryptsoft.com), Cryptsoft Pty Ltd
Robert Relyea (rrelyea@redhat.com), Red Hat

Editors:

Chris Zimman (chris@wmpp.com), Individual
Dieter Bong (dieter.bong@utimaco.com), Utimaco IS GmbH

Additional artifacts:

This prose specification is one component of a Work Product that also includes:

- PKCS #11 header files:
<https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/cos01/include/pkcs11-v3.0/>

Related work:

This specification replaces or supersedes:

- *PKCS #11 Cryptographic Token Interface Current Mechanisms Specification Version 2.40*. Edited by Susan Gleeson, Chris Zimman, Robert Griffin, and Tim Hudson. Latest stage. <http://docs.oasis-open.org/pkcs11/pkcs11-curr/v2.40/pkcs11-curr-v2.40.html>.

This specification is related to:

- *PKCS #11 Cryptographic Token Interface Profiles Version 3.0*. Edited by Tim Hudson. Latest stage. <https://docs.oasis-open.org/pkcs11/pkcs11-profiles/v3.0/pkcs11-profiles-v3.0.html>.
- *PKCS #11 Cryptographic Token Interface Base Specification Version 3.0*. Edited by Chris Zimman and Dieter Bong. Latest stage. <https://docs.oasis-open.org/pkcs11/pkcs11-base/v3.0/pkcs11-base-v3.0.html>.

- *PKCS #11 Cryptographic Token Interface Historical Mechanisms Specification Version 3.0*. Edited by Chris Zimman and Dieter Bong. Latest stage. <https://docs.oasis-open.org/pkcs11/pkcs11-hist/v3.0/pkcs11-hist-v3.0.html>.

Abstract:

This document defines data types, functions and other basic components of the PKCS #11 Cryptoki interface.

Status:

This document was last revised or approved by the OASIS PKCS 11 TC on the above date. The level of approval is also listed above. Check the "Latest stage" location noted above for possible later revisions of this document. Any other numbered Versions and other technical work produced by the Technical Committee (TC) are listed at https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=pkcs11#technical.

TC members should send comments on this document to the TC's email list. Others should send comments to the TC's public comment list, after subscribing to it by following the instructions at the "Send A Comment" button on the TC's web page at <https://www.oasis-open.org/committees/pkcs11/>.

This specification is provided under the [RF on RAND Terms](#) Mode of the [OASIS IPR Policy](#), the mode chosen when the Technical Committee was established. For information on whether any patents have been disclosed that may be essential to implementing this specification, and any offers of patent licensing terms, please refer to the Intellectual Property Rights section of the TC's web page (<https://www.oasis-open.org/committees/pkcs11/ipr.php>).

Note that any machine-readable content ([Computer Language Definitions](#)) declared Normative for this Work Product is provided in separate plain text files. In the event of a discrepancy between any such plain text file and display content in the Work Product's prose narrative document(s), the content in the separate plain text file prevails.

Citation format:

When referencing this specification the following citation format should be used:

[PKCS11-Current-v3.0]

PKCS #11 Cryptographic Token Interface Current Mechanisms Specification Version 3.0. Edited by Chris Zimman and Dieter Bong. 27 March 2020. Candidate OASIS Standard 01. <https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/cos01/pkcs11-curr-v3.0-cos01.html>. Latest stage: <https://docs.oasis-open.org/pkcs11/pkcs11-curr/v3.0/pkcs11-curr-v3.0.html>.

Notices

Copyright © OASIS Open 2020. All Rights Reserved.

All capitalized terms in the following text have the meanings assigned to them in the OASIS Intellectual Property Rights Policy (the "OASIS IPR Policy"). The full [Policy](#) may be found at the OASIS website.

This document and translations of it may be copied and furnished to others, and derivative works that comment on or otherwise explain it or assist in its implementation may be prepared, copied, published, and distributed, in whole or in part, without restriction of any kind, provided that the above copyright notice and this section are included on all such copies and derivative works. However, this document itself may not be modified in any way, including by removing the copyright notice or references to OASIS, except as needed for the purpose of developing any document or deliverable produced by an OASIS Technical Committee (in which case the rules applicable to copyrights, as set forth in the OASIS IPR Policy, must be followed) or as required to translate it into languages other than English.

The limited permissions granted above are perpetual and will not be revoked by OASIS or its successors or assigns.

This document and the information contained herein is provided on an "AS IS" basis and OASIS DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTY THAT THE USE OF THE INFORMATION HEREIN WILL NOT INFRINGE ANY OWNERSHIP RIGHTS OR ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

OASIS requests that any OASIS Party or any other party that believes it has patent claims that would necessarily be infringed by implementations of this OASIS Committee Specification or OASIS Standard, to notify OASIS TC Administrator and provide an indication of its willingness to grant patent licenses to such patent claims in a manner consistent with the IPR Mode of the OASIS Technical Committee that produced this specification.

OASIS invites any party to contact the OASIS TC Administrator if it is aware of a claim of ownership of any patent claims that would necessarily be infringed by implementations of this specification by a patent holder that is not willing to provide a license to such patent claims in a manner consistent with the IPR Mode of the OASIS Technical Committee that produced this specification. OASIS may include such claims on its website, but disclaims any obligation to do so.

OASIS takes no position regarding the validity or scope of any intellectual property or other rights that might be claimed to pertain to the implementation or use of the technology described in this document or the extent to which any license under such rights might or might not be available; neither does it represent that it has made any effort to identify any such rights. Information on OASIS' procedures with respect to rights in any document or deliverable produced by an OASIS Technical Committee can be found on the OASIS website. Copies of claims of rights made available for publication and any assurances of licenses to be made available, or the result of an attempt made to obtain a general license or permission for the use of such proprietary rights by implementers or users of this OASIS Committee Specification or OASIS Standard, can be obtained from the OASIS TC Administrator. OASIS makes no representation that any information or list of intellectual property rights will at any time be complete, or that any claims in such list are, in fact, Essential Claims.

The name "OASIS" is a trademark of [OASIS](#), the owner and developer of this specification, and should be used only to refer to the organization and its official outputs. OASIS welcomes reference to, and implementation and use of, specifications, while reserving the right to enforce its marks against misleading uses. Please see <https://www.oasis-open.org/policies-guidelines/trademark> for above guidance.

Table of Contents

| | | |
|--------|--|----|
| 1 | Introduction | 15 |
| 1.1 | IPR Policy | 15 |
| 1.2 | Terminology | 15 |
| 1.3 | Definitions | 15 |
| 1.4 | Normative References | 17 |
| 1.5 | Non-Normative References | 18 |
| 2 | Mechanisms | 21 |
| 2.1 | RSA | 21 |
| 2.1.1 | Definitions | 22 |
| 2.1.2 | RSA public key objects | 23 |
| 2.1.3 | RSA private key objects | 24 |
| 2.1.4 | PKCS #1 RSA key pair generation | 25 |
| 2.1.5 | X9.31 RSA key pair generation | 26 |
| 2.1.6 | PKCS #1 v1.5 RSA | 26 |
| 2.1.7 | PKCS #1 RSA OAEP mechanism parameters | 27 |
| 2.1.8 | PKCS #1 RSA OAEP | 28 |
| 2.1.9 | PKCS #1 RSA PSS mechanism parameters | 29 |
| 2.1.10 | PKCS #1 RSA PSS | 29 |
| 2.1.11 | ISO/IEC 9796 RSA | 30 |
| 2.1.12 | X.509 (raw) RSA | 31 |
| 2.1.13 | ANSI X9.31 RSA | 32 |
| 2.1.14 | PKCS #1 v1.5 RSA signature with MD2, MD5, SHA-1, SHA-256, SHA-384, SHA-512, RIPE-MD 128 or RIPE-MD 160 | 32 |
| 2.1.15 | PKCS #1 v1.5 RSA signature with SHA-224 | 33 |
| 2.1.16 | PKCS #1 RSA PSS signature with SHA-224 | 33 |
| 2.1.17 | PKCS #1 RSA PSS signature with SHA-1, SHA-256, SHA-384 or SHA-512 | 33 |
| 2.1.18 | PKCS #1 v1.5 RSA signature with SHA3 | 34 |
| 2.1.19 | PKCS #1 RSA PSS signature with SHA3 | 34 |
| 2.1.20 | ANSI X9.31 RSA signature with SHA-1 | 34 |
| 2.1.21 | TPM 1.1b and TPM 1.2 PKCS #1 v1.5 RSA | 34 |
| 2.1.22 | TPM 1.1b and TPM 1.2 PKCS #1 RSA OAEP | 35 |
| 2.1.23 | RSA AES KEY WRAP | 36 |
| 2.1.24 | RSA AES KEY WRAP mechanism parameters | 37 |
| 2.1.25 | FIPS 186-4 | 37 |
| 2.2 | DSA | 37 |
| 2.2.1 | Definitions | 38 |
| 2.2.2 | DSA public key objects | 39 |
| 2.2.3 | DSA Key Restrictions | 40 |
| 2.2.4 | DSA private key objects | 40 |
| 2.2.5 | DSA domain parameter objects | 41 |
| 2.2.6 | DSA key pair generation | 42 |
| 2.2.7 | DSA domain parameter generation | 42 |
| 2.2.8 | DSA probabilistic domain parameter generation | 42 |
| 2.2.9 | DSA Shawe-Taylor domain parameter generation | 43 |

| | |
|---|----|
| 2.2.10 DSA base domain parameter generation | 43 |
| 2.2.11 DSA without hashing | 43 |
| 2.2.12 DSA with SHA-1 | 44 |
| 2.2.13 FIPS 186-4 | 44 |
| 2.2.14 DSA with SHA-224 | 44 |
| 2.2.15 DSA with SHA-256 | 45 |
| 2.2.16 DSA with SHA-384 | 45 |
| 2.2.17 DSA with SHA-512 | 46 |
| 2.2.18 DSA with SHA3-224 | 46 |
| 2.2.19 DSA with SHA3-256 | 47 |
| 2.2.20 DSA with SHA3-384 | 47 |
| 2.2.21 DSA with SHA3-512 | 47 |
| 2.3 Elliptic Curve | 48 |
| 2.3.1 EC Signatures | 50 |
| 2.3.2 Definitions | 50 |
| 2.3.3 ECDSA public key objects..... | 51 |
| 2.3.4 Elliptic curve private key objects | 52 |
| 2.3.5 Edwards Elliptic curve public key objects..... | 54 |
| 2.3.6 Edwards Elliptic curve private key objects | 54 |
| 2.3.7 Montgomery Elliptic curve public key objects..... | 55 |
| 2.3.8 Montgomery Elliptic curve private key objects | 56 |
| 2.3.9 Elliptic curve key pair generation..... | 57 |
| 2.3.10 Edwards Elliptic curve key pair generation | 58 |
| 2.3.11 Montgomery Elliptic curve key pair generation | 58 |
| 2.3.12 ECDSA without hashing | 59 |
| 2.3.13 ECDSA with hashing | 59 |
| 2.3.14 EdDSA..... | 60 |
| 2.3.15 XEdDSA | 60 |
| 2.3.16 EC mechanism parameters..... | 61 |
| 2.3.17 Elliptic curve Diffie-Hellman key derivation | 66 |
| 2.3.18 Elliptic curve Diffie-Hellman with cofactor key derivation | 67 |
| 2.3.19 Elliptic curve Menezes-Qu-Vanstone key derivation..... | 67 |
| 2.3.20 ECDH AES KEY WRAP | 68 |
| 2.3.21 ECDH AES KEY WRAP mechanism parameters | 69 |
| 2.3.22 FIPS 186-4 | 70 |
| 2.4 Diffie-Hellman | 70 |
| 2.4.1 Definitions..... | 71 |
| 2.4.2 Diffie-Hellman public key objects | 71 |
| 2.4.3 X9.42 Diffie-Hellman public key objects | 72 |
| 2.4.4 Diffie-Hellman private key objects | 72 |
| 2.4.5 X9.42 Diffie-Hellman private key objects | 73 |
| 2.4.6 Diffie-Hellman domain parameter objects | 74 |
| 2.4.7 X9.42 Diffie-Hellman domain parameters objects..... | 75 |
| 2.4.8 PKCS #3 Diffie-Hellman key pair generation | 76 |
| 2.4.9 PKCS #3 Diffie-Hellman domain parameter generation | 76 |
| 2.4.10 PKCS #3 Diffie-Hellman key derivation..... | 76 |

| | |
|--|-----|
| 2.4.11 X9.42 Diffie-Hellman mechanism parameters..... | 77 |
| 2.4.12 X9.42 Diffie-Hellman key pair generation..... | 80 |
| 2.4.13 X9.42 Diffie-Hellman domain parameter generation | 81 |
| 2.4.14 X9.42 Diffie-Hellman key derivation | 81 |
| 2.4.15 X9.42 Diffie-Hellman hybrid key derivation | 81 |
| 2.4.16 X9.42 Diffie-Hellman Menezes-Qu-Vanstone key derivation | 82 |
| 2.5 Extended Triple Diffie-Hellman (x3dh)..... | 83 |
| 2.5.1 Definitions | 83 |
| 2.5.2 Extended Triple Diffie-Hellman key objects | 83 |
| 2.5.3 Initiating an Extended Triple Diffie-Hellman key exchange..... | 83 |
| 2.5.4 Responding to an Extended Triple Diffie-Hellman key exchange | 84 |
| 2.5.5 Extended Triple Diffie-Hellman parameters | 85 |
| 2.6 Double Ratchet | 85 |
| 2.6.1 Definitions..... | 86 |
| 2.6.2 Double Ratchet secret key objects..... | 86 |
| 2.6.3 Double Ratchet key derivation | 87 |
| 2.6.4 Double Ratchet Encryption mechanism | 88 |
| 2.6.5 Double Ratchet parameters | 88 |
| 2.7 Wrapping/unwrapping private keys | 89 |
| 2.8 Generic secret key | 91 |
| 2.8.1 Definitions..... | 91 |
| 2.8.2 Generic secret key objects | 92 |
| 2.8.3 Generic secret key generation | 92 |
| 2.9 HMAC mechanisms | 93 |
| 2.9.1 General block cipher mechanism parameters..... | 93 |
| 2.10 AES..... | 93 |
| 2.10.1 Definitions..... | 93 |
| 2.10.2 AES secret key objects | 94 |
| 2.10.3 AES key generation..... | 95 |
| 2.10.4 AES-ECB..... | 95 |
| 2.10.5 AES-CBC..... | 95 |
| 2.10.6 AES-CBC with PKCS padding | 96 |
| 2.10.7 AES-OFB..... | 97 |
| 2.10.8 AES-CFB | 97 |
| 2.10.9 General-length AES-MAC | 98 |
| 2.10.10 AES-MAC | 98 |
| 2.10.11 AES-XCBC-MAC | 98 |
| 2.10.12 AES-XCBC-MAC-96..... | 98 |
| 2.11 AES with Counter | 99 |
| 2.11.1 Definitions..... | 99 |
| 2.11.2 AES with Counter mechanism parameters | 99 |
| 2.11.3 AES with Counter Encryption / Decryption..... | 100 |
| 2.12 AES CBC with Cipher Text Stealing CTS..... | 100 |
| 2.12.1 Definitions..... | 100 |
| 2.12.2 AES CTS mechanism parameters | 100 |
| 2.13 Additional AES Mechanisms | 101 |

| | |
|--|-----|
| 2.13.1 Definitions | 101 |
| 2.13.2 AES-GCM Authenticated Encryption / Decryption | 101 |
| 2.13.3 AES-CCM authenticated Encryption / Decryption | 103 |
| 2.13.4 AES-GMAC | 105 |
| 2.13.5 AES GCM and CCM Mechanism parameters | 105 |
| 2.14 AES CMAC | 108 |
| 2.14.1 Definitions | 108 |
| 2.14.2 Mechanism parameters | 108 |
| 2.14.3 General-length AES-CMAC | 108 |
| 2.14.4 AES-CMAC | 109 |
| 2.15 AES XTS | 109 |
| 2.15.1 Definitions | 109 |
| 2.15.2 AES-XTS secret key objects | 110 |
| 2.15.3 AES-XTS key generation | 110 |
| 2.15.4 AES-XTS | 110 |
| 2.16 AES Key Wrap | 110 |
| 2.16.1 Definitions | 111 |
| 2.16.2 AES Key Wrap Mechanism parameters | 111 |
| 2.16.3 AES Key Wrap | 111 |
| 2.17 Key derivation by data encryption – DES & AES | 111 |
| 2.17.1 Definitions | 112 |
| 2.17.2 Mechanism Parameters | 112 |
| 2.17.3 Mechanism Description | 112 |
| 2.18 Double and Triple-length DES | 113 |
| 2.18.1 Definitions | 113 |
| 2.18.2 DES2 secret key objects | 113 |
| 2.18.3 DES3 secret key objects | 114 |
| 2.18.4 Double-length DES key generation | 115 |
| 2.18.5 Triple-length DES Order of Operations | 115 |
| 2.18.6 Triple-length DES in CBC Mode | 115 |
| 2.18.7 DES and Triple length DES in OFB Mode | 115 |
| 2.18.8 DES and Triple length DES in CFB Mode | 116 |
| 2.19 Double and Triple-length DES CMAC | 116 |
| 2.19.1 Definitions | 117 |
| 2.19.2 Mechanism parameters | 117 |
| 2.19.3 General-length DES3-MAC | 117 |
| 2.19.4 DES3-CMAC | 117 |
| 2.20 SHA-1 | 118 |
| 2.20.1 Definitions | 118 |
| 2.20.2 SHA-1 digest | 118 |
| 2.20.3 General-length SHA-1-HMAC | 119 |
| 2.20.4 SHA-1-HMAC | 119 |
| 2.20.5 SHA-1 key derivation | 119 |
| 2.20.6 SHA-1 HMAC key generation | 120 |
| 2.21 SHA-224 | 120 |
| 2.21.1 Definitions | 120 |

| | |
|--|-----|
| 2.21.2 SHA-224 digest | 121 |
| 2.21.3 General-length SHA-224-HMAC | 121 |
| 2.21.4 SHA-224-HMAC | 121 |
| 2.21.5 SHA-224 key derivation..... | 121 |
| 2.21.6 SHA-224 HMAC key generation..... | 121 |
| 2.22 SHA-256 | 122 |
| 2.22.1 Definitions..... | 122 |
| 2.22.2 SHA-256 digest | 122 |
| 2.22.3 General-length SHA-256-HMAC | 122 |
| 2.22.4 SHA-256-HMAC | 123 |
| 2.22.5 SHA-256 key derivation..... | 123 |
| 2.22.6 SHA-256 HMAC key generation..... | 123 |
| 2.23 SHA-384 | 123 |
| 2.23.1 Definitions..... | 124 |
| 2.23.2 SHA-384 digest | 124 |
| 2.23.3 General-length SHA-384-HMAC | 124 |
| 2.23.4 SHA-384-HMAC | 125 |
| 2.23.5 SHA-384 key derivation..... | 125 |
| 2.23.6 SHA-384 HMAC key generation..... | 125 |
| 2.24 SHA-512 | 125 |
| 2.24.1 Definitions..... | 126 |
| 2.24.2 SHA-512 digest | 126 |
| 2.24.3 General-length SHA-512-HMAC | 126 |
| 2.24.4 SHA-512-HMAC | 126 |
| 2.24.5 SHA-512 key derivation..... | 127 |
| 2.24.6 SHA-512 HMAC key generation..... | 127 |
| 2.25 SHA-512/224 | 127 |
| 2.25.1 Definitions..... | 127 |
| 2.25.2 SHA-512/224 digest | 127 |
| 2.25.3 General-length SHA-512/224-HMAC | 128 |
| 2.25.4 SHA-512/224-HMAC | 128 |
| 2.25.5 SHA-512/224 key derivation..... | 128 |
| 2.25.6 SHA-512/224 HMAC key generation | 128 |
| 2.26 SHA-512/256 | 129 |
| 2.26.1 Definitions..... | 129 |
| 2.26.2 SHA-512/256 digest | 129 |
| 2.26.3 General-length SHA-512/256-HMAC | 130 |
| 2.26.4 SHA-512/256-HMAC | 130 |
| 2.26.5 SHA-512/256 key derivation..... | 130 |
| 2.26.6 SHA-512/256 HMAC key generation | 130 |
| 2.27 SHA-512/t | 131 |
| 2.27.1 Definitions..... | 131 |
| 2.27.2 SHA-512/t digest | 131 |
| 2.27.3 General-length SHA-512/t-HMAC | 131 |
| 2.27.4 SHA-512/t-HMAC | 132 |
| 2.27.5 SHA-512/t key derivation..... | 132 |

| | |
|--|-----|
| 2.27.6 SHA-512/t HMAC key generation | 132 |
| 2.28 SHA3-224 | 132 |
| 2.28.1 Definitions | 132 |
| 2.28.2 SHA3-224 digest | 133 |
| 2.28.3 General-length SHA3-224-HMAC | 133 |
| 2.28.4 SHA3-224-HMAC | 133 |
| 2.28.5 SHA3-224 key derivation..... | 133 |
| 2.28.6 SHA3-224 HMAC key generation | 133 |
| 2.29 SHA3-256 | 134 |
| 2.29.1 Definitions | 134 |
| 2.29.2 SHA3-256 digest | 134 |
| 2.29.3 General-length SHA3-256-HMAC | 135 |
| 2.29.4 SHA3-256-HMAC | 135 |
| 2.29.5 SHA3-256 key derivation..... | 135 |
| 2.29.6 SHA3-256 HMAC key generation | 135 |
| 2.30 SHA3-384 | 136 |
| 2.30.1 Definitions | 136 |
| 2.30.2 SHA3-384 digest | 136 |
| 2.30.3 General-length SHA3-384-HMAC | 136 |
| 2.30.4 SHA3-384-HMAC | 137 |
| 2.30.5 SHA3-384 key derivation..... | 137 |
| 2.30.6 SHA3-384 HMAC key generation | 137 |
| 2.31 SHA3-512 | 137 |
| 2.31.1 Definitions | 138 |
| 2.31.2 SHA3-512 digest | 138 |
| 2.31.3 General-length SHA3-512-HMAC | 138 |
| 2.31.4 SHA3-512-HMAC | 138 |
| 2.31.5 SHA3-512 key derivation..... | 139 |
| 2.31.6 SHA3-512 HMAC key generation | 139 |
| 2.32 SHAKE..... | 139 |
| 2.32.1 Definitions..... | 139 |
| 2.32.2 SHAKE Key Derivation..... | 139 |
| 2.33 Blake2b-160..... | 140 |
| 2.33.1 Definitions | 140 |
| 2.33.2 BLAKE2B-160 digest..... | 140 |
| 2.33.3 General-length BLAKE2B-160-HMAC | 141 |
| 2.33.4 BLAKE2B-160-HMAC | 141 |
| 2.33.5 BLAKE2B-160 key derivation..... | 141 |
| 2.33.6 BLAKE2B-160 HMAC key generation..... | 141 |
| 2.34 BLAKE2B-256..... | 141 |
| 2.34.1 Definitions | 142 |
| 2.34.2 BLAKE2B-256 digest..... | 142 |
| 2.34.3 General-length BLAKE2B-256-HMAC | 142 |
| 2.34.4 BLAKE2B-256-HMAC | 143 |
| 2.34.5 BLAKE2B-256 key derivation | 143 |
| 2.34.6 BLAKE2B-256 HMAC key generation..... | 143 |

| | |
|---|-----|
| 2.35 BLAKE2B-384..... | 143 |
| 2.35.1 Definitions..... | 144 |
| 2.35.2 BLAKE2B-384 digest..... | 144 |
| 2.35.3 General-length BLAKE2B-384-HMAC | 144 |
| 2.35.4 BLAKE2B-384-HMAC | 144 |
| 2.35.5 BLAKE2B-384 key derivation..... | 145 |
| 2.35.6 BLAKE2B-384 HMAC key generation..... | 145 |
| 2.36 BLAKE2B-512..... | 145 |
| 2.36.1 Definitions..... | 145 |
| 2.36.2 BLAKE2B-512 digest..... | 145 |
| 2.36.3 General-length BLAKE2B-512-HMAC | 146 |
| 2.36.4 BLAKE2B-512-HMAC | 146 |
| 2.36.5 BLAKE2B-512 key derivation..... | 146 |
| 2.36.6 BLAKE2B-512 HMAC key generation..... | 146 |
| 2.37 PKCS #5 and PKCS #5-style password-based encryption (PBE)..... | 147 |
| 2.37.1 Definitions..... | 147 |
| 2.37.2 Password-based encryption/authentication mechanism parameters..... | 147 |
| 2.37.3 PKCS #5 PBKDF2 key generation mechanism parameters | 148 |
| 2.37.4 PKCS #5 PBKDF2 key generation | 150 |
| 2.38 PKCS #12 password-based encryption/authentication mechanisms | 150 |
| 2.38.1 SHA-1-PBE for 3-key triple-DES-CBC | 151 |
| 2.38.2 SHA-1-PBE for 2-key triple-DES-CBC | 151 |
| 2.38.3 SHA-1-PBE for SHA-1-HMAC..... | 151 |
| 2.39 SSL | 152 |
| 2.39.1 Definitions..... | 152 |
| 2.39.2 SSL mechanism parameters | 152 |
| 2.39.3 Pre-master key generation | 154 |
| 2.39.4 Master key derivation | 155 |
| 2.39.5 Master key derivation for Diffie-Hellman | 155 |
| 2.39.6 Key and MAC derivation..... | 156 |
| 2.39.7 MD5 MACing in SSL 3.0 | 157 |
| 2.39.8 SHA-1 MACing in SSL 3.0 | 157 |
| 2.40 TLS 1.2 Mechanisms | 158 |
| 2.40.1 Definitions..... | 158 |
| 2.40.2 TLS 1.2 mechanism parameters | 158 |
| 2.40.3 TLS MAC | 161 |
| 2.40.4 Master key derivation | 162 |
| 2.40.5 Master key derivation for Diffie-Hellman | 162 |
| 2.40.6 Key and MAC derivation..... | 163 |
| 2.40.7 CKM_TLS12_KEY_SAFE_DERIVE..... | 164 |
| 2.40.8 Generic Key Derivation using the TLS PRF | 164 |
| 2.40.9 Generic Key Derivation using the TLS12 PRF | 165 |
| 2.41 WTLS | 166 |
| 2.41.1 Definitions..... | 166 |
| 2.41.2 WTLS mechanism parameters..... | 166 |
| 2.41.3 Pre master secret key generation for RSA key exchange suite..... | 169 |

| | |
|--|-----|
| 2.41.4 Master secret key derivation | 170 |
| 2.41.5 Master secret key derivation for Diffie-Hellman and Elliptic Curve Cryptography | 170 |
| 2.41.6 WTLS PRF (pseudorandom function) | 171 |
| 2.41.7 Server Key and MAC derivation | 171 |
| 2.41.8 Client key and MAC derivation | 172 |
| 2.42 SP 800-108 Key Derivation | 173 |
| 2.42.1 Definitions | 173 |
| 2.42.2 Mechanism Parameters | 174 |
| 2.42.3 Counter Mode KDF | 179 |
| 2.42.4 Feedback Mode KDF | 180 |
| 2.42.5 Double Pipeline Mode KDF | 180 |
| 2.42.6 Deriving Additional Keys | 181 |
| 2.42.7 Key Derivation Attribute Rules | 182 |
| 2.42.8 Constructing PRF Input Data | 182 |
| 2.42.8.1 Sample Counter Mode KDF | 183 |
| 2.42.8.2 Sample SCP03 Counter Mode KDF | 184 |
| 2.42.8.3 Sample Feedback Mode KDF | 185 |
| 2.42.8.4 Sample Double-Pipeline Mode KDF | 186 |
| 2.43 Miscellaneous simple key derivation mechanisms | 187 |
| 2.43.1 Definitions | 187 |
| 2.43.2 Parameters for miscellaneous simple key derivation mechanisms | 187 |
| 2.43.3 Concatenation of a base key and another key | 188 |
| 2.43.4 Concatenation of a base key and data | 189 |
| 2.43.5 Concatenation of data and a base key | 189 |
| 2.43.6 XORing of a key and data | 190 |
| 2.43.7 Extraction of one key from another key | 191 |
| 2.44 CMS | 191 |
| 2.44.1 Definitions | 192 |
| 2.44.2 CMS Signature Mechanism Objects | 192 |
| 2.44.3 CMS mechanism parameters | 192 |
| 2.44.4 CMS signatures | 193 |
| 2.45 Blowfish | 194 |
| 2.45.1 Definitions | 195 |
| 2.45.2 BLOWFISH secret key objects | 195 |
| 2.45.3 Blowfish key generation | 196 |
| 2.45.4 Blowfish-CBC | 196 |
| 2.45.5 Blowfish-CBC with PKCS padding | 196 |
| 2.46 Twofish | 197 |
| 2.46.1 Definitions | 197 |
| 2.46.2 Twofish secret key objects | 197 |
| 2.46.3 Twofish key generation | 198 |
| 2.46.4 Twofish -CBC | 198 |
| 2.46.5 Twofish-CBC with PKCS padding | 198 |
| 2.47 CAMELLIA | 198 |
| 2.47.1 Definitions | 199 |
| 2.47.2 Camellia secret key objects | 199 |

| | |
|--|-----|
| 2.47.3 Camellia key generation | 200 |
| 2.47.4 Camellia-ECB | 200 |
| 2.47.5 Camellia-CBC | 201 |
| 2.47.6 Camellia-CBC with PKCS padding | 201 |
| 2.47.7 CAMELLIA with Counter mechanism parameters | 202 |
| 2.47.8 General-length Camellia-MAC | 203 |
| 2.47.9 Camellia-MAC | 203 |
| 2.48 Key derivation by data encryption - Camellia | 203 |
| 2.48.1 Definitions | 203 |
| 2.48.2 Mechanism Parameters | 204 |
| 2.49 ARIA | 204 |
| 2.49.1 Definitions | 204 |
| 2.49.2 Aria secret key objects | 205 |
| 2.49.3 ARIA key generation | 205 |
| 2.49.4 ARIA-ECB | 205 |
| 2.49.5 ARIA-CBC | 206 |
| 2.49.6 ARIA-CBC with PKCS padding | 207 |
| 2.49.7 General-length ARIA-MAC | 207 |
| 2.49.8 ARIA-MAC | 208 |
| 2.50 Key derivation by data encryption - ARIA | 208 |
| 2.50.1 Definitions | 208 |
| 2.50.2 Mechanism Parameters | 208 |
| 2.51 SEED | 209 |
| 2.51.1 Definitions | 210 |
| 2.51.2 SEED secret key objects | 210 |
| 2.51.3 SEED key generation | 211 |
| 2.51.4 SEED-ECB | 211 |
| 2.51.5 SEED-CBC | 211 |
| 2.51.6 SEED-CBC with PKCS padding | 211 |
| 2.51.7 General-length SEED-MAC | 211 |
| 2.51.8 SEED-MAC | 211 |
| 2.52 Key derivation by data encryption - SEED | 212 |
| 2.52.1 Definitions | 212 |
| 2.52.2 Mechanism Parameters | 212 |
| 2.53 OTP | 212 |
| 2.53.1 Usage overview | 212 |
| 2.53.2 Case 1: Generation of OTP values | 213 |
| 2.53.3 Case 2: Verification of provided OTP values | 214 |
| 2.53.4 Case 3: Generation of OTP keys | 214 |
| 2.53.5 OTP objects | 215 |
| 2.53.5.1 Key objects | 215 |
| 2.53.6 OTP-related notifications | 218 |
| 2.53.7 OTP mechanisms | 218 |
| 2.53.7.1 OTP mechanism parameters | 218 |
| 2.53.8 RSA SecurID | 222 |
| 2.53.8.1 RSA SecurID secret key objects | 222 |

| | |
|---|-----|
| 2.53.8.2 RSA SecurID key generation | 223 |
| 2.53.8.3 SecurID OTP generation and validation..... | 224 |
| 2.53.8.4 Return values..... | 224 |
| 2.53.9 OATH HOTP..... | 224 |
| 2.53.9.1 OATH HOTP secret key objects | 224 |
| 2.53.9.2 HOTP key generation | 225 |
| 2.53.9.3 HOTP OTP generation and validation..... | 225 |
| 2.53.10 ActivIdentity ACTI | 225 |
| 2.53.10.1 ACTI secret key objects | 225 |
| 2.53.10.2 ACTI key generation | 226 |
| 2.53.10.3 ACTI OTP generation and validation | 226 |
| 2.54 CT-KIP | 227 |
| 2.54.1 Principles of Operation | 227 |
| 2.54.2 Mechanisms | 227 |
| 2.54.3 Definitions..... | 228 |
| 2.54.4 CT-KIP Mechanism parameters | 228 |
| 2.54.5 CT-KIP key derivation | 228 |
| 2.54.6 CT-KIP key wrap and key unwrap..... | 229 |
| 2.54.7 CT-KIP signature generation..... | 229 |
| 2.55 GOST 28147-89 | 229 |
| 2.55.1 Definitions..... | 230 |
| 2.55.2 GOST 28147-89 secret key objects | 230 |
| 2.55.3 GOST 28147-89 domain parameter objects | 231 |
| 2.55.4 GOST 28147-89 key generation | 231 |
| 2.55.5 GOST 28147-89-ECB | 232 |
| 2.55.6 GOST 28147-89 encryption mode except ECB | 232 |
| 2.55.7 GOST 28147-89-MAC..... | 233 |
| 2.55.8 GOST 28147-89 keys wrapping/unwrapping with GOST 28147-89 | 233 |
| 2.56 GOST R 34.11-94..... | 234 |
| 2.56.1 Definitions..... | 234 |
| 2.56.2 GOST R 34.11-94 domain parameter objects..... | 234 |
| 2.56.3 GOST R 34.11-94 digest..... | 235 |
| 2.56.4 GOST R 34.11-94 HMAC | 236 |
| 2.57 GOST R 34.10-2001..... | 236 |
| 2.57.1 Definitions..... | 237 |
| 2.57.2 GOST R 34.10-2001 public key objects | 237 |
| 2.57.3 GOST R 34.10-2001 private key objects | 238 |
| 2.57.4 GOST R 34.10-2001 domain parameter objects..... | 240 |
| 2.57.5 GOST R 34.10-2001 mechanism parameters..... | 241 |
| 2.57.6 GOST R 34.10-2001 key pair generation..... | 242 |
| 2.57.7 GOST R 34.10-2001 without hashing | 242 |
| 2.57.8 GOST R 34.10-2001 with GOST R 34.11-94..... | 243 |
| 2.57.9 GOST 28147-89 keys wrapping/unwrapping with GOST R 34.10-2001 | 243 |
| 2.57.10 Common key derivation with assistance of GOST R 34.10-2001 keys | 244 |
| 2.58 ChaCha20..... | 244 |
| 2.58.1 Definitions..... | 244 |
| 2.58.2 ChaCha20 secret key objects | 244 |

| | |
|--|-----|
| 2.58.3 ChaCha20 mechanism parameters | 245 |
| 2.58.4 ChaCha20 key generation..... | 245 |
| 2.58.5 ChaCha20 mechanism | 246 |
| 2.59 Salsa20 | 247 |
| 2.59.1 Definitions | 247 |
| 2.59.2 Salsa20 secret key objects..... | 247 |
| 2.59.3 Salsa20 mechanism parameters | 248 |
| 2.59.4 Salsa20 key generation..... | 248 |
| 2.59.5 Salsa20 mechanism | 248 |
| 2.60 Poly1305 | 249 |
| 2.60.1 Definitions | 249 |
| 2.60.2 Poly1305 secret key objects..... | 250 |
| 2.60.3 Poly1305 mechanism | 250 |
| 2.61 Chacha20/Poly1305 and Salsa20/Poly1305 Authenticated Encryption / Decryption..... | 250 |
| 2.61.1 Definitions | 251 |
| 2.61.2 Usage | 251 |
| 2.61.3 ChaCha20/Poly1305 and Salsa20/Poly1305 Mechanism parameters | 252 |
| 2.62 HKDF Mechanisms | 253 |
| 2.62.1 Definitions | 254 |
| 2.62.2 HKDF mechanism parameters | 254 |
| 2.62.3 HKDF derive | 255 |
| 2.62.4 HKDF Data | 256 |
| 2.62.5 HKDF Key gen | 256 |
| 2.63 NULL Mechanism | 256 |
| 2.63.1 Definitions | 256 |
| 2.63.2 CKM_NULL mechanism parameters | 256 |
| 3 PKCS #11 Implementation Conformance | 257 |
| Appendix A. Acknowledgments | 258 |
| Appendix B. Manifest Constants | 260 |
| Appendix C. Revision History | 261 |

1 Introduction

This document defines mechanisms that are anticipated to be used with the current version of PKCS #11.
All text is normative unless otherwise labeled.

1.1 IPR Policy

This specification is provided under the [RF on RAND Terms](#) Mode of the [OASIS IPR Policy](#), the mode chosen when the Technical Committee was established. For information on whether any patents have been disclosed that may be essential to implementing this specification, and any offers of patent licensing terms, please refer to the Intellectual Property Rights section of the TC's web page (<https://www.oasis-open.org/committees/pkcs11/ipr.php>).

1.2 Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119]

1.3 Definitions

For the purposes of this standard, the following definitions apply. Please refer to the [PKCS#11-Base] for further definitions:

AES *Advanced Encryption Standard, as defined in FIPS PUB 197.*

CAMELLIA *The Camellia encryption algorithm, as defined in RFC 3713.*

BLOWFISH *The Blowfish Encryption Algorithm of Bruce Schneier, www.schneier.com.*

CBC *Cipher-Block Chaining mode, as defined in FIPS PUB 81.*

CDMF *Commercial Data Masking Facility, a block encipherment method specified by International Business Machines Corporation and based on DES.*

CMAC *Cipher-based Message Authenticate Code as defined in [NIST sp800-38b] and [RFC 4493].*

CMS *Cryptographic Message Syntax (see RFC 2630)*

CT-KIP *Cryptographic Token Key Initialization Protocol (as defined in [CT-KIP])*

DES *Data Encryption Standard, as defined in FIPS PUB 46-3.*

DSA *Digital Signature Algorithm, as defined in FIPS PUB 186-2.*

EC *Elliptic Curve*

ECB *Electronic Codebook mode, as defined in FIPS PUB 81.*

ECDH *Elliptic Curve Diffie-Hellman.*

| | | |
|----|--------------------------|---|
| 35 | ECDSA | <i>Elliptic Curve DSA, as in ANSI X9.62.</i> |
| 36 | ECMQV | <i>Elliptic Curve Menezes-Qu-Vanstone</i> |
| 37 | GOST 28147-89 | <i>The encryption algorithm, as defined in Part 2 [GOST 28147-89]</i> |
| 38 | | <i>and [RFC 4357] [RFC 4490], and RFC [4491].</i> |
| 39 | GOST R 34.11-94 | <i>Hash algorithm, as defined in [GOST R 34.11-94] and [RFC 4357],</i> |
| 40 | | <i>[RFC 4490], and [RFC 4491].</i> |
| 41 | GOST R 34.10-2001 | <i>The digital signature algorithm, as defined in [GOST R 34.10-2001]</i> |
| 42 | | <i>and [RFC 4357], [RFC 4490], and [RFC 4491].</i> |
| 43 | IV | <i>Initialization Vector.</i> |
| 44 | MAC | <i>Message Authentication Code.</i> |
| 45 | MQV | <i>Menezes-Qu-Vanstone</i> |
| 46 | OAEP | <i>Optimal Asymmetric Encryption Padding for RSA.</i> |
| 47 | PKCS | <i>Public-Key Cryptography Standards.</i> |
| 48 | PRF | <i>Pseudo random function.</i> |
| 49 | PTD | <i>Personal Trusted Device, as defined in MeT-PTD</i> |
| 50 | RSA | <i>The RSA public-key cryptosystem.</i> |
| 51 | SHA-1 | <i>The (revised) Secure Hash Algorithm with a 160-bit message digest,</i> |
| 52 | | <i>as defined in FIPS PUB 180-2.</i> |
| 53 | SHA-224 | <i>The Secure Hash Algorithm with a 224-bit message digest, as</i> |
| 54 | | <i>defined in RFC 3874. Also defined in FIPS PUB 180-2 with Change</i> |
| 55 | | <i>Notice 1.</i> |
| 56 | SHA-256 | <i>The Secure Hash Algorithm with a 256-bit message digest, as</i> |
| 57 | | <i>defined in FIPS PUB 180-2.</i> |
| 58 | SHA-384 | <i>The Secure Hash Algorithm with a 384-bit message digest, as</i> |
| 59 | | <i>defined in FIPS PUB 180-2.</i> |
| 60 | SHA-512 | <i>The Secure Hash Algorithm with a 512-bit message digest, as</i> |
| 61 | | <i>defined in FIPS PUB 180-2.</i> |
| 62 | SSL | <i>The Secure Sockets Layer 3.0 protocol.</i> |
| 63 | SO | <i>A Security Officer user.</i> |
| 64 | TLS | <i>Transport Layer Security.</i> |
| 65 | WIM | <i>Wireless Identification Module.</i> |
| 66 | WTLS | <i>Wireless Transport Layer Security.</i> |
| 67 | | |

1.4 Normative References

- [ARIA] National Security Research Institute, Korea, "Block Cipher Algorithm ARIA", URL: <http://tools.ietf.org/html/rfc5794>
- [BLOWFISH] B. Schneier. Description of a New Variable-Length Key, 64-Bit Block Cipher (Blowfish), December 1993.
URL: <https://www.schneier.com/paper-blowfish-fse.html>
- [CAMELLIA] M. Matsui, J. Nakajima, S. Moriai. A Description of the Camellia Encryption Algorithm, April 2004.
URL: <http://www.ietf.org/rfc/rfc3713.txt>
- [CDMF] Johnson, D.B. The Commercial Data Masking Facility (CDMF) data privacy algorithm, March 1994.
URL: <http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=5389557>
- [CHACHA] D. Bernstein, ChaCha, a variant of Salsa20, Jan 2008.
URL: <http://cr.yp.to/chacha/chacha-20080128.pdf>
- [DH] W. Diffie, M. Hellman. New Directions in Cryptography. Nov, 1976.
URL: <http://www-ee.stanford.edu/~hellman/publications/24.pdf>
- [FIPS PUB 81] NIST. *FIPS 81: DES Modes of Operation*. December 1980.
URL: <http://csrc.nist.gov/publications/fips/fips81/fips81.htm>
- [FIPS PUB 186-4] NIST. FIPS 186-4: Digital Signature Standard. July 2013.
URL: <http://nvlpubs.nist.gov/nistpubs/FIPS/NIST.FIPS.186-4.pdf>
- [FIPS PUB 197] NIST. FIPS 197: Advanced Encryption Standard. November 26, 2001.
URL: <http://csrc.nist.gov/publications/fips/fips197/fips-197.pdf>
- [FIPS SP 800-56A] NIST. Special Publication 800-56A Revision 2: *Recommendation for Pair-Wise Key Establishment Schemes Using Discrete Logarithm Cryptography*, May 2013.
URL: <http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-56Ar2.pdf>
- [FIPS SP 800-108] NIST. Special Publication 800-108 (Revised): *Recommendation for Key Derivation Using Pseudorandom Functions*, October 2009.
URL: <https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-108.pdf>
- [GOST] V. Dolmatov, A. Degtyarev. GOST R. 34.11-2012: Hash Function. August 2013.
URL: <http://tools.ietf.org/html/rfc6986>
- [MD2] B. Kaliski. RSA Laboratories. The MD2 Message-Digest Algorithm. April, 1992.
URL: <http://tools.ietf.org/html/rfc1319>
- [MD5] RSA Data Security. R. Rivest. The MD5 Message-Digest Algorithm. April, 1992.
URL: <http://tools.ietf.org/html/rfc1319>
- [OAEP] M. Bellare, P. Rogaway. Optimal Asymmetric Encryption – How to Encrypt with RSA. Nov 19, 1995.
URL: <http://cseweb.ucsd.edu/users/mihir/papers/oae.pdf>
- [PKCS11-Base] PKCS #11 Cryptographic Token Interface Base Specification Version 3.0. Edited by Chris Zimman and Dieter Bong. Latest version. <https://docs.oasis-open.org/pkcs11/pkcs11-base/v3.0/pkcs11-base-v3.0.html>.
- [PKCS11-Hist] PKCS #11 Cryptographic Token Interface Historical Mechanisms Specification Version 3.0. Edited by Chris Zimman and Dieter Bong. Latest version.
<https://docs.oasis-open.org/pkcs11/pkcs11-hist/v3.0/pkcs11-hist-v3.0.html>.
- [PKCS11-Prof] PKCS #11 Cryptographic Token Interface Profiles Version 3.0. Edited by Tim Hudson. Latest version. <https://docs.oasis-open.org/pkcs11/pkcs11-profiles/v3.0/pkcs11-profiles-v3.0.html>.
- [POLY1305] D.J. Bernstein. The Poly1305-AES message-authentication code. Jan 2005.
URL: <https://cr.yp.to/mac/poly1305-20050329.pdf>
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.
URL: <http://www.ietf.org/rfc/rfc2119.txt>.

| | | |
|-----|-----------|--|
| 120 | [RIPEMD] | H. Dobbertin, A. Bosselaers, B. Preneel. The hash function RIPEMD-160, Feb 13, 2012. |
| 121 | | URL: http://homes.esat.kuleuven.be/~bosselae/ripemd160.html |
| 122 | | |
| 123 | [SALSA] | D. Bernstein, ChaCha, a variant of Salsa20, Jan 2008. |
| 124 | | URL: http://cr.yp.to/chacha/chacha-20080128.pdf |
| 125 | [SEED] | KISA. SEED 128 Algorithm Specification. Sep 2003. |
| 126 | | URL: http://seed.kisa.or.kr/html/egovframework/iwt/ds/ko/ref/%5B2%5D_SEED+128_Specification_english_M.pdf |
| 127 | | |
| 128 | [SHA-1] | NIST. FIPS 180-4: Secure Hash Standard. March 2012. |
| 129 | | URL: http://csrc.nist.gov/publications/fips/fips180-4/fips-180-4.pdf |
| 130 | [SHA-2] | NIST. FIPS 180-4: Secure Hash Standard. March 2012. |
| 131 | | URL: http://csrc.nist.gov/publications/fips/fips180-4/fips-180-4.pdf |
| 132 | [TWOFISH] | B. Schneier, J. Kelsey, D. Whiting, C. Hall, N. Ferguson. Twofish: A 128-Bit Block Cipher. June 15, 1998. |
| 133 | | URL: https://www.schneier.com/paper-twofish-paper.pdf |
| 134 | | |

135 1.5 Non-Normative References

| | | |
|-----|----------------|--|
| 136 | [CAP-1.2] | Common Alerting Protocol Version 1.2. 01 July 2010. OASIS Standard. |
| 137 | | URL: http://docs.oasis-open.org/emergency/cap/v1.2/CAP-v1.2-os.html |
| 138 | [AES KEYWRAP] | National Institute of Standards and Technology, NIST Special Publication 800-38F, Recommendation for Block Cipher Modes of Operation: Methods for Key Wrapping, December 2012, |
| 139 | | http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-38F.pdf |
| 140 | | |
| 141 | | |
| 142 | [ANSI C] | ANSI/ISO. American National Standard for Programming Languages – C. 1990. |
| 143 | [ANSI X9.31] | Accredited Standards Committee X9. Digital Signatures Using Reversible Public Key Cryptography for the Financial Services Industry (rDSA). 1998. |
| 144 | | |
| 145 | [ANSI X9.42] | Accredited Standards Committee X9. Public Key Cryptography for the Financial Services Industry: Agreement of Symmetric Keys Using Discrete Logarithm Cryptography. 2003. |
| 146 | | |
| 147 | | |
| 148 | [ANSI X9.62] | Accredited Standards Committee X9. Public Key Cryptography for the Financial Services Industry: The Elliptic Curve Digital Signature Algorithm (ECDSA). 1998. |
| 149 | | |
| 150 | [ANSI X9.63] | Accredited Standards Committee X9. Public Key Cryptography for the Financial Services Industry: Key Agreement and Key Transport Using Elliptic Curve Cryptography. 2001. |
| 151 | | URL: http://webstore.ansi.org/RecordDetail.aspx?sku=X9.63-2011 |
| 152 | | |
| 153 | | |
| 154 | [BRAINPOOL] | ECC Brainpool Standard Curves and Curve Generation, v1.0, 19.10.2005 |
| 155 | | URL: http://www.ecc-brainpool.org |
| 156 | [CT-KIP] | RSA Laboratories. Cryptographic Token Key Initialization Protocol. Version 1.0, December 2005. |
| 157 | | URL: ftp://ftp.rsasecurity.com/pub/otps/ct-kip/ct-kip-v1-0.pdf . |
| 158 | | |
| 159 | [CC/PP] | CCPP-STRUCT-VOCAB, G. Klyne, F. Reynolds, C. , H. Ohto, J. Hjelm, M. H. Butler, L. Tran, Editors, W3C Recommendation, 15 January 2004, |
| 160 | | URL: http://www.w3.org/TR/2004/REC-CCPP-struct-vocab-20040115/ |
| 161 | | Latest version available at http://www.w3.org/TR/CCPP-struct-vocab/ |
| 162 | | |
| 163 | [LEGIFRANCE] | Avis relatif aux paramètres de courbes elliptiques définis par l'Etat français (Publication of elliptic curve parameters by the French state) |
| 164 | | URL: |
| 165 | | https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000024668816 |
| 166 | | |
| 167 | | |
| 168 | [NIST AES CTS] | National Institute of Standards and Technology, Addendum to NIST Special Publication 800-38A, "Recommendation for Block Cipher Modes of Operation: Three Variants of Ciphertext Stealing for CBC Mode" |
| 169 | | |
| 170 | | |

171 URL: [http://csrc.nist.gov/publications/nistpubs/800-38a/addendum-to-nist_sp800-](http://csrc.nist.gov/publications/nistpubs/800-38a/addendum-to-nist_sp800-38A.pdf)
172 [38A.pdf](http://csrc.nist.gov/publications/nistpubs/800-38a/addendum-to-nist_sp800-38A.pdf)

173 **[PKCS11-UG]** *PKCS #11 Cryptographic Token Interface Usage Guide Version 2.41*. Edited by
174 John Leiseboer and Robert Griffin. version: [http://docs.oasis-](http://docs.oasis-open.org/pkcs11/pkcs11-ug/v2.40/pkcs11-ug-v2.40.html)
175 [open.org/pkcs11/pkcs11-ug/v2.40/pkcs11-ug-v2.40.html](http://docs.oasis-open.org/pkcs11/pkcs11-ug/v2.40/pkcs11-ug-v2.40.html).

176 **[RFC 2865]** Rigney et al, "Remote Authentication Dial In User Service (RADIUS)", IETF
177 RFC2865, June 2000.
178 URL: <http://www.ietf.org/rfc/rfc2865.txt>.

179 **[RFC 3686]** Housley, "Using Advanced Encryption Standard (AES) Counter Mode With IPsec
180 Encapsulating Security Payload (ESP)," IETF RFC 3686, January 2004.
181 URL: <http://www.ietf.org/rfc/rfc3686.txt>.

182 **[RFC 3717]** Matsui, et al, "A Description of the Camellia Encryption Algorithm," IETF RFC
183 3717, April 2004.
184 URL: <http://www.ietf.org/rfc/rfc3713.txt>.

185 **[RFC 3610]** Whiting, D., Housley, R., and N. Ferguson, "Counter with CBC-MAC (CCM)",
186 IETF RFC 3610, September 2003.
187 URL: <http://www.ietf.org/rfc/rfc3610.txt>

188 **[RFC 3874]** Smit et al, "A 224-bit One-way Hash Function: SHA-224," IETF RFC 3874, June
189 2004.
190 URL: <http://www.ietf.org/rfc/rfc3874.txt>.

191 **[RFC 3748]** Aboba et al, "Extensible Authentication Protocol (EAP)", IETF RFC 3748, June
192 2004.
193 URL: <http://www.ietf.org/rfc/rfc3748.txt>.

194 **[RFC 4269]** South Korean Information Security Agency (KISA) "The SEED Encryption
195 Algorithm", December 2005.
196 URL: <ftp://ftp.rfc-editor.org/in-notes/rfc4269.txt>

197 **[RFC 4309]** Housley, R., "Using Advanced Encryption Standard (AES) CCM Mode with IPsec
198 Encapsulating Security Payload (ESP)," IETF RFC 4309, December 2005.
199 URL: <http://www.ietf.org/rfc/rfc4309.txt>

200 **[RFC 4357]** V. Popov, I. Kurepkin, S. Leontiev "Additional Cryptographic Algorithms for Use
201 with GOST 28147-89, GOST R 34.10-94, GOST R 34.10-2001, and GOST R
202 34.11-94 Algorithms", January 2006.
203 URL: <http://www.ietf.org/rfc/rfc4357.txt>

204 **[RFC 4490]** S. Leontiev, Ed. G. Chudov, Ed. "Using the GOST 28147-89, GOST R 34.11-
205 94, GOST R 34.10-94, and GOST R 34.10-2001 Algorithms with Cryptographic
206 Message Syntax (CMS)", May 2006.
207 URL: <http://www.ietf.org/rfc/rfc4490.txt>

208 **[RFC 4491]** S. Leontiev, Ed., D. Shefanovski, Ed., "Using the GOST R 34.10-94, GOST R
209 34.10-2001, and GOST R 34.11-94 Algorithms with the Internet X.509 Public Key
210 Infrastructure Certificate and CRL Profile", May 2006.
211 URL: <http://www.ietf.org/rfc/rfc4491.txt>

212 **[RFC 4493]** J. Song et al. *RFC 4493: The AES-CMAC Algorithm*. June 2006.
213 URL: <http://www.ietf.org/rfc/rfc4493.txt>

214 **[RFC 5705]** Rescorla, E., "The Keying Material Exporters for Transport Layer Security (TLS)",
215 RFC 5705, March 2010.
216 URL: <http://www.ietf.org/rfc/rfc5705.txt>

217 **[RFC 5869]** H. Krawczyk, P. Eronen, "HMAC-based Extract-and-Expand Key Derivation
218 Function (HKDF)", May 2010
219 URL: <http://www.ietf.org/rfc/rfc5869.txt>

220 **[RFC 7539]** Y Nir, A. Langley. *RFC 7539: ChaCha20 and Poly1305 for IETF Protocols*, May
221 2015
222 URL: <https://tools.ietf.org/rfc/rfc7539.txt>

| | | |
|-----|-------------------|--|
| 223 | [RFC 7748] | Aboba et al, "Elliptic Curves for Security", IETF RFC 7748, January 2016 |
| 224 | | URL: https://tools.ietf.org/html/rfc7748 |
| 225 | [RFC 8032] | Aboba et al, "Edwards-Curve Digital Signature Algorithm (EdDSA)", IETF RFC |
| 226 | | 8032, January 2017 |
| 227 | | URL: https://tools.ietf.org/html/rfc8032 |
| 228 | [SEC 1] | Standards for Efficient Cryptography Group (SECG). <i>Standards for Efficient</i> |
| 229 | | <i>Cryptography (SEC) 1: Elliptic Curve Cryptography</i> . Version 1.0, September 20, |
| 230 | | 2000. |
| 231 | [SEC 2] | Standards for Efficient Cryptography Group (SECG). <i>Standards for Efficient</i> |
| 232 | | <i>Cryptography (SEC) 2: Recommended Elliptic Curve Domain Parameters</i> . |
| 233 | | Version 1.0, September 20, 2000. |
| 234 | [SIGNAL] | The X3DH Key Agreement Protocol, Revision 1, 2016-11-04, Moxie Marlinspike, |
| 235 | | Trevor Perrin (editor) |
| 236 | | URL: https://signal.org/docs/specifications/x3dh/ |
| 237 | [TLS] | [RFC2246] Dierks, T. and C. Allen, "The TLS Protocol Version 1.0", RFC 2246, |
| 238 | | January 1999. http://www.ietf.org/rfc/rfc2246.txt , superseded by [RFC4346] |
| 239 | | Dierks, T. and E. Rescorla, "The Transport Layer Security (TLS) Protocol Version |
| 240 | | 1.1", RFC 4346, April 2006. http://www.ietf.org/rfc/rfc4346.txt , which was |
| 241 | | superseded by [5246] Dierks, T. and E. Rescorla, "The Transport Layer Security |
| 242 | | (TLS) Protocol Version 1.2", RFC 5246, August 2008. |
| 243 | | URL: http://www.ietf.org/rfc/rfc5246.txt |
| 244 | [TLS12] | [RFC5246] Dierks, T. and E. Rescorla, "The Transport Layer Security (TLS) |
| 245 | | Protocol Version 1.2", RFC 5246, August 2008. |
| 246 | | URL: http://www.ietf.org/rfc/rfc5246.txt |
| 247 | [TLS13] | [RFC8446] E. Rescorla, "The Transport Layer Security (TLS) Protocol Version |
| 248 | | 1.3", RFC 8446, August 2018. |
| 249 | | URL: http://www.ietf.org/rfc/rfc8446.txt |
| 250 | [WIM] | WAP. Wireless Identity Module. — WAP-260-WIM-20010712-a. July 2001. |
| 251 | | URL: http://technical.openmobilealliance.org/tech/affiliates/LicenseAgreement.as |
| 252 | | p?DocName=/wap/wap-260-wim-20010712-a.pdf |
| 253 | [WPKI] | Wireless Application Protocol: Public Key Infrastructure Definition. — WAP-217- |
| 254 | | WPKI-20010424-a. April 2001. |
| 255 | | URL: http://technical.openmobilealliance.org/tech/affiliates/LicenseAgreement.as |
| 256 | | p?DocName=/wap/wap-217-wpki-20010424-a.pdf |
| 257 | [WTLS] | WAP. Wireless Transport Layer Security Version — WAP-261-WTLS-20010406- |
| 258 | | a. April 2001. |
| 259 | | URL: http://technical.openmobilealliance.org/tech/affiliates/LicenseAgreement.as |
| 260 | | p?DocName=/wap/wap-261-wtls-20010406-a.pdf |
| 261 | [XEDDSA] | The XEdDSA and VEdDSA Signature Schemes - Revision 1, 2016-10-20, |
| 262 | | Trevor Perrin (editor) |
| 263 | | URL: https://signal.org/docs/specifications/xeddsa/ |
| 264 | [X.500] | ITU-T. Information Technology — Open Systems Interconnection — The |
| 265 | | Directory: Overview of Concepts, Models and Services. February 2001. Identical |
| 266 | | to ISO/IEC 9594-1 |
| 267 | [X.509] | ITU-T. Information Technology — Open Systems Interconnection — The |
| 268 | | Directory: Public-key and Attribute Certificate Frameworks. March 2000. |
| 269 | | Identical to ISO/IEC 9594-8 |
| 270 | [X.680] | ITU-T. Information Technology — Abstract Syntax Notation One (ASN.1): |
| 271 | | Specification of Basic Notation. July 2002. Identical to ISO/IEC 8824-1 |
| 272 | [X.690] | ITU-T. Information Technology — ASN.1 Encoding Rules: Specification of Basic |
| 273 | | Encoding Rules (BER), Canonical Encoding Rules (CER), and Distinguished |
| 274 | | Encoding Rules (DER). July 2002. Identical to ISO/IEC 8825-1 |
| 275 | | |

2 Mechanisms

A mechanism specifies precisely how a certain cryptographic process is to be performed. PKCS #11 implementations MAY use one or more mechanisms defined in this document.

The following table shows which Cryptoki mechanisms are supported by different cryptographic operations. For any particular token, of course, a particular operation may well support only a subset of the mechanisms listed. There is also no guarantee that a token which supports one mechanism for some operations supports any other mechanism for any other operation (or even supports that same mechanism for any other operation). For example, even if a token is able to create RSA digital signatures with the **CKM_RSA_PKCS** mechanism, it may or may not be the case that the same token can also perform RSA encryption with **CKM_RSA_PKCS**.

Each mechanism description is preceded by a table, of the following format, mapping mechanisms to API functions.

| Mechanism | Functions | | | | | | |
|-----------|-------------------|---------------|----------------------|--------|-------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/Key Pair | Wrap & Unwrap | Derive |
| | | | | | | | |

¹ SR = SignRecover, VR = VerifyRecover.

² Single-part operations only.

³ Mechanism can only be used for wrapping, not unwrapping.

The remainder of this section will present in detail the mechanisms supported by Cryptoki and the parameters which are supplied to them.

In general, if a mechanism makes no mention of the ulMinKeyLen and ulMaxKeyLen fields of the CK_MECHANISM_INFO structure, then those fields have no meaning for that particular mechanism.

2.1 RSA

Table 1, Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|----------------------------|-------------------|----------------|----------------------|--------|-------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/Key Pair | Wrap & Unwrap | Derive |
| CKM_RSA_PKCS_KEY_PAIR_GEN | | | | | ✓ | | |
| CKM_RSA_X9_31_KEY_PAIR_GEN | | | | | ✓ | | |
| CKM_RSA_PKCS | ✓ ² | ✓ ² | ✓ | | | ✓ | |
| CKM_RSA_PKCS_OAEP | ✓ ² | | | | | ✓ | |
| CKM_RSA_PKCS_PSS | | ✓ ² | | | | | |
| CKM_RSA_9796 | | ✓ ² | ✓ | | | | |
| CKM_RSA_X_509 | ✓ ² | ✓ ² | ✓ | | | ✓ | |
| CKM_RSA_X9_31 | | ✓ ² | | | | | |
| CKM_SHA1_RSA_PKCS | | ✓ | | | | | |
| CKM_SHA256_RSA_PKCS | | ✓ | | | | | |
| CKM_SHA384_RSA_PKCS | | ✓ | | | | | |

| Mechanism | Functions | | | | | | |
|---------------------------|-------------------------|---------------------|--------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR 1 | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA512_RSA_PKCS | | ✓ | | | | | |
| CKM_SHA1_RSA_PKCS_PSS | | ✓ | | | | | |
| CKM_SHA256_RSA_PKCS_PSS | | ✓ | | | | | |
| CKM_SHA384_RSA_PKCS_PSS | | ✓ | | | | | |
| CKM_SHA512_RSA_PKCS_PSS | | ✓ | | | | | |
| CKM_SHA1_RSA_X9_31 | | ✓ | | | | | |
| CKM_RSA_PKCS_TPM_1_1 | ✓ ² | | | | | ✓ | |
| CKM_RSA_PKCS_OAEP_TPM_1_1 | ✓ ² | | | | | ✓ | |
| CKM_SHA3_224_RSA_PKCS | | ✓ | | | | | |
| CKM_SHA3_256_RSA_PKCS | | ✓ | | | | | |
| CKM_SHA3_384_RSA_PKCS | | ✓ | | | | | |
| CKM_SHA3_512_RSA_PKCS | | ✓ | | | | | |
| CKM_SHA3_224_RSA_PKCS_PSS | | ✓ | | | | | |
| CKM_SHA3_256_RSA_PKCS_PSS | | ✓ | | | | | |
| CKM_SHA3_384_RSA_PKCS_PSS | | ✓ | | | | | |
| CKM_SHA3_512_RSA_PKCS_PSS | | ✓ | | | | | |

2.1.1 Definitions

This section defines the RSA key type “CKK_RSA” for type CK_KEY_TYPE as used in the CK_A_KEY_TYPE attribute of RSA key objects.

Mechanisms:

- CKM_RSA_PKCS_KEY_PAIR_GEN
- CKM_RSA_PKCS
- CKM_RSA_9796
- CKM_RSA_X_509
- CKM_MD2_RSA_PKCS
- CKM_MD5_RSA_PKCS
- CKM_SHA1_RSA_PKCS
- CKM_SHA224_RSA_PKCS
- CKM_SHA256_RSA_PKCS
- CKM_SHA384_RSA_PKCS
- CKM_SHA512_RSA_PKCS
- CKM_RIPEMD128_RSA_PKCS
- CKM_RIPEMD160_RSA_PKCS
- CKM_RSA_PKCS_OAEP
- CKM_RSA_X9_31_KEY_PAIR_GEN
- CKM_RSA_X9_31
- CKM_SHA1_RSA_X9_31
- CKM_RSA_PKCS_PSS
- CKM_SHA1_RSA_PKCS_PSS

320 CKM_SHA224_RSA_PKCS_PSS
 321 CKM_SHA256_RSA_PKCS_PSS
 322 CKM_SHA512_RSA_PKCS_PSS
 323 CKM_SHA384_RSA_PKCS_PSS
 324 CKM_RSA_PKCS_TPM_1_1
 325 CKM_RSA_PKCS_OAEP_TPM_1_1
 326 CKM_RSA_AES_KEY_WRAP
 327 CKM_SHA3_224_RSA_PKCS
 328 CKM_SHA3_256_RSA_PKCS
 329 CKM_SHA3_384_RSA_PKCS
 330 CKM_SHA3_512_RSA_PKCS
 331 CKM_SHA3_224_RSA_PKCS_PSS
 332 CKM_SHA3_256_RSA_PKCS_PSS
 333 CKM_SHA3_384_RSA_PKCS_PSS
 334 CKM_SHA3_512_RSA_PKCS_PSS
 335

336 2.1.2 RSA public key objects

337 RSA public key objects (object class **CKO_PUBLIC_KEY**, key type **CKK_RSA**) hold RSA public keys.
 338 The following table defines the RSA public key object attributes, in addition to the common attributes
 339 defined for this object class:

340 *Table 2, RSA Public Key Object Attributes*

| Attribute | Data type | Meaning |
|----------------------------------|-------------|-------------------------------|
| CKA_MODULUS ^{1,4} | Big integer | Modulus n |
| CKA_MODULUS_BITS ^{2,3} | CK_ULONG | Length in bits of modulus n |
| CKA_PUBLIC_EXPONENT ¹ | Big integer | Public exponent e |

341 - Refer to [PKCS11-Base] table 11 for footnotes

342 Depending on the token, there may be limits on the length of key components. See PKCS #1 for more
 343 information on RSA keys.

344 The following is a sample template for creating an RSA public key object:

```

345 CK_OBJECT_CLASS class = CKO_PUBLIC_KEY;
346 CK_KEY_TYPE keyType = CKK_RSA;
347 CK_UTF8CHAR label[] = "An RSA public key object";
348 CK_BYTE modulus[] = {...};
349 CK_BYTE exponent[] = {...};
350 CK_BBOOL true = CK_TRUE;
351 CK_ATTRIBUTE template[] = {
352     {CKA_CLASS, &class, sizeof(class)},
353     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
354     {CKA_TOKEN, &true, sizeof(true)},
355     {CKA_LABEL, label, sizeof(label)-1},
356     {CKA_WRAP, &true, sizeof(true)},
357     {CKA_ENCRYPT, &true, sizeof(true)},
358     {CKA_MODULUS, modulus, sizeof(modulus)},
  
```

```

359         {CKA_PUBLIC_EXPONENT, exponent, sizeof(exponent)}
360     };

```

361 2.1.3 RSA private key objects

362 RSA private key objects (object class **CKO_PRIVATE_KEY**, key type **CKK_RSA**) hold RSA private keys.
363 The following table defines the RSA private key object attributes, in addition to the common attributes
364 defined for this object class:

365 Table 3, RSA Private Key Object Attributes

| Attribute | Data type | Meaning |
|---|-------------|-----------------------------------|
| CKA_MODULUS ^{1,4,6} | Big integer | Modulus n |
| CKA_PUBLIC_EXPONENT ^{4,6} | Big integer | Public exponent e |
| CKA_PRIVATE_EXPONENT ^{1,4,6,7} | Big integer | Private exponent d |
| CKA_PRIME_1 ^{4,6,7} | Big integer | Prime p |
| CKA_PRIME_2 ^{4,6,7} | Big integer | Prime q |
| CKA_EXPONENT_1 ^{4,6,7} | Big integer | Private exponent d modulo $p-1$ |
| CKA_EXPONENT_2 ^{4,6,7} | Big integer | Private exponent d modulo $q-1$ |
| CKA_COEFFICIENT ^{4,6,7} | Big integer | CRT coefficient $q^{-1} \bmod p$ |

366 - Refer to [PKCS11-Base] table 11 for footnotes

367 Depending on the token, there may be limits on the length of the key components. See PKCS #1 for
368 more information on RSA keys.

369 Tokens vary in what they actually store for RSA private keys. Some tokens store all of the above
370 attributes, which can assist in performing rapid RSA computations. Other tokens might store only the
371 **CKA_MODULUS** and **CKA_PRIVATE_EXPONENT** values. Effective with version 2.40, tokens **MUST**
372 also store **CKA_PUBLIC_EXPONENT**. This permits the retrieval of sufficient data to reconstitute the
373 associated public key.

374 Because of this, Cryptoki is flexible in dealing with RSA private key objects. When a token generates an
375 RSA private key, it stores whichever of the fields in Table 3 it keeps track of. Later, if an application asks
376 for the values of the key's various attributes, Cryptoki supplies values only for attributes whose values it
377 can obtain (i.e., if Cryptoki is asked for the value of an attribute it cannot obtain, the request fails). Note
378 that a Cryptoki implementation may or may not be able and/or willing to supply various attributes of RSA
379 private keys which are not actually stored on the token. *E.g.*, if a particular token stores values only for
380 the **CKA_PRIVATE_EXPONENT**, **CKA_PRIME_1**, and **CKA_PRIME_2** attributes, then Cryptoki is
381 certainly *able* to report values for all the attributes above (since they can all be computed efficiently from
382 these three values). However, a Cryptoki implementation may or may not actually do this extra
383 computation. The only attributes from Table 3 for which a Cryptoki implementation is *required* to be able
384 to return values are **CKA_MODULUS** and **CKA_PRIVATE_EXPONENT**.

385 If an RSA private key object is created on a token, and more attributes from Table 3 are supplied to the
386 object creation call than are supported by the token, the extra attributes are likely to be thrown away. If
387 an attempt is made to create an RSA private key object on a token with insufficient attributes for that
388 particular token, then the object creation call fails and returns **CKR_TEMPLATE_INCOMPLETE**.

389 Note that when generating an RSA private key, there is no **CKA_MODULUS_BITS** attribute specified.
390 This is because RSA private keys are only generated as part of an RSA key *pair*, and the
391 **CKA_MODULUS_BITS** attribute for the pair is specified in the template for the RSA public key.

392 The following is a sample template for creating an RSA private key object:

```

393     CK_OBJECT_CLASS class = CKO_PRIVATE_KEY;
394     CK_KEY_TYPE keyType = CKK_RSA;
395     CK_UTF8CHAR label[] = "An RSA private key object";
396     CK_BYTE subject[] = {...};
397     CK_BYTE id[] = {123};

```



```

398     CK_BYTE modulus[] = {...};
399     CK_BYTE publicExponent[] = {...};
400     CK_BYTE privateExponent[] = {...};
401     CK_BYTE prime1[] = {...};
402     CK_BYTE prime2[] = {...};
403     CK_BYTE exponent1[] = {...};
404     CK_BYTE exponent2[] = {...};
405     CK_BYTE coefficient[] = {...};
406     CK_BBOOL true = CK_TRUE;
407     CK_ATTRIBUTE template[] = {
408         {CKA_CLASS, &class, sizeof(class)},
409         {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
410         {CKA_TOKEN, &true, sizeof(true)},
411         {CKA_LABEL, label, sizeof(label)-1},
412         {CKA_SUBJECT, subject, sizeof(subject)},
413         {CKA_ID, id, sizeof(id)},
414         {CKA_SENSITIVE, &true, sizeof(true)},
415         {CKA_DECRYPT, &true, sizeof(true)},
416         {CKA_SIGN, &true, sizeof(true)},
417         {CKA_MODULUS, modulus, sizeof(modulus)},
418         {CKA_PUBLIC_EXPONENT, publicExponent,
419             sizeof(publicExponent)},
420         {CKA_PRIVATE_EXPONENT, privateExponent,
421             sizeof(privateExponent)},
422         {CKA_PRIME_1, prime1, sizeof(prime1)},
423         {CKA_PRIME_2, prime2, sizeof(prime2)},
424         {CKA_EXPONENT_1, exponent1, sizeof(exponent1)},
425         {CKA_EXPONENT_2, exponent2, sizeof(exponent2)},
426         {CKA_COEFFICIENT, coefficient, sizeof(coefficient)}
427     };

```

428 2.1.4 PKCS #1 RSA key pair generation

429 The PKCS #1 RSA key pair generation mechanism, denoted **CKM_RSA_PKCS_KEY_PAIR_GEN**, is a
430 key pair generation mechanism based on the RSA public-key cryptosystem, as defined in PKCS #1.

431 It does not have a parameter.

432 The mechanism generates RSA public/private key pairs with a particular modulus length in bits and public
433 exponent, as specified in the **CKA_MODULUS_BITS** and **CKA_PUBLIC_EXPONENT** attributes of the
434 template for the public key. The **CKA_PUBLIC_EXPONENT** may be omitted in which case the
435 mechanism shall supply the public exponent attribute using the default value of 0x10001 (65537).
436 Specific implementations may use a random value or an alternative default if 0x10001 cannot be used by
437 the token.

438 Note: Implementations strictly compliant with version 2.11 or prior versions may generate an error
439 if this attribute is omitted from the template. Experience has shown that many implementations of 2.11
440 and prior did allow the **CKA_PUBLIC_EXPONENT** attribute to be omitted from the template, and
441 behaved as described above. The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**,
442 **CKA_MODULUS**, and **CKA_PUBLIC_EXPONENT** attributes to the new public key.
443 **CKA_PUBLIC_EXPONENT** will be copied from the template if supplied.
444 **CKR_TEMPLATE_INCONSISTENT** shall be returned if the implementation cannot use the supplied
445 exponent value. It contributes the **CKA_CLASS** and **CKA_KEY_TYPE** attributes to the new private key; it

may also contribute some of the following attributes to the new private key: **CKA_MODULUS**, **CKA_PUBLIC_EXPONENT**, **CKA_PRIVATE_EXPONENT**, **CKA_PRIME_1**, **CKA_PRIME_2**, **CKA_EXPONENT_1**, **CKA_EXPONENT_2**, **CKA_COEFFICIENT**. Other attributes supported by the RSA public and private key types (specifically, the flags indicating which functions the keys support) may also be specified in the templates for the keys, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.5 X9.31 RSA key pair generation

The X9.31 RSA key pair generation mechanism, denoted **CKM_RSA_X9_31_KEY_PAIR_GEN**, is a key pair generation mechanism based on the RSA public-key cryptosystem, as defined in X9.31.

It does not have a parameter.

The mechanism generates RSA public/private key pairs with a particular modulus length in bits and public exponent, as specified in the **CKA_MODULUS_BITS** and **CKA_PUBLIC_EXPONENT** attributes of the template for the public key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_MODULUS**, and **CKA_PUBLIC_EXPONENT** attributes to the new public key. It contributes the **CKA_CLASS** and **CKA_KEY_TYPE** attributes to the new private key; it may also contribute some of the following attributes to the new private key: **CKA_MODULUS**, **CKA_PUBLIC_EXPONENT**, **CKA_PRIVATE_EXPONENT**, **CKA_PRIME_1**, **CKA_PRIME_2**, **CKA_EXPONENT_1**, **CKA_EXPONENT_2**, **CKA_COEFFICIENT**. Other attributes supported by the RSA public and private key types (specifically, the flags indicating which functions the keys support) may also be specified in the templates for the keys, or else are assigned default initial values. Unlike the **CKM_RSA_PKCS_KEY_PAIR_GEN** mechanism, this mechanism is guaranteed to generate *p* and *q* values, **CKA_PRIME_1** and **CKA_PRIME_2** respectively, that meet the strong primes requirement of X9.31.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.6 PKCS #1 v1.5 RSA

The PKCS #1 v1.5 RSA mechanism, denoted **CKM_RSA_PKCS**, is a multi-purpose mechanism based on the RSA public-key cryptosystem and the block formats initially defined in PKCS #1 v1.5. It supports single-part encryption and decryption; single-part signatures and verification with and without message recovery; key wrapping; and key unwrapping. This mechanism corresponds only to the part of PKCS #1 v1.5 that involves RSA; it does not compute a message digest or a DigestInfo encoding as specified for the md2withRSAEncryption and md5withRSAEncryption algorithms in PKCS #1 v1.5.

This mechanism does not have a parameter.

This mechanism can wrap and unwrap any secret key of appropriate length. Of course, a particular token may not be able to wrap/unwrap every appropriate-length secret key that it supports. For wrapping, the "input" to the encryption operation is the value of the **CKA_VALUE** attribute of the key that is wrapped; similarly for unwrapping. The mechanism does not wrap the key type or any other information about the key, except the key length; the application must convey these separately. In particular, the mechanism contributes only the **CKA_CLASS** and **CKA_VALUE** (and **CKA_VALUE_LEN**, if the key has it) attributes to the recovered key during unwrapping; other attributes must be specified in the template.

Constraints on key types and the length of the data are summarized in the following table. For encryption, decryption, signatures and signature verification, the input and output data may begin at the same location in memory. In the table, *k* is the length in bytes of the RSA modulus.

Table 4, PKCS #1 v1.5 RSA: Key And Data Length

| Function | Key type | Input length | Output length | Comments |
|------------------------|-----------------|------------------|---------------|---------------|
| C_Encrypt ¹ | RSA public key | $\leq k-11$ | k | block type 02 |
| C_Decrypt ¹ | RSA private key | k | $\leq k-11$ | block type 02 |
| C_Sign ¹ | RSA private key | $\leq k-11$ | k | block type 01 |
| C_SignRecover | RSA private key | $\leq k-11$ | k | block type 01 |
| C_Verify ¹ | RSA public key | $\leq k-11, k^2$ | N/A | block type 01 |
| C_VerifyRecover | RSA public key | k | $\leq k-11$ | block type 01 |
| C_WrapKey | RSA public key | $\leq k-11$ | k | block type 02 |
| C_UnwrapKey | RSA private key | k | $\leq k-11$ | block type 02 |

¹ Single-part operations only.

² Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.7 PKCS #1 RSA OAEP mechanism parameters

◆ CK_RSA_PKCS_MGF_TYPE; CK_RSA_PKCS_MGF_TYPE_PTR

CK_RSA_PKCS_MGF_TYPE is used to indicate the Message Generation Function (MGF) applied to a message block when formatting a message block for the PKCS #1 OAEP encryption scheme or the PKCS #1 PSS signature scheme. It is defined as follows:

```
typedef CK_ULONG CK_RSA_PKCS_MGF_TYPE;
```

The following MGFs are defined in PKCS #1. The following table lists the defined functions.

Table 5, PKCS #1 Mask Generation Functions

| Source Identifier | Value |
|-------------------|--------------|
| CKG_MGF1_SHA1 | 0x00000001UL |
| CKG_MGF1_SHA224 | 0x00000005UL |
| CKG_MGF1_SHA256 | 0x00000002UL |
| CKG_MGF1_SHA384 | 0x00000003UL |
| CKG_MGF1_SHA512 | 0x00000004UL |
| CKG_MGF1_SHA3_224 | 0x00000006UL |
| CKG_MGF1_SHA3_256 | 0x00000007UL |
| CKG_MGF1_SHA3_384 | 0x00000008UL |
| CKG_MGF1_SHA3_512 | 0x00000009UL |

CK_RSA_PKCS_MGF_TYPE_PTR is a pointer to a **CK_RSA_PKCS_MGF_TYPE**.

◆ CK_RSA_PKCS_OAEP_SOURCE_TYPE; CK_RSA_PKCS_OAEP_SOURCE_TYPE_PTR

CK_RSA_PKCS_OAEP_SOURCE_TYPE is used to indicate the source of the encoding parameter when formatting a message block for the PKCS #1 OAEP encryption scheme. It is defined as follows:

```
typedef CK_ULONG CK_RSA_PKCS_OAEP_SOURCE_TYPE;
```

The following encoding parameter sources are defined in PKCS #1. The following table lists the defined sources along with the corresponding data type for the *pSourceData* field in the **CK_RSA_PKCS_OAEP_PARAMS** structure defined below.

Table 6, PKCS #1 RSA OAEP: Encoding parameter sources

| Source Identifier | Value | Data Type |
|--------------------|--------------|--|
| CKZ_DATA_SPECIFIED | 0x00000001UL | Array of CK_BYTE containing the value of the encoding parameter. If the parameter is empty, <i>pSourceData</i> must be NULL and <i>ulSourceDataLen</i> must be zero. |

CK_RSA_PKCS_OAEP_SOURCE_TYPE_PTR is a pointer to a **CK_RSA_PKCS_OAEP_SOURCE_TYPE**.

◆ CK_RSA_PKCS_OAEP_PARAMS; CK_RSA_PKCS_OAEP_PARAMS_PTR

CK_RSA_PKCS_OAEP_PARAMS is a structure that provides the parameters to the **CKM_RSA_PKCS_OAEP** mechanism. The structure is defined as follows:

```
typedef struct CK_RSA_PKCS_OAEP_PARAMS {
    CK_MECHANISM_TYPE      hashAlg;
    CK_RSA_PKCS_MGF_TYPE   mgf;
    CK_RSA_PKCS_OAEP_SOURCE_TYPE source;
    CK_VOID_PTR            pSourceData;
    CK_ULONG               ulSourceDataLen;
} CK_RSA_PKCS_OAEP_PARAMS;
```

The fields of the structure have the following meanings:

hashAlg *mechanism ID of the message digest algorithm used to calculate the digest of the encoding parameter*

mgf *mask generation function to use on the encoded block*

source *source of the encoding parameter*

pSourceData *data used as the input for the encoding parameter source*

ulSourceDataLen *length of the encoding parameter source input*

CK_RSA_PKCS_OAEP_PARAMS_PTR is a pointer to a **CK_RSA_PKCS_OAEP_PARAMS**.

2.1.8 PKCS #1 RSA OAEP

The PKCS #1 RSA OAEP mechanism, denoted **CKM_RSA_PKCS_OAEP**, is a multi-purpose mechanism based on the RSA public-key cryptosystem and the OAEP block format defined in PKCS #1. It supports single-part encryption and decryption; key wrapping; and key unwrapping.

It has a parameter, a **CK_RSA_PKCS_OAEP_PARAMS** structure.

This mechanism can wrap and unwrap any secret key of appropriate length. Of course, a particular token may not be able to wrap/unwrap every appropriate-length secret key that it supports. For wrapping, the “input” to the encryption operation is the value of the **CKA_VALUE** attribute of the key that is wrapped; similarly for unwrapping. The mechanism does not wrap the key type or any other information about the

key, except the key length; the application must convey these separately. In particular, the mechanism contributes only the **CKA_CLASS** and **CKA_VALUE** (and **CKA_VALUE_LEN**, if the key has it) attributes to the recovered key during unwrapping; other attributes must be specified in the template.

Constraints on key types and the length of the data are summarized in the following table. For encryption and decryption, the input and output data may begin at the same location in memory. In the table, k is the length in bytes of the RSA modulus, and $hLen$ is the output length of the message digest algorithm specified by the *hashAlg* field of the **CK_RSA_PKCS_OAEP_PARAMS** structure.

Table 7, PKCS #1 RSA OAEP: Key And Data Length

| Function | Key type | Input length | Output length |
|------------------------|-----------------|------------------|------------------|
| C_Encrypt ¹ | RSA public key | $\leq k-2-2hLen$ | k |
| C_Decrypt ¹ | RSA private key | k | $\leq k-2-2hLen$ |
| C_WrapKey | RSA public key | $\leq k-2-2hLen$ | k |
| C_UnwrapKey | RSA private key | k | $\leq k-2-2hLen$ |

¹ Single-part operations only.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.9 PKCS #1 RSA PSS mechanism parameters

◆ **CK_RSA_PKCS_PSS_PARAMS; CK_RSA_PKCS_PSS_PARAMS_PTR**

CK_RSA_PKCS_PSS_PARAMS is a structure that provides the parameters to the **CKM_RSA_PKCS_PSS** mechanism. The structure is defined as follows:

```
typedef struct CK_RSA_PKCS_PSS_PARAMS {
    CK_MECHANISM_TYPE    hashAlg;
    CK_RSA_PKCS_MGF_TYPE mgf;
    CK_ULONG              sLen;
} CK_RSA_PKCS_PSS_PARAMS;
```

The fields of the structure have the following meanings:

hashAlg *hash algorithm used in the PSS encoding; if the signature mechanism does not include message hashing, then this value must be the mechanism used by the application to generate the message hash; if the signature mechanism includes hashing, then this value must match the hash algorithm indicated by the signature mechanism*

mgf *mask generation function to use on the encoded block*

sLen *length, in bytes, of the salt value used in the PSS encoding; typical values are the length of the message hash and zero*

CK_RSA_PKCS_PSS_PARAMS_PTR is a pointer to a **CK_RSA_PKCS_PSS_PARAMS**.

2.1.10 PKCS #1 RSA PSS

The PKCS #1 RSA PSS mechanism, denoted **CKM_RSA_PKCS_PSS**, is a mechanism based on the RSA public-key cryptosystem and the PSS block format defined in PKCS #1. It supports single-part signature generation and verification without message recovery. This mechanism corresponds only to the

part of PKCS #1 that involves block formatting and RSA, given a hash value; it does not compute a hash value on the message to be signed.

It has a parameter, a **CK_RSA_PKCS_PSS_PARAMS** structure. The *sLen* field must be less than or equal to $k^*-2\cdot hLen$ and *hLen* is the length of the input to the C_Sign or C_Verify function. k^* is the length in bytes of the RSA modulus, except if the length in bits of the RSA modulus is one more than a multiple of 8, in which case k^* is one less than the length in bytes of the RSA modulus.

Constraints on key types and the length of the data are summarized in the following table. In the table, *k* is the length in bytes of the RSA.

Table 8, PKCS #1 RSA PSS: Key And Data Length

| Function | Key type | Input length | Output length |
|-----------------------|-----------------|------------------------|---------------|
| C_Sign ¹ | RSA private key | <i>hLen</i> | <i>k</i> |
| C_Verify ¹ | RSA public key | <i>hLen</i> , <i>k</i> | N/A |

¹ Single-part operations only.

² Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.11 ISO/IEC 9796 RSA

The ISO/IEC 9796 RSA mechanism, denoted **CKM_RSA_9796**, is a mechanism for single-part signatures and verification with and without message recovery based on the RSA public-key cryptosystem and the block formats defined in ISO/IEC 9796 and its annex A.

This mechanism processes only byte strings, whereas ISO/IEC 9796 operates on bit strings. Accordingly, the following transformations are performed:

- Data is converted between byte and bit string formats by interpreting the most-significant bit of the leading byte of the byte string as the leftmost bit of the bit string, and the least-significant bit of the trailing byte of the byte string as the rightmost bit of the bit string (this assumes the length in bits of the data is a multiple of 8).
- A signature is converted from a bit string to a byte string by padding the bit string on the left with 0 to 7 zero bits so that the resulting length in bits is a multiple of 8, and converting the resulting bit string as above; it is converted from a byte string to a bit string by converting the byte string as above, and removing bits from the left so that the resulting length in bits is the same as that of the RSA modulus.

This mechanism does not have a parameter.

Constraints on key types and the length of input and output data are summarized in the following table. In the table, *k* is the length in bytes of the RSA modulus.

Table 9, ISO/IEC 9796 RSA: Key And Data Length

| Function | Key type | Input length | Output length |
|-----------------------|-----------------|------------------------------------|----------------------------|
| C_Sign ¹ | RSA private key | $\leq \lfloor k/2 \rfloor$ | <i>k</i> |
| C_SignRecover | RSA private key | $\leq \lfloor k/2 \rfloor$ | <i>k</i> |
| C_Verify ¹ | RSA public key | $\leq \lfloor k/2 \rfloor$, k^2 | N/A |
| C_VerifyRecover | RSA public key | <i>k</i> | $\leq \lfloor k/2 \rfloor$ |

¹ Single-part operations only.

² Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.12 X.509 (raw) RSA

The X.509 (raw) RSA mechanism, denoted **CKM_RSA_X_509**, is a multi-purpose mechanism based on the RSA public-key cryptosystem. It supports single-part encryption and decryption; single-part signatures and verification with and without message recovery; key wrapping; and key unwrapping. All these operations are based on so-called “raw” RSA, as assumed in X.509.

“Raw” RSA as defined here encrypts a byte string by converting it to an integer, most-significant byte first, applying “raw” RSA exponentiation, and converting the result to a byte string, most-significant byte first. The input string, considered as an integer, must be less than the modulus; the output string is also less than the modulus.

This mechanism does not have a parameter.

This mechanism can wrap and unwrap any secret key of appropriate length. Of course, a particular token may not be able to wrap/unwrap every appropriate-length secret key that it supports. For wrapping, the “input” to the encryption operation is the value of the **CKA_VALUE** attribute of the key that is wrapped; similarly for unwrapping. The mechanism does not wrap the key type, key length, or any other information about the key; the application must convey these separately, and supply them when unwrapping the key.

Unfortunately, X.509 does not specify how to perform padding for RSA encryption. For this mechanism, padding should be performed by prepending plaintext data with 0-valued bytes. In effect, to encrypt the sequence of plaintext bytes $b_1 b_2 \dots b_n$ ($n \leq k$), Cryptoki forms $P = 2^{n-1}b_1 + 2^{n-2}b_2 + \dots + b_n$. This number must be less than the RSA modulus. The k -byte ciphertext (k is the length in bytes of the RSA modulus) is produced by raising P to the RSA public exponent modulo the RSA modulus. Decryption of a k -byte ciphertext C is accomplished by raising C to the RSA private exponent modulo the RSA modulus, and returning the resulting value as a sequence of exactly k bytes. If the resulting plaintext is to be used to produce an unwrapped key, then however many bytes are specified in the template for the length of the key are taken *from the end* of this sequence of bytes.

Technically, the above procedures may differ very slightly from certain details of what is specified in X.509.

Executing cryptographic operations using this mechanism can result in the error returns **CKR_DATA_INVALID** (if plaintext is supplied which has the same length as the RSA modulus and is numerically at least as large as the modulus) and **CKR_ENCRYPTED_DATA_INVALID** (if ciphertext is supplied which has the same length as the RSA modulus and is numerically at least as large as the modulus).

Constraints on key types and the length of input and output data are summarized in the following table. In the table, k is the length in bytes of the RSA modulus.

Table 10, X.509 (Raw) RSA: Key And Data Length

| Function | Key type | Input length | Output length |
|------------------------|-----------------|---------------|----------------------------------|
| C_Encrypt ¹ | RSA public key | $\leq k$ | k |
| C_Decrypt ¹ | RSA private key | k | k |
| C_Sign ¹ | RSA private key | $\leq k$ | k |
| C_SignRecover | RSA private key | $\leq k$ | k |
| C_Verify ¹ | RSA public key | $\leq k, k^2$ | N/A |
| C_VerifyRecover | RSA public key | k | k |
| C_WrapKey | RSA public key | $\leq k$ | k |
| C_UnwrapKey | RSA private key | k | $\leq k$ (specified in template) |

¹ Single-part operations only.

² Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

This mechanism is intended for compatibility with applications that do not follow the PKCS #1 or ISO/IEC 9796 block formats.

2.1.13 ANSI X9.31 RSA

The ANSI X9.31 RSA mechanism, denoted **CKM_RSA_X9_31**, is a mechanism for single-part signatures and verification without message recovery based on the RSA public-key cryptosystem and the block formats defined in ANSI X9.31.

This mechanism applies the header and padding fields of the hash encapsulation. The trailer field must be applied by the application.

This mechanism processes only byte strings, whereas ANSI X9.31 operates on bit strings. Accordingly, the following transformations are performed:

- Data is converted between byte and bit string formats by interpreting the most-significant bit of the leading byte of the byte string as the leftmost bit of the bit string, and the least-significant bit of the trailing byte of the byte string as the rightmost bit of the bit string (this assumes the length in bits of the data is a multiple of 8).
- A signature is converted from a bit string to a byte string by padding the bit string on the left with 0 to 7 zero bits so that the resulting length in bits is a multiple of 8, and converting the resulting bit string as above; it is converted from a byte string to a bit string by converting the byte string as above, and removing bits from the left so that the resulting length in bits is the same as that of the RSA modulus.

This mechanism does not have a parameter.

Constraints on key types and the length of input and output data are summarized in the following table. In the table, k is the length in bytes of the RSA modulus. For all operations, the k value must be at least 128 and a multiple of 32 as specified in ANSI X9.31.

Table 11, ANSI X9.31 RSA: Key And Data Length

| Function | Key type | Input length | Output length |
|-----------------------|-----------------|-----------------|---------------|
| C_Sign ¹ | RSA private key | $\leq k-2$ | k |
| C_Verify ¹ | RSA public key | $\leq k-2, k^2$ | N/A |

¹ Single-part operations only.

² Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.14 PKCS #1 v1.5 RSA signature with MD2, MD5, SHA-1, SHA-256, SHA-384, SHA-512, RIPE-MD 128 or RIPE-MD 160

The PKCS #1 v1.5 RSA signature with MD2 mechanism, denoted **CKM_MD2_RSA_PKCS**, performs single- and multiple-part digital signatures and verification operations without message recovery. The operations performed are as described initially in PKCS #1 v1.5 with the object identifier *md2WithRSAEncryption*, and as in the scheme RSASSA-PKCS1-v1_5 in the current version of PKCS #1, where the underlying hash function is MD2.

Similarly, the PKCS #1 v1.5 RSA signature with MD5 mechanism, denoted **CKM_MD5_RSA_PKCS**, performs the same operations described in PKCS #1 with the object identifier *md5WithRSAEncryption*. The PKCS #1 v1.5 RSA signature with SHA-1 mechanism, denoted **CKM_SHA1_RSA_PKCS**, performs the same operations, except that it uses the hash function SHA-1 with object identifier *sha1WithRSAEncryption*.

Likewise, the PKCS #1 v1.5 RSA signature with SHA-256, SHA-384, and SHA-512 mechanisms, denoted **CKM_SHA256_RSA_PKCS**, **CKM_SHA384_RSA_PKCS**, and **CKM_SHA512_RSA_PKCS** respectively, perform the same operations using the SHA-256, SHA-384 and SHA-512 hash functions with the object

identifiers sha256WithRSAEncryption, sha384WithRSAEncryption and sha512WithRSAEncryption respectively.

The PKCS #1 v1.5 RSA signature with RIPEMD-128 or RIPEMD-160, denoted **CKM_RIPEMD128_RSA_PKCS** and **CKM_RIPEMD160_RSA_PKCS** respectively, perform the same operations using the RIPE-MD 128 and RIPE-MD 160 hash functions.

None of these mechanisms has a parameter.

Constraints on key types and the length of the data for these mechanisms are summarized in the following table. In the table, k is the length in bytes of the RSA modulus. For the PKCS #1 v1.5 RSA signature with MD2 and PKCS #1 v1.5 RSA signature with MD5 mechanisms, k must be at least 27; for the PKCS #1 v1.5 RSA signature with SHA-1 mechanism, k must be at least 31, and so on for other underlying hash functions, where the minimum is always 11 bytes more than the length of the hash value.

Table 12, PKCS #1 v1.5 RSA Signatures with Various Hash Functions: Key And Data Length

| Function | Key type | Input length | Output length | Comments |
|----------|-----------------|--------------|---------------|---------------|
| C_Sign | RSA private key | any | k | block type 01 |
| C_Verify | RSA public key | any, k^2 | N/A | block type 01 |

2 Data length, signature length.

For these mechanisms, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.15 PKCS #1 v1.5 RSA signature with SHA-224

The PKCS #1 v1.5 RSA signature with SHA-224 mechanism, denoted **CKM_SHA224_RSA_PKCS**, performs similarly as the other **CKM_SHAX_RSA_PKCS** mechanisms but uses the SHA-224 hash function.

2.1.16 PKCS #1 RSA PSS signature with SHA-224

The PKCS #1 RSA PSS signature with SHA-224 mechanism, denoted **CKM_SHA224_RSA_PKCS_PSS**, performs similarly as the other **CKM_SHAX_RSA_PKCS_PSS** mechanisms but uses the SHA-224 hash function.

2.1.17 PKCS #1 RSA PSS signature with SHA-1, SHA-256, SHA-384 or SHA-512

The PKCS #1 RSA PSS signature with SHA-1 mechanism, denoted **CKM_SHA1_RSA_PKCS_PSS**, performs single- and multiple-part digital signatures and verification operations without message recovery. The operations performed are as described in PKCS #1 with the object identifier id-RSASSA-PSS, i.e., as in the scheme RSASSA-PSS in PKCS #1 where the underlying hash function is SHA-1.

The PKCS #1 RSA PSS signature with SHA-256, SHA-384, and SHA-512 mechanisms, denoted **CKM_SHA256_RSA_PKCS_PSS**, **CKM_SHA384_RSA_PKCS_PSS**, and **CKM_SHA512_RSA_PKCS_PSS** respectively, perform the same operations using the SHA-256, SHA-384 and SHA-512 hash functions.

The mechanisms have a parameter, a **CK_RSA_PKCS_PSS_PARAMS** structure. The *sLen* field must be less than or equal to $k^*-2-hLen$ where $hLen$ is the length in bytes of the hash value. k^* is the length in bytes of the RSA modulus, except if the length in bits of the RSA modulus is one more than a multiple of 8, in which case k^* is one less than the length in bytes of the RSA modulus.

Constraints on key types and the length of the data are summarized in the following table. In the table, k is the length in bytes of the RSA modulus.

Table 13, PKCS #1 RSA PSS Signatures with Various Hash Functions: Key And Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------|--------------|---------------|
| C_Sign | RSA private key | any | k |
| C_Verify | RSA public key | any, k^2 | N/A |

2 Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.18 PKCS #1 v1.5 RSA signature with SHA3

The PKCS #1 v1.5 RSA signature with SHA3-224, SHA3-256, SHA3-384, SHA3-512 mechanisms, denoted **CKM_SHA3_224_RSA_PKCS**, **CKM_SHA3_256_RSA_PKCS**, **CKM_SHA3_384_RSA_PKCS**, and **CKM_SHA3_512_RSA_PKCS** respectively, performs similarly as the other **CKM_SHAX_RSA_PKCS** mechanisms but uses the corresponding SHA3 hash functions.

2.1.19 PKCS #1 RSA PSS signature with SHA3

The PKCS #1 RSA PSS signature with SHA3-224, SHA3-256, SHA3-384, SHA3-512 mechanisms, denoted **CKM_SHA3_224_RSA_PKCS_PSS**, **CKM_SHA3_256_RSA_PKCS_PSS**, **CKM_SHA3_384_RSA_PKCS_PSS**, and **CKM_SHA3_512_RSA_PKCS_PSS** respectively, performs similarly as the other **CKM_SHAX_RSA_PKCS_PSS** mechanisms but uses the corresponding SHA-3 hash functions.

2.1.20 ANSI X9.31 RSA signature with SHA-1

The ANSI X9.31 RSA signature with SHA-1 mechanism, denoted **CKM_SHA1_RSA_X9_31**, performs single- and multiple-part digital signatures and verification operations without message recovery. The operations performed are as described in ANSI X9.31.

This mechanism does not have a parameter.

Constraints on key types and the length of the data for these mechanisms are summarized in the following table. In the table, k is the length in bytes of the RSA modulus. For all operations, the k value must be at least 128 and a multiple of 32 as specified in ANSI X9.31.

Table 14, ANSI X9.31 RSA Signatures with SHA-1: Key And Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------|--------------|---------------|
| C_Sign | RSA private key | any | k |
| C_Verify | RSA public key | any, k^2 | N/A |

2 Data length, signature length.

For these mechanisms, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.21 TPM 1.1b and TPM 1.2 PKCS #1 v1.5 RSA

The TPM 1.1b and TPM 1.2 PKCS #1 v1.5 RSA mechanism, denoted **CKM_RSA_PKCS_TPM_1_1**, is a multi-use mechanism based on the RSA public-key cryptosystem and the block formats initially defined in PKCS #1 v1.5, with additional formatting rules defined in TCGA TPM Specification Version 1.1b. Additional formatting rules remained the same in TCG TPM Specification 1.2. The mechanism supports single-part encryption and decryption; key wrapping; and key unwrapping.

This mechanism does not have a parameter. It differs from the standard PKCS#1 v1.5 RSA encryption mechanism in that the plaintext is wrapped in a **TCPA_BOUND_DATA** (**TPM_BOUND_DATA** for TPM 1.2) structure before being submitted to the PKCS#1 v1.5 encryption process. On encryption, the version field of the **TCPA_BOUND_DATA** (**TPM_BOUND_DATA** for TPM 1.2) structure must contain 0x01, 0x01, 0x00, 0x00. On decryption, any structure of the form 0x01, 0x01, 0xXX, 0xYY may be accepted.

This mechanism can wrap and unwrap any secret key of appropriate length. Of course, a particular token may not be able to wrap/unwrap every appropriate-length secret key that it supports. For wrapping, the “input” to the encryption operation is the value of the **CKA_VALUE** attribute of the key that is wrapped; similarly for unwrapping. The mechanism does not wrap the key type or any other information about the key, except the key length; the application must convey these separately. In particular, the mechanism contributes only the **CKA_CLASS** and **CKA_VALUE** (and **CKA_VALUE_LEN**, if the key has it) attributes to the recovered key during unwrapping; other attributes must be specified in the template.

Constraints on key types and the length of the data are summarized in the following table. For encryption and decryption, the input and output data may begin at the same location in memory. In the table, *k* is the length in bytes of the RSA modulus.

Table 15, TPM 1.1b and TPM 1.2 PKCS #1 v1.5 RSA: Key And Data Length

| Function | Key type | Input length | Output length |
|------------------------|-----------------|---------------|---------------|
| C_Encrypt ¹ | RSA public key | $\leq k-11-5$ | <i>k</i> |
| C_Decrypt ¹ | RSA private key | <i>k</i> | $\leq k-11-5$ |
| C_WrapKey | RSA public key | $\leq k-11-5$ | <i>k</i> |
| C_UnwrapKey | RSA private key | <i>k</i> | $\leq k-11-5$ |

1. Single-part operations only.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.22 TPM 1.1b and TPM 1.2 PKCS #1 RSA OAEP

The TPM 1.1b and TPM 1.2 PKCS #1 RSA OAEP mechanism, denoted **CKM_RSA_PKCS_OAEP_TPM_1_1**, is a multi-purpose mechanism based on the RSA public-key cryptosystem and the OAEP block format defined in PKCS #1, with additional formatting defined in TCPA TPM Specification Version 1.1b. Additional formatting rules remained the same in TCG TPM Specification 1.2. The mechanism supports single-part encryption and decryption; key wrapping; and key unwrapping.

This mechanism does not have a parameter. It differs from the standard PKCS#1 OAEP RSA encryption mechanism in that the plaintext is wrapped in a TCPA_BOUND_DATA (TPM_BOUND_DATA for TPM 1.2) structure before being submitted to the encryption process and that all of the values of the parameters that are passed to a standard CKM_RSA_PKCS_OAEP operation are fixed. On encryption, the version field of the TCPA_BOUND_DATA (TPM_BOUND_DATA for TPM 1.2) structure must contain 0x01, 0x01, 0x00, 0x00. On decryption, any structure of the form 0x01, 0x01, 0xXX, 0xYY may be accepted.

This mechanism can wrap and unwrap any secret key of appropriate length. Of course, a particular token may not be able to wrap/unwrap every appropriate-length secret key that it supports. For wrapping, the “input” to the encryption operation is the value of the **CKA_VALUE** attribute of the key that is wrapped; similarly for unwrapping. The mechanism does not wrap the key type or any other information about the key, except the key length; the application must convey these separately. In particular, the mechanism contributes only the **CKA_CLASS** and **CKA_VALUE** (and **CKA_VALUE_LEN**, if the key has it) attributes to the recovered key during unwrapping; other attributes must be specified in the template.

Constraints on key types and the length of the data are summarized in the following table. For encryption and decryption, the input and output data may begin at the same location in memory. In the table, *k* is the length in bytes of the RSA modulus.

Table 16, TPM 1.1b and TPM 1.2 PKCS #1 RSA OAEP: Key And Data Length

| Function | Key type | Input length | Output length |
|------------------------|-----------------|-----------------|-----------------|
| C_Encrypt ¹ | RSA public key | $\leq k-2-40-5$ | k |
| C_Decrypt ¹ | RSA private key | k | $\leq k-2-40-5$ |
| C_WrapKey | RSA public key | $\leq k-2-40-5$ | k |
| C_UnwrapKey | RSA private key | k | $\leq k-2-40-5$ |

¹ Single-part operations only.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of RSA modulus sizes, in bits.

2.1.23 RSA AES KEY WRAP

The RSA AES key wrap mechanism, denoted **CKM_RSA_AES_KEY_WRAP**, is a mechanism based on the RSA public-key cryptosystem and the AES key wrap mechanism. It supports single-part key wrapping; and key unwrapping.

It has a parameter, a **CK_RSA_AES_KEY_WRAP_PARAMS** structure.

The mechanism can wrap and unwrap a target asymmetric key of any length and type using an RSA key.

- A temporary AES key is used for wrapping the target key using **CKM_AES_KEY_WRAP_KWP** mechanism.
- The temporary AES key is wrapped with the wrapping RSA key using **CKM_RSA_PKCS_OAEP** mechanism.

For wrapping, the mechanism -

- Generates a temporary random AES key of *ulAESKeyBits* length. This key is not accessible to the user - no handle is returned.
- Wraps the AES key with the wrapping RSA key using **CKM_RSA_PKCS_OAEP** with parameters of *OAEPParams*.
- Wraps the target key with the temporary AES key using **CKM_AES_KEY_WRAP_KWP** ([AES KEYWRAP] section 6.3).
- Zeroizes the temporary AES key
- Concatenates two wrapped keys and outputs the concatenated blob. The first is the wrapped AES key, and the second is the wrapped target key.

The recommended format for an asymmetric target key being wrapped is as a PKCS8 PrivateKeyInfo

The use of Attributes in the PrivateKeyInfo structure is OPTIONAL. In case of conflicts between the object attribute template, and Attributes in the PrivateKeyInfo structure, an error should be thrown

For unwrapping, the mechanism -

- Splits the input into two parts. The first is the wrapped AES key, and the second is the wrapped target key. The length of the first part is equal to the length of the unwrapping RSA key.
- Un-wraps the temporary AES key from the first part with the private RSA key using **CKM_RSA_PKCS_OAEP** with parameters of *OAEPParams*.
- Un-wraps the target key from the second part with the temporary AES key using **CKM_AES_KEY_WRAP_KWP** ([AES KEYWRAP] section 6.3).

- Zeroizes the temporary AES key.
- Returns the handle to the newly unwrapped target key.

Table 17, CKM_RSA_AES_KEY_WRAP Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_RSA_AES_KEY_WRAP | | | | | | ✓ | |
| ¹ SR = SignRecover, VR = VerifyRecover | | | | | | | |

2.1.24 RSA AES KEY WRAP mechanism parameters

◆ CK_RSA_AES_KEY_WRAP_PARAMS; CK_RSA_AES_KEY_WRAP_PARAMS_PTR

CK_RSA_AES_KEY_WRAP_PARAMS is a structure that provides the parameters to the CKM_RSA_AES_KEY_WRAP mechanism. It is defined as follows:

```
typedef struct CK_RSA_AES_KEY_WRAP_PARAMS {
    CK_ULONG          ulAESKeyBits;
    CK_RSA_PKCS_OAEP_PARAMS_PTR pOAEPParams;
} CK_RSA_AES_KEY_WRAP_PARAMS;
```

The fields of the structure have the following meanings:

ulAESKeyBits *length of the temporary AES key in bits. Can be only 128, 192 or 256.*

pOAEPParams *pointer to the parameters of the temporary AES key wrapping. See also the description of PKCS #1 RSA OAEP mechanism parameters.*

CK_RSA_AES_KEY_WRAP_PARAMS_PTR is a pointer to a CK_RSA_AES_KEY_WRAP_PARAMS.

2.1.25 FIPS 186-4

When CKM_RSA_PKCS is operated in FIPS mode, the length of the modulus SHALL only be 1024, 2048, or 3072 bits.

2.2 DSA

Table 18, DSA Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-----------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_DSA_KEY_PAIR_GEN | | | | | ✓ | | |
| CKM_DSA_PARAMETER_GEN | | | | | ✓ | | |

| Mechanism | Functions | | | | | | |
|-------------------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_DSA_PROBABILISTIC_PARAMETER_GEN | | | | | ✓ | | |
| CKM_DSA_SHAWA_TAYLOR_PARAMETER_GEN | | | | | ✓ | | |
| CKM_DSA_FIPS_G_GEN | | | | | ✓ | | |
| CKM_DSA | | ✓ ² | | | | | |
| CKM_DSA_SHA1 | | ✓ | | | | | |
| CKM_DSA_SHA224 | | ✓ | | | | | |
| CKM_DSA_SHA256 | | ✓ | | | | | |
| CKM_DSA_SHA384 | | ✓ | | | | | |
| CKM_DSA_SHA512 | | ✓ | | | | | |
| CKM_DSA_SHA3_224 | | ✓ | | | | | |
| CKM_DSA_SHA3_256 | | ✓ | | | | | |
| CKM_DSA_SHA3_384 | | ✓ | | | | | |
| CKM_DSA_SHA3_512 | | ✓ | | | | | |

2.2.1 Definitions

This section defines the key type “CKK_DSA” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of DSA key objects.

Mechanisms:

- CKM_DSA_KEY_PAIR_GEN
- CKM_DSA
- CKM_DSA_SHA1
- CKM_DSA_SHA224
- CKM_DSA_SHA256
- CKM_DSA_SHA384
- CKM_DSA_SHA512
- CKM_DSA_SHA3_224
- CKM_DSA_SHA3_256
- CKM_DSA_SHA3_384
- CKM_DSA_SHA3_512
- CKM_DSA_PARAMETER_GEN
- CKM_DSA_PROBABILISTIC_PARAMETER_GEN
- CKM_DSA_SHAWA_TAYLOR_PARAMETER_GEN
- CKM_DSA_FIPS_G_GEN

◆ CK_DSA_PARAMETER_GEN_PARAM

CK_DSA_PARAMETER_GEN_PARAM is a structure which provides and returns parameters for the NIST FIPS 186-4 parameter generating algorithms.

CK_DSA_PARAMETER_GEN_PARAM_PTR is a pointer to a CK_DSA_PARAMETER_GEN_PARAM.

```
typedef struct CK_DSA_PARAMETER_GEN_PARAM {
    CK_MECHANISM_TYPE    hash;
    CK_BYTE_PTR          pSeed;
    CK_ULONG              ulSeedLen;
    CK_ULONG              ulIndex;
} CK_DSA_PARAMETER_GEN_PARAM;
```

The fields of the structure have the following meanings:

hash Mechanism value for the base hash used in PQG generation, Valid values are CKM_SHA_1, CKM_SHA224, CKM_SHA256, CKM_SHA384, CKM_SHA512.

pSeed Seed value used to generate PQ and G. This value is returned by CKM_DSA_PROBABILISTIC_PARAMETER_GEN, CKM_DSA_SHAWE_TAYLOR_PARAMETER_GEN, and passed into CKM_DSA_FIPS_G_GEN.

ulSeedLen Length of seed value.

ulIndex Index value for generating G. Input for CKM_DSA_FIPS_G_GEN. Ignored by CKM_DSA_PROBABILISTIC_PARAMETER_GEN and CKM_DSA_SHAWE_TAYLOR_PARAMETER_GEN.

2.2.2 DSA public key objects

DSA public key objects (object class **CKO_PUBLIC_KEY**, key type **CKK_DSA**) hold DSA public keys. The following table defines the DSA public key object attributes, in addition to the common attributes defined for this object class:

Table 19, DSA Public Key Object Attributes

| Attribute | Data type | Meaning |
|-----------------------------|-------------|--|
| CKA_PRIME ^{1,3} | Big integer | Prime <i>p</i> (512 to 3072 bits, in steps of 64 bits) |
| CKA_SUBPRIME ^{1,3} | Big integer | Subprime <i>q</i> (160, 224 bits, or 256 bits) |
| CKA_BASE ^{1,3} | Big integer | Base <i>g</i> |
| CKA_VALUE ^{1,4} | Big integer | Public value <i>y</i> |

- Refer to [PKCS11-Base] table 11 for footnotes

The **CKA_PRIME**, **CKA_SUBPRIME** and **CKA_BASE** attribute values are collectively the “DSA domain parameters”. See FIPS PUB 186-4 for more information on DSA keys.

The following is a sample template for creating a DSA public key object:

```
CK_OBJECT_CLASS class = CKO_PUBLIC_KEY;
CK_KEY_TYPE keyType = CKK_DSA;
CK_UTF8CHAR label[] = "A DSA public key object";
CK_BYTE prime[] = {...};
CK_BYTE subprime[] = {...};
```

```

936 CK_BYTE base[] = {...};
937 CK_BYTE value[] = {...};
938 CK_BBOOL true = CK_TRUE;
939 CK_ATTRIBUTE template[] = {
940     {CKA_CLASS, &class, sizeof(class)},
941     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
942     {CKA_TOKEN, &true, sizeof(true)},
943     {CKA_LABEL, label, sizeof(label)-1},
944     {CKA_PRIME, prime, sizeof(prime)},
945     {CKA_SUBPRIME, subprime, sizeof(subprime)},
946     {CKA_BASE, base, sizeof(base)},
947     {CKA_VALUE, value, sizeof(value)}
948 };
949

```

2.2.3 DSA Key Restrictions

FIPS PUB 186-4 specifies permitted combinations of prime and sub-prime lengths. They are:

- Prime: 1024 bits, Subprime: 160
- Prime: 2048 bits, Subprime: 224
- Prime: 2048 bits, Subprime: 256
- Prime: 3072 bits, Subprime: 256

Earlier versions of FIPS 186 permitted smaller prime lengths, and those are included here for backwards compatibility. An implementation that is compliant to FIPS 186-4 does not permit the use of primes of any length less than 1024 bits.

2.2.4 DSA private key objects

DSA private key objects (object class **CKO_PRIVATE_KEY**, key type **CKK_DSA**) hold DSA private keys. The following table defines the DSA private key object attributes, in addition to the common attributes defined for this object class:

Table 20, DSA Private Key Object Attributes

| Attribute | Data type | Meaning |
|-------------------------------|-------------|---|
| CKA_PRIME ^{1,4,6} | Big integer | Prime p (512 to 1024 bits, in steps of 64 bits) |
| CKA_SUBPRIME ^{1,4,6} | Big integer | Subprime q (160 bits, 224 bits, or 256 bits) |
| CKA_BASE ^{1,4,6} | Big integer | Base g |
| CKA_VALUE ^{1,4,6,7} | Big integer | Private value x |

- Refer to [PKCS11-Base] table 11 for footnotes

The **CKA_PRIME**, **CKA_SUBPRIME** and **CKA_BASE** attribute values are collectively the “DSA domain parameters”. See FIPS PUB 186-4 for more information on DSA keys.

Note that when generating a DSA private key, the DSA domain parameters are *not* specified in the key's template. This is because DSA private keys are only generated as part of a DSA key *pair*, and the DSA domain parameters for the pair are specified in the template for the DSA public key.

The following is a sample template for creating a DSA private key object:

```

971 CK_OBJECT_CLASS class = CKO_PRIVATE_KEY;
972 CK_KEY_TYPE keyType = CKK_DSA;
973 CK_UTF8CHAR label[] = "A DSA private key object";
974 CK_BYTE subject[] = {...};

```



```

975     CK_BYTE id[] = {123};
976     CK_BYTE prime[] = {...};
977     CK_BYTE subprime[] = {...};
978     CK_BYTE base[] = {...};
979     CK_BYTE value[] = {...};
980     CK_BBOOL true = CK_TRUE;
981     CK_ATTRIBUTE template[] = {
982         {CKA_CLASS, &class, sizeof(class)},
983         {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
984         {CKA_TOKEN, &true, sizeof(true)},
985         {CKA_LABEL, label, sizeof(label)-1},
986         {CKA_SUBJECT, subject, sizeof(subject)},
987         {CKA_ID, id, sizeof(id)},
988         {CKA_SENSITIVE, &true, sizeof(true)},
989         {CKA_SIGN, &true, sizeof(true)},
990         {CKA_PRIME, prime, sizeof(prime)},
991         {CKA_SUBPRIME, subprime, sizeof(subprime)},
992         {CKA_BASE, base, sizeof(base)},
993         {CKA_VALUE, value, sizeof(value)}
994     };

```

2.2.5 DSA domain parameter objects

DSA domain parameter objects (object class **CKO_DOMAIN_PARAMETERS**, key type **CKK_DSA**) hold DSA domain parameters. The following table defines the DSA domain parameter object attributes, in addition to the common attributes defined for this object class:

Table 21, DSA Domain Parameter Object Attributes

| Attribute | Data type | Meaning |
|-------------------------------|-------------|---|
| CKA_PRIME ^{1,4} | Big integer | Prime p (512 to 1024 bits, in steps of 64 bits) |
| CKA_SUBPRIME ^{1,4} | Big integer | Subprime q (160 bits, 224 bits, or 256 bits) |
| CKA_BASE ^{1,4} | Big integer | Base g |
| CKA_PRIME_BITS ^{2,3} | CK_ULONG | Length of the prime value. |

- Refer to [PKCS11-Base] table 11 for footnotes

The **CKA_PRIME**, **CKA_SUBPRIME** and **CKA_BASE** attribute values are collectively the “DSA domain parameters”. See FIPS PUB 186-4 for more information on DSA domain parameters.

To ensure backwards compatibility, if **CKA_SUBPRIME_BITS** is not specified for a call to **C_GenerateKey**, it takes on a default based on the value of **CKA_PRIME_BITS** as follows:

- If **CKA_PRIME_BITS** is less than or equal to 1024 then **CKA_SUBPRIME_BITS** shall be 160 bits
- If **CKA_PRIME_BITS** equals 2048 then **CKA_SUBPRIME_BITS** shall be 224 bits
- If **CKA_PRIME_BITS** equals 3072 then **CKA_SUBPRIME_BITS** shall be 256 bits

The following is a sample template for creating a DSA domain parameter object:

```

1010     CK_OBJECT_CLASS class = CKO_DOMAIN_PARAMETERS;
1011     CK_KEY_TYPE keyType = CKK_DSA;
1012     CK_UTF8CHAR label[] = "A DSA domain parameter object";
1013     CK_BYTE prime[] = {...};
1014     CK_BYTE subprime[] = {...};

```

```

1015     CK_BYTE base[] = {...};
1016     CK_BBOOL true = CK_TRUE;
1017     CK_ATTRIBUTE template[] = {
1018         {CKA_CLASS, &class, sizeof(class)},
1019         {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
1020         {CKA_TOKEN, &true, sizeof(true)},
1021         {CKA_LABEL, label, sizeof(label)-1},
1022         {CKA_PRIME, prime, sizeof(prime)},
1023         {CKA_SUBPRIME, subprime, sizeof(subprime)},
1024         {CKA_BASE, base, sizeof(base)},
1025     };

```

1026 2.2.6 DSA key pair generation

1027 The DSA key pair generation mechanism, denoted **CKM_DSA_KEY_PAIR_GEN**, is a key pair generation
1028 mechanism based on the Digital Signature Algorithm defined in FIPS PUB 186-2.

1029 This mechanism does not have a parameter.

1030 The mechanism generates DSA public/private key pairs with a particular prime, subprime and base, as
1031 specified in the **CKA_PRIME**, **CKA_SUBPRIME**, and **CKA_BASE** attributes of the template for the public
1032 key.

1033 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
1034 public key and the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_PRIME**, **CKA_SUBPRIME**, **CKA_BASE**, and
1035 **CKA_VALUE** attributes to the new private key. Other attributes supported by the DSA public and private
1036 key types (specifically, the flags indicating which functions the keys support) may also be specified in the
1037 templates for the keys, or else are assigned default initial values.

1038 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
1039 specify the supported range of DSA prime sizes, in bits.

1040 2.2.7 DSA domain parameter generation

1041 The DSA domain parameter generation mechanism, denoted **CKM_DSA_PARAMETER_GEN**, is a
1042 domain parameter generation mechanism based on the Digital Signature Algorithm defined in FIPS PUB
1043 186-2.

1044 This mechanism does not have a parameter.

1045 The mechanism generates DSA domain parameters with a particular prime length in bits, as specified in
1046 the **CKA_PRIME_BITS** attribute of the template.

1047 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_PRIME**, **CKA_SUBPRIME**,
1048 **CKA_BASE** and **CKA_PRIME_BITS** attributes to the new object. Other attributes supported by the DSA
1049 domain parameter types may also be specified in the template, or else are assigned default initial values.

1050 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
1051 specify the supported range of DSA prime sizes, in bits.

1052 2.2.8 DSA probabilistic domain parameter generation

1053 The DSA probabilistic domain parameter generation mechanism, denoted
1054 **CKM_DSA_PROBABILISTIC_PARAMETER_GEN**, is a domain parameter generation mechanism based
1055 on the Digital Signature Algorithm defined in FIPS PUB 186-4, section Appendix A.1.1 Generation and
1056 Validation of Probable Primes..

1057 This mechanism takes a **CK_DSA_PARAMETER_GEN_PARAM** which supplies the base hash and
1058 returns the seed (*pSeed*) and the length (*ulSeedLen*).

The mechanism generates DSA the prime and subprime domain parameters with a particular prime length in bits, as specified in the **CKA_PRIME_BITS** attribute of the template and the subprime length as specified in the **CKA_SUBPRIME_BITS** attribute of the template.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_PRIME**, **CKA_SUBPRIME**, **CKA_PRIME_BITS**, and **CKA_SUBPRIME_BITS** attributes to the new object. **CKA_BASE** is not set by this call. Other attributes supported by the DSA domain parameter types may also be specified in the template, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of DSA prime sizes, in bits.

2.2.9 DSA Shawe-Taylor domain parameter generation

The DSA Shawe-Taylor domain parameter generation mechanism, denoted **CKM_DSA_SHAWE_TAYLOR_PARAMETER_GEN**, is a domain parameter generation mechanism based on the Digital Signature Algorithm defined in FIPS PUB 186-4, section Appendix A.1.2 Construction and Validation of Provable Primes p and q.

This mechanism takes a **CK_DSA_PARAMETER_GEN_PARAM** which supplies the base hash and returns the seed (pSeed) and the length (ulSeedLen).

The mechanism generates DSA the prime and subprime domain parameters with a particular prime length in bits, as specified in the **CKA_PRIME_BITS** attribute of the template and the subprime length as specified in the **CKA_SUBPRIME_BITS** attribute of the template.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_PRIME**, **CKA_SUBPRIME**, **CKA_PRIME_BITS**, and **CKA_SUBPRIME_BITS** attributes to the new object. **CKA_BASE** is not set by this call. Other attributes supported by the DSA domain parameter types may also be specified in the template, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of DSA prime sizes, in bits.

2.2.10 DSA base domain parameter generation

The DSA base domain parameter generation mechanism, denoted **CKM_DSA_FIPS_G_GEN**, is a base parameter generation mechanism based on the Digital Signature Algorithm defined in FIPS PUB 186-4, section Appendix A.2 Generation of Generator G.

This mechanism takes a **CK_DSA_PARAMETER_GEN_PARAM** which supplies the base hash the seed (pSeed) and the length (ulSeedLen) and the index value.

The mechanism generates the DSA base with the domain parameter specified in the **CKA_PRIME** and **CKA_SUBPRIME** attributes of the template.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_BASE** attributes to the new object. Other attributes supported by the DSA domain parameter types may also be specified in the template, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of DSA prime sizes, in bits.

2.2.11 DSA without hashing

The DSA without hashing mechanism, denoted **CKM_DSA**, is a mechanism for single-part signatures and verification based on the Digital Signature Algorithm defined in FIPS PUB 186-2. (This mechanism corresponds only to the part of DSA that processes the 20-byte hash value; it does not compute the hash value.)

For the purposes of this mechanism, a DSA signature is a 40-byte string, corresponding to the concatenation of the DSA values *r* and *s*, each represented most-significant byte first.

It does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 22, DSA: Key And Data Length

| Function | Key type | Input length | Output length |
|-----------------------|-----------------|---|----------------------|
| C_Sign ¹ | DSA private key | 20, 28, 32, 48, or 64 bits | 2*length of subprime |
| C_Verify ¹ | DSA public key | (20, 28, 32, 48, or 64 bits), (2*length of subprime) ² | N/A |

¹ Single-part operations only.

² Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of DSA prime sizes, in bits.

2.2.12 DSA with SHA-1

The DSA with SHA-1 mechanism, denoted **CKM_DSA_SHA1**, is a mechanism for single- and multiple-part signatures and verification based on the Digital Signature Algorithm defined in FIPS PUB 186-2. This mechanism computes the entire DSA specification, including the hashing with SHA-1.

For the purposes of this mechanism, a DSA signature is a 40-byte string, corresponding to the concatenation of the DSA values *r* and *s*, each represented most-significant byte first.

This mechanism does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 23, DSA with SHA-1: Key And Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------|-------------------------------------|-------------------|
| C_Sign | DSA private key | any | 2*subprime length |
| C_Verify | DSA public key | any, 2*subprime length ² | N/A |

² Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of DSA prime sizes, in bits.

2.2.13 FIPS 186-4

When CKM_DSA is operated in FIPS mode, only the following bit lengths of *p* and *q*, represented by *L* and *N*, SHALL be used:

L = 1024, *N* = 160

L = 2048, *N* = 224

L = 2048, *N* = 256

L = 3072, *N* = 256

2.2.14 DSA with SHA-224

The DSA with SHA-1 mechanism, denoted **CKM_DSA_SHA224**, is a mechanism for single- and multiple-part signatures and verification based on the Digital Signature Algorithm defined in FIPS PUB 186-4.

This mechanism computes the entire DSA specification, including the hashing with SHA-224.

For the purposes of this mechanism, a DSA signature is a string of length $2 \times \text{subprime}$, corresponding to the concatenation of the DSA values r and s , each represented most-significant byte first.

This mechanism does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 24, DSA with SHA-244: Key And Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------|--|-----------------------------------|
| C_Sign | DSA private key | any | $2 \times \text{subprime}$ length |
| C_Verify | DSA public key | any, $2 \times \text{subprime}$ length ² | N/A |

² Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of DSA prime sizes, in bits.

2.2.15 DSA with SHA-256

The DSA with SHA-1 mechanism, denoted **CKM_DSA_SHA256**, is a mechanism for single- and multiple-part signatures and verification based on the Digital Signature Algorithm defined in FIPS PUB 186-4. This mechanism computes the entire DSA specification, including the hashing with SHA-256.

For the purposes of this mechanism, a DSA signature is a string of length $2 \times \text{subprime}$, corresponding to the concatenation of the DSA values r and s , each represented most-significant byte first.

This mechanism does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 25, DSA with SHA-256: Key And Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------|--|-----------------------------------|
| C_Sign | DSA private key | any | $2 \times \text{subprime}$ length |
| C_Verify | DSA public key | any, $2 \times \text{subprime}$ length ² | N/A |

² Data length, signature length.

2.2.16 DSA with SHA-384

The DSA with SHA-1 mechanism, denoted **CKM_DSA_SHA384**, is a mechanism for single- and multiple-part signatures and verification based on the Digital Signature Algorithm defined in FIPS PUB 186-4. This mechanism computes the entire DSA specification, including the hashing with SHA-384.

For the purposes of this mechanism, a DSA signature is a string of length $2 \times \text{subprime}$, corresponding to the concatenation of the DSA values r and s , each represented most-significant byte first.

This mechanism does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 26, DSA with SHA-384: Key And Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------|-------------------------------------|-------------------|
| C_Sign | DSA private key | any | 2*subprime length |
| C_Verify | DSA public key | any, 2*subprime length ² | N/A |

² Data length, signature length.

2.2.17 DSA with SHA-512

The DSA with SHA-1 mechanism, denoted **CKM_DSA_SHA512**, is a mechanism for single- and multiple-part signatures and verification based on the Digital Signature Algorithm defined in FIPS PUB 186-4. This mechanism computes the entire DSA specification, including the hashing with SHA-512.

For the purposes of this mechanism, a DSA signature is a string of length 2*subprime, corresponding to the concatenation of the DSA values *r* and *s*, each represented most-significant byte first.

This mechanism does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 27, DSA with SHA-512: Key And Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------|-------------------------------------|-------------------|
| C_Sign | DSA private key | any | 2*subprime length |
| C_Verify | DSA public key | any, 2*subprime length ² | N/A |

² Data length, signature length.

2.2.18 DSA with SHA3-224

The DSA with SHA3-224 mechanism, denoted **CKM_DSA_SHA3_224**, is a mechanism for single- and multiple-part signatures and verification based on the Digital Signature Algorithm defined in FIPS PUB 186-4. This mechanism computes the entire DSA specification, including the hashing with SHA3-224.

For the purposes of this mechanism, a DSA signature is a string of length 2*subprime, corresponding to the concatenation of the DSA values *r* and *s*, each represented most-significant byte first.

This mechanism does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 28, DSA with SHA3-224: Key And Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------|-------------------------------------|-------------------|
| C_Sign | DSA private key | any | 2*subprime length |
| C_Verify | DSA public key | any, 2*subprime length ² | N/A |

² Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of DSA prime sizes, in bits.

2.2.19 DSA with SHA3-256

The DSA with SHA3-256 mechanism, denoted **CKM_DSA_SHA3_256**, is a mechanism for single- and multiple-part signatures and verification based on the Digital Signature Algorithm defined in FIPS PUB 186-4. This mechanism computes the entire DSA specification, including the hashing with SHA3-256.

For the purposes of this mechanism, a DSA signature is a string of length $2 \times \text{subprime}$, corresponding to the concatenation of the DSA values r and s , each represented most-significant byte first.

This mechanism does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 29, DSA with SHA3-256: Key And Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------|--|-----------------------------------|
| C_Sign | DSA private key | any | $2 \times \text{subprime}$ length |
| C_Verify | DSA public key | any, $2 \times \text{subprime}$ length ² | N/A |

² Data length, signature length.

2.2.20 DSA with SHA3-384

The DSA with SHA3-384 mechanism, denoted **CKM_DSA_SHA3_384**, is a mechanism for single- and multiple-part signatures and verification based on the Digital Signature Algorithm defined in FIPS PUB 186-4. This mechanism computes the entire DSA specification, including the hashing with SHA3-384.

For the purposes of this mechanism, a DSA signature is a string of length $2 \times \text{subprime}$, corresponding to the concatenation of the DSA values r and s , each represented most-significant byte first.

This mechanism does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 30, DSA with SHA3-384: Key And Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------|--|-----------------------------------|
| C_Sign | DSA private key | any | $2 \times \text{subprime}$ length |
| C_Verify | DSA public key | any, $2 \times \text{subprime}$ length ² | N/A |

² Data length, signature length.

2.2.21 DSA with SHA3-512

The DSA with SHA3-512 mechanism, denoted **CKM_DSA_SHA3_512**, is a mechanism for single- and multiple-part signatures and verification based on the Digital Signature Algorithm defined in FIPS PUB 186-4. This mechanism computes the entire DSA specification, including the hashing with SHA3-512.

For the purposes of this mechanism, a DSA signature is a string of length $2 \times \text{subprime}$, corresponding to the concatenation of the DSA values r and s , each represented most-significant byte first.

This mechanism does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

1213 Table 31, DSA with SHA3-512: Key And Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------|--|-------------------|
| C_Sign | DSA private key | any | 2*subprime length |
| C_Verify | DSA public key | any, 2*subprime length ² | N/A |

² Data length, signature length.

2.3 Elliptic Curve

The Elliptic Curve (EC) cryptosystem (also related to ECDSA) in this document was originally based on the one described in the ANSI X9.62 and X9.63 standards developed by the ANSI X9F1 working group.

The EC cryptosystem developed by the ANSI X9F1 working group was created at a time when EC curves were always represented in their Weierstrass form. Since that time, new curves represented in Edwards form (RFC 8032) and Montgomery form (RFC 7748) have become more common. To support these new curves, the EC cryptosystem in this document has been extended from the original. Additional key generation mechanisms have been added as well as an additional signature generation mechanism.

Table 32, Elliptic Curve Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|----------------------------------|-------------------|----------------|----------------------|--------|--------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_EC_KEY_PAIR_GEN | | | | | ✓ | | |
| CKM_EC_KEY_PAIR_GEN_W_EXTRA_BITS | | | | | ✓ | | |
| CKM_EC_EDWARDS_KEY_PAIR_GEN | | | | | ✓ | | |
| CKM_EC_MONTGOMERY_KEY_PAIR_GEN | | | | | ✓ | | |
| CKM_ECDSA | | ✓ ² | | | | | |
| CKM_ECDSA_SHA1 | | ✓ | | | | | |
| CKM_ECDSA_SHA224 | | ✓ | | | | | |
| CKM_ECDSA_SHA256 | | ✓ | | | | | |
| CKM_ECDSA_SHA384 | | ✓ | | | | | |
| CKM_ECDSA_SHA512 | | ✓ | | | | | |
| CKM_ECDSA_SHA3_224 | | ✓ | | | | | |
| CKM_ECDSA_SHA3_256 | | ✓ | | | | | |
| CKM_ECDSA_SHA3_384 | | ✓ | | | | | |
| CKM_ECDSA_SHA3_512 | | ✓ | | | | | |
| CKM_EDDSA | | ✓ | | | | | |
| CKM_XEDDSA | | ✓ | | | | | |
| CKM_ECDH1_DERIVE | | | | | | | ✓ |
| CKM_ECDH1_COFACTOR_DERIVE | | | | | | | ✓ |

| Mechanism | Functions | | | | | | |
|-----------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_ECMQV_DERIVE | | | | | | | ✓ |
| CKM_ECDH_AES_KEY_WRAP | | | | | | ✓ | |

1226

1227 *Table 33, Mechanism Information Flags*

| | | |
|---------------------|--------------|---|
| CKF_EC_F_P | 0x00100000UL | True if the mechanism can be used with EC domain parameters over F_p |
| CKF_EC_F_2M | 0x00200000UL | True if the mechanism can be used with EC domain parameters over F_{2^m} |
| CKF_EC_ECPARAMETERS | 0x00400000UL | True if the mechanism can be used with EC domain parameters of the choice ecParameters |
| CKF_EC_OID | 0x00800000UL | True if the mechanism can be used with EC domain parameters of the choice old |
| CKF_EC_UNCOMPRESS | 0x01000000UL | True if the mechanism can be used with elliptic curve point uncompressed |
| CKF_EC_COMPRESS | 0x02000000UL | True if the mechanism can be used with elliptic curve point compressed |
| CKF_EC_CURVENAME | 0x04000000UL | True if the mechanism can be used with EC domain parameters of the choice curveName |

1228 Note: CKF_EC_NAMEDCURVE is deprecated with PKCS#11 3.00. It is replaced by CKF_EC_OID.

1229 In these standards, there are two different varieties of EC defined:

1230 1. EC using a field with an odd prime number of elements (i.e. the finite field F_p).

1231 2. EC using a field of characteristic two (i.e. the finite field F_{2^m}).

1232 An EC key in Cryptoki contains information about which variety of EC it is suited for. It is preferable that a
1233 Cryptoki library, which can perform EC mechanisms, be capable of performing operations with the two
1234 varieties of EC, however this is not required. The **CK_MECHANISM_INFO** structure **CKF_EC_F_P** flag
1235 identifies a Cryptoki library supporting EC keys over F_p whereas the **CKF_EC_F_2M** flag identifies a
1236 Cryptoki library supporting EC keys over F_{2^m} . A Cryptoki library that can perform EC mechanisms must
1237 set either or both of these flags for each EC mechanism.

1238 In these specifications there are also four representation methods to define the domain parameters for an
1239 EC key. Only the **ecParameters**, the **old** and the **curveName** choices are supported in Cryptoki. The
1240 **CK_MECHANISM_INFO** structure **CKF_EC_ECPARAMETERS** flag identifies a Cryptoki library
1241 supporting the **ecParameters** choice whereas the **CKF_EC_OID** flag identifies a Cryptoki library
1242 supporting the **old** choice, and the **CKF_EC_CURVENAME** flag identifies a Cryptoki library supporting
1243 the **curveName** choice. A Cryptoki library that can perform EC mechanisms must set the appropriate
1244 flag(s) for each EC mechanism.

1245 In these specifications, an EC public key (i.e. EC point Q) or the base point G when the **ecParameters**
1246 choice is used can be represented as an octet string of the uncompressed form or the compressed form.
1247 The **CK_MECHANISM_INFO** structure **CKF_EC_UNCOMPRESS** flag identifies a Cryptoki library
1248 supporting the uncompressed form whereas the **CKF_EC_COMPRESS** flag identifies a Cryptoki library
1249 supporting the compressed form. A Cryptoki library that can perform EC mechanisms must set either or
1250 both of these flags for each EC mechanism.

Note that an implementation of a Cryptoki library supporting EC with only one variety, one representation of domain parameters or one form may encounter difficulties achieving interoperability with other implementations.

If an attempt to create, generate, derive or unwrap an EC key of an unsupported curve is made, the attempt should fail with the error code CKR_CURVE_NOT_SUPPORTED. If an attempt to create, generate, derive, or unwrap an EC key with invalid or of an unsupported representation of domain parameters is made, that attempt should fail with the error code CKR_DOMAIN_PARAMS_INVALID. If an attempt to create, generate, derive, or unwrap an EC key of an unsupported form is made, that attempt should fail with the error code CKR_TEMPLATE_INCONSISTENT.

2.3.1 EC Signatures

For the purposes of these mechanisms, an ECDSA signature is an octet string of even length which is at most two times $nLen$ octets, where $nLen$ is the length in octets of the base point order n . The signature octets correspond to the concatenation of the ECDSA values r and s , both represented as an octet string of equal length of at most $nLen$ with the most significant byte first. If r and s have different octet length, the shorter of both must be padded with leading zero octets such that both have the same octet length. Loosely spoken, the first half of the signature is r and the second half is s . For signatures created by a token, the resulting signature is always of length $2nLen$. For signatures passed to a token for verification, the signature may have a shorter length but must be composed as specified before.

If the length of the hash value is larger than the bit length of n , only the leftmost bits of the hash up to the length of n will be used. Any truncation is done by the token.

Note: For applications, it is recommended to encode the signature as an octet string of length two times $nLen$ if possible. This ensures that the application works with PKCS#11 modules which have been implemented based on an older version of this document. Older versions required all signatures to have length two times $nLen$. It may be impossible to encode the signature with the maximum length of two times $nLen$ if the application just gets the integer values of r and s (i.e. without leading zeros), but does not know the base point order n , because r and s can have any value between zero and the base point order n .

An EdDSA signature is an octet string of even length which is two times $nLen$ octets, where $nLen$ is calculated as EdDSA parameter b divided by 8. The signature octets correspond to the concatenation of the EdDSA values R and S as defined in [RFC 8032], both represented as an octet string of equal length of $nLen$ bytes in little endian order.

2.3.2 Definitions

This section defines the key type "CKK_EC" for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

Note: CKK_ECDSA is deprecated. It is replaced by CKK_EC.

Mechanisms:

- CKM_EC_KEY_PAIR_GEN
- CKM_EC_EDWARDS_KEY_PAIR_GEN
- CKM_EC_MONTGOMERY_KEY_PAIR_GEN
- CKM_ECDSA
- CKM_ECDSA_SHA1
- CKM_ECDSA_SHA224
- CKM_ECDSA_SHA256
- CKM_ECDSA_SHA384
- CKM_ECDSA_SHA512
- CKM_ECDSA_SHA3_224

| | |
|------|---------------------------|
| 1298 | CKM_ECDSA_SHA3_256 |
| 1299 | CKM_ECDSA_SHA3_384 |
| 1300 | CKM_ECDSA_SHA3_512 |
| 1301 | CKM_EDDSA |
| 1302 | CKM_XEDDSA |
| 1303 | CKM_ECDH1_DERIVE |
| 1304 | CKM_ECDH1_COFACTOR_DERIVE |
| 1305 | CKM_ECMQV_DERIVE |
| 1306 | CKM_ECDH_AES_KEY_WRAP |
| 1307 | |
| 1308 | CKD_NULL |
| 1309 | CKD_SHA1_KDF |
| 1310 | CKD_SHA224_KDF |
| 1311 | CKD_SHA256_KDF |
| 1312 | CKD_SHA384_KDF |
| 1313 | CKD_SHA512_KDF |
| 1314 | CKD_SHA3_224_KDF |
| 1315 | CKD_SHA3_256_KDF |
| 1316 | CKD_SHA3_384_KDF |
| 1317 | CKD_SHA3_512_KDF |
| 1318 | CKD_SHA1_KDF_SP800 |
| 1319 | CKD_SHA224_KDF_SP800 |
| 1320 | CKD_SHA256_KDF_SP800 |
| 1321 | CKD_SHA384_KDF_SP800 |
| 1322 | CKD_SHA512_KDF_SP800 |
| 1323 | CKD_SHA3_224_KDF_SP800 |
| 1324 | CKD_SHA3_256_KDF_SP800 |
| 1325 | CKD_SHA3_384_KDF_SP800 |
| 1326 | CKD_SHA3_512_KDF_SP800 |
| 1327 | CKD_BLAKE2B_160_KDF |
| 1328 | CKD_BLAKE2B_256_KDF |
| 1329 | CKD_BLAKE2B_384_KDF |
| 1330 | CKD_BLAKE2B_512_KDF |

1331 2.3.3 ECDSA public key objects

1332 EC (also related to ECDSA) public key objects (object class **CKO_PUBLIC_KEY**, key type **CKK_EC**)
 1333 hold EC public keys. The following table defines the EC public key object attributes, in addition to the
 1334 common attributes defined for this object class:

1335 Table 34, Elliptic Curve Public Key Object Attributes

| Attribute | Data type | Meaning |
|------------------------------|------------|--|
| CKA_EC_PARAMS ^{1,3} | Byte array | DER-encoding of an ANSI X9.62 Parameters value |
| CKA_EC_POINT ^{1,4} | Byte array | DER-encoding of ANSI X9.62 ECPoint value Q |

1336 - Refer to [PKCS11-Base] table 11 for footnotes

1337 Note: CKA_ECDSA_PARAMS is deprecated. It is replaced by CKA_EC_PARAMS.

1338 The **CKA_EC_PARAMS** attribute value is known as the “EC domain parameters” and is defined in ANSI
1339 X9.62 as a choice of three parameter representation methods with the following syntax:

```
1340     Parameters ::= CHOICE {  
1341         ecParameters      ECPParameters,  
1342         oId                CURVES.&id({CurveNames}),  
1343         implicitlyCA       NULL,  
1344         curveName          PrintableString  
1345     }
```

1346
1347 This allows detailed specification of all required values using choice **ecParameters**, the use of **old** as an
1348 object identifier substitute for a particular set of elliptic curve domain parameters, or **implicitlyCA** to
1349 indicate that the domain parameters are explicitly defined elsewhere, or **curveName** to specify a curve
1350 name as e.g. define in [ANSI X9.62], [BRAINPOOL], [SEC 2], [LEGIFRANCE]. The use of **old** or
1351 **curveName** is recommended over the choice **ecParameters**. The choice **implicitlyCA** must not be used
1352 in Cryptoki.

1353 The following is a sample template for creating an EC (ECDSA) public key object:

```
1354     CK_OBJECT_CLASS class = CKO_PUBLIC_KEY;  
1355     CK_KEY_TYPE keyType = CKK_EC;  
1356     CK_UTF8CHAR label[] = "An EC public key object";  
1357     CK_BYTE ecParams[] = {...};  
1358     CK_BYTE ecPoint[] = {...};  
1359     CK_BBOOL true = CK_TRUE;  
1360     CK_ATTRIBUTE template[] = {  
1361         {CKA_CLASS, &class, sizeof(class)},  
1362         {CKA_KEY_TYPE, &keyType, sizeof(keyType)},  
1363         {CKA_TOKEN, &true, sizeof(true)},  
1364         {CKA_LABEL, label, sizeof(label)-1},  
1365         {CKA_EC_PARAMS, ecParams, sizeof(ecParams)},  
1366         {CKA_EC_POINT, ecPoint, sizeof(ecPoint)}  
1367     };
```

1368 2.3.4 Elliptic curve private key objects

1369 EC (also related to ECDSA) private key objects (object class **CKO_PRIVATE_KEY**, key type **CKK_EC**)
1370 hold EC private keys. See Section 2.3 for more information about EC. The following table defines the EC
1371 private key object attributes, in addition to the common attributes defined for this object class:

Table 35, Elliptic Curve Private Key Object Attributes

| Attribute | Data type | Meaning |
|--------------------------------|-------------|--|
| CKA_EC_PARAMS ^{1,4,6} | Byte array | DER-encoding of an ANSI X9.62 Parameters value |
| CKA_VALUE ^{1,4,6,7} | Big integer | ANSI X9.62 private value <i>d</i> |

- Refer to [PKCS11-Base] table 11 for footnotes

The **CKA_EC_PARAMS** attribute value is known as the “EC domain parameters” and is defined in ANSI X9.62 as a choice of three parameter representation methods with the following syntax:

```
Parameters ::= CHOICE {
    ecParameters      ECParameters,
    oId                CURVES.&id({CurveNames}),
    implicitlyCA       NULL,
    curveName          PrintableString
}
```

This allows detailed specification of all required values using choice **ecParameters**, the use of **old** as an object identifier substitute for a particular set of elliptic curve domain parameters, or **implicitlyCA** to indicate that the domain parameters are explicitly defined elsewhere, or **curveName** to specify a curve name as e.g. define in [ANSI X9.62], [BRAINPOOL], [SEC 2], [LEGIFRANCE]. The use of **old** or **curveName** is recommended over the choice **ecParameters**. The choice **implicitlyCA** must not be used in Cryptoki. Note that when generating an EC private key, the EC domain parameters are *not* specified in the key's template. This is because EC private keys are only generated as part of an EC key *pair*, and the EC domain parameters for the pair are specified in the template for the EC public key.

The following is a sample template for creating an EC (ECDSA) private key object:

```
CK_OBJECT_CLASS class = CKO_PRIVATE_KEY;
CK_KEY_TYPE keyType = CKK_EC;
CK_UTF8CHAR label[] = "An EC private key object";
CK_BYTE subject[] = {...};
CK_BYTE id[] = {123};
CK_BYTE ecParams[] = {...};
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_SUBJECT, subject, sizeof(subject)},
    {CKA_ID, id, sizeof(id)},
    {CKA_SENSITIVE, &true, sizeof(true)},
    {CKA_DERIVE, &true, sizeof(true)},
    {CKA_EC_PARAMS, ecParams, sizeof(ecParams)},
    {CKA_VALUE, value, sizeof(value)}
};
```

2.3.5 Edwards Elliptic curve public key objects

Edwards EC public key objects (object class **CKO_PUBLIC_KEY**, key type **CKK_EC_EDWARDS**) hold Edwards EC public keys. The following table defines the Edwards EC public key object attributes, in addition to the common attributes defined for this object class:

Table 36, Edwards Elliptic Curve Public Key Object Attributes

| Attribute | Data type | Meaning |
|------------------------------|------------|--|
| CKA_EC_PARAMS ^{1,3} | Byte array | DER-encoding of a Parameters value as defined above |
| CKA_EC_POINT ^{1,4} | Byte array | DER-encoding of the b-bit public key value in little endian order as defined in RFC 8032 |

- Refer to [PKCS #11-Base] table 11 for footnotes

The **CKA_EC_PARAMS** attribute value is known as the “EC domain parameters” and is defined in ANSI X9.62 as a choice of three parameter representation methods. A 4th choice is added to support Edwards and Montgomery Elliptic curves. The **CKA_EC_PARAMS** attribute has the following syntax:

```
Parameters ::= CHOICE {
    ecParameters      ECPParameters,
    oId                CURVES.&id({CurveNames}),
    implicitlyCA       NULL,
    curveName          PrintableString
}
```

Edwards EC public keys only support the use of the **curveName** selection to specify a curve name as defined in [RFC 8032] and the use of the **oId** selection to specify a curve through an EdDSA algorithm as defined in [RFC 8410]. Note that keys defined by RFC 8032 and RFC 8410 are incompatible.

The following is a sample template for creating an Edwards EC public key object with Edwards25519 being specified as **curveName**:

```
CK_OBJECT_CLASS class = CKO_PUBLIC_KEY;
CK_KEY_TYPE keyType = CKK_EC;
CK_UTF8CHAR label[] = "An Edwards EC public key object";
CK_BYTE ecParams[] = {0x13, 0x0c, 0x65, 0x64, 0x77, 0x61,
    0x72, 0x64, 0x73, 0x32, 0x35, 0x35, 0x31, 0x39};
CK_BYTE ecPoint[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_EC_PARAMS, ecParams, sizeof(ecParams)},
    {CKA_EC_POINT, ecPoint, sizeof(ecPoint)}
};
```

2.3.6 Edwards Elliptic curve private key objects

Edwards EC private key objects (object class **CKO_PRIVATE_KEY**, key type **CKK_EC_EDWARDS**) hold Edwards EC private keys. See Section 2.3 for more information about EC. The following table defines the Edwards EC private key object attributes, in addition to the common attributes defined for this object class:

Table 37, Edwards Elliptic Curve Private Key Object Attributes

| Attribute | Data type | Meaning |
|--------------------------------|-------------|---|
| CKA_EC_PARAMS ^{1,4,6} | Byte array | DER-encoding of a Parameters value as defined above |
| CKA_VALUE ^{1,4,6,7} | Big integer | b-bit private key value in little endian order as defined in RFC 8032 |

- Refer to [PKCS #11-Base] table 11 for footnotes

The **CKA_EC_PARAMS** attribute value is known as the “EC domain parameters” and is defined in ANSI X9.62 as a choice of three parameter representation methods. A 4th choice is added to support Edwards and Montgomery Elliptic curves. The CKA_EC_PARAMS attribute has the following syntax:

```
Parameters ::= CHOICE {
    ecParameters      ECPParameters,
    oId                CURVES.&id({CurveNames}),
    implicitlyCA       NULL,
    curveName          PrintableString
}
```

Edwards EC private keys only support the use of the **curveName** selection to specify a curve name as defined in [RFC 8032] and the use of the **oId** selection to specify a curve through an EdDSA algorithm as defined in [RFC 8410]. Note that keys defined by RFC 8032 and RFC 8410 are incompatible.

Note that when generating an Edwards EC private key, the EC domain parameters are *not* specified in the key’s template. This is because Edwards EC private keys are only generated as part of an Edwards EC key *pair*, and the EC domain parameters for the pair are specified in the template for the Edwards EC public key.

The following is a sample template for creating an Edwards EC private key object:

```
CK_OBJECT_CLASS class = CKO_PRIVATE_KEY;
CK_KEY_TYPE keyType = CKK_EC;
CK_UTF8CHAR label[] = "An Edwards EC private key object";
CK_BYTE subject[] = {...};
CK_BYTE id[] = {123};
CK_BYTE ecParams[] = {...};
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_SUBJECT, subject, sizeof(subject)},
    {CKA_ID, id, sizeof(id)},
    {CKA_SENSITIVE, &true, sizeof(true)},
    {CKA_DERIVE, &true, sizeof(true)},
    {CKA_VALUE, value, sizeof(value)}
};
```

2.3.7 Montgomery Elliptic curve public key objects

Montgomery EC public key objects (object class **CKO_PUBLIC_KEY**, key type **CKK_EC_MONTGOMERY**) hold Montgomery EC public keys. The following table defines the

1493 Montgomery EC public key object attributes, in addition to the common attributes defined for this object
1494 class:

1495 Table 38, Montgomery Elliptic Curve Public Key Object Attributes

| Attribute | Data type | Meaning |
|------------------------------|------------|--|
| CKA_EC_PARAMS ^{1,3} | Byte array | DER-encoding of a Parameters value as defined above |
| CKA_EC_POINT ^{1,4} | Byte array | DER-encoding of the public key value in little endian order as defined in RFC 7748 |

1496 - Refer to [PKCS #11-Base] table 11 for footnotes

1497 The **CKA_EC_PARAMS** attribute value is known as the “EC domain parameters” and is defined in ANSI
1498 X9.62 as a choice of three parameter representation methods. A 4th choice is added to support Edwards
1499 and Montgomery Elliptic curves. The CKA_EC_PARAMS attribute has the following syntax:

```
1500 Parameters ::= CHOICE {  
1501     ecParameters      ECPParameters,  
1502     oId                CURVES.&id({CurveNames}),  
1503     implicitlyCA       NULL,  
1504     curveName          PrintableString  
1505 }
```

1506 Montgomery EC public keys only support the use of the **curveName** selection to specify a curve name as
1507 defined in [RFC7748] and the use of the **oId** selection to specify a curve through an ECDH algorithm as
1508 defined in [RFC 8410]. Note that keys defined by RFC 7748 and RFC 8410 are incompatible.

1509 The following is a sample template for creating a Montgomery EC public key object:

```
1510 CK_OBJECT_CLASS class = CKO_PUBLIC_KEY;  
1511 CK_KEY_TYPE keyType = CKK_EC;  
1512 CK_UTF8CHAR label[] = "A Montgomery EC public key object";  
1513 CK_BYTE ecParams[] = {...};  
1514 CK_BYTE ecPoint[] = {...};  
1515 CK_BBOOL true = CK_TRUE;  
1516 CK_ATTRIBUTE template[] = {  
1517     {CKA_CLASS, &class, sizeof(class)},  
1518     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},  
1519     {CKA_TOKEN, &true, sizeof(true)},  
1520     {CKA_LABEL, label, sizeof(label)-1},  
1521     {CKA_EC_PARAMS, ecParams, sizeof(ecParams)},  
1522     {CKA_EC_POINT, ecPoint, sizeof(ecPoint)}  
1523 };
```

1524 **2.3.8 Montgomery Elliptic curve private key objects**

1525 Montgomery EC private key objects (object class **CKO_PRIVATE_KEY**, key type
1526 **CKK_EC_MONTGOMERY**) hold Montgomery EC private keys. See Section 2.3 for more information
1527 about EC. The following table defines the Montgomery EC private key object attributes, in addition to the
1528 common attributes defined for this object class:

Table 39, Montgomery Elliptic Curve Private Key Object Attributes

| Attribute | Data type | Meaning |
|--------------------------------|-------------|---|
| CKA_EC_PARAMS ^{1,4,6} | Byte array | DER-encoding of a Parameters value as defined above |
| CKA_VALUE ^{1,4,6,7} | Big integer | Private key value in little endian order as defined in RFC 7748 |

- Refer to [PKCS #11-Base] table 11 for footnotes

The **CKA_EC_PARAMS** attribute value is known as the “EC domain parameters” and is defined in ANSI X9.62 as a choice of three parameter representation methods. A 4th choice is added to support Edwards and Montgomery Elliptic curves. The CKA_EC_PARAMS attribute has the following syntax:

```
Parameters ::= CHOICE {
    ecParameters      ECPParameters,
    oId                CURVES.&id({CurveNames}),
    implicitlyCA       NULL,
    curveName          PrintableString
}
```

Edwards EC private keys only support the use of the **curveName** selection to specify a curve name as defined in [RFC7748] and the use of the **oId** selection to specify a curve through an ECDH algorithm as defined in [RFC 8410]. Note that keys defined by RFC 7748 and RFC 8410 are incompatible.

Note that when generating a Montgomery EC private key, the EC domain parameters are *not* specified in the key’s template. This is because Montgomery EC private keys are only generated as part of a Montgomery EC key *pair*, and the EC domain parameters for the pair are specified in the template for the Montgomery EC public key.

The following is a sample template for creating a Montgomery EC private key object:

```
CK_OBJECT_CLASS class = CKO_PRIVATE_KEY;
CK_KEY_TYPE keyType = CKK_EC;
CK_UTF8CHAR label[] = "A Montgomery EC private key object";
CK_BYTE subject[] = {...};
CK_BYTE id[] = {123};
CK_BYTE ecParams[] = {...};
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_SUBJECT, subject, sizeof(subject)},
    {CKA_ID, id, sizeof(id)},
    {CKA_SENSITIVE, &true, sizeof(true)},
    {CKA_DERIVE, &true, sizeof(true)},
    {CKA_VALUE, value, sizeof(value)}
};
```

2.3.9 Elliptic curve key pair generation

The EC (also related to ECDSA) key pair generation mechanism, denoted CKM_EC_KEY_PAIR_GEN, is a key pair generation mechanism that uses the method defined by the ANSI X9.62 and X9.63 standards.

The EC (also related to ECDSA) key pair generation mechanism, denoted **CKM_EC_KEY_PAIR_GEN_W_EXTRA_BITS**, is a key pair generation mechanism that uses the method defined by FIPS 186-4 Appendix B.4.1.

These mechanisms do not have a parameter.

These mechanisms generate EC public/private key pairs with particular EC domain parameters, as specified in the **CKA_EC_PARAMS** attribute of the template for the public key. Note that this version of Cryptoki does not include a mechanism for generating these EC domain parameters.

These mechanism contribute the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_EC_POINT** attributes to the new public key and the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_EC_PARAMS** and **CKA_VALUE** attributes to the new private key. Other attributes supported by the EC public and private key types (specifically, the flags indicating which functions the keys support) may also be specified in the templates for the keys, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the minimum and maximum supported number of bits in the field sizes, respectively. For example, if a Cryptoki library supports only ECDSA using a field of characteristic 2 which has between 2^{200} and 2^{300} elements, then *ulMinKeySize* = 201 and *ulMaxKeySize* = 301 (when written in binary notation, the number 2^{200} consists of a 1 bit followed by 200 0 bits. It is therefore a 201-bit number. Similarly, 2^{300} is a 301-bit number).

2.3.10 Edwards Elliptic curve key pair generation

The Edwards EC key pair generation mechanism, denoted **CKM_EC_EDWARDS_KEY_PAIR_GEN**, is a key pair generation mechanism for EC keys over curves represented in Edwards form.

This mechanism does not have a parameter.

The mechanism can only generate EC public/private key pairs over the curves *edwards25519* and *edwards448* as defined in RFC 8032 or the curves *id-Ed25519* and *id-Ed448* as defined in RFC 8410. These curves can only be specified in the **CKA_EC_PARAMS** attribute of the template for the public key using the **curveName** or the *old* methods. Attempts to generate keys over these curves using any other EC key pair generation mechanism will fail with **CKR_CURVE_NOT_SUPPORTED**.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_EC_POINT** attributes to the new public key and the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_EC_PARAMS** and **CKA_VALUE** attributes to the new private key. Other attributes supported by the Edwards EC public and private key types (specifically, the flags indicating which functions the keys support) may also be specified in the templates for the keys, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the minimum and maximum supported number of bits in the field sizes, respectively. For this mechanism, the only allowed values are 255 and 448 as RFC 8032 only defines curves of these two sizes. A Cryptoki implementation may support one or both of these curves and should set the *ulMinKeySize* and *ulMaxKeySize* fields accordingly.

2.3.11 Montgomery Elliptic curve key pair generation

The Montgomery EC key pair generation mechanism, denoted **CKM_EC_MONTGOMERY_KEY_PAIR_GEN**, is a key pair generation mechanism for EC keys over curves represented in Montgomery form.

This mechanism does not have a parameter.

The mechanism can only generate Montgomery EC public/private key pairs over the curves *curve25519* and *curve448* as defined in RFC 7748 or the curves *id-X25519* and *id-X448* as defined in RFC 8410. These curves can only be specified in the **CKA_EC_PARAMS** attribute of the template for the public key using the **curveName** or *old* methods. Attempts to generate keys over these curves using any other EC key pair generation mechanism will fail with **CKR_CURVE_NOT_SUPPORTED**.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_EC_POINT** attributes to the new public key and the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_EC_PARAMS** and **CKA_VALUE**

attributes to the new private key. Other attributes supported by the EC public and private key types (specifically, the flags indicating which functions the keys support) may also be specified in the templates for the keys, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the minimum and maximum supported number of bits in the field sizes, respectively. For this mechanism, the only allowed values are 255 and 448 as RFC 7748 only defines curves of these two sizes. A Cryptoki implementation may support one or both of these curves and should set the *ulMinKeySize* and *ulMaxKeySize* fields accordingly.

2.3.12 ECDSA without hashing

Refer section 2.3.1 for signature encoding.

The ECDSA without hashing mechanism, denoted **CKM_ECDSA**, is a mechanism for single-part signatures and verification for ECDSA. (This mechanism corresponds only to the part of ECDSA that processes the hash value, which should not be longer than 1024 bits; it does not compute the hash value.)

This mechanism does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 40, ECDSA without hashing: Key and Data Length

| Function | Key type | Input length | Output length |
|-----------------------|-------------------|--|---------------|
| C_Sign ¹ | ECDSA private key | any ³ | 2nLen |
| C_Verify ¹ | ECDSA public key | any ³ , ≤2nLen ² | N/A |

¹ Single-part operations only.

² Data length, signature length.

³ Input the entire raw digest. Internally, this will be truncated to the appropriate number of bits.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the minimum and maximum supported number of bits in the field sizes, respectively. For example, if a Cryptoki library supports only ECDSA using a field of characteristic 2 which has between 2^{200} and 2^{300} elements (inclusive), then *ulMinKeySize* = 201 and *ulMaxKeySize* = 301 (when written in binary notation, the number 2^{200} consists of a 1 bit followed by 200 0 bits. It is therefore a 201-bit number. Similarly, 2^{300} is a 301-bit number).

2.3.13 ECDSA with hashing

Refer to section 2.3.1 for signature encoding.

The ECDSA with SHA-1, SHA-224, SHA-384, SHA-512, SHA3-224, SHA3-256, SHA3-384, SHA3-512 mechanism, denoted

CKM_ECDSA [SHA1|SHA224|SHA384|SHA512|SHA3_224|SHA3_256|SHA3_384|SHA3_512]

respectively, is a mechanism for single- and multiple-part signatures and verification for ECDSA. This mechanism computes the entire ECDSA specification, including the hashing with SHA-1, SHA-224, SHA-384, SHA-512, SHA3-224, SHA3-256, SHA3-384, SHA3-512 respectively.

This mechanism does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 41, ECDSA with hashing: Key and Data Length

| Function | Key type | Input length | Output length |
|----------|-------------------|--------------------------|---------------|
| C_Sign | ECDSA private key | any | 2nLen |
| C_Verify | ECDSA public key | any, ≤2nLen ² | N/A |

² Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the minimum and maximum supported number of bits in the field sizes, respectively. For example, if a Cryptoki library supports only ECDSA using a field of characteristic 2 which has between 2^{200} and 2^{300} elements, then *ulMinKeySize* = 201 and *ulMaxKeySize* = 301 (when written in binary notation, the number 2^{200} consists of a 1 bit followed by 200 0 bits. It is therefore a 201-bit number. Similarly, 2^{300} is a 301-bit number).

2.3.14 EdDSA

The EdDSA mechanism, denoted **CKM_EDDSA**, is a mechanism for single-part and multipart signatures and verification for EdDSA. This mechanism implements the five EdDSA signature schemes defined in RFC 8032 and RFC 8410.

For curves according to RFC 8032, this mechanism has an optional parameter, a **CK_EDDSA_PARAMS** structure. The absence or presence of the parameter as well as its content is used to identify which signature scheme is to be used. The following table enumerates the five signature schemes defined in RFC 8032 and all supported permutations of the mechanism parameter and its content.

Table 42, Mapping to RFC 8032 Signature Schemes

| Signature Scheme | Mechanism Param | phFlag | Context Data |
|------------------|---------------------|--------|--------------|
| Ed25519 | <i>Not Required</i> | N/A | N/A |
| Ed25519ctx | <i>Required</i> | False | Optional |
| Ed25519ph | <i>Required</i> | True | Optional |
| Ed448 | <i>Required</i> | False | Optional |
| Ed448ph | <i>Required</i> | True | Optional |

For curves according to RFC 8410, the mechanism is implicitly given by the curve, which is EdDSA in pure mode.

Constraints on key types and the length of data are summarized in the following table:

Table 43, EdDSA: Key and Data Length

| Function | Key type | Input length | Output length |
|----------|-----------------------------------|---------------------|---------------|
| C_Sign | <i>CKK_EC_EDWARDS private key</i> | any | <i>2bLen</i> |
| C_Verify | <i>CKK_EC_EDWARDS public key</i> | any, $\leq 2bLen^2$ | N/A |

² Data length, signature length.

Note that for EdDSA in pure mode, Ed25519 and Ed448 the data must be processed twice. Therefore, a token might need to cache all the data, especially when used with C_SignUpdate/C_VerifyUpdate. If tokens are unable to do so they can return CKR_TOKEN_RESOURCE_EXCEEDED.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the minimum and maximum supported number of bits in the field sizes, respectively. For this mechanism, the only allowed values are 255 and 448 as RFC 8032 and RFC 8410 only define curves of these two sizes. A Cryptoki implementation may support one or both of these curves and should set the *ulMinKeySize* and *ulMaxKeySize* fields accordingly.

2.3.15 XEdDSA

The XEdDSA mechanism, denoted **CKM_XEDDSA**, is a mechanism for single-part signatures and verification for XEdDSA. This mechanism implements the XEdDSA signature scheme defined in **[XEDDSA]**. CKM_XEDDSA operates on CKK_EC_MONTGOMERY type EC keys, which allows these

keys to be used both for signing/verification and for Diffie-Hellman style key-exchanges. This double use is necessary for the Extended Triple Diffie-Hellman where the long-term identity key is used to sign short-term keys and also contributes to the DH key-exchange.

This mechanism has a parameter, a **CK_XEDDSA_PARAMS** structure.

Table 44, XEdDSA: Key and Data Length

| Function | Key type | Input length | Output length |
|-----------------------|----------------------------------|-------------------------------------|---------------|
| C_Sign ¹ | CKK_EC_MONTGOMERY <i>private</i> | any ³ | 2b |
| C_Verify ¹ | CKK_EC_MONTGOMERY <i>public</i> | any ³ , ≤2b ² | N/A |

² Data length, signature length.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the minimum and maximum supported number of bits in the field sizes, respectively. For this mechanism, the only allowed values are 255 and 448 as **[XEDDSA]** only defines curves of these two sizes. A Cryptoki implementation may support one or both of these curves and should set the *ulMinKeySize* and *ulMaxKeySize* fields accordingly.

2.3.16 EC mechanism parameters

◆ CK_EDDSA_PARAMS, CK_EDDSA_PARAMS_PTR

CK_EDDSA_PARAMS is a structure that provides the parameters for the **CKM_EDDSA** signature mechanism. The structure is defined as follows:

```
typedef struct CK_EDDSA_PARAMS {
    CK_BBOOL      phFlag;
    CK_ULONG      ulContextDataLen;
    CK_BYTE_PTR   pContextData;
} CK_EDDSA_PARAMS;
```

The fields of the structure have the following meanings:

phFlag a Boolean value which indicates if Prehashed variant of EdDSA should be used

ulContextDataLen the length in bytes of the context data where 0 ≤ *ulContextDataLen* ≤ 255.

pContextData context data shared between the signer and verifier

CK_EDDSA_PARAMS_PTR is a pointer to a **CK_EDDSA_PARAMS**.

◆ CK_XEDDSA_PARAMS, CK_XEDDSA_PARAMS_PTR

CK_XEDDSA_PARAMS is a structure that provides the parameters for the **CKM_XEDDSA** signature mechanism. The structure is defined as follows:

```

1721     typedef struct CK_XEDDSA_PARAMS {
1722         CK_XEDDSA_HASH_TYPE hash;
1723     } CK_XEDDSA_PARAMS;

```

1724

1725 The fields of the structure have the following meanings:

1726 *hash* *a Hash mechanism to be used by the mechanism.*

1727 **CK_XEDDSA_PARAMS_PTR** is a pointer to a **CK_XEDDSA_PARAMS**.

1728

1729 ♦ **CK_XEDDSA_HASH_TYPE, CK_XEDDSA_HASH_TYPE_PTR**

1730 **CK_XEDDSA_HASH_TYPE** is used to indicate the hash function used in XEDDSA. It is defined as follows:

```

1732     typedef CK_ULONG CK_XEDDSA_HASH_TYPE;

```

1733

1734 The following table lists the defined functions.

1735 *Table 45, EC: Key Derivation Functions*

| Source Identifier |
|-------------------|
| CKM_BLAKE2B_256 |
| CKM_BLAKE2B_512 |
| CKM_SHA3_256 |
| CKM_SHA3_512 |
| CKM_SHA256 |
| CKM_SHA512 |

1736

1737 **CK_XEDDSA_HASH_TYPE_PTR** is a pointer to a **CK_XEDDSA_HASH_TYPE**.

1738

1739 ♦ **CK_EC_KDF_TYPE, CK_EC_KDF_TYPE_PTR**

1740 **CK_EC_KDF_TYPE** is used to indicate the Key Derivation Function (KDF) applied to derive keying data from a shared secret. The key derivation function will be used by the EC key agreement schemes. It is defined as follows:

```

1743     typedef CK_ULONG CK_EC_KDF_TYPE;

```

1744

1745 The following table lists the defined functions.

1746 *Table 46, EC: Key Derivation Functions*

| Source Identifier |
|-------------------|
| CKD_NULL |
| CKD_SHA1_KDF |
| CKD_SHA224_KDF |
| CKD_SHA256_KDF |
| CKD_SHA384_KDF |
| CKD_SHA512_KDF |
| CKD_SHA3_224_KDF |

| |
|------------------------|
| CKD_SHA3_256_KDF |
| CKD_SHA3_384_KDF |
| CKD_SHA3_512_KDF |
| CKD_SHA1_KDF_SP800 |
| CKD_SHA224_KDF_SP800 |
| CKD_SHA256_KDF_SP800 |
| CKD_SHA384_KDF_SP800 |
| CKD_SHA512_KDF_SP800 |
| CKD_SHA3_224_KDF_SP800 |
| CKD_SHA3_256_KDF_SP800 |
| CKD_SHA3_384_KDF_SP800 |
| CKD_SHA3_512_KDF_SP800 |
| CKD_BLAKE2B_160_KDF |
| CKD_BLAKE2B_256_KDF |
| CKD_BLAKE2B_384_KDF |
| CKD_BLAKE2B_512_KDF |

1747 The key derivation function **CKD_NULL** produces a raw shared secret value without applying any key
1748 derivation function.

1749 The key derivation functions

1750 **CKD_[SHA1|SHA224|SHA384|SHA512|SHA3_224|SHA3_256|SHA3_384|SHA3_512]_KDF**, which are
1751 based on SHA-1, SHA-224, SHA-384, SHA-512, SHA3-224, SHA3-256, SHA3-384, SHA3-512
1752 respectively, derive keying data from the shared secret value as defined in [ANSI X9.63].

1753 The key derivation functions

1754 **CKD_[SHA1|SHA224|SHA384|SHA512|SHA3_224|SHA3_256|SHA3_384|SHA3_512]_KDF_SP800**,
1755 which are based on SHA-1, SHA-224, SHA-384, SHA-512, SHA3-224, SHA3-256, SHA3-384, SHA3-512
1756 respectively, derive keying data from the shared secret value as defined in [FIPS SP800-56A] section
1757 5.8.1.1.

1758 The key derivation functions **CKD_BLAKE2B_[160|256|384|512]_KDF**, which are based on the Blake2b
1759 family of hashes, derive keying data from the shared secret value as defined in [FIPS SP800-56A] section
1760 5.8.1.1. **CK_EC_KDF_TYPE_PTR** is a pointer to a **CK_EC_KDF_TYPE**.

1761

1762 ♦ **CK_ECDH1_DERIVE_PARAMS, CK_ECDH1_DERIVE_PARAMS_PTR**

1763 **CK_ECDH1_DERIVE_PARAMS** is a structure that provides the parameters for the
1764 **CKM_ECDH1_DERIVE** and **CKM_ECDH1_COFACTOR_DERIVE** key derivation mechanisms, where
1765 each party contributes one key pair. The structure is defined as follows:

```
1766     typedef struct CK_ECDH1_DERIVE_PARAMS {
1767         CK_EC_KDF_TYPE    kdf;
1768         CK_ULONG           ulSharedDataLen;
1769         CK_BYTE_PTR       pSharedData;
1770         CK_ULONG           ulPublicDataLen;
1771         CK_BYTE_PTR       pPublicData;
1772     } CK_ECDH1_DERIVE_PARAMS;
```

1773

1774 The fields of the structure have the following meanings:

1775 *kdf* *key derivation function used on the shared secret value*

| | | |
|------|---------------------------------|---|
| 1776 | <i>ulSharedDataLen</i> | <i>the length in bytes of the shared info</i> |
| 1777 | <i>pSharedData</i> | <i>some data shared between the two parties</i> |
| 1778 | <i>ulPublicDataLen</i> | <i>the length in bytes of the other party's EC public key</i> |
| 1779 | <i>pPublicData</i> ¹ | <i>pointer to other party's EC public key value. A token MUST be able to accept this value encoded as a raw octet string (as per section A.5.2 of [ANSI X9.62]). A token MAY, in addition, support accepting this value as a DER-encoded ECPoint (as per section E.6 of [ANSI X9.62]) i.e. the same as a CKA_EC_POINT encoding. The calling application is responsible for converting the offered public key to the compressed or uncompressed forms of these encodings if the token does not support the offered form.</i> |

1787 With the key derivation function **CKD_NULL**, *pSharedData* must be NULL and *ulSharedDataLen* must be
1788 zero. With the key derivation functions
1789 **CKD_[SHA1|SHA224|SHA384|SHA512|SHA3_224|SHA3_256|SHA3_384|SHA3_512]_KDF**,
1790 **CKD_[SHA1|SHA224|SHA384|SHA512|SHA3_224|SHA3_256|SHA3_384|SHA3_512]_KDF_SP800**, an
1791 optional *pSharedData* may be supplied, which consists of some data shared by the two parties intending
1792 to share the shared secret. Otherwise, *pSharedData* must be NULL and *ulSharedDataLen* must be zero.
1793 **CK_ECDH1_DERIVE_PARAMS_PTR** is a pointer to a **CK_ECDH1_DERIVE_PARAMS**.
1794 ♦ **CK_ECDH2_DERIVE_PARAMS, CK_ECDH2_DERIVE_PARAMS_PTR**

1795 **CK_ECDH2_DERIVE_PARAMS** is a structure that provides the parameters to the
1796 **CKM_ECMQV_DERIVE** key derivation mechanism, where each party contributes two key pairs. The
1797 structure is defined as follows:

```

1798     typedef struct CK_ECDH2_DERIVE_PARAMS {
1799         CK_EC_KDF_TYPE kdf;
1800         CK_ULONG ulSharedDataLen;
1801         CK_BYTE_PTR pSharedData;
1802         CK_ULONG ulPublicDataLen;
1803         CK_BYTE_PTR pPublicData;
1804         CK_ULONG ulPrivateDataLen;
1805         CK_OBJECT_HANDLE hPrivateData;
1806         CK_ULONG ulPublicDataLen2;
1807         CK_BYTE_PTR pPublicData2;
1808     } CK_ECDH2_DERIVE_PARAMS;

```

1809
1810 The fields of the structure have the following meanings:

| | | |
|------|------------------------|---|
| 1811 | <i>kdf</i> | <i>key derivation function used on the shared secret value</i> |
| 1812 | <i>ulSharedDataLen</i> | <i>the length in bytes of the shared info</i> |
| 1813 | <i>pSharedData</i> | <i>some data shared between the two parties</i> |
| 1814 | <i>ulPublicDataLen</i> | <i>the length in bytes of the other party's first EC public key</i> |

1 The encoding in V2.20 was not specified and resulted in different implementations choosing different encodings. Applications relying only on a V2.20 encoding (e.g. the DER variant) other than the one specified now (raw) may not work with all V2.30 compliant tokens.

| | | |
|------|-------------------------|---|
| 1815 | <i>pPublicData</i> | <i>pointer to other party's first EC public key value. Encoding rules are</i> |
| 1816 | | <i>as per pPublicData of CK_ECDH1_DERIVE_PARAMS</i> |
| 1817 | <i>ulPrivateDataLen</i> | <i>the length in bytes of the second EC private key</i> |
| 1818 | <i>hPrivateData</i> | <i>key handle for second EC private key value</i> |
| 1819 | <i>ulPublicDataLen2</i> | <i>the length in bytes of the other party's second EC public key</i> |
| 1820 | <i>pPublicData2</i> | <i>pointer to other party's second EC public key value. Encoding rules</i> |
| 1821 | | <i>are as per pPublicData of CK_ECDH1_DERIVE_PARAMS</i> |

1822 With the key derivation function **CKD_NULL**, *pSharedData* must be NULL and *ulSharedDataLen* must be
 1823 zero. With the key derivation function **CKD_SHA1_KDF**, an optional *pSharedData* may be supplied,
 1824 which consists of some data shared by the two parties intending to share the shared secret. Otherwise,
 1825 *pSharedData* must be NULL and *ulSharedDataLen* must be zero.

1826 **CK_ECDH2_DERIVE_PARAMS_PTR** is a pointer to a **CK_ECDH2_DERIVE_PARAMS**.

1827

1828 ♦ **CK_ECMQV_DERIVE_PARAMS, CK_ECMQV_DERIVE_PARAMS_PTR**

1829 **CK_ECMQV_DERIVE_PARAMS** is a structure that provides the parameters to the
 1830 **CKM_ECMQV_DERIVE** key derivation mechanism, where each party contributes two key pairs. The
 1831 structure is defined as follows:

```

1832     typedef struct CK_ECMQV_DERIVE_PARAMS {
1833         CK_EC_KDF_TYPE      kdf;
1834         CK_ULONG             ulSharedDataLen;
1835         CK_BYTE_PTR          pSharedData;
1836         CK_ULONG             ulPublicDataLen;
1837         CK_BYTE_PTR          pPublicData;
1838         CK_ULONG             ulPrivateDataLen;
1839         CK_OBJECT_HANDLE     hPrivateData;
1840         CK_ULONG             ulPublicDataLen2;
1841         CK_BYTE_PTR          pPublicData2;
1842         CK_OBJECT_HANDLE     publicKey;
1843     } CK_ECMQV_DERIVE_PARAMS;
  
```

1844

1845 The fields of the structure have the following meanings:

| | | |
|------|-------------------------|---|
| 1846 | <i>kdf</i> | <i>key derivation function used on the shared secret value</i> |
| 1847 | <i>ulSharedDataLen</i> | <i>the length in bytes of the shared info</i> |
| 1848 | <i>pSharedData</i> | <i>some data shared between the two parties</i> |
| 1849 | <i>ulPublicDataLen</i> | <i>the length in bytes of the other party's first EC public key</i> |
| 1850 | <i>pPublicData</i> | <i>pointer to other party's first EC public key value. Encoding rules are</i> |
| 1851 | | <i>as per pPublicData of CK_ECDH1_DERIVE_PARAMS</i> |
| 1852 | <i>ulPrivateDataLen</i> | <i>the length in bytes of the second EC private key</i> |
| 1853 | <i>hPrivateData</i> | <i>key handle for second EC private key value</i> |

1854 *ulPublicDataLen2* the length in bytes of the other party's second EC public key

1855 *pPublicData2* pointer to other party's second EC public key value. Encoding rules

1856 are as per *pPublicData* of **CK_ECDH1_DERIVE_PARAMS**

1857 *publicKey* Handle to the first party's ephemeral public key

1858 With the key derivation function **CKD_NULL**, *pSharedData* must be NULL and *ulSharedDataLen* must be

1859 zero. With the key derivation functions

1860 **CKD_[SHA1|SHA224|SHA384|SHA512|SHA3_224|SHA3_256|SHA3_384|SHA3_512]_KDF**,

1861 **CKD_[SHA1|SHA224|SHA384|SHA512|SHA3_224|SHA3_256|SHA3_384|SHA3_512]_KDF_SP800**, an

1862 optional *pSharedData* may be supplied, which consists of some data shared by the two parties intending

1863 to share the shared secret. Otherwise, *pSharedData* must be NULL and *ulSharedDataLen* must be zero.

1864 **CK_ECMQV_DERIVE_PARAMS_PTR** is a pointer to a **CK_ECMQV_DERIVE_PARAMS**.

1865 2.3.17 Elliptic curve Diffie-Hellman key derivation

1866 The elliptic curve Diffie-Hellman (ECDH) key derivation mechanism, denoted **CKM_ECDH1_DERIVE**, is a

1867 mechanism for key derivation based on the Diffie-Hellman version of the elliptic curve key agreement

1868 scheme, as defined in ANSI X9.63, where each party contributes one key pair all using the same EC

1869 domain parameters.

1870 It has a parameter, a **CK_ECDH1_DERIVE_PARAMS** structure.

1871 This mechanism derives a secret value, and truncates the result according to the **CKA_KEY_TYPE**

1872 attribute of the template and, if it has one and the key type supports it, the **CKA_VALUE_LEN** attribute of

1873 the template. (The truncation removes bytes from the leading end of the secret value.) The mechanism

1874 contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key

1875 type must be specified in the template.

1876 This mechanism has the following rules about key sensitivity and extractability:

- 1877 • The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both
- 1878 be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some
- 1879 default value.
- 1880 • If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_FALSE**, then the derived key
- 1881 will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_TRUE**, then the
- 1882 derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its
- 1883 **CKA_SENSITIVE** attribute.
- 1884 • Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_FALSE**, then the
- 1885 derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to
- 1886 **CK_TRUE**, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite*
- 1887 value from its **CKA_EXTRACTABLE** attribute.

1888 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure

1889 specify the minimum and maximum supported number of bits in the field sizes, respectively. For

1890 example, if a Cryptoki library supports only EC using a field of characteristic 2 which has between 2^{200}

1891 and 2^{300} elements, then *ulMinKeySize* = 201 and *ulMaxKeySize* = 301 (when written in binary notation,

1892 the number 2^{200} consists of a 1 bit followed by 200 0 bits. It is therefore a 201-bit number. Similarly, 2^{300}

1893 is a 301-bit number).

1894 Constraints on key types are summarized in the following table:

Table 47: ECDH: Allowed Key Types

| Function | Key type |
|----------|-----------------------------|
| C_Derive | CKK_EC or CKK_EC_MONTGOMERY |

2.3.18 Elliptic curve Diffie-Hellman with cofactor key derivation

The elliptic curve Diffie-Hellman (ECDH) with cofactor key derivation mechanism, denoted **CKM_ECDH1_COFACTOR_DERIVE**, is a mechanism for key derivation based on the cofactor Diffie-Hellman version of the elliptic curve key agreement scheme, as defined in ANSI X9.63, where each party contributes one key pair all using the same EC domain parameters. Cofactor multiplication is computationally efficient and helps to prevent security problems like small group attacks.

It has a parameter, a **CK_ECDH1_DERIVE_PARAMS** structure.

This mechanism derives a secret value, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. (The truncation removes bytes from the leading end of the secret value.) The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

This mechanism has the following rules about key sensitivity and extractability:

- The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both be specified to be either CK_TRUE or CK_FALSE. If omitted, these attributes each take on some default value.
- If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_FALSE, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.
- Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_FALSE, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_TRUE, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the minimum and maximum supported number of bits in the field sizes, respectively. For example, if a Cryptoki library supports only EC using a field of characteristic 2 which has between 2^{200} and 2^{300} elements, then *ulMinKeySize* = 201 and *ulMaxKeySize* = 301 (when written in binary notation, the number 2^{200} consists of a 1 bit followed by 200 0 bits. It is therefore a 201-bit number. Similarly, 2^{300} is a 301-bit number).

Constraints on key types are summarized in the following table:

Table 48: ECDH with cofactor: Allowed Key Types

| Function | Key type |
|----------|----------|
| C_Derive | CKK_EC |

2.3.19 Elliptic curve Menezes-Qu-Vanstone key derivation

The elliptic curve Menezes-Qu-Vanstone (ECMQV) key derivation mechanism, denoted **CKM_ECMQV_DERIVE**, is a mechanism for key derivation based the MQV version of the elliptic curve key agreement scheme, as defined in ANSI X9.63, where each party contributes two key pairs all using the same EC domain parameters.

It has a parameter, a **CK_ECMQV_DERIVE_PARAMS** structure.

This mechanism derives a secret value, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. (The truncation removes bytes from the leading end of the secret value.) The mechanism

contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

This mechanism has the following rules about key sensitivity and extractability:

- The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both be specified to be either CK_TRUE or CK_FALSE. If omitted, these attributes each take on some default value.
- If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_FALSE, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.
- Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_FALSE, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_TRUE, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the minimum and maximum supported number of bits in the field sizes, respectively. For example, if a Cryptoki library supports only EC using a field of characteristic 2 which has between 2^{200} and 2^{300} elements, then *ulMinKeySize* = 201 and *ulMaxKeySize* = 301 (when written in binary notation, the number 2^{200} consists of a 1 bit followed by 200 0 bits. It is therefore a 201-bit number. Similarly, 2^{300} is a 301-bit number).

Constraints on key types are summarized in the following table:

Table 49: ECDH MQV: Allowed Key Types

| Function | Key type |
|----------|----------|
| C_Derive | CKK_EC |

2.3.20 ECDH AES KEY WRAP

The ECDH AES KEY WRAP mechanism, denoted **CKM_ECDH_AES_KEY_WRAP**, is a mechanism based on elliptic curve public-key crypto-system and the AES key wrap mechanism. It supports single-part key wrapping; and key unwrapping.

It has a parameter, a **CK_ECDH_AES_KEY_WRAP_PARAMS** structure.

The mechanism can wrap and unwrap an asymmetric target key of any length and type using an EC key.

- A temporary AES key is derived from a temporary EC key and the wrapping EC key using the **CKM_ECDH1_DERIVE** mechanism.
- The derived AES key is used for wrapping the target key using the **CKM_AES_KEY_WRAP_KWP** mechanism.

For wrapping, the mechanism -

- Generates a temporary random EC key (transport key) having the same parameters as the wrapping EC key (and domain parameters). Saves the transport key public key material.
- Performs ECDH operation using **CKM_ECDH1_DERIVE** with parameters of kdf, ulSharedDataLen and pSharedData using the private key of the transport EC key and the public key of wrapping EC key and gets the first ulAESKeyBits bits of the derived key to be the temporary AES key.
- Wraps the target key with the temporary AES key using **CKM_AES_KEY_WRAP_KWP** ([AES KEYWRAP] section 6.3).
- Zeroizes the temporary AES key and EC transport private key.

- Concatenates public key material of the transport key and output the concatenated blob. The first part is the public key material of the transport key and the second part is the wrapped target key.

The recommended format for an asymmetric target key being wrapped is as a PKCS8 PrivateKeyInfo

The use of Attributes in the PrivateKeyInfo structure is OPTIONAL. In case of conflicts between the object attribute template, and Attributes in the PrivateKeyInfo structure, an error should be thrown.

For unwrapping, the mechanism -

- Splits the input into two parts. The first part is the public key material of the transport key and the second part is the wrapped target key. The length of the first part is equal to the length of the public key material of the unwrapping EC key.
- Note: since the transport key and the wrapping EC key share the same domain, the length of the public key material of the transport key is the same length of the public key material of the unwrapping EC key.*
- Performs ECDH operation using **CKM_ECDH1_DERIVE** with parameters of kdf, ulSharedDataLen and pSharedData using the private part of unwrapping EC key and the public part of the transport EC key and gets first ulAESKeyBits bits of the derived key to be the temporary AES key.
 - Un-wraps the target key from the second part with the temporary AES key using **CKM_AES_KEY_WRAP_KWP** ([AES KEYWRAP] section 6.3).
 - Zeroizes the temporary AES key.

Table 50, CKM_ECDH_AES_KEY_WRAP Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_ECDH_AES_KEY_WRAP | | | | | | ✓ | |
| ¹ SR = SignRecover, VR = VerifyRecover | | | | | | | |

Constraints on key types are summarized in the following table:

Table 51: ECDH AES Key Wrap: Allowed Key Types

| Function | Key type |
|----------|-----------------------------|
| C_Derive | CKK_EC or CKK_EC_MONTGOMERY |

2.3.21 ECDH AES KEY WRAP mechanism parameters

◆ **CK_ECDH_AES_KEY_WRAP_PARAMS; CK_ECDH_AES_KEY_WRAP_PARAMS_PTR**

CK_ECDH_AES_KEY_WRAP_PARAMS is a structure that provides the parameters to the **CKM_ECDH_AES_KEY_WRAP** mechanism. It is defined as follows:

```
typedef struct CK_ECDH_AES_KEY_WRAP_PARAMS {
    CK_ULONG          ulAESKeyBits;
```

```

2017         CK_EC_KDF_TYPE    kdf;
2018         CK_ULONG           ulSharedDataLen;
2019         CK_BYTE_PTR        pSharedData;
2020     }    CK_ECDH_AES_KEY_WRAP_PARAMS;
2021

```

The fields of the structure have the following meanings:

| | | |
|------|------------------------|---|
| 2023 | <i>ulAESKeyBits</i> | <i>length of the temporary AES key in bits. Can be only 128, 192 or 256.</i> |
| 2026 | <i>kdf</i> | <i>key derivation function used on the shared secret value to generate AES key.</i> |
| 2028 | <i>ulSharedDataLen</i> | <i>the length in bytes of the shared info</i> |
| 2029 | <i>pSharedData</i> | <i>Some data shared between the two parties</i> |

CK_ECDH_AES_KEY_WRAP_PARAMS_PTR is a pointer to a **CK_ECDH_AES_KEY_WRAP_PARAMS**.

2.3.22 FIPS 186-4

When CKM_ECDSA is operated in FIPS mode, the curves SHALL either be NIST recommended curves (with a fixed set of domain parameters) or curves with domain parameters generated as specified by ANSI X9.64. The NIST recommended curves are:

P-192, P-224, P-256, P-384, P-521
 K-163, B-163, K-233, B-233
 K-283, B-283, K-409, B-409
 K-571, B-571

2.4 Diffie-Hellman

Table 52, Diffie-Hellman Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|----------------------------|-------------------|---------------|----------------------|--------|--------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_DH_PKCS_KEY_PAIR_GEN | | | | | ✓ | | |
| CKM_DH_PKCS_PARAMETER_GEN | | | | | ✓ | | |
| CKM_DH_PKCS_DERIVE | | | | | | | ✓ |
| CKM_X9_42_DH_KEY_PAIR_GEN | | | | | ✓ | | |
| CKM_X9_42_DH_PARAMETER_GEN | | | | | ✓ | | |
| CKM_X9_42_DH_DERIVE | | | | | | | ✓ |
| CKM_X9_42_DH_HYBRID_DERIVE | | | | | | | ✓ |

| Mechanism | Functions | | | | | | |
|----------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_X9_42_MQV_DERIVE | | | | | | | ✓ |

2.4.1 Definitions

This section defines the key type “CKK_DH” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of [DH] key objects.

Mechanisms:

CKM_DH_PKCS_KEY_PAIR_GEN
CKM_DH_PKCS_PARAMETER_GEN
CKM_DH_PKCS_DERIVE
CKM_X9_42_DH_KEY_PAIR_GEN
CKM_X9_42_DH_PARAMETER_GEN
CKM_X9_42_DH_DERIVE
CKM_X9_42_DH_HYBRID_DERIVE
CKM_X9_42_MQV_DERIVE

2.4.2 Diffie-Hellman public key objects

Diffie-Hellman public key objects (object class **CKO_PUBLIC_KEY**, key type **CKK_DH**) hold Diffie-Hellman public keys. The following table defines the Diffie-Hellman public key object attributes, in addition to the common attributes defined for this object class:

Table 53, Diffie-Hellman Public Key Object Attributes

| Attribute | Data type | Meaning |
|--------------------------|-------------|------------------|
| CKA_PRIME ^{1,3} | Big integer | Prime p |
| CKA_BASE ^{1,3} | Big integer | Base g |
| CKA_VALUE ^{1,4} | Big integer | Public value y |

¹ - Refer to [PKCS11-Base] table 11 for footnotes

The **CKA_PRIME** and **CKA_BASE** attribute values are collectively the “Diffie-Hellman domain parameters”. Depending on the token, there may be limits on the length of the key components. See PKCS #3 for more information on Diffie-Hellman keys.

The following is a sample template for creating a Diffie-Hellman public key object:

```
CK_OBJECT_CLASS class = CKO_PUBLIC_KEY;
CK_KEY_TYPE keyType = CKK_DH;
CK_UTF8CHAR label[] = "A Diffie-Hellman public key object";
CK_BYTE prime[] = {...};
CK_BYTE base[] = {...};
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
```



```

2077     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
2078     {CKA_TOKEN, &true, sizeof(true)},
2079     {CKA_LABEL, label, sizeof(label)-1},
2080     {CKA_PRIME, prime, sizeof(prime)},
2081     {CKA_BASE, base, sizeof(base)},
2082     {CKA_VALUE, value, sizeof(value)}
2083 };

```

2084 2.4.3 X9.42 Diffie-Hellman public key objects

2085 X9.42 Diffie-Hellman public key objects (object class **CKO_PUBLIC_KEY**, key type **CKK_X9_42_DH**)
2086 hold X9.42 Diffie-Hellman public keys. The following table defines the X9.42 Diffie-Hellman public key
2087 object attributes, in addition to the common attributes defined for this object class:

2088 *Table 54, X9.42 Diffie-Hellman Public Key Object Attributes*

| Attribute | Data type | Meaning |
|-----------------------------|-------------|---|
| CKA_PRIME ^{1,3} | Big integer | Prime p (≥ 1024 bits, in steps of 256 bits) |
| CKA_BASE ^{1,3} | Big integer | Base g |
| CKA_SUBPRIME ^{1,3} | Big integer | Subprime q (≥ 160 bits) |
| CKA_VALUE ^{1,4} | Big integer | Public value y |

2089 - Refer to [PKCS11-Base] table 11 for footnotes

2090 The **CKA_PRIME**, **CKA_BASE** and **CKA_SUBPRIME** attribute values are collectively the "X9.42 Diffie-
2091 Hellman domain parameters". See the ANSI X9.42 standard for more information on X9.42 Diffie-
2092 Hellman keys.

2093 The following is a sample template for creating a X9.42 Diffie-Hellman public key object:

```

2094 CK_OBJECT_CLASS class = CKO_PUBLIC_KEY;
2095 CK_KEY_TYPE keyType = CKK_X9_42_DH;
2096 CK_UTF8CHAR label[] = "A X9.42 Diffie-Hellman public key
2097     object";
2098 CK_BYTE prime[] = {...};
2099 CK_BYTE base[] = {...};
2100 CK_BYTE subprime[] = {...};
2101 CK_BYTE value[] = {...};
2102 CK_BBOOL true = CK_TRUE;
2103 CK_ATTRIBUTE template[] = {
2104     {CKA_CLASS, &class, sizeof(class)},
2105     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
2106     {CKA_TOKEN, &true, sizeof(true)},
2107     {CKA_LABEL, label, sizeof(label)-1},
2108     {CKA_PRIME, prime, sizeof(prime)},
2109     {CKA_BASE, base, sizeof(base)},
2110     {CKA_SUBPRIME, subprime, sizeof(subprime)},
2111     {CKA_VALUE, value, sizeof(value)}
2112 };

```

2113 2.4.4 Diffie-Hellman private key objects

2114 Diffie-Hellman private key objects (object class **CKO_PRIVATE_KEY**, key type **CKK_DH**) hold Diffie-
2115 Hellman private keys. The following table defines the Diffie-Hellman private key object attributes, in
2116 addition to the common attributes defined for this object class:

2117 Table 55, Diffie-Hellman Private Key Object Attributes

| Attribute | Data type | Meaning |
|-------------------------------|-------------|-------------------------------------|
| CKA_PRIME ^{1,4,6} | Big integer | Prime p |
| CKA_BASE ^{1,4,6} | Big integer | Base g |
| CKA_VALUE ^{1,4,6,7} | Big integer | Private value x |
| CKA_VALUE_BITS ^{2,6} | CK_ULONG | Length in bits of private value x |

2118 - Refer to [PKCS11-Base] table 11 for footnotes

2119 The **CKA_PRIME** and **CKA_BASE** attribute values are collectively the “Diffie-Hellman domain
2120 parameters”. Depending on the token, there may be limits on the length of the key components. See
2121 PKCS #3 for more information on Diffie-Hellman keys.

2122 Note that when generating a Diffie-Hellman private key, the Diffie-Hellman parameters are *not* specified in
2123 the key’s template. This is because Diffie-Hellman private keys are only generated as part of a Diffie-
2124 Hellman key *pair*, and the Diffie-Hellman parameters for the pair are specified in the template for the
2125 Diffie-Hellman public key.

2126 The following is a sample template for creating a Diffie-Hellman private key object:

```
2127 CK_OBJECT_CLASS class = CKO_PRIVATE_KEY;
2128 CK_KEY_TYPE keyType = CKK_DH;
2129 CK_UTF8CHAR label[] = "A Diffie-Hellman private key object";
2130 CK_BYTE subject[] = {...};
2131 CK_BYTE id[] = {123};
2132 CK_BYTE prime[] = {...};
2133 CK_BYTE base[] = {...};
2134 CK_BYTE value[] = {...};
2135 CK_BBOOL true = CK_TRUE;
2136 CK_ATTRIBUTE template[] = {
2137     {CKA_CLASS, &class, sizeof(class)},
2138     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
2139     {CKA_TOKEN, &true, sizeof(true)},
2140     {CKA_LABEL, label, sizeof(label)-1},
2141     {CKA_SUBJECT, subject, sizeof(subject)},
2142     {CKA_ID, id, sizeof(id)},
2143     {CKA_SENSITIVE, &true, sizeof(true)},
2144     {CKA_DERIVE, &true, sizeof(true)},
2145     {CKA_PRIME, prime, sizeof(prime)},
2146     {CKA_BASE, base, sizeof(base)},
2147     {CKA_VALUE, value, sizeof(value)}
2148 };
```

2149 **2.4.5 X9.42 Diffie-Hellman private key objects**

2150 X9.42 Diffie-Hellman private key objects (object class **CKO_PRIVATE_KEY**, key type **CKK_X9_42_DH**)
2151 hold X9.42 Diffie-Hellman private keys. The following table defines the X9.42 Diffie-Hellman private key
2152 object attributes, in addition to the common attributes defined for this object class:

Table 56, X9.42 Diffie-Hellman Private Key Object Attributes

| Attribute | Data type | Meaning |
|-------------------------------|-------------|---|
| CKA_PRIME ^{1,4,6} | Big integer | Prime p (≥ 1024 bits, in steps of 256 bits) |
| CKA_BASE ^{1,4,6} | Big integer | Base g |
| CKA_SUBPRIME ^{1,4,6} | Big integer | Subprime q (≥ 160 bits) |
| CKA_VALUE ^{1,4,6,7} | Big integer | Private value x |

- Refer to [PKCS11-Base] table 11 for footnotes

The **CKA_PRIME**, **CKA_BASE** and **CKA_SUBPRIME** attribute values are collectively the “X9.42 Diffie-Hellman domain parameters”. Depending on the token, there may be limits on the length of the key components. See the ANSI X9.42 standard for more information on X9.42 Diffie-Hellman keys.

Note that when generating a X9.42 Diffie-Hellman private key, the X9.42 Diffie-Hellman domain parameters are *not* specified in the key’s template. This is because X9.42 Diffie-Hellman private keys are only generated as part of a X9.42 Diffie-Hellman key *pair*, and the X9.42 Diffie-Hellman domain parameters for the pair are specified in the template for the X9.42 Diffie-Hellman public key.

The following is a sample template for creating a X9.42 Diffie-Hellman private key object:

```

CK_OBJECT_CLASS class = CKO_PRIVATE_KEY;
CK_KEY_TYPE keyType = CKK_X9_42_DH;
CK_UTF8CHAR label[] = "A X9.42 Diffie-Hellman private key object";
CK_BYTE subject[] = {...};
CK_BYTE id[] = {123};
CK_BYTE prime[] = {...};
CK_BYTE base[] = {...};
CK_BYTE subprime[] = {...};
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_SUBJECT, subject, sizeof(subject)},
    {CKA_ID, id, sizeof(id)},
    {CKA_SENSITIVE, &true, sizeof(true)},
    {CKA_DERIVE, &true, sizeof(true)},
    {CKA_PRIME, prime, sizeof(prime)},
    {CKA_BASE, base, sizeof(base)},
    {CKA_SUBPRIME, subprime, sizeof(subprime)},
    {CKA_VALUE, value, sizeof(value)}
};

```

2.4.6 Diffie-Hellman domain parameter objects

Diffie-Hellman domain parameter objects (object class **CKO_DOMAIN_PARAMETERS**, key type **CKK_DH**) hold Diffie-Hellman domain parameters. The following table defines the Diffie-Hellman domain parameter object attributes, in addition to the common attributes defined for this object class:

2191 Table 57, Diffie-Hellman Domain Parameter Object Attributes

| Attribute | Data type | Meaning |
|-------------------------------|-------------|----------------------------|
| CKA_PRIME ^{1,4} | Big integer | Prime p |
| CKA_BASE ^{1,4} | Big integer | Base g |
| CKA_PRIME_BITS ^{2,3} | CK_ULONG | Length of the prime value. |

2192 - Refer to [PKCS11-Base] table 11 for footnotes

2193 The **CKA_PRIME** and **CKA_BASE** attribute values are collectively the “Diffie-Hellman domain
2194 parameters”. Depending on the token, there may be limits on the length of the key components. See
2195 PKCS #3 for more information on Diffie-Hellman domain parameters.

2196 The following is a sample template for creating a Diffie-Hellman domain parameter object:

```
2197 CK_OBJECT_CLASS class = CKO_DOMAIN_PARAMETERS;
2198 CK_KEY_TYPE keyType = CKK_DH;
2199 CK_UTF8CHAR label[] = "A Diffie-Hellman domain parameters
2200     object";
2201 CK_BYTE prime[] = {...};
2202 CK_BYTE base[] = {...};
2203 CK_BBOOL true = CK_TRUE;
2204 CK_ATTRIBUTE template[] = {
2205     {CKA_CLASS, &class, sizeof(class)},
2206     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
2207     {CKA_TOKEN, &true, sizeof(true)},
2208     {CKA_LABEL, label, sizeof(label)-1},
2209     {CKA_PRIME, prime, sizeof(prime)},
2210     {CKA_BASE, base, sizeof(base)},
2211 };
```

2212 2.4.7 X9.42 Diffie-Hellman domain parameters objects

2213 X9.42 Diffie-Hellman domain parameters objects (object class **CKO_DOMAIN_PARAMETERS**, key type
2214 **CKK_X9_42_DH**) hold X9.42 Diffie-Hellman domain parameters. The following table defines the X9.42
2215 Diffie-Hellman domain parameters object attributes, in addition to the common attributes defined for this
2216 object class:

2217 Table 58, X9.42 Diffie-Hellman Domain Parameters Object Attributes

| Attribute | Data type | Meaning |
|----------------------------------|-------------|---|
| CKA_PRIME ^{1,4} | Big integer | Prime p (≥ 1024 bits, in steps of 256 bits) |
| CKA_BASE ^{1,4} | Big integer | Base g |
| CKA_SUBPRIME ^{1,4} | Big integer | Subprime q (≥ 160 bits) |
| CKA_PRIME_BITS ^{2,3} | CK_ULONG | Length of the prime value. |
| CKA_SUBPRIME_BITS ^{2,3} | CK_ULONG | Length of the subprime value. |

2218 - Refer to [PKCS11-Base] table 11 for footnotes

2219 The **CKA_PRIME**, **CKA_BASE** and **CKA_SUBPRIME** attribute values are collectively the “X9.42 Diffie-
2220 Hellman domain parameters”. Depending on the token, there may be limits on the length of the domain
2221 parameters components. See the ANSI X9.42 standard for more information on X9.42 Diffie-Hellman
2222 domain parameters.

2223 The following is a sample template for creating a X9.42 Diffie-Hellman domain parameters object:

```
2224 CK_OBJECT_CLASS class = CKO_DOMAIN_PARAMETERS;
2225 CK_KEY_TYPE keyType = CKK_X9_42_DH;
```

```

2226     CK_UTF8CHAR label[] = "A X9.42 Diffie-Hellman domain
2227         parameters object";
2228     CK_BYTE prime[] = {...};
2229     CK_BYTE base[] = {...};
2230     CK_BYTE subprime[] = {...};
2231     CK_BBOOL true = CK_TRUE;
2232     CK_ATTRIBUTE template[] = {
2233         {CKA_CLASS, &class, sizeof(class)},
2234         {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
2235         {CKA_TOKEN, &true, sizeof(true)},
2236         {CKA_LABEL, label, sizeof(label)-1},
2237         {CKA_PRIME, prime, sizeof(prime)},
2238         {CKA_BASE, base, sizeof(base)},
2239         {CKA_SUBPRIME, subprime, sizeof(subprime)},
2240     };

```

2241 2.4.8 PKCS #3 Diffie-Hellman key pair generation

2242 The PKCS #3 Diffie-Hellman key pair generation mechanism, denoted
2243 **CKM_DH_PKCS_KEY_PAIR_GEN**, is a key pair generation mechanism based on Diffie-Hellman key
2244 agreement, as defined in PKCS #3. This is what PKCS #3 calls "phase I". It does not have a parameter.

2245 The mechanism generates Diffie-Hellman public/private key pairs with a particular prime and base, as
2246 specified in the **CKA_PRIME** and **CKA_BASE** attributes of the template for the public key. If the
2247 **CKA_VALUE_BITS** attribute of the private key is specified, the mechanism limits the length in bits of the
2248 private value, as described in PKCS #3.

2249 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
2250 public key and the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_PRIME**, **CKA_BASE**, and **CKA_VALUE** (and
2251 the **CKA_VALUE_BITS** attribute, if it is not already provided in the template) attributes to the new private
2252 key; other attributes required by the Diffie-Hellman public and private key types must be specified in the
2253 templates.

2254 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
2255 specify the supported range of Diffie-Hellman prime sizes, in bits.

2256 2.4.9 PKCS #3 Diffie-Hellman domain parameter generation

2257 The PKCS #3 Diffie-Hellman domain parameter generation mechanism, denoted
2258 **CKM_DH_PKCS_PARAMETER_GEN**, is a domain parameter generation mechanism based on Diffie-
2259 Hellman key agreement, as defined in PKCS #3.

2260 It does not have a parameter.

2261 The mechanism generates Diffie-Hellman domain parameters with a particular prime length in bits, as
2262 specified in the **CKA_PRIME_BITS** attribute of the template.

2263 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_PRIME**, **CKA_BASE**, and
2264 **CKA_PRIME_BITS** attributes to the new object. Other attributes supported by the Diffie-Hellman domain
2265 parameter types may also be specified in the template, or else are assigned default initial values.

2266 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
2267 specify the supported range of Diffie-Hellman prime sizes, in bits.

2268 2.4.10 PKCS #3 Diffie-Hellman key derivation

2269 The PKCS #3 Diffie-Hellman key derivation mechanism, denoted **CKM_DH_PKCS_DERIVE**, is a
2270 mechanism for key derivation based on Diffie-Hellman key agreement, as defined in PKCS #3. This is
2271 what PKCS #3 calls "phase II".

It has a parameter, which is the public value of the other party in the key agreement protocol, represented as a Cryptoki “Big integer” (i.e., a sequence of bytes, most-significant byte first).

This mechanism derives a secret key from a Diffie-Hellman private key and the public value of the other party. It computes a Diffie-Hellman secret value from the public value and private key according to PKCS #3, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. (The truncation removes bytes from the leading end of the secret value.) The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

This mechanism has the following rules about key sensitivity and extractability²:

- The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both be specified to be either CK_TRUE or CK_FALSE. If omitted, these attributes each take on some default value.
- If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_FALSE, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.
- Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_FALSE, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_TRUE, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of Diffie-Hellman prime sizes, in bits.

2.4.11 X9.42 Diffie-Hellman mechanism parameters

◆ CK_X9_42_DH_KDF_TYPE, CK_X9_42_DH_KDF_TYPE_PTR

CK_X9_42_DH_KDF_TYPE is used to indicate the Key Derivation Function (KDF) applied to derive keying data from a shared secret. The key derivation function will be used by the X9.42 Diffie-Hellman key agreement schemes. It is defined as follows:

```
typedef CK_ULONG CK_X9_42_DH_KDF_TYPE;
```

The following table lists the defined functions.

Table 59, X9.42 Diffie-Hellman Key Derivation Functions

| Source Identifier |
|--------------------------|
| CKD_NULL |
| CKD_SHA1_KDF_ASN1 |
| CKD_SHA1_KDF_CONCATENATE |

The key derivation function **CKD_NULL** produces a raw shared secret value without applying any key derivation function whereas the key derivation functions **CKD_SHA1_KDF_ASN1** and **CKD_SHA1_KDF_CONCATENATE**, which are both based on SHA-1, derive keying data from the shared secret value as defined in the ANSI X9.42 standard.

CK_X9_42_DH_KDF_TYPE_PTR is a pointer to a **CK_X9_42_DH_KDF_TYPE**.

² Note that the rules regarding the **CKA_SENSITIVE**, **CKA_EXTRACTABLE**, **CKA_ALWAYS_SENSITIVE**, and **CKA_NEVER_EXTRACTABLE** attributes have changed in version 2.11 to match the policy used by other key derivation mechanisms such as **CKM_SSL3_MASTER_KEY_DERIVE**.

2309 ♦ **CK_X9_42_DH1_DERIVE_PARAMS, CK_X9_42_DH1_DERIVE_PARAMS_PTR**

2310 **CK_X9_42_DH1_DERIVE_PARAMS** is a structure that provides the parameters to the
 2311 **CKM_X9_42_DH_DERIVE** key derivation mechanism, where each party contributes one key pair. The
 2312 structure is defined as follows:

```
2313     typedef struct CK_X9_42_DH1_DERIVE_PARAMS {
2314         CK_X9_42_DH_KDF_TYPE    kdf;
2315         CK_ULONG                 ulOtherInfoLen;
2316         CK_BYTE_PTR              pOtherInfo;
2317         CK_ULONG                 ulPublicDataLen;
2318         CK_BYTE_PTR              pPublicData;
2319     } CK_X9_42_DH1_DERIVE_PARAMS;
```

2320

2321 The fields of the structure have the following meanings:

| | | |
|------|------------------------|---|
| 2322 | <i>kdf</i> | <i>key derivation function used on the shared secret value</i> |
| 2323 | <i>ulOtherInfoLen</i> | <i>the length in bytes of the other info</i> |
| 2324 | <i>pOtherInfo</i> | <i>some data shared between the two parties</i> |
| 2325 | <i>ulPublicDataLen</i> | <i>the length in bytes of the other party's X9.42 Diffie-Hellman public</i> |
| 2326 | | <i>key</i> |
| 2327 | <i>pPublicData</i> | <i>pointer to other party's X9.42 Diffie-Hellman public key value</i> |

2328 With the key derivation function **CKD_NULL**, *pOtherInfo* must be NULL and *ulOtherInfoLen* must be zero.
 2329 With the key derivation function **CKD_SHA1_KDF_ASN1**, *pOtherInfo* must be supplied, which contains
 2330 an octet string, specified in ASN.1 DER encoding, consisting of mandatory and optional data shared by
 2331 the two parties intending to share the shared secret. With the key derivation function
 2332 **CKD_SHA1_KDF_CONCATENATE**, an optional *pOtherInfo* may be supplied, which consists of some
 2333 data shared by the two parties intending to share the shared secret. Otherwise, *pOtherInfo* must be
 2334 NULL and *ulOtherInfoLen* must be zero.

2335 **CK_X9_42_DH1_DERIVE_PARAMS_PTR** is a pointer to a **CK_X9_42_DH1_DERIVE_PARAMS**.

2336 • **CK_X9_42_DH2_DERIVE_PARAMS, CK_X9_42_DH2_DERIVE_PARAMS_PTR**

2337 **CK_X9_42_DH2_DERIVE_PARAMS** is a structure that provides the parameters to the
 2338 **CKM_X9_42_DH_HYBRID_DERIVE** and **CKM_X9_42_MQV_DERIVE** key derivation mechanisms,
 2339 where each party contributes two key pairs. The structure is defined as follows:

```
2340     typedef struct CK_X9_42_DH2_DERIVE_PARAMS {
2341         CK_X9_42_DH_KDF_TYPE    kdf;
2342         CK_ULONG                 ulOtherInfoLen;
2343         CK_BYTE_PTR              pOtherInfo;
2344         CK_ULONG                 ulPublicDataLen;
2345         CK_BYTE_PTR              pPublicData;
2346         CK_ULONG                 ulPrivateDataLen;
2347         CK_OBJECT_HANDLE         hPrivateData;
2348         CK_ULONG                 ulPublicDataLen2;
2349         CK_BYTE_PTR              pPublicData2;
2350     } CK_X9_42_DH2_DERIVE_PARAMS;
```


| | | |
|------|--|---|
| 2351 | | |
| 2352 | The fields of the structure have the following meanings: | |
| 2353 | <i>kdf</i> | <i>key derivation function used on the shared secret value</i> |
| 2354 | <i>ulOtherInfoLen</i> | <i>the length in bytes of the other info</i> |
| 2355 | <i>pOtherInfo</i> | <i>some data shared between the two parties</i> |
| 2356 | <i>ulPublicDataLen</i> | <i>the length in bytes of the other party's first X9.42 Diffie-Hellman</i> |
| 2357 | | <i>public key</i> |
| 2358 | <i>pPublicData</i> | <i>pointer to other party's first X9.42 Diffie-Hellman public key value</i> |
| 2359 | <i>ulPrivateDataLen</i> | <i>the length in bytes of the second X9.42 Diffie-Hellman private key</i> |
| 2360 | <i>hPrivateData</i> | <i>key handle for second X9.42 Diffie-Hellman private key value</i> |
| 2361 | <i>ulPublicDataLen2</i> | <i>the length in bytes of the other party's second X9.42 Diffie-Hellman</i> |
| 2362 | | <i>public key</i> |
| 2363 | <i>pPublicData2</i> | <i>pointer to other party's second X9.42 Diffie-Hellman public key</i> |
| 2364 | | <i>value</i> |

2365 With the key derivation function **CKD_NULL**, *pOtherInfo* must be NULL and *ulOtherInfoLen* must be zero.
2366 With the key derivation function **CKD_SHA1_KDF_ASN1**, *pOtherInfo* must be supplied, which contains
2367 an octet string, specified in ASN.1 DER encoding, consisting of mandatory and optional data shared by
2368 the two parties intending to share the shared secret. With the key derivation function
2369 **CKD_SHA1_KDF_CONCATENATE**, an optional *pOtherInfo* may be supplied, which consists of some
2370 data shared by the two parties intending to share the shared secret. Otherwise, *pOtherInfo* must be
2371 NULL and *ulOtherInfoLen* must be zero.

2372 **CK_X9_42_DH2_DERIVE_PARAMS_PTR** is a pointer to a **CK_X9_42_DH2_DERIVE_PARAMS**.

2373 • **CK_X9_42_MQV_DERIVE_PARAMS, CK_X9_42_MQV_DERIVE_PARAMS_PTR**

2374 **CK_X9_42_MQV_DERIVE_PARAMS** is a structure that provides the parameters to the
2375 **CKM_X9_42_MQV_DERIVE** key derivation mechanism, where each party contributes two key pairs. The
2376 structure is defined as follows:

```

2377     typedef struct CK_X9_42_MQV_DERIVE_PARAMS {
2378         CK_X9_42_DH_KDF_TYPE    kdf;
2379         CK_ULONG                 ulOtherInfoLen;
2379         CK_BYTE_PTR              pOtherInfo;
2380         CK_ULONG                 ulPublicDataLen;
2381         CK_BYTE_PTR              pPublicData;
2382         CK_ULONG                 ulPrivateDataLen;
2383         CK_OBJECT_HANDLE         hPrivateData;
2384         CK_ULONG                 ulPublicDataLen2;
2385         CK_BYTE_PTR              pPublicData2;
2386         CK_OBJECT_HANDLE         publicKey;
2387     } CK_X9_42_MQV_DERIVE_PARAMS;
2388 
```

| | | |
|------|--|---|
| 2389 | | |
| 2390 | The fields of the structure have the following meanings: | |
| 2391 | <i>kdf</i> | <i>key derivation function used on the shared secret value</i> |
| 2392 | <i>ulOtherInfoLen</i> | <i>the length in bytes of the other info</i> |
| 2393 | <i>pOtherInfo</i> | <i>some data shared between the two parties</i> |
| 2394 | <i>ulPublicDataLen</i> | <i>the length in bytes of the other party's first X9.42 Diffie-Hellman</i> |
| 2395 | | <i>public key</i> |
| 2396 | <i>pPublicData</i> | <i>pointer to other party's first X9.42 Diffie-Hellman public key value</i> |
| 2397 | <i>ulPrivateDataLen</i> | <i>the length in bytes of the second X9.42 Diffie-Hellman private key</i> |
| 2398 | <i>hPrivateData</i> | <i>key handle for second X9.42 Diffie-Hellman private key value</i> |
| 2399 | <i>ulPublicDataLen2</i> | <i>the length in bytes of the other party's second X9.42 Diffie-Hellman</i> |
| 2400 | | <i>public key</i> |
| 2401 | <i>pPublicData2</i> | <i>pointer to other party's second X9.42 Diffie-Hellman public key</i> |
| 2402 | | <i>value</i> |
| 2403 | <i>publicKey</i> | <i>Handle to the first party's ephemeral public key</i> |

2404 With the key derivation function **CKD_NULL**, *pOtherInfo* must be NULL and *ulOtherInfoLen* must be zero.
2405 With the key derivation function **CKD_SHA1_KDF_ASN1**, *pOtherInfo* must be supplied, which contains
2406 an octet string, specified in ASN.1 DER encoding, consisting of mandatory and optional data shared by
2407 the two parties intending to share the shared secret. With the key derivation function
2408 **CKD_SHA1_KDF_CONCATENATE**, an optional *pOtherInfo* may be supplied, which consists of some
2409 data shared by the two parties intending to share the shared secret. Otherwise, *pOtherInfo* must be
2410 NULL and *ulOtherInfoLen* must be zero.

2411 **CK_X9_42_MQV_DERIVE_PARAMS_PTR** is a pointer to a **CK_X9_42_MQV_DERIVE_PARAMS**.

2412 2.4.12 X9.42 Diffie-Hellman key pair generation

2413 The X9.42 Diffie-Hellman key pair generation mechanism, denoted **CKM_X9_42_DH_KEY_PAIR_GEN**,
2414 is a key pair generation mechanism based on Diffie-Hellman key agreement, as defined in the ANSI
2415 X9.42 standard.

2416 It does not have a parameter.

2417 The mechanism generates X9.42 Diffie-Hellman public/private key pairs with a particular prime, base and
2418 subprime, as specified in the **CKA_PRIME**, **CKA_BASE** and **CKA_SUBPRIME** attributes of the template
2419 for the public key.

2420 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
2421 public key and the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_PRIME**, **CKA_BASE**, **CKA_SUBPRIME**, and
2422 **CKA_VALUE** attributes to the new private key; other attributes required by the X9.42 Diffie-Hellman
2423 public and private key types must be specified in the templates.

2424 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
2425 specify the supported range of X9.42 Diffie-Hellman prime sizes, in bits, for the **CKA_PRIME** attribute.

2.4.13 X9.42 Diffie-Hellman domain parameter generation

The X9.42 Diffie-Hellman domain parameter generation mechanism, denoted **CKM_X9_42_DH_PARAMETER_GEN**, is a domain parameters generation mechanism based on X9.42 Diffie-Hellman key agreement, as defined in the ANSI X9.42 standard.

It does not have a parameter.

The mechanism generates X9.42 Diffie-Hellman domain parameters with particular prime and subprime length in bits, as specified in the **CKA_PRIME_BITS** and **CKA_SUBPRIME_BITS** attributes of the template for the domain parameters.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_PRIME**, **CKA_BASE**, **CKA_SUBPRIME**, **CKA_PRIME_BITS** and **CKA_SUBPRIME_BITS** attributes to the new object. Other attributes supported by the X9.42 Diffie-Hellman domain parameter types may also be specified in the template for the domain parameters, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of X9.42 Diffie-Hellman prime sizes, in bits.

2.4.14 X9.42 Diffie-Hellman key derivation

The X9.42 Diffie-Hellman key derivation mechanism, denoted **CKM_X9_42_DH_DERIVE**, is a mechanism for key derivation based on the Diffie-Hellman key agreement scheme, as defined in the ANSI X9.42 standard, where each party contributes one key pair, all using the same X9.42 Diffie-Hellman domain parameters.

It has a parameter, a **CK_X9_42_DH1_DERIVE_PARAMS** structure.

This mechanism derives a secret value, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. (The truncation removes bytes from the leading end of the secret value.) The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template. Note that in order to validate this mechanism it may be required to use the **CKA_VALUE** attribute as the key of a general-length MAC mechanism (e.g. **CKM_SHA_1_HMAC_GENERAL**) over some test data.

This mechanism has the following rules about key sensitivity and extractability:

- The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some default value.
- If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_FALSE**, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_TRUE**, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.
- Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_FALSE**, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_TRUE**, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of X9.42 Diffie-Hellman prime sizes, in bits, for the **CKA_PRIME** attribute.

2.4.15 X9.42 Diffie-Hellman hybrid key derivation

The X9.42 Diffie-Hellman hybrid key derivation mechanism, denoted **CKM_X9_42_DH_HYBRID_DERIVE**, is a mechanism for key derivation based on the Diffie-Hellman hybrid key agreement scheme, as defined in the ANSI X9.42 standard, where each party contributes two key pair, all using the same X9.42 Diffie-Hellman domain parameters.

It has a parameter, a **CK_X9_42_DH2_DERIVE_PARAMS** structure.

This mechanism derives a secret value, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. (The truncation removes bytes from the leading end of the secret value.) The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template. Note that in order to validate this mechanism it may be required to use the **CKA_VALUE** attribute as the key of a general-length MAC mechanism (e.g. **CKM_SHA_1_HMAC_GENERAL**) over some test data.

This mechanism has the following rules about key sensitivity and extractability:

- The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some default value.
- If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_FALSE**, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_TRUE**, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.
- Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_FALSE**, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_TRUE**, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of X9.42 Diffie-Hellman prime sizes, in bits, for the **CKA_PRIME** attribute.

2.4.16 X9.42 Diffie-Hellman Menezes-Qu-Vanstone key derivation

The X9.42 Diffie-Hellman Menezes-Qu-Vanstone (MQV) key derivation mechanism, denoted **CKM_X9_42_MQV_DERIVE**, is a mechanism for key derivation based the MQV scheme, as defined in the ANSI X9.42 standard, where each party contributes two key pairs, all using the same X9.42 Diffie-Hellman domain parameters.

It has a parameter, a **CK_X9_42_MQV_DERIVE_PARAMS** structure.

This mechanism derives a secret value, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. (The truncation removes bytes from the leading end of the secret value.) The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template. Note that in order to validate this mechanism it may be required to use the **CKA_VALUE** attribute as the key of a general-length MAC mechanism (e.g. **CKM_SHA_1_HMAC_GENERAL**) over some test data.

This mechanism has the following rules about key sensitivity and extractability:

- The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some default value.
- If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_FALSE**, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_TRUE**, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.
- Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_FALSE**, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_TRUE**, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of X9.42 Diffie-Hellman prime sizes, in bits, for the **CKA_PRIME** attribute.

2.5 Extended Triple Diffie-Hellman (x3dh)

The Extended Triple Diffie-Hellman mechanism described here is the one described in [SIGNAL].

Table 60, Extended Triple Diffie-Hellman Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_X3DH_INITIALIZE | | | | | | | ✓ |
| CKM_X3DH_RESPOND | | | | | | | ✓ |

2.5.1 Definitions

Mechanisms:

CKM_X3DH_INITIALIZE

CKM_X3DH_RESPOND

2.5.2 Extended Triple Diffie-Hellman key objects

Extended Triple Diffie-Hellman uses Elliptic Curve keys in Montgomery representation (**CKK_EC_MONTGOMERY**). Three different kinds of keys are used, they differ in their lifespan:

- identity keys are long-term keys, which identify the peer,
- prekeys are short-term keys, which should be rotated often (weekly to hourly)
- onetime prekeys are keys, which should be used only once.

Any peer intending to be contacted using X3DH must publish their so-called prekey-bundle, consisting of their:

- public Identity key,
- current prekey, signed using XEDDA with their identity key
- optionally a batch of One-time public keys.

2.5.3 Initiating an Extended Triple Diffie-Hellman key exchange

Initiating an Extended Triple Diffie-Hellman key exchange starts by retrieving the following required public keys (the so-called prekey-bundle) of the other peer: the Identity key, the signed public Prekey, and optionally one One-time public key.

When the necessary key material is available, the initiating party calls CKM_X3DH_INITIALIZE, also providing the following additional parameters:

- the initiators identity key
- the initiators ephemeral key (a fresh, one-time **CKK_EC_MONTGOMERY** type key)

CK_X3DH_INITIATE_PARAMS is a structure that provides the parameters to the **CKM_X3DH_INITIALIZE** key exchange mechanism. The structure is defined as follows:

```
typedef struct CK_X3DH_INITIATE_PARAMS {  
    CK_X3DH_KDF_TYPE    kdf;  
    CK_OBJECT_HANDLE    pPeer_identity;
```

```

2555     CK_OBJECT_HANDLE    pPeer_prekey;
2556     CK_BYTE_PTR          pPrekey_signature;
2557     CK_BYTE_PTR          pOnetime_key;
2558     CK_OBJECT_HANDLE    pOwn_identity;
2559     CK_OBJECT_HANDLE    pOwn_ephemeral;
2560 } CK_X3DH_INITIATE_PARAMS;

```

2561 *Table 61, Extended Triple Diffie-Hellman Initiate Message parameters:*

| Parameter | Data type | Meaning |
|-------------------|------------------|--|
| kdf | CK_X3DH_KDF_TYPE | <i>Key derivation function</i> |
| pPeer_identity | Key handle | <i>Peers public Identity key (from the prekey-bundle)</i> |
| pPeer_prekey | Key Handle | Peers public prekey (from the prekey-bundle) |
| pPrekey_signature | Byte array | <i>XEDDSA signature of PEER_PREKEY (from prekey-bundle)</i> |
| pOnetime_key | Byte array | Optional one-time public prekey of peer (from the prekey-bundle) |
| pOwn_identity | Key Handle | Initiators Identity key |
| pOwn_ephemeral | Key Handle | Initiators ephemeral key |

2562

2563 2.5.4 Responding to an Extended Triple Diffie-Hellman key exchange

2564 Responding an Extended Triple Diffie-Hellman key exchange is done by executing a
2565 CKM_X3DH_RESPOND mechanism. **CK_X3DH_RESPOND_PARAMS** is a structure that provides the
2566 parameters to the **CKM_X3DH_RESPOND** key exchange mechanism. All these parameter should be
2567 supplied by the Initiator in a message to the responder. The structure is defined as follows:

```

2568     typedef struct CK_X3DH_RESPOND_PARAMS {
2569         CK_X3DH_KDF_TYPE    kdf;
2570         CK_BYTE_PTR          pIdentity_id;
2571         CK_BYTE_PTR          pPrekey_id;
2572         CK_BYTE_PTR          pOnetime_id;
2573         CK_OBJECT_HANDLE    pInitiator_identity;
2574         CK_BYTE_PTR          pInitiator_ephemeral;
2575     } CK_X3DH_RESPOND_PARAMS;

```

2576

2577 *Table 62, Extended Triple Diffie-Hellman 1st Message parameters:*

| Parameter | Data type | Meaning |
|----------------------|------------------|--|
| kdf | CK_X3DH_KDF_TYPE | <i>Key derivation function</i> |
| pIdentity_id | Byte array | <i>Peers public Identity key identifier (from the prekey-bundle)</i> |
| pPrekey_id | Byte array | Peers public prekey identifier (from the prekey-bundle) |
| pOnetime_id | Byte array | Optional one-time public prekey of peer (from the prekey-bundle) |
| pInitiator_identity | Key handle | Initiators Identity key |
| pInitiator_ephemeral | Byte array | Initiators ephemeral key |

2578

2579 Where the *_id fields are identifiers marking which key has been used from the prekey-bundle, these
2580 identifiers could be the keys themselves.

2581

2582 This mechanism has the following rules about key sensitivity and extractability³:

- 2583 1 The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both
2584 be specified to be either CK_TRUE or CK_FALSE. If omitted, these attributes each take on some
2585 default value.
- 2586 2 If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_FALSE, then the derived key
2587 will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE, then the
2588 derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its
2589 **CKA_SENSITIVE** attribute.
- 2590 3 Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_FALSE, then the
2591 derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to
2592 CK_TRUE, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite*
2593 value from its **CKA_EXTRACTABLE** attribute.

2594 **2.5.5 Extended Triple Diffie-Hellman parameters**

- 2595 • **CK_X3DH_KDF_TYPE, CK_X3DH_KDF_TYPE_PTR**

2596 **CK_X3DH_KDF_TYPE** is used to indicate the Key Derivation Function (KDF) applied to derive keying
2597 data from a shared secret. The key derivation function will be used by the X3DH key agreement
2598 schemes. It is defined as follows:

2599 `typedef CK_ULONG CK_X3DH_KDF_TYPE;`

2600

2601 The following table lists the defined functions.

2602 *Table 63, X3DH: Key Derivation Functions*

| Source Identifier |
|---------------------|
| CKD_NULL |
| CKD_BLAKE2B_256_KDF |
| CKD_BLAKE2B_512_KDF |
| CKD_SHA3_256_KDF |
| CKD_SHA256_KDF |
| CKD_SHA3_512_KDF |
| CKD_SHA512_KDF |

2603 **2.6 Double Ratchet**

2604 The Double Ratchet is a key management algorithm managing the ongoing renewal and maintenance of
2605 short-lived session keys providing forward secrecy and break-in recovery for encrypt/decrypt operations.
2606 The algorithm is described in **[DoubleRatchet]**. The Signal protocol uses X3DH to exchange a shared
2607 secret in the first step, which is then used to derive a Double Ratchet secret key.

3 Note that the rules regarding the CKA_SENSITIVE, CKA_EXTRACTABLE, CKA_ALWAYS_SENSITIVE, and CKA_NEVER_EXTRACTABLE attributes have changed in version 2.11 to match the policy used by other key derivation mechanisms such as CKM_SSL3_MASTER_KEY_DERIVE.

2608 Table 64, Double Ratchet Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|--------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_X2RATCHET_INITIALIZE | | | | | | | ✓ |
| CKM_X2RATCHET_RESPOND | | | | | | | ✓ |
| CKM_X2RATCHET_ENCRYPT | ✓ | | | | | ✓ | |
| CKM_X2RATCHET_DECRYPT | ✓ | | | | | ✓ | |

2609

2610 2.6.1 Definitions

2611 This section defines the key type “CKK_X2RATCHET” for type CK_KEY_TYPE as used in the
2612 CKA_KEY_TYPE attribute of key objects.

2613 Mechanisms:

2614 CKM_X2RATCHET_INITIALIZE

2615 CKM_X2RATCHET_RESPOND

2616 CKM_X2RATCHET_ENCRYPT

2617 CKM_X2RATCHET_DECRYPT

2618 2.6.2 Double Ratchet secret key objects

2619 Double Ratchet secret key objects (object class CKO_SECRET_KEY, key type CKK_X2RATCHET) hold
2620 Double Ratchet keys. Double Ratchet secret keys can only be derived from shared secret keys using the
2621 mechanism CKM_X2RATCHET_INITIALIZE or CKM_X2RATCHET_RESPOND. In the Signal protocol
2622 these are seeded with the shared secret derived from an Extended Triple Diffie-Hellman [X3DH] key-
2623 exchange. The following table defines the Double Ratchet secret key object attributes, in addition to the
2624 common attributes defined for this object class:

2625 Table 65, Double Ratchet Secret Key Object Attributes

| Attribute | Data type | Meaning |
|--------------------------|------------|---|
| CKA_X2RATCHET_RK | Byte array | Root key |
| CKA_X2RATCHET_HKS | Byte array | Sender Header key |
| CKA_X2RATCHET_HKR | Byte array | Receiver Header key |
| CKA_X2RATCHET_NHKS | Byte array | Next Sender Header Key |
| CKA_X2RATCHET_NHKR | Byte array | Next Receiver Header Key |
| CKA_X2RATCHET_CKS | Byte array | Sender Chain key |
| CKA_X2RATCHET_CKR | Byte array | Receiver Chain key |
| CKA_X2RATCHET_DHS | Byte array | Sender DH secret key |
| CKA_X2RATCHET_DHP | Byte array | Sender DH public key |
| CKA_X2RATCHET_DHR | Byte array | Receiver DH public key |
| CKA_X2RATCHET_NS | ULONG | Message number send |
| CKA_X2RATCHET_NR | ULONG | Message number receive |
| CKA_X2RATCHET_PNS | ULONG | Previous message number send |
| CKA_X2RATCHET_BOBS1STMSG | BOOL | Is this bob and has he ever sent a message? |
| CKA_X2RATCHET_ISALICE | BOOL | Is this Alice? |
| CKA_X2RATCHET_BAGSIZE | ULONG | How many out-of-order keys do we store |

| Attribute | Data type | Meaning |
|-------------------|------------|-------------------|
| CKA_X2RATCHET_BAG | Byte array | Out-of-order keys |

2.6.3 Double Ratchet key derivation

The Double Ratchet key derivation mechanisms depend on who is the initiating party, and who the receiving, denoted **CKM_X2RATCHET_INITIALIZE** and **CKM_X2RATCHET_RESPOND**, are the key derivation mechanisms for the Double Ratchet. Usually the keys are derived from a shared secret by executing a X3DH key exchange.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Additionally the attribute flags indicating which functions the key supports are also contributed by the mechanism.

For this mechanism, the only allowed values are 255 and 448 as RFC 8032 only defines curves of these two sizes. A Cryptoki implementation may support one or both of these curves and should set the *ulMinKeySize* and *ulMaxKeySize* fields accordingly.

- **CK_X2RATCHET_INITIALIZE_PARAMS;**
CK_X2RATCHET_INITIALIZE_PARAMS_PTR

CK_X2RATCHET_INITIALIZE_PARAMS provides the parameters to the **CKM_X2RATCHET_INITIALIZE** mechanism. It is defined as follows:

```
typedef struct CK_X2RATCHET_INITIALIZE_PARAMS {
    CK_BYTE_PTR          sk;
    CK_OBJECT_HANDLE     peer_public_prekey;
    CK_OBJECT_HANDLE     peer_public_identity;
    CK_OBJECT_HANDLE     own_public_identity;
    CK_BBOOL             bEncryptedHeader;
    CK_ULONG             eCurve;
    CK_MECHANISM_TYPE     aeadMechanism;
    CK_X2RATCHET_KDF_TYPE kdfMechanism;
} CK_X2RATCHET_INITIALIZE_PARAMS;
```

The fields of the structure have the following meanings:

| | |
|------------------------------|---|
| <i>sk</i> | <i>the shared secret with peer (derived using X3DH)</i> |
| <i>peers_public_prekey</i> | <i>Peers public prekey which the Initiator used in the X3DH</i> |
| <i>peers_public_identity</i> | <i>Peers public identity which the Initiator used in the X3DH</i> |
| <i>own_public_identity</i> | <i>Initiators public identity as used in the X3DH</i> |
| <i>bEncryptedHeader</i> | <i>whether the headers are encrypted</i> |
| <i>eCurve</i> | <i>255 for curve 25519 or 448 for curve 448</i> |
| <i>aeadMechanism</i> | <i>a mechanism supporting AEAD encryption</i> |
| <i>kdfMechanism</i> | <i>a Key Derivation Mechanism, such as CKD_BLAKE2B_512_KDF</i> |

- **CK_X2RATCHET_RESPOND_PARAMS;**
CK_X2RATCHET_RESPOND_PARAMS_PTR

CK_X2RATCHET_RESPOND_PARAMS provides the parameters to the **CKM_X2RATCHET_RESPOND** mechanism. It is defined as follows:

```
typedef struct CK_X2RATCHET_RESPOND_PARAMS {
    CK_BYTE_PTR          sk;
    CK_OBJECT_HANDLE     own_prekey;
    CK_OBJECT_HANDLE     initiator_identity;
    CK_OBJECT_HANDLE     own_public_identity;
    CK_BBOOL             bEncryptedHeader;
    CK_ULONG             eCurve;
    CK_MECHANISM_TYPE    aeadMechanism;
    CK_X2RATCHET_KDF_TYPE kdfMechanism;
} CK_X2RATCHET_RESPOND_PARAMS;
```

The fields of the structure have the following meanings:

| | |
|----------------------------|--|
| <i>sk</i> | <i>shared secret with the Initiator</i> |
| <i>own_prekey</i> | <i>Own Prekey pair that the Initiator used</i> |
| <i>initiator_identity</i> | <i>Initiators public identity key used</i> |
| <i>own_public_identity</i> | <i>as used in the prekey bundle by the initiator in the X3DH</i> |
| <i>bEncryptedHeader</i> | <i>whether the headers are encrypted</i> |
| <i>eCurve</i> | <i>255 for curve 25519 or 448 for curve 448</i> |
| <i>aeadMechanism</i> | <i>a mechanism supporting AEAD encryption</i> |
| <i>kdfMechanism</i> | <i>a Key Derivation Mechanism, such as CKD_BLAKE2B_512_KDF</i> |

2.6.4 Double Ratchet Encryption mechanism

The Double Ratchet encryption mechanism, denoted **CKM_X2RATCHET_ENCRYPT** and **CKM_X2RATCHET_DECRYPT**, are a mechanisms for single part encryption and decryption based on the Double Ratchet and its underlying AEAD cipher.

2.6.5 Double Ratchet parameters

- **CK_X2RATCHET_KDF_TYPE, CK_X2RATCHET_KDF_TYPE_PTR**

CK_X2RATCHET_KDF_TYPE is used to indicate the Key Derivation Function (KDF) applied to derive keying data from a shared secret. The key derivation function will be used by the X key derivation scheme. It is defined as follows:

```
typedef CK_ULONG CK_X2RATCHET_KDF_TYPE;
```

2698 The following table lists the defined functions.

2699 Table 66, X2RATCHET: Key Derivation Functions

| Source Identifier |
|---------------------|
| CKD_NULL |
| CKD_BLAKE2B_256_KDF |
| CKD_BLAKE2B_512_KDF |
| CKD_SHA3_256_KDF |
| CKD_SHA256_KDF |
| CKD_SHA3_512_KDF |
| CKD_SHA512_KDF |

2700

2701 **2.7 Wrapping/unwrapping private keys**

2702
2703
2704
2705
2706

Cryptoki Versions 2.01 and up allow the use of secret keys for wrapping and unwrapping RSA private keys, Diffie-Hellman private keys, X9.42 Diffie-Hellman private keys, EC (also related to ECDSA) private keys and DSA private keys. For wrapping, a private key is BER-encoded according to PKCS #8's PrivateKeyInfo ASN.1 type. PKCS #8 requires an algorithm identifier for the type of the private key. The object identifiers for the required algorithm identifiers are as follows:

2707
2708
2709
2710
2711
2712
2713
2714
2715
2716
2717
2718
2719

```
rsaEncryption OBJECT IDENTIFIER ::= { pkcs-1 1 }

dhKeyAgreement OBJECT IDENTIFIER ::= { pkcs-3 1 }

dhpublicnumber OBJECT IDENTIFIER ::= { iso(1) member-body(2)
    us(840) ansi-x942(10046) number-type(2) 1 }

id-ecPublicKey OBJECT IDENTIFIER ::= { iso(1) member-body(2)
    us(840) ansi-x9-62(10045) publicKeyType(2) 1 }

id-dsa OBJECT IDENTIFIER ::= {
    iso(1) member-body(2) us(840) x9-57(10040) x9cm(4) 1 }
```

2720
2721
2722
2723
2724
2725
2726

```
where
pkcs-1 OBJECT IDENTIFIER ::= {
    iso(1) member-body(2) US(840) rsadsi(113549) pkcs(1) 1 }

pkcs-3 OBJECT IDENTIFIER ::= {
    iso(1) member-body(2) US(840) rsadsi(113549) pkcs(1) 3 }
```

2727
2728

These parameters for the algorithm identifiers have the following types, respectively:

2729
2730
2731
2732
2733
2734

```
NULL

DHParameter ::= SEQUENCE {
    prime          INTEGER,  -- p
    base           INTEGER,  -- g
    privateValueLength  INTEGER OPTIONAL
```

```

2735     }
2736
2737     DomainParameters ::= SEQUENCE {
2738         prime          INTEGER,    -- p
2739         base           INTEGER,    -- g
2740         subprime       INTEGER,    -- q
2741         cofactor       INTEGER OPTIONAL, -- j
2742         validationParms ValidationParms OPTIONAL
2743     }
2744
2745     ValidationParms ::= SEQUENCE {
2746         Seed           BIT STRING, -- seed
2747         PGenCounter    INTEGER      -- parameter verification
2748     }
2749
2750     Parameters ::= CHOICE {
2751         ecParameters    ECParameters,
2752         namedCurve      CURVES.&id({CurveNames}),
2753         implicitlyCA     NULL
2754     }
2755
2756     Dss-Parms ::= SEQUENCE {
2757         p INTEGER,
2758         q INTEGER,
2759         g INTEGER
2760     }
2761

```

2762 For the X9.42 Diffie-Hellman domain parameters, the **cofactor** and the **validationParms** optional fields
 2763 should not be used when wrapping or unwrapping X9.42 Diffie-Hellman private keys since their values
 2764 are not stored within the token.

2765 For the EC domain parameters, the use of **namedCurve** is recommended over the choice
 2766 **ecParameters**. The choice **implicitlyCA** must not be used in Cryptoki.

2767 Within the PrivateKeyInfo type:

- 2768 • RSA private keys are BER-encoded according to PKCS #1's RSAPrivateKey ASN.1 type. This type
 2769 requires values to be present for *all* the attributes specific to Cryptoki's RSA private key objects. In
 2770 other words, if a Cryptoki library does not have values for an RSA private key's **CKA_MODULUS**,
 2771 **CKA_PUBLIC_EXPONENT**, **CKA_PRIVATE_EXPONENT**, **CKA_PRIME_1**, **CKA_PRIME_2**,
 2772 **CKA_EXPONENT_1**, **CKA_EXPONENT_2**, and **CKA_COEFFICIENT** values, it must not create an
 2773 RSAPrivateKey BER-encoding of the key, and so it must not prepare it for wrapping.
- 2774 • Diffie-Hellman private keys are represented as BER-encoded ASN.1 type INTEGER.
- 2775 • X9.42 Diffie-Hellman private keys are represented as BER-encoded ASN.1 type INTEGER.
- 2776 • EC (also related with ECDSA) private keys are BER-encoded according to SECG SEC 1
 2777 ECPPrivateKey ASN.1 type:

```

2778     ECPPrivateKey ::= SEQUENCE {
2779         Version          INTEGER { ecPrivkeyVer1(1) }
2780             (ecPrivkeyVer1),
2781         privateKey       OCTET STRING,
2782         parameters       [0] Parameters OPTIONAL,

```

2783 publicKey [1] BIT STRING OPTIONAL
2784 }
2785

2786 Since the EC domain parameters are placed in the PKCS #8's privateKeyAlgorithm field, the optional
2787 **parameters** field in an ECPrivateKey must be omitted. A Cryptoki application must be able to
2788 unwrap an ECPrivateKey that contains the optional **publicKey** field; however, what is done with this
2789 **publicKey** field is outside the scope of Cryptoki.

- 2790 • DSA private keys are represented as BER-encoded ASN.1 type INTEGER.

2791 Once a private key has been BER-encoded as a PrivateKeyInfo type, the resulting string of bytes is
2792 encrypted with the secret key. This encryption must be done in CBC mode with PKCS padding.

2793 Unwrapping a wrapped private key undoes the above procedure. The CBC-encrypted ciphertext is
2794 decrypted, and the PKCS padding is removed. The data thereby obtained are parsed as a
2795 PrivateKeyInfo type, and the wrapped key is produced. An error will result if the original wrapped key
2796 does not decrypt properly, or if the decrypted unpadded data does not parse properly, or its type does not
2797 match the key type specified in the template for the new key. The unwrapping mechanism contributes
2798 only those attributes specified in the PrivateKeyInfo type to the newly-unwrapped key; other attributes
2799 must be specified in the template, or will take their default values.

2800 Earlier drafts of PKCS #11 Version 2.0 and Version 2.01 used the object identifier

```
2801       DSA OBJECT IDENTIFIER ::= { algorithm 12 }  
2802       algorithm OBJECT IDENTIFIER ::= {  
2803         iso(1) identifier-organization(3) oiw(14) secsig(3)  
2804         algorithm(2) }  
2805
```

2806 with associated parameters

```
2807       DSAParameters ::= SEQUENCE {  
2808         prime1 INTEGER, -- modulus p  
2809         prime2 INTEGER, -- modulus q  
2810         base INTEGER -- base g  
2811       }
```

2813 for wrapping DSA private keys. Note that although the two structures for holding DSA domain
2814 parameters appear identical when instances of them are encoded, the two corresponding object
2815 identifiers are different.

2816 2.8 Generic secret key

2817 Table 67, Generic Secret Key Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|----------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_GENERIC_SECRET_KEY_GEN | | | | | ✓ | | |

2818 2.8.1 Definitions

2819 This section defines the key type “CKK_GENERIC_SECRET” for type CK_KEY_TYPE as used in the
2820 CKA_KEY_TYPE attribute of key objects.

Mechanisms:

CKM_GENERIC_SECRET_KEY_GEN

2.8.2 Generic secret key objects

Generic secret key objects (object class **CKO_SECRET_KEY**, key type **CKK_GENERIC_SECRET**) hold generic secret keys. These keys do not support encryption or decryption; however, other keys can be derived from them and they can be used in HMAC operations. The following table defines the generic secret key object attributes, in addition to the common attributes defined for this object class:

These key types are used in several of the mechanisms described in this section.

Table 68, Generic Secret Key Object Attributes

| Attribute | Data type | Meaning |
|------------------------------|------------|------------------------------|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key value (arbitrary length) |
| CKA_VALUE_LEN ^{2,3} | CK_ULONG | Length in bytes of key value |

- Refer to [PKCS11-Base] table 11 for footnotes

The following is a sample template for creating a generic secret key object:

```
CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_GENERIC_SECRET;
CK_UTF8CHAR label[] = "A generic secret key object";
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_DERIVE, &true, sizeof(true)},
    {CKA_VALUE, value, sizeof(value)}
};
```

CKA_CHECK_VALUE: The value of this attribute is derived from the key object by taking the first three bytes of the SHA-1 hash of the generic secret key object's CKA_VALUE attribute.

2.8.3 Generic secret key generation

The generic secret key generation mechanism, denoted **CKM_GENERIC_SECRET_KEY_GEN**, is used to generate generic secret keys. The generated keys take on any attributes provided in the template passed to the **C_GenerateKey** call, and the **CKA_VALUE_LEN** attribute specifies the length of the key to be generated.

It does not have a parameter.

The template supplied must specify a value for the **CKA_VALUE_LEN** attribute. If the template specifies an object type and a class, they must have the following values:

```
CK_OBJECT_CLASS = CKO_SECRET_KEY;
CK_KEY_TYPE = CKK_GENERIC_SECRET;
```

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of key sizes, in bits.

2.9 HMAC mechanisms

Refer to **RFC2104** and **FIPS 198** for HMAC algorithm description. The HMAC secret key shall correspond to the PKCS11 generic secret key type or the mechanism specific key types (see mechanism definition). Such keys, for use with HMAC operations can be created using `C_CreateObject` or `C_GenerateKey`.

The RFC also specifies test vectors for the various hash function based HMAC mechanisms described in the respective hash mechanism descriptions. The RFC should be consulted to obtain these test vectors.

2.9.1 General block cipher mechanism parameters

• **CK_MAC_GENERAL_PARAMS; CK_MAC_GENERAL_PARAMS_PTR**

CK_MAC_GENERAL_PARAMS provides the parameters to the general-length MACing mechanisms of the DES, DES3 (triple-DES), AES, Camellia, SEED, and ARIA ciphers. It also provides the parameters to the general-length HMACing mechanisms (i.e., SHA-1, SHA-256, SHA-384, SHA-512, and SHA-512/T family) and the two SSL 3.0 MACing mechanisms, (i.e., MD5 and SHA-1). It holds the length of the MAC that these mechanisms produce. It is defined as follows:

```
typedef CK_ULONG CK_MAC_GENERAL_PARAMS;
```

CK_MAC_GENERAL_PARAMS_PTR is a pointer to a **CK_MAC_GENERAL_PARAMS**.

2.10 AES

For the Advanced Encryption Standard (AES) see [FIPS PUB 197].

Table 69, AES Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_AES_KEY_GEN | | | | | ✓ | | |
| CKM_AES_ECB | ✓ | | | | | ✓ | |
| CKM_AES_CBC | ✓ | | | | | ✓ | |
| CKM_AES_CBC_PAD | ✓ | | | | | ✓ | |
| CKM_AES_MAC_GENERAL | | ✓ | | | | | |
| CKM_AES_MAC | | ✓ | | | | | |
| CKM_AES_OFB | ✓ | | | | | ✓ | |
| CKM_AES_CFB64 | ✓ | | | | | ✓ | |
| CKM_AES_CFB8 | ✓ | | | | | ✓ | |
| CKM_AES_CFB128 | ✓ | | | | | ✓ | |
| CKM_AES_CFB1 | ✓ | | | | | ✓ | |
| CKM_AES_XCBC_MAC | | ✓ | | | | | |
| CKM_AES_XCBC_MAC_96 | | ✓ | | | | | |

2.10.1 Definitions

This section defines the key type "CKK_AES" for type `CK_KEY_TYPE` as used in the `CKA_KEY_TYPE` attribute of key objects.

Mechanisms:

CKM_AES_KEY_GEN
CKM_AES_ECB
CKM_AES_CBC
CKM_AES_MAC
CKM_AES_MAC_GENERAL
CKM_AES_CBC_PAD
CKM_AES_OFB
CKM_AES_CFB64
CKM_AES_CFB8
CKM_AES_CFB128
CKM_AES_CFB1
CKM_AES_XCBC_MAC
CKM_AES_XCBC_MAC_96

2.10.2 AES secret key objects

AES secret key objects (object class **CKO_SECRET_KEY**, key type **CKK_AES**) hold AES keys. The following table defines the AES secret key object attributes, in addition to the common attributes defined for this object class:

Table 70, AES Secret Key Object Attributes

| Attribute | Data type | Meaning |
|--------------------------------|------------|---------------------------------|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key value (16, 24, or 32 bytes) |
| CKA_VALUE_LEN ^{2,3,6} | CK_ULONG | Length in bytes of key value |

- Refer to [PKCS11-Base] table 11 for footnotes

The following is a sample template for creating an AES secret key object:

```
CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_AES;
CK_UTF8CHAR label[] = "An AES secret key object";
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_ENCRYPT, &true, sizeof(true)},
    {CKA_VALUE, value, sizeof(value)}
};
```

CKA_CHECK_VALUE: The value of this attribute is derived from the key object by taking the first three bytes of the ECB encryption of a single block of null (0x00) bytes, using the default cipher associated with the key type of the secret key object.

2.10.3 AES key generation

The AES key generation mechanism, denoted **CKM_AES_KEY_GEN**, is a key generation mechanism for NIST's Advanced Encryption Standard.

It does not have a parameter.

The mechanism generates AES keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the AES key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of AES key sizes, in bytes.

2.10.4 AES-ECB

AES-ECB, denoted **CKM_AES_ECB**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on NIST Advanced Encryption Standard and electronic codebook mode.

It does not have a parameter.

This mechanism can wrap and unwrap any secret key. Of course, a particular token may not be able to wrap/unwrap every secret key that it supports. For wrapping, the mechanism encrypts the value of the **CKA_VALUE** attribute of the key that is wrapped, padded on the trailing end with up to block size minus one null bytes so that the resulting length is a multiple of the block size. The output data is the same length as the padded input data. It does not wrap the key type, key length, or any other information about the key; the application must convey these separately.

For unwrapping, the mechanism decrypts the wrapped key, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one, and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

Constraints on key types and the length of data are summarized in the following table:

Table 71, AES-ECB: Key And Data Length

| Function | Key type | Input length | Output length | Comments |
|-------------|----------|------------------------|---|---------------|
| C_Encrypt | AES | multiple of block size | same as input length | no final part |
| C_Decrypt | AES | multiple of block size | same as input length | no final part |
| C_WrapKey | AES | any | input length rounded up to multiple of block size | |
| C_UnwrapKey | AES | multiple of block size | determined by type of key being unwrapped or CKA_VALUE_LEN | |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of AES key sizes, in bytes.

2.10.5 AES-CBC

AES-CBC, denoted **CKM_AES_CBC**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on NIST's Advanced Encryption Standard and cipher-block chaining mode.

It has a parameter, a 16-byte initialization vector.

This mechanism can wrap and unwrap any secret key. Of course, a particular token may not be able to wrap/unwrap every secret key that it supports. For wrapping, the mechanism encrypts the value of the **CKA_VALUE** attribute of the key that is wrapped, padded on the trailing end with up to block size minus one null bytes so that the resulting length is a multiple of the block size. The output data is the same length as the padded input data. It does not wrap the key type, key length, or any other information about the key; the application must convey these separately.

For unwrapping, the mechanism decrypts the wrapped key, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one, and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

Constraints on key types and the length of data are summarized in the following table:

Table 72, AES-CBC: Key And Data Length

| Function | Key type | Input length | Output length | Comments |
|-------------|----------|------------------------|--|---------------|
| C_Encrypt | AES | multiple of block size | same as input length | no final part |
| C_Decrypt | AES | multiple of block size | same as input length | no final part |
| C_WrapKey | AES | any | input length rounded up to multiple of the block size | |
| C_UnwrapKey | AES | multiple of block size | determined by type of key being unwrapped or CKA_VALUE_LEN | |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of AES key sizes, in bytes.

2.10.6 AES-CBC with PKCS padding

AES-CBC with PKCS padding, denoted **CKM_AES_CBC_PAD**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on NIST's Advanced Encryption Standard; cipher-block chaining mode; and the block cipher padding method detailed in PKCS #7.

It has a parameter, a 16-byte initialization vector.

The PKCS padding in this mechanism allows the length of the plaintext value to be recovered from the ciphertext value. Therefore, when unwrapping keys with this mechanism, no value should be specified for the **CKA_VALUE_LEN** attribute.

In addition to being able to wrap and unwrap secret keys, this mechanism can wrap and unwrap RSA, Diffie-Hellman, X9.42 Diffie-Hellman, EC (also related to ECDSA) and DSA private keys (see Section 2.7 for details). The entries in the table below for data length constraints when wrapping and unwrapping keys do not apply to wrapping and unwrapping private keys.

Constraints on key types and the length of data are summarized in the following table:

2983 Table 73, AES-CBC with PKCS Padding: Key And Data Length

| Function | Key type | Input length | Output length |
|-------------|----------|------------------------|--|
| C_Encrypt | AES | any | input length rounded up to multiple of the block size |
| C_Decrypt | AES | multiple of block size | between 1 and block size bytes shorter than input length |
| C_WrapKey | AES | any | input length rounded up to multiple of the block size |
| C_UnwrapKey | AES | multiple of block size | between 1 and block length bytes shorter than input length |

2984 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
 2985 specify the supported range of AES key sizes, in bytes.

2986 2.10.7 AES-OFB

2987 AES-OFB, denoted CKM_AES_OFB. It is a mechanism for single and multiple-part encryption and
 2988 decryption with AES. AES-OFB mode is described in [NIST sp800-38a].

2989 It has a parameter, an initialization vector for this mode. The initialization vector has the same length as
 2990 the block size.

2991 Constraints on key types and the length of data are summarized in the following table:
 2992
 2993

2994 Table 74, AES-OFB: Key And Data Length

| Function | Key type | Input length | Output length | Comments |
|-----------|----------|--------------|----------------------|---------------|
| C_Encrypt | AES | any | same as input length | no final part |
| C_Decrypt | AES | any | same as input length | no final part |

2995 For this mechanism the CK_MECHANISM_INFO structure is as specified for CBC mode.

2996 2.10.8 AES-CFB

2997 Cipher AES has a cipher feedback mode, AES-CFB, denoted CKM_AES_CFB8, CKM_AES_CFB64, and
 2998 CKM_AES_CFB128. It is a mechanism for single and multiple-part encryption and decryption with AES.
 2999 AES-OFB mode is described [NIST sp800-38a].

3000 It has a parameter, an initialization vector for this mode. The initialization vector has the same length as
 3001 the block size.

3002 Constraints on key types and the length of data are summarized in the following table:
 3003
 3004

3005 Table 75, AES-CFB: Key And Data Length

| Function | Key type | Input length | Output length | Comments |
|-----------|----------|--------------|----------------------|---------------|
| C_Encrypt | AES | any | same as input length | no final part |
| C_Decrypt | AES | any | same as input length | no final part |

3006 For this mechanism the CK_MECHANISM_INFO structure is as specified for CBC mode.

2.10.9 General-length AES-MAC

General-length AES-MAC, denoted **CKM_AES_MAC_GENERAL**, is a mechanism for single- and multiple-part signatures and verification, based on NIST Advanced Encryption Standard as defined in FIPS PUB 197 and data authentication as defined in FIPS PUB 113.

It has a parameter, a **CK_MAC_GENERAL_PARAMS** structure, which specifies the output length desired from the mechanism.

The output bytes from this mechanism are taken from the start of the final AES cipher block produced in the MACing process.

Constraints on key types and the length of data are summarized in the following table:

Table 76, General-length AES-MAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------|-------------|--|
| C_Sign | AES | any | 1-block size, as specified in parameters |
| C_Verify | AES | any | 1-block size, as specified in parameters |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of AES key sizes, in bytes.

2.10.10 AES-MAC

AES-MAC, denoted by **CKM_AES_MAC**, is a special case of the general-length AES-MAC mechanism. AES-MAC always produces and verifies MACs that are half the block size in length.

It does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 77, AES-MAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------|-------------|------------------------|
| C_Sign | AES | Any | ½ block size (8 bytes) |
| C_Verify | AES | Any | ½ block size (8 bytes) |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of AES key sizes, in bytes.

2.10.11 AES-XCBC-MAC

AES-XCBC-MAC, denoted **CKM_AES_XCBC_MAC**, is a mechanism for single and multiple part signatures and verification; based on NIST's Advanced Encryption Standard and [RFC 3566].

It does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 78, AES-XCBC-MAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------|-------------|------------------|
| C_Sign | AES | Any | 16 bytes |
| C_Verify | AES | Any | 16 bytes |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of AES key sizes, in bytes.

2.10.12 AES-XCBC-MAC-96

AES-XCBC-MAC-96, denoted **CKM_AES_XCBC_MAC_96**, is a mechanism for single and multiple part signatures and verification; based on NIST's Advanced Encryption Standard and [RFC 3566].

It does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 79, AES-XCBC-MAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------|-------------|------------------|
| C_Sign | AES | Any | 12 bytes |
| C_Verify | AES | Any | 12 bytes |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of AES key sizes, in bytes.

2.11 AES with Counter

Table 80, AES with Counter Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-------------|-------------------|---------------|----------------------|--------|-------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/Key Pair | Wrap & Unwrap | Derive |
| CKM_AES_CTR | ✓ | | | | | ✓ | |

2.11.1 Definitions

Mechanisms:

CKM_AES_CTR

2.11.2 AES with Counter mechanism parameters

◆ CK_AES_CTR_PARAMS; CK_AES_CTR_PARAMS_PTR

CK_AES_CTR_PARAMS is a structure that provides the parameters to the **CKM_AES_CTR** mechanism. It is defined as follows:

```
typedef struct CK_AES_CTR_PARAMS {
    CK_ULONG    ulCounterBits;
    CK_BYTE     cb[16];
} CK_AES_CTR_PARAMS;
```

ulCounterBits specifies the number of bits in the counter block (*cb*) that shall be incremented. This number shall be such that $0 < ulCounterBits \leq 128$. For any values outside this range the mechanism shall return **CKR_MECHANISM_PARAM_INVALID**.

It's up to the caller to initialize all of the bits in the counter block including the counter bits. The counter bits are the least significant bits of the counter block (*cb*). They are a big-endian value usually starting with 1. The rest of 'cb' is for the nonce, and maybe an optional IV.

E.g. as defined in [RFC 3686]:

```

0          1          2          3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     Nonce                                     |
+-----+-----+-----+-----+-----+-----+-----+-----+
|               Initialization Vector (IV)               |
|                                                           |
+-----+-----+-----+-----+-----+-----+-----+-----+
```


3072 | Block Counter |
 3073 +-----+
 3074

3075 This construction permits each packet to consist of up to $2^{32}-1$ blocks = 4,294,967,295 blocks =
 3076 68,719,476,720 octets.

3077 **CK_AES_CTR_PARAMS_PTR** is a pointer to a **CK_AES_CTR_PARAMS**.

3078 2.11.3 AES with Counter Encryption / Decryption

3079 Generic AES counter mode is described in NIST Special Publication 800-38A and in RFC 3686. These
 3080 describe encryption using a counter block which may include a nonce to guarantee uniqueness of the
 3081 counter block. Since the nonce is not incremented, the mechanism parameter must specify the number of
 3082 counter bits in the counter block.

3083 The block counter is incremented by 1 after each block of plaintext is processed. There is no support for
 3084 any other increment functions in this mechanism.

3085 If an attempt to encrypt/decrypt is made which will cause an overflow of the counter block's counter bits,
 3086 then the mechanism shall return **CKR_DATA_LEN_RANGE**. Note that the mechanism should allow the
 3087 final post increment of the counter to overflow (if it implements it this way) but not allow any further
 3088 processing after this point. E.g. if ulCounterBits = 2 and the counter bits start as 1 then only 3 blocks of
 3089 data can be processed.

3090

3091 2.12 AES CBC with Cipher Text Stealing CTS

3092 Ref [NIST AES CTS]

3093 This mode allows unpadded data that has length that is not a multiple of the block size to be encrypted to
 3094 the same length of cipher text.

3095 *Table 81, AES CBC with Cipher Text Stealing CTS Mechanisms vs. Functions*

| Mechanism | Functions | | | | | | |
|-------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_AES_CTS | ✓ | | | | | ✓ | |

3096 2.12.1 Definitions

3097 Mechanisms:

3098 CKM_AES_CTS

3099 2.12.2 AES CTS mechanism parameters

3100 It has a parameter, a 16-byte initialization vector.

Table 82, AES-CTS: Key And Data Length

| Function | Key type | Input length | Output length | Comments |
|-----------|----------|-----------------------------------|----------------------|---------------|
| C_Encrypt | AES | Any, \geq block size (16 bytes) | same as input length | no final part |
| C_Decrypt | AES | any, \geq block size (16 bytes) | same as input length | no final part |

2.13 Additional AES Mechanisms

Table 83, Additional AES Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|--------------|-------------------|---------------|----------------------|--------|--------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_AES_GCM | ✓ | | | | | ✓ | |
| CKM_AES_CCM | ✓ | | | | | ✓ | |
| CKM_AES_GMAC | | ✓ | | | | | |

2.13.1 Definitions

Mechanisms:

CKM_AES_GCM

CKM_AES_CCM

CKM_AES_GMAC

Generator Functions:

CKG_NO_GENERATE

CKG_GENERATE

CKG_GENERATE_COUNTER

CKG_GENERATE_RANDOM

2.13.2 AES-GCM Authenticated Encryption / Decryption

Generic GCM mode is described in [GCM]. To set up for AES-GCM use the following process, where *K* (key) and AAD (additional authenticated data) are as described in [GCM]. AES-GCM uses CK_GCM_PARAMS for Encrypt, Decrypt and CK_GCM_MESSAGE_PARAMS for MessageEncrypt and MessageDecrypt.

Encrypt:

- Set the IV length *ulIvLen* in the parameter block.
- Set the IV data *pIv* in the parameter block.
- Set the AAD data *pAAD* and size *ulAADLen* in the parameter block. *pAAD* may be NULL if *ulAADLen* is 0.
- Set the tag length *ulTagBits* in the parameter block.
- Call C_EncryptInit() for **CKM_AES_GCM** mechanism with parameters and key *K*.

- 3128 • Call C_Encrypt(), or C_EncryptUpdate()*⁴ C_EncryptFinal(), for the plaintext obtaining ciphertext
3129 and authentication tag output.
- 3130 Decrypt:
- 3131 • Set the IV length *ulIvLen* in the parameter block.
- 3132 • Set the IV data *pIv* in the parameter block.
- 3133 • Set the AAD data *pAAD* and size *ulAADLen* in the parameter block. *pAAD* may be NULL if
3134 *ulAADLen* is 0.
- 3135 • Set the tag length *ulTagBits* in the parameter block.
- 3136 • Call C_DecryptInit() for **CKM_AES_GCM** mechanism with parameters and key *K*.
- 3137 • Call C_Decrypt(), or C_DecryptUpdate()*¹ C_DecryptFinal(), for the ciphertext, including the
3138 appended tag, obtaining plaintext output. Note: since **CKM_AES_GCM** is an AEAD cipher, no
3139 data should be returned until C_Decrypt() or C_DecryptFinal().
- 3140 MessageEncrypt:
- 3141 • Set the IV length *ulIvLen* in the parameter block.
- 3142 • Set *pIv* to hold the IV data returned from C_EncryptMessage() and C_EncryptMessageBegin(). If
3143 *ulIvFixedBits* is not zero, then the most significant bits of *pIv* contain the fixed IV. If *ivGenerator* is
3144 set to CKG_NO_GENERATE, *pIv* is an input parameter with the full IV.
- 3145 • Set the *ulIvFixedBits* and *ivGenerator* fields in the parameter block.
- 3146 • Set the tag length *ulTagBits* in the parameter block.
- 3147 • Set *pTag* to hold the tag data returned from C_EncryptMessage() or the final
3148 C_EncryptMessageNext().
- 3149 • Call C_MessageEncryptInit() for **CKM_AES_GCM** mechanism key *K*.
- 3150 • Call C_EncryptMessage(), or C_EncryptMessageBegin() followed by C_EncryptMessageNext()*⁵.
3151 The mechanism parameter is passed to all three of these functions.
- 3152 • Call C_MessageEncryptFinal() to close the message decryption.
- 3153 MessageDecrypt:
- 3154 • Set the IV length *ulIvLen* in the parameter block.
- 3155 • Set the IV data *pIv* in the parameter block.
- 3156 • The *ulIvFixedBits* and *ivGenerator* fields are ignored.
- 3157 • Set the tag length *ulTagBits* in the parameter block.
- 3158 • Set the tag data *pTag* in the parameter block before C_DecryptMessage() or the final
3159 C_DecryptMessageNext().
- 3160 • Call C_MessageDecryptInit() for **CKM_AES_GCM** mechanism key *K*.
- 3161 • Call C_DecryptMessage(), or C_DecryptMessageBegin followed by C_DecryptMessageNext()*⁶.
3162 The mechanism parameter is passed to all three of these functions.
- 3163 • Call C_MessageDecryptFinal() to close the message decryption.

4 "*" indicates 0 or more calls may be made as required

5 "*" indicates 0 or more calls may be made as required

6 "*" indicates 0 or more calls may be made as required

3164 In *pIv* the least significant bit of the initialization vector is the rightmost bit. *ullvLen* is the length of the
3165 initialization vector in bytes.

3166 On MessageEncrypt, the meaning of *ivGenerator* is as follows: CKG_NO_GENERATE means the IV is
3167 passed in on MessageEncrypt and no internal IV generation is done. CKG_GENERATE means that the
3168 non-fixed portion of the IV is generated by the module internally. The generation method is not defined.
3169 CKG_GENERATE_COUNTER means that the non-fixed portion of the IV is generated by the module
3170 internally by use of an incrementing counter. CKG_GENERATE_RANDOM means that the non-fixed
3171 portion of the IV is generated by the module internally using a PRNG. In any case the entire IV, including
3172 the fixed portion, is returned in *pIv*.

3173 Modules must implement CKG_GENERATE. Modules may also reject *ullvFixedBits* values which are too
3174 large. Zero is always an acceptable value for *ullvFixedBits*.

3175 In Encrypt and Decrypt the tag is appended to the cipher text and the least significant bit of the tag is the
3176 rightmost bit and the tag bits are the rightmost *ulTagBits* bits. In MessageEncrypt the tag is returned in
3177 the *pTag* field of CK_GCM_MESSAGE_PARAMS. In MessageDecrypt the tag is provided by the *pTag*
3178 field of CK_GCM_MESSAGE_PARAMS.

3179 The key type for *K* must be compatible with **CKM_AES_ECB** and the
3180 C_EncryptInit()/C_DecryptInit()/C_MessageEncryptInit()/C_MessageDecryptInit() calls shall behave, with
3181 respect to *K*, as if they were called directly with **CKM_AES_ECB**, *K* and NULL parameters.

3182 2.13.3 AES-CCM authenticated Encryption / Decryption

3183 For IPsec (RFC 4309) and also for use in ZFS encryption. Generic CCM mode is described in [RFC
3184 3610].

3185 To set up for AES-CCM use the following process, where *K* (key), nonce and additional authenticated
3186 data are as described in [RFC 3610]. AES-CCM uses CK_CCM_PARAMS for Encrypt and Decrypt, and
3187 CK_CCM_MESSAGE_PARAMS for MessageEncrypt and MessageDecrypt.

3188 Encrypt:

- 3189 • Set the message/data length *ulDataLen* in the parameter block.
- 3190 • Set the nonce length *ulNonceLen* and the nonce data *pNonce* in the parameter block.
- 3191 • Set the AAD data *pAAD* and size *ulAADLen* in the parameter block. *pAAD* may be NULL if
3192 *ulAADLen* is 0.
- 3193 • Set the MAC length *ulMACLen* in the parameter block.
- 3194 • Call C_EncryptInit() for **CKM_AES_CCM** mechanism with parameters and key *K*.
- 3195 • Call C_Encrypt(), C_EncryptUpdate(), or C_EncryptFinal(), for the plaintext obtaining the final
3196 ciphertext output and the MAC. The total length of data processed must be *ulDataLen*. The output
3197 length will be *ulDataLen* + *ulMACLen*.

3198 Decrypt:

- 3199 • Set the message/data length *ulDataLen* in the parameter block. This length must not include the
3200 length of the MAC that is appended to the cipher text.
- 3201 • Set the nonce length *ulNonceLen* and the nonce data *pNonce* in the parameter block.
- 3202 • Set the AAD data *pAAD* and size *ulAADLen* in the parameter block. *pAAD* may be NULL if
3203 *ulAADLen* is 0.
- 3204 • Set the MAC length *ulMACLen* in the parameter block.
- 3205 • Call C_DecryptInit() for **CKM_AES_CCM** mechanism with parameters and key *K*.
- 3206 • Call C_Decrypt(), C_DecryptUpdate(), or C_DecryptFinal(), for the ciphertext, including the
3207 appended MAC, obtaining plaintext output. The total length of data processed must be *ulDataLen*
3208 + *ulMACLen*. Note: since **CKM_AES_CCM** is an AEAD cipher, no data should be returned until
3209 C_Decrypt() or C_DecryptFinal().

3210 MessageEncrypt:

- 3211 • Set the message/data length *ulDataLen* in the parameter block.
- 3212 • Set the nonce length *ulNonceLen*.
- 3213 • Set *pNonce* to hold the nonce data returned from `C_EncryptMessage()` and
3214 `C_EncryptMessageBegin()`. If *ulNonceFixedBits* is not zero, then the most significant bits of
3215 *pNonce* contain the fixed nonce. If *nonceGenerator* is set to `CKG_NO_GENERATE`, *pNonce* is
3216 an input parameter with the full nonce.
- 3217 • Set the *ulNonceFixedBits* and *nonceGenerator* fields in the parameter block.
- 3218 • Set the MAC length *ulMACLen* in the parameter block.
- 3219 • Set *pMAC* to hold the MAC data returned from `C_EncryptMessage()` or the final
3220 `C_EncryptMessageNext()`.
- 3221 • Call `C_MessageEncryptInit()` for **CKM_AES_CCM** mechanism key *K*.
- 3222 • Call `C_EncryptMessage()`, or `C_EncryptMessageBegin()` followed by
3223 `C_EncryptMessageNext()`^{*7}. The mechanism parameter is passed to all three functions.
- 3224 • Call `C_MessageEncryptFinal()` to close the message encryption.
- 3225 • The MAC is returned in *pMac* of the `CK_CCM_MESSAGE_PARAMS` structure.

3226 MessageDecrypt:

- 3227 • Set the message/data length *ulDataLen* in the parameter block.
- 3228 • Set the nonce length *ulNonceLen* and the nonce data *pNonce* in the parameter block
- 3229 • The *ulNonceFixedBits* and *nonceGenerator* fields in the parameter block are ignored.
- 3230 • Set the MAC length *ulMACLen* in the parameter block.
- 3231 • Set the MAC data *pMAC* in the parameter block before `C_DecryptMessage()` or the final
3232 `C_DecryptMessageNext()`.
- 3233 • Call `C_MessageDecryptInit()` for **CKM_AES_CCM** mechanism key *K*.
- 3234 • Call `C_DecryptMessage()`, or `C_DecryptMessageBegin()` followed by
3235 `C_DecryptMessageNext()`^{*8}. The mechanism parameter is passed to all three functions.
- 3236 • Call `C_MessageDecryptFinal()` to close the message decryption.

3237 In *pNonce* the least significant bit of the nonce is the rightmost bit. *ulNonceLen* is the length of the nonce
3238 in bytes.

3239 On MessageEncrypt, the meaning of *nonceGenerator* is as follows: `CKG_NO_GENERATE` means the
3240 nonce is passed in on MessageEncrypt and no internal MAC generation is done. `CKG_GENERATE`
3241 means that the non-fixed portion of the nonce is generated by the module internally. The generation
3242 method is not defined. `CKG_GENERATE_COUNTER` means that the non-fixed portion of the nonce is
3243 generated by the module internally by use of an incrementing counter. `CKG_GENERATE_RANDOM`
3244 means that the non-fixed portion of the nonce is generated by the module internally using a PRNG. In any
3245 case the entire nonce, including the fixed portion, is returned in *pNonce*.

3246 Modules must implement `CKG_GENERATE`. Modules may also reject *ulNonceFixedBits* values which are
3247 too large. Zero is always an acceptable value for *ulNonceFixedBits*.

7 "*" indicates 0 or more calls may be made as required

8 "*" indicates 0 or more calls may be made as required

In Encrypt and Decrypt the MAC is appended to the cipher text and the least significant byte of the MAC is the rightmost byte and the MAC bytes are the rightmost *ulMACLen* bytes. In MessageEncrypt the MAC is returned in the *pMAC* field of CK_CCM_MESSAGE_PARAMS. In MessageDecrypt the MAC is provided by the *pMAC* field of CK_CCM_MESSAGE_PARAMS.

The key type for K must be compatible with **CKM_AES_ECB** and the C_EncryptInit()/C_DecryptInit()/C_MessageEncryptInit()/C_MessageDecryptInit() calls shall behave, with respect to K, as if they were called directly with **CKM_AES_ECB**, K and NULL parameters.

2.13.4 AES-GMAC

AES-GMAC, denoted **CKM_AES_GMAC**, is a mechanism for single and multiple-part signatures and verification. It is described in NIST Special Publication 800-38D [GMAC]. GMAC is a special case of GCM that authenticates only the Additional Authenticated Data (AAD) part of the GCM mechanism parameters. When GMAC is used with C_Sign or C_Verify, *pData* points to the AAD. GMAC does not use plaintext or ciphertext.

The signature produced by GMAC, also referred to as a Tag, the tag's length is determined by the CK_GCM_PARAMS field *ulTagBits*.

The IV length is determined by the CK_GCM_PARAMS field *ulIvLen*.

Constraints on key types and the length of data are summarized in the following table:

Table 84, AES-GMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------|-------------------|-------------------------------------|
| C_Sign | CKK_AES | < 2 ⁶⁴ | Depends on param's <i>ulTagBits</i> |
| C_Verify | CKK_AES | < 2 ⁶⁴ | Depends on param's <i>ulTagBits</i> |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of AES key sizes, in bytes.

2.13.5 AES GCM and CCM Mechanism parameters

◆ CK_GENERATOR_FUNCTION

Functions to generate unique IVs and nonces.

```
typedef CK_ULONG CK_GENERATOR_FUNCTION;
```

◆ CK_GCM_PARAMS; CK_GCM_PARAMS_PTR

CK_GCM_PARAMS is a structure that provides the parameters to the CKM_AES_GCM mechanism when used for Encrypt or Decrypt. It is defined as follows:

```
typedef struct CK_GCM_PARAMS {
    CK_BYTE_PTR    pIv;
    CK_ULONG       ulIvLen;
    CK_ULONG       ulIvBits;
    CK_BYTE_PTR    pAAD;
    CK_ULONG       ulAADLen;
    CK_ULONG       ulTagBits;
} CK_GCM_PARAMS;
```

The fields of the structure have the following meanings:

plv *pointer to initialization vector*

| | | |
|------|------------------|---|
| 3286 | <i>ullvLen</i> | <i>length of initialization vector in bytes. The length of the initialization vector can be any number between 1 and $(2^{32}) - 1$. 96-bit (12 byte) IV values can be processed more efficiently, so that length is recommended for situations in which efficiency is critical.</i> |
| 3287 | | |
| 3288 | | |
| 3289 | | |
| 3290 | <i>ullvBits</i> | <i>length of initialization vector in bits. Do not use ullvBits to specify the length of the initialization vector, but ullvLen instead.</i> |
| 3291 | | |
| 3292 | <i>pAAD</i> | <i>pointer to additional authentication data. This data is authenticated but not encrypted.</i> |
| 3293 | | |
| 3294 | <i>ulAADLen</i> | <i>length of pAAD in bytes. The length of the AAD can be any number between 0 and $(2^{32}) - 1$.</i> |
| 3295 | | |
| 3296 | <i>ulTagBits</i> | <i>length of authentication tag (output following cipher text) in bits. Can be any value between 0 and 128.</i> |
| 3297 | | |

3298 **CK_GCM_PARAMS_PTR** is a pointer to a **CK_GCM_PARAMS**.

3299 ♦ **CK_GCM_MESSAGE_PARAMS; CK_GCM_MESSAGE_PARAMS_PTR**

3300 **CK_GCM_MESSAGE_PARAMS** is a structure that provides the parameters to the **CKM_AES_GCM**
 3301 mechanism when used for MessageEncrypt or MessageDecrypt. It is defined as follows:

```

3302     typedef struct CK_GCM_MESSAGE_PARAMS {
3303         CK_BYTE_PTR    pIv;
3304         CK_ULONG        ulIvLen;
3305         CK_ULONG        ulIvFixedBits;
3306         CK_GENERATOR_FUNCTION    ivGenerator;
3307         CK_BYTE_PTR    pTag;
3308         CK_ULONG        ulTagBits;
3309     } CK_GCM_MESSAGE_PARAMS;
  
```

3310

3311 The fields of the structure have the following meanings:

| | | |
|------|----------------------|---|
| 3312 | <i>pIv</i> | <i>pointer to initialization vector</i> |
| 3313 | <i>ullvLen</i> | <i>length of initialization vector in bytes. The length of the initialization vector can be any number between 1 and $(2^{32}) - 1$. 96-bit (12 byte) IV values can be processed more efficiently, so that length is recommended for situations in which efficiency is critical.</i> |
| 3314 | | |
| 3315 | | |
| 3316 | | |
| 3317 | <i>ullvFixedBits</i> | <i>number of bits of the original IV to preserve when generating an new IV. These bits are counted from the Most significant bits (to the right).</i> |
| 3318 | | |
| 3319 | | |
| 3320 | <i>ivGenerator</i> | <i>Function used to generate a new IV. Each IV must be unique for a given session.</i> |
| 3321 | | |
| 3322 | <i>pTag</i> | <i>location of the authentication tag which is returned on MessageEncrypt, and provided on MessageDecrypt.</i> |
| 3323 | | |
| 3324 | <i>ulTagBits</i> | <i>length of authentication tag in bits. Can be any value between 0 and 128.</i> |
| 3325 | | |

3326 **CK_GCM_MESSAGE_PARAMS_PTR** is a pointer to a **CK_GCM_MESSAGE_PARAMS**.

3327

3328 ♦ **CK_CCM_PARAMS; CK_CCM_PARAMS_PTR**

3329 **CK_CCM_PARAMS** is a structure that provides the parameters to the **CKM_AES_CCM** mechanism
3330 when used for Encrypt or Decrypt. It is defined as follows:

```
3331     typedef struct CK_CCM_PARAMS {  
3332         CK_ULONG      ulDataLen; /*plaintext or ciphertext*/  
3333         CK_BYTE_PTR   pNonce;  
3334         CK_ULONG      ulNonceLen;  
3335         CK_BYTE_PTR   pAAD;  
3336         CK_ULONG      ulAADLen;  
3337         CK_ULONG      ulMACLen;  
3338     } CK_CCM_PARAMS;
```

3339 The fields of the structure have the following meanings, where L is the size in bytes of the data length's
3340 length ($2 \leq L \leq 8$):

3341 *ulDataLen* *length of the data where $0 \leq ulDataLen < 2^{(8L)}$.*

3342 *pNonce* *the nonce.*

3343 *ulNonceLen* *length of pNonce in bytes where $7 \leq ulNonceLen \leq 13$.*

3344 *pAAD* *Additional authentication data. This data is authenticated but not*
3345 *encrypted.*

3346 *ulAADLen* *length of pAAD in bytes where $0 \leq ulAADLen \leq (2^{32}) - 1$.*

3347 *ulMACLen* *length of the MAC (output following cipher text) in bytes. Valid*
3348 *values are 4, 6, 8, 10, 12, 14, and 16.*

3349 **CK_CCM_PARAMS_PTR** is a pointer to a **CK_CCM_PARAMS**.

3350 ♦ **CK_CCM_MESSAGE_PARAMS; CK_CCM_MESSAGE_PARAMS_PTR**

3351 **CK_CCM_MESSAGE_PARAMS** is a structure that provides the parameters to the **CKM_AES_CCM**
3352 mechanism when used for MessageEncrypt or MessageDecrypt. It is defined as follows:

```
3353     typedef struct CK_CCM_MESSAGE_PARAMS {  
3354         CK_ULONG      ulDataLen; /*plaintext or ciphertext*/  
3355         CK_BYTE_PTR   pNonce;  
3356         CK_ULONG      ulNonceLen;  
3357         CK_ULONG      ulNonceFixedBits;  
3358         CK_GENERATOR_FUNCTION  nonceGenerator;  
3359         CK_BYTE_PTR   pMAC;  
3360         CK_ULONG      ulMACLen;  
3361     } CK_CCM_MESSAGE_PARAMS;
```

3362

3363 The fields of the structure have the following meanings, where L is the size in bytes of the data length's
3364 length ($2 \leq L \leq 8$):

3365 *ulDataLen* *length of the data where $0 \leq ulDataLen < 2^{(8L)}$.*

3366 *pNonce* the nonce.

3367 *ulNonceLen* length of *pNonce* in bytes where $7 \leq ulNonceLen \leq 13$.

3368 *ulNonceFixedBits* number of bits of the original nonce to preserve when generating a
 3369 new nonce. These bits are counted from the Most significant bits (to
 3370 the right).

3371 *nonceGenerator* Function used to generate a new nonce. Each nonce must be
 3372 unique for a given session.

3373 *pMAC* location of the CCM MAC returned on *MessageEncrypt*, provided on
 3374 *MessageDecrypt*

3375 *ulMACLen* length of the MAC (output following cipher text) in bytes. Valid
 3376 values are 4, 6, 8, 10, 12, 14, and 16.

3377 **CK_CCM_MESSAGE_PARAMS_PTR** is a pointer to a **CK_CCM_MESSAGE_PARAMS**.
 3378

2.14 AES CMAC

Table 85, Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_AES_CMACH | | ✓ | | | | | |
| CKM_AES_CMACH | | ✓ | | | | | |

¹ SR = SignRecover, VR = VerifyRecover

2.14.1 Definitions

Mechanisms:

CKM_AES_CMACH

CKM_AES_CMACH

2.14.2 Mechanism parameters

CKM_AES_CMACH

CKM_AES_CMACH does not use a mechanism parameter.

2.14.3 General-length AES-CMAC

General-length AES-CMAC, denoted **CKM_AES_CMACH**, is a mechanism for single- and multiple-part signatures and verification, based on [NIST SP800-38B] and [RFC 4493].

It has a parameter, a **CK_MAC_GENERAL_PARAMS** structure, which specifies the output length desired from the mechanism.

The output bytes from this mechanism are taken from the start of the final AES cipher block produced in the MACing process.

Constraints on key types and the length of data are summarized in the following table:

3397 Table 86, General-length AES-CMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------|-------------|--|
| C_Sign | CKK_AES | any | 1-block size, as specified in parameters |
| C_Verify | CKK_AES | any | 1-block size, as specified in parameters |

3398 References [NIST SP800-38B] and [RFC 4493] recommend that the output MAC is not truncated to less
 3399 than 64 bits. The MAC length must be specified before the communication starts, and must not be
 3400 changed during the lifetime of the key. It is the caller's responsibility to follow these rules.

3401 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
 3402 specify the supported range of AES key sizes, in bytes.

3403 2.14.4 AES-CMAC

3404 AES-CMAC, denoted **CKM_AES_CMAC**, is a special case of the general-length AES-CMAC mechanism.
 3405 AES-MAC always produces and verifies MACs that are a full block size in length, the default output length
 3406 specified by [RFC 4493].

3407 Constraints on key types and the length of data are summarized in the following table:

3408 Table 87, AES-CMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------|-------------|-----------------------|
| C_Sign | CKK_AES | any | Block size (16 bytes) |
| C_Verify | CKK_AES | any | Block size (16 bytes) |

3409 References [NIST SP800-38B] and [RFC 4493] recommend that the output MAC is not truncated to less
 3410 than 64 bits. The MAC length must be specified before the communication starts, and must not be
 3411 changed during the lifetime of the key. It is the caller's responsibility to follow these rules.

3412 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
 3413 specify the supported range of AES key sizes, in bytes.

3414 2.15 AES XTS

3415 Table 88, Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_AES_XTS | ✓ | | | | | ✓ | |
| CKM_AES_XTS_KEY_GEN | | | | | ✓ | | |

3416 2.15.1 Definitions

3417 This section defines the key type "CKK_AES_XTS" for type CK_KEY_TYPE as used in the
 3418 CKA_KEY_TYPE attribute of key objects.

3419 Mechanisms:

3420 CKM_AES_XTS

3421 CKM_AES_XTS_KEY_GEN

2.15.2 AES-XTS secret key objects

Table 89, AES-XTS Secret Key Object Attributes

| Attribute | Data type | Meaning |
|--------------------------------|------------|------------------------------|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key value (32 or 64 bytes) |
| CKA_VALUE_LEN ^{2,3,6} | CK_ULONG | Length in bytes of key value |

- Refer to [PKCS11-Base] table 11 for footnotes

2.15.3 AES-XTS key generation

The double-length AES-XTS key generation mechanism, denoted **CKM_AES_XTS_KEY_GEN**, is a key generation mechanism for double-length AES-XTS keys.

The mechanism generates AES-XTS keys with a particular length in bytes as specified in the CKA_VALUE_LEN attributes of the template for the key.

This mechanism contributes the CKA_CLASS, CKA_KEY_TYPE, and CKA_VALUE attributes to the new key. Other attributes supported by the double-length AES-XTS key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the ulMinKeySize and ulMaxKeySize fields of the CK_MECHANISM_INFO structure specify the supported range of AES-XTS key sizes, in bytes.

2.15.4 AES-XTS

AES-XTS (XEX-based Tweaked CodeBook mode with CipherText Stealing), denoted **CKM_AES_XTS**, is a mechanism for single- and multiple-part encryption and decryption. It is specified in NIST SP800-38E.

Its single parameter is a Data Unit Sequence Number 16 bytes long. Supported key lengths are 32 and 64 bytes. Keys are internally split into half-length sub-keys of 16 and 32 bytes respectively. Constraints on key types and the length of data are summarized in the following table:

Table 90, AES-XTS: Key And Data Length

| Function | Key type | Input length | Output length | Comments |
|-----------|-------------|-----------------------------------|----------------------|---------------|
| C_Encrypt | CKK_AES_XTS | Any, \geq block size (16 bytes) | Same as input length | No final part |
| C_Decrypt | CKK_AES_XTS | Any, \geq block size (16 bytes) | Same as input length | No final part |

2.16 AES Key Wrap

Table 91, AES Key Wrap Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---|-------------------|---------------|----------------------|--------|-------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/Key Pair | Wrap & Unwrap | Derive |
| CKM_AES_KEY_WRAP | ✓ | | | | | ✓ | |
| CKM_AES_KEY_WRAP_PAD | ✓ | | | | | ✓ | |
| CKM_AES_KEY_WRAP_KWP | ✓ | | | | | ✓ | |
| ¹ SR = SignRecover, VR = VerifyRecover | | | | | | | |

2.16.1 Definitions

Mechanisms:

CKM_AES_KEY_WRAP

CKM_AES_KEY_WRAP_PAD

CKM_AES_KEY_WRAP_KWP

2.16.2 AES Key Wrap Mechanism parameters

The mechanisms will accept an optional mechanism parameter as the Initialization vector which, if present, must be a fixed size array of 8 bytes for CKM_AES_KEY_WRAP and CKM_AES_KEY_WRAP_PAD, resp. 4 bytes for CKM_AES_KEY_WRAP_KWP; and, if NULL, will use the default initial value defined in Section 4.3 resp. 6.2 / 6.3 of [AES KEYWRAP].

The type of this parameter is CK_BYTE_PTR and the pointer points to the array of bytes to be used as the initial value. The length shall be either 0 and the pointer NULL; or 8 for CKM_AES_KEY_WRAP / CKM_AES_KEY_WRAP_PAD, resp. 4 for CKM_AES_KEY_WRAP_KWP, and the pointer non-NULL.

2.16.3 AES Key Wrap

The mechanisms support only single-part operations, single part wrapping and unwrapping, and single-part encryption and decryption.

The CKM_AES_KEY_WRAP mechanism can only wrap a key resp. encrypt a block of data whose size is an exact multiple of the AES Key Wrap algorithm block size. Wrapping / encryption is done as defined in Section 6.2 of [AES KEYWRAP].

The CKM_AES_KEY_WRAP_PAD mechanism can wrap a key or encrypt a block of data of any length. It does the padding detailed in PKCS #7 of inputs (keys or data blocks), always producing wrapped output that is larger than the input key/data to be wrapped. This padding is done by the token before being passed to the AES key wrap algorithm, which then wraps / encrypts the padded block of data as defined in Section 6.2 of [AES KEYWRAP].

The CKM_AES_KEY_WRAP_KWP mechanism can wrap a key or encrypt block of data of any length. The input is padded and wrapped / encrypted as defined in Section 6.3 of [AES KEYWRAP], which produces same results as RFC 5649.

2.17 Key derivation by data encryption – DES & AES

These mechanisms allow derivation of keys using the result of an encryption operation as the key value. They are for use with the C_DeriveKey function.

Table 92, Key derivation by data encryption Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_DES_ECB_ENCRYPT_DATA | | | | | | | ✓ |
| CKM_DES_CBC_ENCRYPT_DATA | | | | | | | ✓ |
| CKM_DES3_ECB_ENCRYPT_DATA | | | | | | | ✓ |
| CKM_DES3_CBC_ENCRYPT_DATA | | | | | | | ✓ |
| CKM_AES_ECB_ENCRYPT_DATA | | | | | | | ✓ |
| CKM_AES_CBC_ENCRYPT_DATA | | | | | | | ✓ |

2.17.1 Definitions

Mechanisms:

```
CKM_DES_ECB_ENCRYPT_DATA
CKM_DES_CBC_ENCRYPT_DATA
CKM_DES3_ECB_ENCRYPT_DATA
CKM_DES3_CBC_ENCRYPT_DATA
CKM_AES_ECB_ENCRYPT_DATA
CKM_AES_CBC_ENCRYPT_DATA

typedef struct CK_DES_CBC_ENCRYPT_DATA_PARAMS {
    CK_BYTE      iv[8];
    CK_BYTE_PTR  pData;
    CK_ULONG     length;
} CK_DES_CBC_ENCRYPT_DATA_PARAMS;

typedef CK_DES_CBC_ENCRYPT_DATA_PARAMS CK_PTR
      CK_DES_CBC_ENCRYPT_DATA_PARAMS_PTR;

typedef struct CK_AES_CBC_ENCRYPT_DATA_PARAMS {
    CK_BYTE      iv[16];
    CK_BYTE_PTR  pData;
    CK_ULONG     length;
} CK_AES_CBC_ENCRYPT_DATA_PARAMS;

typedef CK_AES_CBC_ENCRYPT_DATA_PARAMS CK_PTR
      CK_AES_CBC_ENCRYPT_DATA_PARAMS_PTR;
```

2.17.2 Mechanism Parameters

Uses CK_KEY_DERIVATION_STRING_DATA as defined in section 2.43.2

Table 93, Mechanism Parameters

| | |
|---|--|
| CKM_DES_ECB_ENCRYPT_DATA CKM_DES3_ECB_ENCRYPT_DATA | Uses CK_KEY_DERIVATION_STRING_DATA structure. Parameter is the data to be encrypted and must be a multiple of 8 bytes long. |
| CKM_AES_ECB_ENCRYPT_DATA | Uses CK_KEY_DERIVATION_STRING_DATA structure. Parameter is the data to be encrypted and must be a multiple of 16 long. |
| CKM_DES_CBC_ENCRYPT_DATA CKM_DES3_CBC_ENCRYPT_DATA | Uses CK_DES_CBC_ENCRYPT_DATA_PARAMS. Parameter is an 8 byte IV value followed by the data. The data value part must be a multiple of 8 bytes long. |
| CKM_AES_CBC_ENCRYPT_DATA | Uses CK_AES_CBC_ENCRYPT_DATA_PARAMS. Parameter is an 16 byte IV value followed by the data. The data value part must be a multiple of 16 bytes long. |

2.17.3 Mechanism Description

The mechanisms will function by performing the encryption over the data provided using the base key. The resulting cipher text shall be used to create the key value of the resulting key. If not all the cipher text

3510 is used then the part discarded will be from the trailing end (least significant bytes) of the cipher text data.
 3511 The derived key shall be defined by the attribute template supplied but constrained by the length of cipher
 3512 text available for the key value and other normal PKCS11 derivation constraints.

3513 Attribute template handling, attribute defaulting and key value preparation will operate as per the SHA-1
 3514 Key Derivation mechanism in section 2.20.5.

3515 If the data is too short to make the requested key then the mechanism returns
 3516 CKR_DATA_LEN_RANGE.

3517 2.18 Double and Triple-length DES

3518 Table 94, Double and Triple-Length DES Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|----------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_DES2_KEY_GEN | | | | | ✓ | | |
| CKM_DES3_KEY_GEN | | | | | ✓ | | |
| CKM_DES3_ECB | ✓ | | | | | ✓ | |
| CKM_DES3_CBC | ✓ | | | | | ✓ | |
| CKM_DES3_CBC_PAD | ✓ | | | | | ✓ | |
| CKM_DES3_MAC_GENERAL | | ✓ | | | | | |
| CKM_DES3_MAC | | ✓ | | | | | |

3519 2.18.1 Definitions

3520 This section defines the key type “CKK_DES2” and “CKK_DES3” for type CK_KEY_TYPE as used in the
 3521 CKA_KEY_TYPE attribute of key objects.

3522 Mechanisms:

3523 CKM_DES2_KEY_GEN
 3524 CKM_DES3_KEY_GEN
 3525 CKM_DES3_ECB
 3526 CKM_DES3_CBC
 3527 CKM_DES3_MAC
 3528 CKM_DES3_MAC_GENERAL
 3529 CKM_DES3_CBC_PAD

3530 2.18.2 DES2 secret key objects

3531 DES2 secret key objects (object class **CKO_SECRET_KEY**, key type **CKK_DES2**) hold double-length
 3532 DES keys. The following table defines the DES2 secret key object attributes, in addition to the common
 3533 attributes defined for this object class:

3534 Table 95, DES2 Secret Key Object Attributes

| Attribute | Data type | Meaning |
|------------------------------|------------|----------------------------------|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key value (always 16 bytes long) |

3535 - Refer to [PKCS11-Base] table 11 for footnotes

DES2 keys must always have their parity bits properly set as described in FIPS PUB 46-3 (*i.e.*, each of the DES keys comprising a DES2 key must have its parity bits properly set). Attempting to create or unwrap a DES2 key with incorrect parity will return an error.

The following is a sample template for creating a double-length DES secret key object:

```
CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_DES2;
CK_UTF8CHAR label[] = "A DES2 secret key object";
CK_BYTE value[16] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_ENCRYPT, &true, sizeof(true)},
    {CKA_VALUE, value, sizeof(value)}
};
```

CKA_CHECK_VALUE: The value of this attribute is derived from the key object by taking the first three bytes of the ECB encryption of a single block of null (0x00) bytes, using the default cipher associated with the key type of the secret key object.

2.18.3 DES3 secret key objects

DES3 secret key objects (object class **CKO_SECRET_KEY**, key type **CKK_DES3**) hold triple-length DES keys. The following table defines the DES3 secret key object attributes, in addition to the common attributes defined for this object class:

Table 96, DES3 Secret Key Object Attributes

| Attribute | Data type | Meaning |
|------------------------------|------------|----------------------------------|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key value (always 24 bytes long) |

- Refer to [PKCS11-Base] table 11 for footnotes

DES3 keys must always have their parity bits properly set as described in FIPS PUB 46-3 (*i.e.*, each of the DES keys comprising a DES3 key must have its parity bits properly set). Attempting to create or unwrap a DES3 key with incorrect parity will return an error.

The following is a sample template for creating a triple-length DES secret key object:

```
CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_DES3;
CK_UTF8CHAR label[] = "A DES3 secret key object";
CK_BYTE value[24] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_ENCRYPT, &true, sizeof(true)},
    {CKA_VALUE, value, sizeof(value)}
};
```

3580
 3581 CKA_CHECK_VALUE: The value of this attribute is derived from the key object by taking the first three
 3582 bytes of the ECB encryption of a single block of null (0x00) bytes, using the default cipher associated with
 3583 the key type of the secret key object.

3584 2.18.4 Double-length DES key generation

3585 The double-length DES key generation mechanism, denoted **CKM_DES2_KEY_GEN**, is a key
 3586 generation mechanism for double-length DES keys. The DES keys making up a double-length DES key
 3587 both have their parity bits set properly, as specified in FIPS PUB 46-3.

3588 It does not have a parameter.

3589 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
 3590 key. Other attributes supported by the double-length DES key type (specifically, the flags indicating which
 3591 functions the key supports) may be specified in the template for the key, or else are assigned default
 3592 initial values.

3593 Double-length DES keys can be used with all the same mechanisms as triple-DES keys:
 3594 **CKM_DES3_ECB**, **CKM_DES3_CBC**, **CKM_DES3_CBC_PAD**, **CKM_DES3_MAC_GENERAL**, and
 3595 **CKM_DES3_MAC**. Triple-DES encryption with a double-length DES key is equivalent to encryption with
 3596 a triple-length DES key with K1=K3 as specified in FIPS PUB 46-3.

3597 When double-length DES keys are generated, it is token-dependent whether or not it is possible for either
 3598 of the component DES keys to be “weak” or “semi-weak” keys.

3599 2.18.5 Triple-length DES Order of Operations

3600 Triple-length DES encryptions are carried out as specified in FIPS PUB 46-3: encrypt, decrypt, encrypt.
 3601 Decryptions are carried out with the opposite three steps: decrypt, encrypt, decrypt. The mathematical
 3602 representations of the encrypt and decrypt operations are as follows:

3603 $DES3-E(\{K1, K2, K3\}, P) = E(K3, D(K2, E(K1, P)))$
 3604 $DES3-D(\{K1, K2, K3\}, C) = D(K1, E(K2, D(K3, C)))$

3605 2.18.6 Triple-length DES in CBC Mode

3606 Triple-length DES operations in CBC mode, with double or triple-length keys, are performed using outer
 3607 CBC as defined in X9.52. X9.52 describes this mode as TCBC. The mathematical representations of the
 3608 CBC encrypt and decrypt operations are as follows:

3609 $DES3-CBC-E(\{K1, K2, K3\}, P) = E(K3, D(K2, E(K1, P + I)))$
 3610 $DES3-CBC-D(\{K1, K2, K3\}, C) = D(K1, E(K2, D(K3, C))) + I$

3611 The value *I* is either an 8-byte initialization vector or the previous block of cipher text that is added to the
 3612 current input block. The addition operation is used is addition modulo-2 (XOR).

3613 2.18.7 DES and Triple length DES in OFB Mode

3614 Table 97, DES and Triple Length DES in OFB Mode Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_DES_OFB64 | ✓ | | | | | | |
| CKM_DES_OFB8 | ✓ | | | | | | |
| CKM_DES_CFB64 | ✓ | | | | | | |

| Mechanism | Functions | | | | | | |
|--------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_DES_CFB8 | ✓ | | | | | | |

3615

3616 Cipher DES has a output feedback mode, DES-OFB, denoted **CKM_DES_OFB8** and
3617 **CKM_DES_OFB64**. It is a mechanism for single and multiple-part encryption and decryption with DES.

3618 It has a parameter, an initialization vector for this mode. The initialization vector has the same length as
3619 the block size.

3620 Constraints on key types and the length of data are summarized in the following table:

3621 *Table 98, OFB: Key And Data Length*

| Function | Key type | Input length | Output length | Comments |
|-----------|-----------------------------------|--------------|----------------------|---------------|
| C_Encrypt | CKK_DES, CKK_DES2, CKK_DES3 | any | same as input length | no final part |
| C_Decrypt | CKK_DES, CKK_DES2, CKK_DES3 | any | same as input length | no final part |

3622 For this mechanism the **CK_MECHANISM_INFO** structure is as specified for CBC mode.

3623 2.18.8 DES and Triple length DES in CFB Mode

3624 Cipher DES has a cipher feedback mode, DES-CFB, denoted **CKM_DES_CFB8** and **CKM_DES_CFB64**.
3625 It is a mechanism for single and multiple-part encryption and decryption with DES.

3626 It has a parameter, an initialization vector for this mode. The initialization vector has the same length as
3627 the block size.

3628 Constraints on key types and the length of data are summarized in the following table:

3629 *Table 99, CFB: Key And Data Length*

| Function | Key type | Input length | Output length | Comments |
|-----------|-----------------------------------|--------------|----------------------|---------------|
| C_Encrypt | CKK_DES, CKK_DES2, CKK_DES3 | any | same as input length | no final part |
| C_Decrypt | CKK_DES, CKK_DES2, CKK_DES3 | any | same as input length | no final part |

3630 For this mechanism the **CK_MECHANISM_INFO** structure is as specified for CBC mode.

3631 2.19 Double and Triple-length DES CMAC

3632 *Table 100, Double and Triple-length DES CMAC Mechanisms vs. Functions*

| Mechanism | Functions | | | | | | |
|-----------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_DES3_CMAC_GENERAL | | ✓ | | | | | |
| CKM_DES3_CMAC | | ✓ | | | | | |

¹ SR = SignRecover, VR = VerifyRecover.

2.19.1 Definitions

Mechanisms:

CKM_DES3_CMAC_GENERAL

CKM_DES3_CMAC

2.19.2 Mechanism parameters

CKM_DES3_CMAC_GENERAL uses the existing **CK_MAC_GENERAL_PARAMS** structure.

CKM_DES3_CMAC does not use a mechanism parameter.

2.19.3 General-length DES3-MAC

General-length DES3-CMAC, denoted **CKM_DES3_CMAC_GENERAL**, is a mechanism for single- and multiple-part signatures and verification with DES3 or DES2 keys, based on [NIST sp800-38b].

It has a parameter, a **CK_MAC_GENERAL_PARAMS** structure, which specifies the output length desired from the mechanism.

The output bytes from this mechanism are taken from the start of the final DES3 cipher block produced in the MACing process.

Constraints on key types and the length of data are summarized in the following table:

Table 101, General-length DES3-CMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------------------|-------------|--|
| C_Sign | CKK_DES3 CKK_DES2 | any | 1-block size, as specified in parameters |
| C_Verify | CKK_DES3 CKK_DES2 | any | 1-block size, as specified in parameters |

Reference [NIST sp800-38b] recommends that the output MAC is not truncated to less than 64 bits (which means using the entire block for DES). The MAC length must be specified before the communication starts, and must not be changed during the lifetime of the key. It is the caller's responsibility to follow these rules.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure are not used

2.19.4 DES3-CMAC

DES3-CMAC, denoted **CKM_DES3_CMAC**, is a special case of the general-length DES3-CMAC mechanism. DES3-MAC always produces and verifies MACs that are a full block size in length, since the DES3 block length is the minimum output length recommended by [NIST sp800-38b].

Constraints on key types and the length of data are summarized in the following table:

3661 Table 102, DES3-CMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------------------|-------------|----------------------|
| C_Sign | CKK_DES3 CKK_DES2 | any | Block size (8 bytes) |
| C_Verify | CKK_DES3 CKK_DES2 | any | Block size (8 bytes) |

3662 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
3663 are not used.

3664 2.20 SHA-1

3665 Table 103, SHA-1 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA_1 | | | | ✓ | | | |
| CKM_SHA_1_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA_1_HMAC | | ✓ | | | | | |
| CKM_SHA1_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA_1_KEY_GEN | | | | | ✓ | | |

3666 2.20.1 Definitions

3667 This section defines the key type “CKK_SHA_1_HMAC” for type CK_KEY_TYPE as used in the
3668 CKA_KEY_TYPE attribute of key objects.

3669 Mechanisms:

3670 CKM_SHA_1
3671 CKM_SHA_1_HMAC
3672 CKM_SHA_1_HMAC_GENERAL
3673 CKM_SHA1_KEY_DERIVATION
3674 CKM_SHA_1_KEY_GEN

3675

3676 2.20.2 SHA-1 digest

3677 The SHA-1 mechanism, denoted **CKM_SHA_1**, is a mechanism for message digesting, following the
3678 Secure Hash Algorithm with a 160-bit message digest defined in FIPS PUB 180-2.

3679 It does not have a parameter.

3680 Constraints on the length of input and output data are summarized in the following table. For single-part
3681 digesting, the data and the digest may begin at the same location in memory.

Table 104, SHA-1: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 20 |

2.20.3 General-length SHA-1-HMAC

The general-length SHA-1-HMAC mechanism, denoted **CKM_SHA_1_HMAC_GENERAL**, is a mechanism for signatures and verification. It uses the HMAC construction, based on the SHA-1 hash function. The keys it uses are generic secret keys and **CKK_SHA_1_HMAC**.

It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which holds the length in bytes of the desired output. This length should be in the range 1-20 (the output size of SHA-1 is 20 bytes). Signatures (MACs) produced by this mechanism will be taken from the start of the full 20-byte HMAC output.

Table 105, General-length SHA-1-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|---|-------------|-------------------------------|
| C_Sign | generic secret CKK_SHA_1_HMAC | any | 1-20, depending on parameters |
| C_Verify | generic secret CKK_SHA_1_HMAC | any | 1-20, depending on parameters |

2.20.4 SHA-1-HMAC

The SHA-1-HMAC mechanism, denoted **CKM_SHA_1_HMAC**, is a special case of the general-length SHA-1-HMAC mechanism in Section 2.20.3.

It has no parameter, and always produces an output of length 20.

2.20.5 SHA-1 key derivation

SHA-1 key derivation, denoted **CKM_SHA1_KEY_DERIVATION**, is a mechanism which provides the capability of deriving a secret key by digesting the value of another secret key with SHA-1.

The value of the base key is digested once, and the result is used to make the value of derived secret key.

- If no length or key type is provided in the template, then the key produced by this mechanism will be a generic secret key. Its length will be 20 bytes (the output size of SHA-1).
- If no key type is provided in the template, but a length is, then the key produced by this mechanism will be a generic secret key of the specified length.
- If no length was provided in the template, but a key type is, then that key type must have a well-defined length. If it does, then the key produced by this mechanism will be of the type specified in the template. If it doesn't, an error will be returned.
- If both a key type and a length are provided in the template, the length must be compatible with that key type. The key produced by this mechanism will be of the specified type and length.

If a DES, DES2, or CDMF key is derived with this mechanism, the parity bits of the key will be set properly.

If the requested type of key requires more than 20 bytes, such as DES3, an error is generated.

This mechanism has the following rules about key sensitivity and extractability:

- The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some default value.

- If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_FALSE, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.
- Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_FALSE, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_TRUE, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

2.20.6 SHA-1 HMAC key generation

The SHA-1-HMAC key generation mechanism, denoted **CKM_SHA_1_KEY_GEN**, is a key generation mechanism for NIST's SHA-1-HMAC.

It does not have a parameter.

The mechanism generates SHA-1-HMAC keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the SHA-1-HMAC key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of **CKM_SHA_1_HMAC** key sizes, in bytes.

2.21 SHA-224

Table 106, SHA-224 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---------------------------|-------------------|---------------|----------------------|--------|-------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA224 | | | | ✓ | | | |
| CKM_SHA224_HMAC | | ✓ | | | | | |
| CKM_SHA224_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA224_RSA_PKCS | | ✓ | | | | | |
| CKM_SHA224_RSA_PKCS_PSS | | ✓ | | | | | |
| CKM_SHA224_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA224_KEY_GEN | | | | | ✓ | | |

2.21.1 Definitions

This section defines the key type "CKK_SHA224_HMAC" for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

Mechanisms:

CKM_SHA224

CKM_SHA224_HMAC

CKM_SHA224_HMAC_GENERAL

CKM_SHA224_KEY_DERIVATION

CKM_SHA224_KEY_GEN

2.21.2 SHA-224 digest

The SHA-224 mechanism, denoted **CKM_SHA224**, is a mechanism for message digesting, following the Secure Hash Algorithm with a 224-bit message digest defined in 0.

It does not have a parameter.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

Table 107, SHA-224: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 28 |

2.21.3 General-length SHA-224-HMAC

The general-length SHA-224-HMAC mechanism, denoted **CKM_SHA224_HMAC_GENERAL**, is the same as the general-length SHA-1-HMAC mechanism except that it uses the HMAC construction based on the SHA-224 hash function and length of the output should be in the range 1-28. The keys it uses are generic secret keys and **CKK_SHA224_HMAC**. FIPS-198 compliant tokens may require the key length to be at least 14 bytes; that is, half the size of the SHA-224 hash output.

It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which holds the length in bytes of the desired output. This length should be in the range 1-28 (the output size of SHA-224 is 28 bytes). FIPS-198 compliant tokens may constrain the output length to be at least 4 or 14 (half the maximum length). Signatures (MACs) produced by this mechanism will be taken from the start of the full 28-byte HMAC output.

Table 108, General-length SHA-224-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|--|-------------|-------------------------------|
| C_Sign | generic secret CKK_SHA224_HMAC | Any | 1-28, depending on parameters |
| C_Verify | generic secret CKK_SHA224_HMAC | Any | 1-28, depending on parameters |

2.21.4 SHA-224-HMAC

The SHA-224-HMAC mechanism, denoted **CKM_SHA224_HMAC**, is a special case of the general-length SHA-224-HMAC mechanism.

It has no parameter, and always produces an output of length 28.

2.21.5 SHA-224 key derivation

SHA-224 key derivation, denoted **CKM_SHA224_KEY_DERIVATION**, is the same as the SHA-1 key derivation mechanism in Section 12.21.5 except that it uses the SHA-224 hash function and the relevant length is 28 bytes.

2.21.6 SHA-224 HMAC key generation

The SHA-224-HMAC key generation mechanism, denoted **CKM_SHA224_KEY_GEN**, is a key generation mechanism for NIST's SHA224-HMAC.

It does not have a parameter.

The mechanism generates SHA224-HMAC keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the SHA224-HMAC key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of **CKM_SHA224_HMAC** key sizes, in bytes.

2.22 SHA-256

Table 109, SHA-256 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA256 | | | | ✓ | | | |
| CKM_SHA256_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA256_HMAC | | ✓ | | | | | |
| CKM_SHA256_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA256_KEY_GEN | | | | | ✓ | | |

2.22.1 Definitions

This section defines the key type “CKK_SHA256_HMAC” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

Mechanisms:

CKM_SHA256

CKM_SHA256_HMAC

CKM_SHA256_HMAC_GENERAL

CKM_SHA256_KEY_DERIVATION

CKM_SHA256_KEY_GEN

2.22.2 SHA-256 digest

The SHA-256 mechanism, denoted **CKM_SHA256**, is a mechanism for message digesting, following the Secure Hash Algorithm with a 256-bit message digest defined in FIPS PUB 180-2.

It does not have a parameter.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

Table 110, SHA-256: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 32 |

2.22.3 General-length SHA-256-HMAC

The general-length SHA-256-HMAC mechanism, denoted **CKM_SHA256_HMAC_GENERAL**, is the same as the general-length SHA-1-HMAC mechanism in Section 2.20.3, except that it uses the HMAC construction based on the SHA-256 hash function and length of the output should be in the range 1-32. The keys it uses are generic secret keys and CKK_SHA256_HMAC. FIPS-198 compliant tokens may require the key length to be at least 16 bytes; that is, half the size of the SHA-256 hash output.

It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which holds the length in bytes of the desired output. This length should be in the range 1-32 (the output size of SHA-256 is 32 bytes). FIPS-198 compliant tokens may constrain the output length to be at least 4 or 16 (half the maximum length). Signatures (MACs) produced by this mechanism will be taken from the start of the full 32-byte HMAC output.

Table 111, General-length SHA-256-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|------------------------------------|-------------|-------------------------------|
| C_Sign | generic secret, CKK_SHA256_HMAC | Any | 1-32, depending on parameters |
| C_Verify | generic secret, CKK_SHA256_HMAC | Any | 1-32, depending on parameters |

2.22.4 SHA-256-HMAC

The SHA-256-HMAC mechanism, denoted **CKM_SHA256_HMAC**, is a special case of the general-length SHA-256-HMAC mechanism in Section 2.22.3.

It has no parameter, and always produces an output of length 32.

2.22.5 SHA-256 key derivation

SHA-256 key derivation, denoted **CKM_SHA256_KEY_DERIVATION**, is the same as the SHA-1 key derivation mechanism in Section 2.20.5, except that it uses the SHA-256 hash function and the relevant length is 32 bytes.

2.22.6 SHA-256 HMAC key generation

The SHA-256-HMAC key generation mechanism, denoted **CKM_SHA256_KEY_GEN**, is a key generation mechanism for NIST's SHA256-HMAC.

It does not have a parameter.

The mechanism generates SHA256-HMAC keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the SHA256-HMAC key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of **CKM_SHA256_HMAC** key sizes, in bytes.

2.23 SHA-384

Table 112, SHA-384 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-------------------------|-------------------|---------------|----------------------|--------|--------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA384 | | | | ✓ | | | |
| CKM_SHA384_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA384_HMAC | | ✓ | | | | | |

| Mechanism | Functions | | | | | | |
|---------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA384_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA384_KEY_GEN | | | | | ✓ | | |

2.23.1 Definitions

This section defines the key type “CKK_SHA384_HMAC” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

CKM_SHA384

CKM_SHA384_HMAC

CKM_SHA384_HMAC_GENERAL

CKM_SHA384_KEY_DERIVATION

CKM_SHA384_KEY_GEN

2.23.2 SHA-384 digest

The SHA-384 mechanism, denoted **CKM_SHA384**, is a mechanism for message digesting, following the Secure Hash Algorithm with a 384-bit message digest defined in FIPS PUB 180-2.

It does not have a parameter.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

Table 113, SHA-384: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 48 |

2.23.3 General-length SHA-384-HMAC

The general-length SHA-384-HMAC mechanism, denoted **CKM_SHA384_HMAC_GENERAL**, is the same as the general-length SHA-1-HMAC mechanism in Section 2.20.3, except that it uses the HMAC construction based on the SHA-384 hash function and length of the output should be in the range 1-48.

The keys it uses are generic secret keys and CKK_SHA384_HMAC. FIPS-198 compliant tokens may require the key length to be at least 24 bytes; that is, half the size of the SHA-384 hash output.

It has a parameter, a CK_MAC_GENERAL_PARAMS, which holds the length in bytes of the desired output. This length should be in the range 0-48 (the output size of SHA-384 is 48 bytes). FIPS-198 compliant tokens may constrain the output length to be at least 4 or 24 (half the maximum length). Signatures (MACs) produced by this mechanism will be taken from the start of the full 48-byte HMAC output.

Table 114, General-length SHA-384-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|--|-------------|-------------------------------|
| C_Sign | generic secret, CKK_SHA384_ HMAC | Any | 1-48, depending on parameters |
| C_Verify | generic secret, CKK_SHA384_ HMAC | Any | 1-48, depending on parameters |

2.23.4 SHA-384-HMAC

The SHA-384-HMAC mechanism, denoted **CKM_SHA384_HMAC**, is a special case of the general-length SHA-384-HMAC mechanism.

It has no parameter, and always produces an output of length 48.

2.23.5 SHA-384 key derivation

SHA-384 key derivation, denoted **CKM_SHA384_KEY_DERIVATION**, is the same as the SHA-1 key derivation mechanism in Section 2.20.5, except that it uses the SHA-384 hash function and the relevant length is 48 bytes.

2.23.6 SHA-384 HMAC key generation

The SHA-384-HMAC key generation mechanism, denoted **CKM_SHA384_KEY_GEN**, is a key generation mechanism for NIST's SHA384-HMAC.

It does not have a parameter.

The mechanism generates SHA384-HMAC keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the SHA384-HMAC key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of **CKM_SHA384_HMAC** key sizes, in bytes.

2.24 SHA-512

Table 115, SHA-512 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA512 | | | | ✓ | | | |
| CKM_SHA512_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA512_HMAC | | ✓ | | | | | |
| CKM_SHA512_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA512_KEY_GEN | | | | | ✓ | | |

2.24.1 Definitions

This section defines the key type “CKK_SHA512_HMAC” for type CK_KEY_TYPE as used in the CK_A_KEY_TYPE attribute of key objects.

Mechanisms:

CKM_SHA512
CKM_SHA512_HMAC
CKM_SHA512_HMAC_GENERAL
CKM_SHA512_KEY_DERIVATION
CKM_SHA512_KEY_GEN

2.24.2 SHA-512 digest

The SHA-512 mechanism, denoted **CKM_SHA512**, is a mechanism for message digesting, following the Secure Hash Algorithm with a 512-bit message digest defined in FIPS PUB 180-2.

It does not have a parameter.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

Table 116, SHA-512: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 64 |

2.24.3 General-length SHA-512-HMAC

The general-length SHA-512-HMAC mechanism, denoted **CKM_SHA512_HMAC_GENERAL**, is the same as the general-length SHA-1-HMAC mechanism in Section 2.20.3, except that it uses the HMAC construction based on the SHA-512 hash function and length of the output should be in the range 1-64.

The keys it uses are generic secret keys and CKK_SHA512_HMAC. FIPS-198 compliant tokens may require the key length to be at least 32 bytes; that is, half the size of the SHA-512 hash output.

It has a parameter, a CK_MAC_GENERAL_PARAMS, which holds the length in bytes of the desired output. This length should be in the range 0-64 (the output size of SHA-512 is 64 bytes). FIPS-198 compliant tokens may constrain the output length to be at least 4 or 32 (half the maximum length). Signatures (MACs) produced by this mechanism will be taken from the start of the full 64-byte HMAC output.

Table 117, General-length SHA-384-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|------------------------------------|-------------|-------------------------------|
| C_Sign | generic secret, CKK_SHA512_HMAC | Any | 1-64, depending on parameters |
| C_Verify | generic secret, CKK_SHA512_HMAC | Any | 1-64, depending on parameters |

2.24.4 SHA-512-HMAC

The SHA-512-HMAC mechanism, denoted **CKM_SHA512_HMAC**, is a special case of the general-length SHA-512-HMAC mechanism.

It has no parameter, and always produces an output of length 64.

2.24.5 SHA-512 key derivation

SHA-512 key derivation, denoted **CKM_SHA512_KEY_DERIVATION**, is the same as the SHA-1 key derivation mechanism in Section 2.20.5, except that it uses the SHA-512 hash function and the relevant length is 64 bytes.

2.24.6 SHA-512 HMAC key generation

The SHA-512-HMAC key generation mechanism, denoted **CKM_SHA512_KEY_GEN**, is a key generation mechanism for NIST's SHA512-HMAC.

It does not have a parameter.

The mechanism generates SHA512-HMAC keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the SHA512-HMAC key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of **CKM_SHA512_HMAC** key sizes, in bytes.

2.25 SHA-512/224

Table 118, SHA-512/224 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-------------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA512_224 | | | | ✓ | | | |
| CKM_SHA512_224_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA512_224_HMAC | | ✓ | | | | | |
| CKM_SHA512_224_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA512_224_KEY_GEN | | | | | ✓ | | |

2.25.1 Definitions

This section defines the key type "CKK_SHA512_224_HMAC" for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

Mechanisms:

CKM_SHA512_224

CKM_SHA512_224_HMAC

CKM_SHA512_224_HMAC_GENERAL

CKM_SHA512_224_KEY_DERIVATION

CKM_SHA512_224_KEY_GEN

2.25.2 SHA-512/224 digest

The SHA-512/224 mechanism, denoted **CKM_SHA512_224**, is a mechanism for message digesting, following the Secure Hash Algorithm defined in FIPS PUB 180-4, section 5.3.6. It is based on a 512-bit

message digest with a distinct initial hash value and truncated to 224 bits. **CKM_SHA512_224** is the same as **CKM_SHA512_T** with a parameter value of 224.

It does not have a parameter.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

Table 119, SHA-512/224: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 28 |

2.25.3 General-length SHA-512/224-HMAC

The general-length SHA-512/224-HMAC mechanism, denoted **CKM_SHA512_224_HMAC_GENERAL**, is the same as the general-length SHA-1-HMAC mechanism in Section 2.20.3, except that it uses the HMAC construction based on the SHA-512/224 hash function and length of the output should be in the range 1-28. The keys it uses are generic secret keys and **CKK_SHA512_224_HMAC**. FIPS-198 compliant tokens may require the key length to be at least 14 bytes; that is, half the size of the SHA-512/224 hash output.

It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which holds the length in bytes of the desired output. This length should be in the range 0-28 (the output size of SHA-512/224 is 28 bytes). FIPS-198 compliant tokens may constrain the output length to be at least 4 or 14 (half the maximum length). Signatures (MACs) produced by this mechanism will be taken from the start of the full 28-byte HMAC output.

Table 120, General-length SHA-384-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|---|-------------|-------------------------------|
| C_Sign | generic secret, CKK_SHA512_224_HMAC | Any | 1-28, depending on parameters |
| C_Verify | generic secret, CKK_SHA512_224_HMAC | Any | 1-28, depending on parameters |

2.25.4 SHA-512/224-HMAC

The SHA-512-HMAC mechanism, denoted **CKM_SHA512_224_HMAC**, is a special case of the general-length SHA-512/224-HMAC mechanism.

It has no parameter, and always produces an output of length 28.

2.25.5 SHA-512/224 key derivation

The SHA-512/224 key derivation, denoted **CKM_SHA512_224_KEY_DERIVATION**, is the same as the SHA-512 key derivation mechanism in section 2.25.5, except that it uses the SHA-512/224 hash function and the relevant length is 28 bytes.

2.25.6 SHA-512/224 HMAC key generation

The SHA-512/224-HMAC key generation mechanism, denoted **CKM_SHA512_224_KEY_GEN**, is a key generation mechanism for NIST's SHA512/224-HMAC.

It does not have a parameter.

The mechanism generates SHA512/224-HMAC keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

3985 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
 3986 key. Other attributes supported by the SHA512/224-HMAC key type (specifically, the flags indicating
 3987 which functions the key supports) may be specified in the template for the key, or else are assigned
 3988 default initial values.

3989 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
 3990 specify the supported range of **CKM_SHA512_224_HMAC** key sizes, in bytes.

3991 2.26 SHA-512/256

3992 Table 121, SHA-512/256 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-------------------------------|---------------------------------|-------------------------|--------------------|------------|-----------------------------|-------------------------|------------|
| | Encryp t & Decryp t | Sign & Verif y | SR & VR 1 | Diges t | Gen. Key/ Key Pair | Wrap & Unwra p | Deriv e |
| CKM_SHA512_256 | | | | ✓ | | | |
| CKM_SHA512_256_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA512_256_HMAC | | ✓ | | | | | |
| CKM_SHA512_256_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA512_256_KEY_GEN | | | | | ✓ | | |

3993 2.26.1 Definitions

3994 This section defines the key type “CKK_SHA512_256_HMAC” for type CK_KEY_TYPE as used in the
 3995 CKA_KEY_TYPE attribute of key objects.

3996 Mechanisms:

- 3997 CKM_SHA512_256
- 3998 CKM_SHA512_256_HMAC
- 3999 CKM_SHA512_256_HMAC_GENERAL
- 4000 CKM_SHA512_256_KEY_DERIVATION
- 4001 CKM_SHA512_256_KEY_GEN

4002 2.26.2 SHA-512/256 digest

4003 The SHA-512/256 mechanism, denoted **CKM_SHA512_256**, is a mechanism for message digesting,
 4004 following the Secure Hash Algorithm defined in FIPS PUB 180-4, section 5.3.6. It is based on a 512-bit
 4005 message digest with a distinct initial hash value and truncated to 256 bits. **CKM_SHA512_256** is the
 4006 same as **CKM_SHA512_T** with a parameter value of 256.

4007 It does not have a parameter.

4008 Constraints on the length of input and output data are summarized in the following table. For single-part
 4009 digesting, the data and the digest may begin at the same location in memory.

Table 122, SHA-512/256: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 32 |

2.26.3 General-length SHA-512/256-HMAC

The general-length SHA-512/256-HMAC mechanism, denoted **CKM_SHA512_256_HMAC_GENERAL**, is the same as the general-length SHA-1-HMAC mechanism in Section 2.20.3, except that it uses the HMAC construction based on the SHA-512/256 hash function and length of the output should be in the range 1-32. The keys it uses are generic secret keys and **CKK_SHA512_256_HMAC**. FIPS-198 compliant tokens may require the key length to be at least 16 bytes; that is, half the size of the SHA-512/256 hash output.

It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which holds the length in bytes of the desired output. This length should be in the range 1-32 (the output size of SHA-512/256 is 32 bytes). FIPS-198 compliant tokens may constrain the output length to be at least 4 or 16 (half the maximum length). Signatures (MACs) produced by this mechanism will be taken from the start of the full 32-byte HMAC output.

Table 123, General-length SHA-384-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|---|-------------|-------------------------------|
| C_Sign | generic secret, CKK_SHA512_256_HMAC | Any | 1-32, depending on parameters |
| C_Verify | generic secret, CKK_SHA512_256_HMAC | Any | 1-32, depending on parameters |

2.26.4 SHA-512/256-HMAC

The SHA-512-HMAC mechanism, denoted **CKM_SHA512_256_HMAC**, is a special case of the general-length SHA-512/256-HMAC mechanism.

It has no parameter, and always produces an output of length 32.

2.26.5 SHA-512/256 key derivation

The SHA-512/256 key derivation, denoted **CKM_SHA512_256_KEY_DERIVATION**, is the same as the SHA-512 key derivation mechanism in section 2.25.5, except that it uses the SHA-512/256 hash function and the relevant length is 32 bytes.

2.26.6 SHA-512/256 HMAC key generation

The SHA-512/256-HMAC key generation mechanism, denoted **CKM_SHA512_256_KEY_GEN**, is a key generation mechanism for NIST's SHA512/256-HMAC.

It does not have a parameter.

The mechanism generates SHA512/256-HMAC keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the SHA512/256-HMAC key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of **CKM_SHA512_256_HMAC** key sizes, in bytes.

2.27 SHA-512/t

Table 124, SHA-512 / t Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-----------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA512_T | | | | ✓ | | | |
| CKM_SHA512_T_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA512_T_HMAC | | ✓ | | | | | |
| CKM_SHA512_T_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA512_T_KEY_GEN | | | | | ✓ | | |

2.27.1 Definitions

This section defines the key type “CKK_SHA512_T_HMAC” for type CK_KEY_TYPE as used in the CK_A_KEY_TYPE attribute of key objects.

Mechanisms:

- CKM_SHA512_T
- CKM_SHA512_T_HMAC
- CKM_SHA512_T_HMAC_GENERAL
- CKM_SHA512_T_KEY_DERIVATION
- CKM_SHA512_T_KEY_GEN

2.27.2 SHA-512/t digest

The SHA-512/t mechanism, denoted **CKM_SHA512_T**, is a mechanism for message digesting, following the Secure Hash Algorithm defined in FIPS PUB 180-4, section 5.3.6. It is based on a 512-bit message digest with a distinct initial hash value and truncated to t bits.

It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which holds the value of t in bits. The length in bytes of the desired output should be in the range of $0 \leq \lceil t/8 \rceil$, where $0 < t < 512$, and $t \neq 384$.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

Table 125, SHA-512/256: Data Length

| Function | Input length | Digest length |
|----------|--------------|--|
| C_Digest | any | $\lceil t/8 \rceil$, where $0 < t < 512$, and $t \neq 384$ |

2.27.3 General-length SHA-512/t-HMAC

The general-length SHA-512/t-HMAC mechanism, denoted **CKM_SHA512_T_HMAC_GENERAL**, is the same as the general-length SHA-1-HMAC mechanism in Section 2.20.3, except that it uses the HMAC construction based on the SHA-512/t hash function and length of the output should be in the range $0 \leq \lceil t/8 \rceil$, where $0 < t < 512$, and $t \neq 384$.

2.27.4 SHA-512/t-HMAC

The SHA-512/t-HMAC mechanism, denoted **CKM_SHA512_T_HMAC**, is a special case of the general-length SHA-512/t-HMAC mechanism.

It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which holds the value of t in bits. The length in bytes of the desired output should be in the range of $0 \leq t/8 \leq 384$, where $0 < t < 512$, and $t \neq 384$.

2.27.5 SHA-512/t key derivation

The SHA-512/t key derivation, denoted **CKM_SHA512_T_KEY_DERIVATION**, is the same as the SHA-512 key derivation mechanism in section 2.25.5, except that it uses the SHA-512/t hash function and the relevant length is $\lceil t/8 \rceil$ bytes, where $0 < t < 512$, and $t \neq 384$.

2.27.6 SHA-512/t HMAC key generation

The SHA-512/t-HMAC key generation mechanism, denoted **CKM_SHA512_T_KEY_GEN**, is a key generation mechanism for NIST's SHA512/t-HMAC.

It does not have a parameter.

The mechanism generates SHA512/t-HMAC keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the SHA512/t-HMAC key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of **CKM_SHA512_T_HMAC** key sizes, in bytes.

2.28 SHA3-224

Table 126, SHA-224 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-----------------------------|-------------------------|-------------------------|----------------------------|------------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verif y | SR & VR ¹ | Diges t | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA3_224 | | | | ✓ | | | |
| CKM_SHA3_224_HMAC | | ✓ | | | | | |
| CKM_SHA3_224_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA3_224_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA3_224_KEY_GEN | | | | | ✓ | | |

2.28.1 Definitions

Mechanisms:

CKM_SHA3_224

CKM_SHA3_224_HMAC

CKM_SHA3_224_HMAC_GENERAL

CKM_SHA3_224_KEY_DERIVATION

4100 CKM_SHA3_224_KEY_GEN

4101

4102 CKK_SHA3_224_HMAC

4103 2.28.2 SHA3-224 digest

4104 The SHA3-224 mechanism, denoted **CKM_SHA3_224**, is a mechanism for message digesting, following
4105 the Secure Hash 3 Algorithm with a 224-bit message digest defined in FIPS Pub 202.

4106 It does not have a parameter.

4107 Constraints on the length of input and output data are summarized in the following table. For single-part
4108 digesting, the data and the digest may begin at the same location in memory.

4109 *Table 127, SHA3-224: Data Length*

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 28 |

4110 2.28.3 General-length SHA3-224-HMAC

4111 The general-length SHA3-224-HMAC mechanism, denoted **CKM_SHA3_224_HMAC_GENERAL**, is the
4112 same as the general-length SHA-1-HMAC mechanism in section 2.20.4 except that it uses the HMAC
4113 construction based on the SHA3-224 hash function and length of the output should be in the range 1-28.
4114 The keys it uses are generic secret keys and CKK_SHA3_224_HMAC. FIPS-198 compliant tokens may
4115 require the key length to be at least 14 bytes; that is, half the size of the SHA3-224 hash output.

4116 It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which holds the length in bytes of the desired
4117 output. This length should be in the range 1-28 (the output size of SHA3-224 is 28 bytes). FIPS-198
4118 compliant tokens may constrain the output length to be at least 4 or 14 (half the maximum length).
4119 Signatures (MACs) produced by this mechanism shall be taken from the start of the full 28-byte HMAC
4120 output.

4121 *Table 128, General-length SHA3-224-HMAC: Key And Data Length*

| Function | Key type | Data length | Signature length |
|----------|--|-------------|-------------------------------|
| C_Sign | generic secret or CKK_SHA3_224_HMAC | Any | 1-28, depending on parameters |
| C_Verify | generic secret or CKK_SHA3_224_HMAC | Any | 1-28, depending on parameters |

4122 2.28.4 SHA3-224-HMAC

4123 The SHA3-224-HMAC mechanism, denoted **CKM_SHA3_224_HMAC**, is a special case of the general-
4124 length SHA3-224-HMAC mechanism.

4125 It has no parameter, and always produces an output of length 28.

4126 2.28.5 SHA3-224 key derivation

4127 SHA-224 key derivation, denoted **CKM_SHA3_224_KEY_DERIVATION**, is the same as the SHA-1 key
4128 derivation mechanism in Section 2.20.5 except that it uses the SHA3-224 hash function and the relevant
4129 length is 28 bytes.

4130 2.28.6 SHA3-224 HMAC key generation

4131 The SHA3-224-HMAC key generation mechanism, denoted **CKM_SHA3_224_KEY_GEN**, is a key
4132 generation mechanism for NIST's SHA3-224-HMAC.

4133 It does not have a parameter.

4134 The mechanism generates SHA3-224-HMAC keys with a particular length in bytes, as specified in the
 4135 **CKA_VALUE_LEN** attribute of the template for the key.

4136 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
 4137 key. Other attributes supported by the SHA3-224-HMAC key type (specifically, the flags indicating which
 4138 functions the key supports) may be specified in the template for the key, or else are assigned default
 4139 initial values.

4140 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
 4141 specify the supported range of **CKM_SHA3_224_HMAC** key sizes, in bytes.

4142 2.29 SHA3-256

4143 Table 129, SHA3-256 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-----------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA3_256 | | | | ✓ | | | |
| CKM_SHA3_256_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA3_256_HMAC | | ✓ | | | | | |
| CKM_SHA3_256_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA3_256_KEY_GEN | | | | | ✓ | | |

4144 2.29.1 Definitions

4145 Mechanisms:

4146 CKM_SHA3_256
 4147 CKM_SHA3_256_HMAC
 4148 CKM_SHA3_256_HMAC_GENERAL
 4149 CKM_SHA3_256_KEY_DERIVATION
 4150 CKM_SHA3_256_KEY_GEN
 4151
 4152 CKK_SHA3_256_HMAC

4153 2.29.2 SHA3-256 digest

4154 The SHA3-256 mechanism, denoted **CKM_SHA3_256**, is a mechanism for message digesting, following
 4155 the Secure Hash 3 Algorithm with a 256-bit message digest defined in FIPS PUB 202.

4156 It does not have a parameter.

4157 Constraints on the length of input and output data are summarized in the following table. For single-part
 4158 digesting, the data and the digest may begin at the same location in memory.

Table 130, SHA3-256: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 32 |

2.29.3 General-length SHA3-256-HMAC

The general-length SHA3-256-HMAC mechanism, denoted **CKM_SHA3_256_HMAC_GENERAL**, is the same as the general-length SHA-1-HMAC mechanism in Section 2.20.4, except that it uses the HMAC construction based on the SHA3-256 hash function and length of the output should be in the range 1-32. The keys it uses are generic secret keys and **CKK_SHA3_256_HMAC**. FIPS-198 compliant tokens may require the key length to be at least 16 bytes; that is, half the size of the SHA3-256 hash output.

It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which holds the length in bytes of the desired output. This length should be in the range 1-32 (the output size of SHA3-256 is 32 bytes). FIPS-198 compliant tokens may constrain the output length to be at least 4 or 16 (half the maximum length). Signatures (MACs) produced by this mechanism shall be taken from the start of the full 32-byte HMAC output.

Table 131, General-length SHA3-256-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|---|-------------|-------------------------------|
| C_Sign | generic secret or CKK_SHA3_256_HMAC | Any | 1-32, depending on parameters |
| C_Verify | generic secret or CKK_SHA3_256_HMAC | Any | 1-32, depending on parameters |

2.29.4 SHA3-256-HMAC

The SHA-256-HMAC mechanism, denoted **CKM_SHA3_256_HMAC**, is a special case of the general-length SHA-256-HMAC mechanism in Section 2.22.3.

It has no parameter, and always produces an output of length 32.

2.29.5 SHA3-256 key derivation

SHA-256 key derivation, denoted **CKM_SHA3_256_KEY_DERIVATION**, is the same as the SHA-1 key derivation mechanism in Section 2.20.5, except that it uses the SHA3-256 hash function and the relevant length is 32 bytes.

2.29.6 SHA3-256 HMAC key generation

The SHA3-256-HMAC key generation mechanism, denoted **CKM_SHA3_256_KEY_GEN**, is a key generation mechanism for NIST's SHA3-256-HMAC.

It does not have a parameter.

The mechanism generates SHA3-256-HMAC keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the SHA3-256-HMAC key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of **CKM_SHA3_256_HMAC** key sizes, in bytes.

2.30 SHA3-384

Table 132, SHA3-384 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-----------------------------|-------------------------|-------------------------|----------------------------|------------|-----------------------------|-------------------------|--------|
| | Encrypt & Decrypt | Sign & Verif y | SR & VR ¹ | Diges t | Gen. Key/ Key Pair | Wrap & Unwra p | Derive |
| CKM_SHA3_384 | | | | ✓ | | | |
| CKM_SHA3_384_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA3_384_HMAC | | ✓ | | | | | |
| CKM_SHA3_384_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA3_384_KEY_GEN | | | | ✓ | | | |

2.30.1 Definitions

CKM_SHA3_384
CKM_SHA3_384_HMAC
CKM_SHA3_384_HMAC_GENERAL
CKM_SHA3_384_KEY_DERIVATION
CKM_SHA3_384_KEY_GEN
CKK_SHA3_384_HMAC

2.30.2 SHA3-384 digest

The SHA3-384 mechanism, denoted **CKM_SHA3_384**, is a mechanism for message digesting, following the Secure Hash 3 Algorithm with a 384-bit message digest defined in FIPS PUB 202.

It does not have a parameter.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

Table 133, SHA3-384: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 48 |

2.30.3 General-length SHA3-384-HMAC

The general-length SHA3-384-HMAC mechanism, denoted **CKM_SHA3_384_HMAC_GENERAL**, is the same as the general-length SHA-1-HMAC mechanism in Section 2.20.4, except that it uses the HMAC construction based on the SHA-384 hash function and length of the output should be in the range 1-48. The keys it uses are generic secret keys and CKK_SHA3_384_HMAC. FIPS-198 compliant tokens may require the key length to be at least 24 bytes; that is, half the size of the SHA3-384 hash output.

It has a parameter, a CK_MAC_GENERAL_PARAMS, which holds the length in bytes of the desired output. This length should be in the range 1-48 (the output size of SHA3-384 is 48 bytes). FIPS-198 compliant tokens may constrain the output length to be at least 4 or 24 (half the maximum length). Signatures (MACs) produced by this mechanism shall be taken from the start of the full 48-byte HMAC output.

4222 Table 134, General-length SHA3-384-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|--|-------------|-------------------------------|
| C_Sign | generic secret or CKK_SHA3_384_HMAC | Any | 1-48, depending on parameters |
| C_Verify | generic secret or CKK_SHA3_384_HMAC | Any | 1-48, depending on parameters |

4223

4224 2.30.4 SHA3-384-HMAC

4225 The SHA3-384-HMAC mechanism, denoted **CKM_SHA3_384_HMAC**, is a special case of the general-
4226 length SHA3-384-HMAC mechanism.

4227 It has no parameter, and always produces an output of length 48.

4228 2.30.5 SHA3-384 key derivation

4229 SHA3-384 key derivation, denoted **CKM_SHA3_384_KEY_DERIVATION**, is the same as the SHA-1 key
4230 derivation mechanism in Section 2.20.5, except that it uses the SHA-384 hash function and the relevant
4231 length is 48 bytes.

4232 2.30.6 SHA3-384 HMAC key generation

4233 The SHA3-384-HMAC key generation mechanism, denoted **CKM_SHA3_384_KEY_GEN**, is a key
4234 generation mechanism for NIST's SHA3-384-HMAC.

4235 It does not have a parameter.

4236 The mechanism generates SHA3-384-HMAC keys with a particular length in bytes, as specified in the
4237 **CKA_VALUE_LEN** attribute of the template for the key.

4238 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
4239 key. Other attributes supported by the SHA3-384-HMAC key type (specifically, the flags indicating which
4240 functions the key supports) may be specified in the template for the key, or else are assigned default
4241 initial values.

4242 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
4243 specify the supported range of **CKM_SHA3_384_HMAC** key sizes, in bytes.

4244 2.31 SHA3-512

4245 Table 135, SHA-512 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-----------------------------|-------------------------|---------------------|--------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR 1 | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHA3_512 | | | | ✓ | | | |
| CKM_SHA3_512_HMAC_GENERAL | | ✓ | | | | | |
| CKM_SHA3_512_HMAC | | ✓ | | | | | |
| CKM_SHA3_512_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHA3_512_KEY_GEN | | | | ✓ | | | |

2.31.1 Definitions

CKM_SHA3_512
CKM_SHA3_512_HMAC
CKM_SHA3_512_HMAC_GENERAL
CKM_SHA3_512_KEY_DERIVATION
CKM_SHA3_512_KEY_GEN
CKK_SHA3_512_HMAC

2.31.2 SHA3-512 digest

The SHA3-512 mechanism, denoted **CKM_SHA3_512**, is a mechanism for message digesting, following the Secure Hash 3 Algorithm with a 512-bit message digest defined in FIPS PUB 202.

It does not have a parameter.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

Table 136, SHA3-512: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 64 |

2.31.3 General-length SHA3-512-HMAC

The general-length SHA3-512-HMAC mechanism, denoted **CKM_SHA3_512_HMAC_GENERAL**, is the same as the general-length SHA-1-HMAC mechanism in Section 2.20.4, except that it uses the HMAC construction based on the SHA3-512 hash function and length of the output should be in the range 1-64. The keys it uses are generic secret keys and CKK_SHA3_512_HMAC. FIPS-198 compliant tokens may require the key length to be at least 32 bytes; that is, half the size of the SHA3-512 hash output.

It has a parameter, a CK_MAC_GENERAL_PARAMS, which holds the length in bytes of the desired output. This length should be in the range 1-64 (the output size of SHA3-512 is 64 bytes). FIPS-198 compliant tokens may constrain the output length to be at least 4 or 32 (half the maximum length). Signatures (MACs) produced by this mechanism shall be taken from the start of the full 64-byte HMAC output.

Table 137, General-length SHA3-512-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|-------------------------------------|-------------|-------------------------------|
| C_Sign | generic secret or CKK_SHA3_512_HMAC | Any | 1-64, depending on parameters |
| C_Verify | generic secret or CKK_SHA3_512_HMAC | Any | 1-64, depending on parameters |

2.31.4 SHA3-512-HMAC

The SHA3-512-HMAC mechanism, denoted **CKM_SHA3_512_HMAC**, is a special case of the general-length SHA3-512-HMAC mechanism.

It has no parameter, and always produces an output of length 64.

2.31.5 SHA3-512 key derivation

SHA3-512 key derivation, denoted **CKM_SHA3_512_KEY_DERIVATION**, is the same as the SHA-1 key derivation mechanism in Section 2.20.5, except that it uses the SHA-512 hash function and the relevant length is 64 bytes.

2.31.6 SHA3-512 HMAC key generation

The SHA3-512-HMAC key generation mechanism, denoted **CKM_SHA3_512_KEY_GEN**, is a key generation mechanism for NIST's SHA3-512-HMAC.

It does not have a parameter.

The mechanism generates SHA3-512-HMAC keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the SHA3-512-HMAC key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of **CKM_SHA3_512_HMAC** key sizes, in bytes.

2.32 SHAKE

Table 138, SHA-512 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|------------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SHAKE_128_KEY_DERIVATION | | | | | | | ✓ |
| CKM_SHAKE_256_KEY_DERIVATION | | | | | | | ✓ |

2.32.1 Definitions

CKM_SHAKE_128_KEY_DERIVATION

CKM_SHAKE_256_KEY_DERIVATION

2.32.2 SHAKE Key Derivation

SHAKE-128 and SHAKE-256 key derivation, denoted **CKM_SHAKE_128_KEY_DERIVATION** and **CKM_SHAKE_256_KEY_DERIVATION**, implements the SHAKE expansion function defined in FIPS 202 on the input key.

- If no length or key type is provided in the template a **CKR_TEMPLATE_INCOMPLETE** error is generated.
- If no key type is provided in the template, but a length is, then the key produced by this mechanism shall be a generic secret key of the specified length.
- If no length was provided in the template, but a key type is, then that key type must have a well-defined length. If it does, then the key produced by this mechanism shall be of the type specified in the template. If it doesn't, an error shall be returned.
- If both a key type and a length are provided in the template, the length must be compatible with that key type. The key produced by this mechanism shall be of the specified type and length.

If a DES, DES2, or CDMF key is derived with this mechanism, the parity bits of the key shall be set properly.

- 4315 This mechanism has the following rules about key sensitivity and extractability:
- 4316 • The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both
 - 4317 be specified to be either CK_TRUE or CK_FALSE. If omitted, these attributes each take on some
 - 4318 default value.
 - 4319 • If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_FALSE, then the derived key
 - 4320 shall as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE, then the
 - 4321 derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its
 - 4322 **CKA_SENSITIVE** attribute.
 - 4323 • Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_FALSE, then
 - 4324 the derived key shall, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to
 - 4325 CK_TRUE, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite*
 - 4326 value from its **CKA_EXTRACTABLE** attribute.

4327 2.33 Blake2b-160

4328 Table 139, Blake2b-160 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|------------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_BLAKE2B_160 | | | | ✓ | | | |
| CKM_BLAKE2B_160_HMAC | | ✓ | | | | | |
| CKM_BLAKE2B_160_HMAC_GENERAL | | ✓ | | | | | |
| CKM_BLAKE2B_160_KEY_DERIVE | | | | | | | ✓ |
| CKM_BLAKE2B_160_KEY_GEN | | | | | ✓ | | |

4329 2.33.1 Definitions

4330 Mechanisms:

- 4331 CKM_BLAKE2B_160
- 4332 CKM_BLAKE2B_160_HMAC
- 4333 CKM_BLAKE2B_160_HMAC_GENERAL
- 4334 CKM_BLAKE2B_160_KEY_DERIVE
- 4335 CKM_BLAKE2B_160_KEY_GEN
- 4336 CKK_BLAKE2B_160_HMAC

4337 2.33.2 BLAKE2B-160 digest

- 4338 The BLAKE2B-160 mechanism, denoted **CKM_BLAKE2B_160**, is a mechanism for message digesting,
- 4339 following the Blake2b Algorithm with a 160-bit message digest without a key as defined in [RFC 7693](#).
- 4340 It does not have a parameter.
- 4341 Constraints on the length of input and output data are summarized in the following table. For single-part
- 4342 digesting, the data and the digest may begin at the same location in memory.

4343 Table 140, BLAKE2B-160: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 20 |

4344 2.33.3 General-length BLAKE2B-160-HMAC

4345 The general-length BLAKE2B-160-HMAC mechanism, denoted
 4346 **CKM_BLAKE2B_160_HMAC_GENERAL**, is the keyed variant of BLAKE2b-160 and length of the output
 4347 should be in the range 1-20. The keys it uses are generic secret keys and CKK_BLAKE2B_160_HMAC.

4348 It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which holds the length in bytes of the desired
 4349 output. This length should be in the range 1-20 (the output size of BLAKE2B-160 is 20 bytes). Signatures
 4350 (MACs) produced by this mechanism shall be taken from the start of the full 20-byte HMAC output.

4351 Table 141, General-length BLAKE2B-160-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|---|-------------|-------------------------------|
| C_Sign | generic secret or CKK_BLAKE2B_160_H MAC | Any | 1-20, depending on parameters |
| C_Verify | generic secret or CKK_BLAKE2B_160_H MAC | Any | 1-20, depending on parameters |

4352 2.33.4 BLAKE2B-160-HMAC

4353 The BLAKE2B-160-HMAC mechanism, denoted **CKM_BLAKE2B_160_HMAC**, is a special case of the
 4354 general-length BLAKE2B-160-HMAC mechanism.

4355 It has no parameter, and always produces an output of length 20.

4356 2.33.5 BLAKE2B-160 key derivation

4357 BLAKE2B-160 key derivation, denoted **CKM_BLAKE2B_160_KEY_DERIVE**, is the same as the SHA-1
 4358 key derivation mechanism in Section 2.20.5 except that it uses the BLAKE2B-160 hash function and the
 4359 relevant length is 20 bytes.

4360 2.33.6 BLAKE2B-160 HMAC key generation

4361 The BLAKE2B-160-HMAC key generation mechanism, denoted **CKM_BLAKE2B_160_KEY_GEN**, is a
 4362 key generation mechanism for BLAKE2B-160-HMAC.

4363 It does not have a parameter.

4364 The mechanism generates BLAKE2B-160-HMAC keys with a particular length in bytes, as specified in the
 4365 **CKA_VALUE_LEN** attribute of the template for the key.

4366 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
 4367 key. Other attributes supported by the BLAKE2B-160-HMAC key type (specifically, the flags indicating
 4368 which functions the key supports) may be specified in the template for the key, or else are assigned
 4369 default initial values.

4370 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
 4371 specify the supported range of **CKM_BLAKE2B_160_HMAC** key sizes, in bytes.

4372 2.34 BLAKE2B-256

4373 Table 142, BLAKE2B-256 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|------------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_BLAKE2B_256 | | | | ✓ | | | |
| CKM_BLAKE2B_256_HMAC_GENERAL | | ✓ | | | | | |
| CKM_BLAKE2B_256_HMAC | | ✓ | | | | | |
| CKM_BLAKE2B_256_KEY_DERIVE | | | | | | | ✓ |
| CKM_BLAKE2B_256_KEY_GEN | | | | | ✓ | | |

2.34.1 Definitions

Mechanisms:

CKM_BLAKE2B_256
 CKM_BLAKE2B_256_HMAC
 CKM_BLAKE2B_256_HMAC_GENERAL
 CKM_BLAKE2B_256_KEY_DERIVE
 CKM_BLAKE2B_256_KEY_GEN
 CKM_BLAKE2B_256_HMAC

2.34.2 BLAKE2B-256 digest

The BLAKE2B-256 mechanism, denoted **CKM_BLAKE2B_256**, is a mechanism for message digesting, following the Blake2b Algorithm with a 256-bit message digest without a key as defined in RFC 7693.

It does not have a parameter.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

Table 143, BLAKE2B-256: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 32 |

2.34.3 General-length BLAKE2B-256-HMAC

The general-length BLAKE2B-256-HMAC mechanism, denoted **CKM_BLAKE2B_256_HMAC_GENERAL**, is the keyed variant of Blake2b-256 and length of the output should be in the range 1-32. The keys it uses are generic secret keys and CKM_BLAKE2B_256_HMAC.

It has a parameter, a CK_MAC_GENERAL_PARAMS, which holds the length in bytes of the desired output. This length should be in the range 1-32 (the output size of BLAKE2B-256 is 32 bytes). Signatures (MACs) produced by this mechanism shall be taken from the start of the full 32-byte HMAC output.

4396 Table 144, General-length BLAKE2B-256-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|---|-------------|-------------------------------|
| C_Sign | generic secret or CKK_BLAKE2B_256_HMAC | Any | 1-32, depending on parameters |
| C_Verify | generic secret or CKK_BLAKE2B_256_HMAC | Any | 1-32, depending on parameters |

4397 2.34.4 BLAKE2B-256-HMAC

4398 The BLAKE2B-256-HMAC mechanism, denoted **CKM_BLAKE2B_256_HMAC**, is a special case of the
4399 general-length BLAKE2B-256-HMAC mechanism in Section 2.22.3.

4400 It has no parameter, and always produces an output of length 32.

4401 2.34.5 BLAKE2B-256 key derivation

4402 BLAKE2B-256 key derivation, denoted **CKM_BLAKE2B_256_KEY_DERIVE**, is the same as the SHA-1
4403 key derivation mechanism in Section 2.20.5, except that it uses the BLAKE2B-256 hash function and the
4404 relevant length is 32 bytes.

4405 2.34.6 BLAKE2B-256 HMAC key generation

4406 The BLAKE2B-256-HMAC key generation mechanism, denoted **CKM_BLAKE2B_256_KEY_GEN**, is a
4407 key generation mechanism for BLAKE2B-256-HMAC.

4408 It does not have a parameter.

4409 The mechanism generates BLAKE2B-256-HMAC keys with a particular length in bytes, as specified in the
4410 **CKA_VALUE_LEN** attribute of the template for the key.

4411 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
4412 key. Other attributes supported by the BLAKE2B-256-HMAC key type (specifically, the flags indicating
4413 which functions the key supports) may be specified in the template for the key, or else are assigned
4414 default initial values.

4415 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
4416 specify the supported range of **CKM_BLAKE2B_256_HMAC** key sizes, in bytes.

4417 2.35 BLAKE2B-384

4418 Table 145, BLAKE2B-384 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|------------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_BLAKE2B_384 | | | | ✓ | | | |
| CKM_BLAKE2B_384_HMAC_GENERAL | | ✓ | | | | | |
| CKM_BLAKE2B_384_HMAC | | ✓ | | | | | |
| CKM_BLAKE2B_384_KEY_DERIVE | | | | | | | ✓ |
| CKM_BLAKE2B_384_KEY_GEN | | | | ✓ | | | |

2.35.1 Definitions

CKM_BLAKE2B_384
CKM_BLAKE2B_384_HMAC
CKM_BLAKE2B_384_HMAC_GENERAL
CKM_BLAKE2B_384_KEY_DERIVE
CKM_BLAKE2B_384_KEY_GEN
CKK_BLAKE2B_384_HMAC

2.35.2 BLAKE2B-384 digest

The BLAKE2B-384 mechanism, denoted **CKM_BLAKE2B_384**, is a mechanism for message digesting, following the Blake2b Algorithm with a 384-bit message digest without a key as defined in RFC 7693.

It does not have a parameter.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

Table 146, BLAKE2B-384: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 48 |

2.35.3 General-length BLAKE2B-384-HMAC

The general-length BLAKE2B-384-HMAC mechanism, denoted **CKM_BLAKE2B_384_HMAC_GENERAL**, is the keyed variant of the Blake2b-384 hash function and length of the output should be in the range 1-48. The keys it uses are generic secret keys and CKK_BLAKE2B_384_HMAC.

It has a parameter, a CK_MAC_GENERAL_PARAMS, which holds the length in bytes of the desired output. This length should be in the range 1-48 (the output size of BLAKE2B-384 is 48 bytes). Signatures (MACs) produced by this mechanism shall be taken from the start of the full 48-byte HMAC output.

Table 147, General-length BLAKE2B-384-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|---|-------------|-------------------------------|
| C_Sign | generic secret or CKK_BLAKE2B_384_H MAC | Any | 1-48, depending on parameters |
| C_Verify | generic secret or CKK_BLAKE2B_384_H MAC | Any | 1-48, depending on parameters |

2.35.4 BLAKE2B-384-HMAC

The BLAKE2B-384-HMAC mechanism, denoted **CKM_BLAKE2B_384_HMAC**, is a special case of the general-length BLAKE2B-384-HMAC mechanism.

It has no parameter, and always produces an output of length 48.

4448 2.35.5 BLAKE2B-384 key derivation

4449 BLAKE2B-384 key derivation, denoted **CKM_BLAKE2B_384_KEY_DERIVE**, is the same as the SHA-1
 4450 key derivation mechanism in Section 2.20.5, except that it uses the SHA-384 hash function and the
 4451 relevant length is 48 bytes.

4452 2.35.6 BLAKE2B-384 HMAC key generation

4453 The BLAKE2B-384-HMAC key generation mechanism, denoted **CKM_BLAKE2B_384_KEY_GEN**, is a
 4454 key generation mechanism for NIST's BLAKE2B-384-HMAC.

4455 It does not have a parameter.

4456 The mechanism generates BLAKE2B-384-HMAC keys with a particular length in bytes, as specified in the
 4457 **CKA_VALUE_LEN** attribute of the template for the key.

4458 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
 4459 key. Other attributes supported by the BLAKE2B-384-HMAC key type (specifically, the flags indicating
 4460 which functions the key supports) may be specified in the template for the key, or else are assigned
 4461 default initial values.

4462 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
 4463 specify the supported range of **CKM_BLAKE2B_384_HMAC** key sizes, in bytes.

4464 2.36 BLAKE2B-512

4465 *Table 148, SHA-512 Mechanisms vs. Functions*

| Mechanism | Functions | | | | | | |
|------------------------------|-------------------------|---------------------|-------------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_BLAKE2B_512 | | | | ✓ | | | |
| CKM_BLAKE2B_512_HMAC_GENERAL | | ✓ | | | | | |
| CKM_BLAKE2B_512_HMAC | | ✓ | | | | | |
| CKM_BLAKE2B_512_KEY_DERIVE | | | | | | | ✓ |
| CKM_BLAKE2B_512_KEY_GEN | | | | ✓ | | | |

4466 2.36.1 Definitions

4467 CKM_BLAKE2B_512
 4468 CKM_BLAKE2B_512_HMAC
 4469 CKM_BLAKE2B_512_HMAC_GENERAL
 4470 CKM_BLAKE2B_512_KEY_DERIVE
 4471 CKM_BLAKE2B_512_KEY_GEN
 4472 CKM_BLAKE2B_512_HMAC

4473 2.36.2 BLAKE2B-512 digest

4474 The BLAKE2B-512 mechanism, denoted **CKM_BLAKE2B_512**, is a mechanism for message digesting,
 4475 following the Blake2b Algorithm with a 512-bit message digest defined in RFC 7693.

4476 It does not have a parameter.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

Table 149, BLAKE2B-512: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | any | 64 |

2.36.3 General-length BLAKE2B-512-HMAC

The general-length BLAKE2B-512-HMAC mechanism, denoted **CKM_BLAKE2B_512_HMAC_GENERAL**, is the keyed variant of the BLAKE2B-512 hash function and length of the output should be in the range 1-64. The keys it uses are generic secret keys and **CKK_BLAKE2B_512_HMAC**.

It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which holds the length in bytes of the desired output. This length should be in the range 1-64 (the output size of BLAKE2B-512 is 64 bytes). Signatures (MACs) produced by this mechanism shall be taken from the start of the full 64-byte HMAC output.

Table 150, General-length BLAKE2B-512-HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|--|-------------|-------------------------------|
| C_Sign | generic secret or CKK_BLAKE2B_512_HMAC | Any | 1-64, depending on parameters |
| C_Verify | generic secret or CKK_BLAKE2B_512_HMAC | Any | 1-64, depending on parameters |

2.36.4 BLAKE2B-512-HMAC

The BLAKE2B-512-HMAC mechanism, denoted **CKM_BLAKE2B_512_HMAC**, is a special case of the general-length BLAKE2B-512-HMAC mechanism.

It has no parameter, and always produces an output of length 64.

2.36.5 BLAKE2B-512 key derivation

BLAKE2B-512 key derivation, denoted **CKM_BLAKE2B_512_KEY_DERIVE**, is the same as the SHA-1 key derivation mechanism in Section 2.20.5, except that it uses the Blake2b-512 hash function and the relevant length is 64 bytes.

2.36.6 BLAKE2B-512 HMAC key generation

The BLAKE2B-512-HMAC key generation mechanism, denoted **CKM_BLAKE2B_512_KEY_GEN**, is a key generation mechanism for NIST's BLAKE2B-512-HMAC.

It does not have a parameter.

The mechanism generates BLAKE2B-512-HMAC keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the BLAKE2B-512-HMAC key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of **CKM_BLAKE2B_512_HMAC** key sizes, in bytes.

4511

4512 **2.37 PKCS #5 and PKCS #5-style password-based encryption (PBE)**

4513 The mechanisms in this section are for generating keys and IVs for performing password-based
4514 encryption. The method used to generate keys and IVs is specified in PKCS #5.

4515 *Table 151, PKCS 5 Mechanisms vs. Functions*

| Mechanism | Functions | | | | | | |
|-----------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_PBE_SHA1_DES3_EDE_CBC | | | | | ✓ | | |
| CKM_PBE_SHA1_DES2_EDE_CBC | | | | | ✓ | | |
| CKM_PBA_SHA1_WITH_SHA1_HMAC | | | | | ✓ | | |
| CKM_PKCS5_PBKD2 | | | | | ✓ | | |

4516 **2.37.1 Definitions**

4517 Mechanisms:

4518 CKM_PBE_SHA1_DES3_EDE_CBC

4519 CKM_PBE_SHA1_DES2_EDE_CBC

4520 CKM_PKCS5_PBKD2

4521 CKM_PBA_SHA1_WITH_SHA1_HMAC

4522 **2.37.2 Password-based encryption/authentication mechanism parameters**

4523 **◆ CK_PBE_PARAMS; CK_PBE_PARAMS_PTR**

4524 **CK_PBE_PARAMS** is a structure which provides all of the necessary information required by the
4525 CKM_PBE mechanisms (see PKCS #5 and PKCS #12 for information on the PBE generation
4526 mechanisms) and the CKM_PBA_SHA1_WITH_SHA1_HMAC mechanism. It is defined as follows:

```
4527 typedef struct CK_PBE_PARAMS {  
4528     CK_BYTE_PTR      pInitVector;  
4529     CK_UTF8CHAR_PTR  pPassword;  
4530     CK_ULONG         ulPasswordLen;  
4531     CK_BYTE_PTR      pSalt;  
4532     CK_ULONG         ulSaltLen;  
4533     CK_ULONG         ulIteration;  
4534 } CK_PBE_PARAMS;  
4535
```

4536 The fields of the structure have the following meanings:

4537 *pInitVector* *pointer to the location that receives the 8-byte initialization vector*
4538 *(IV), if an IV is required;*

4539 *pPassword* *points to the password to be used in the PBE key generation;*

4540 *ulPasswordLen* *length in bytes of the password information;*

4541 *pSalt* points to the salt to be used in the PBE key generation;

4542 *ulSaltLen* length in bytes of the salt information;

4543 *ulliteration* number of iterations required for the generation.

4544 **CK_PBE_PARAMS_PTR** is a pointer to a **CK_PBE_PARAMS**.

4545 2.37.3 PKCS #5 PBKDF2 key generation mechanism parameters

4546 ♦ **CK_PKCS5_PBKD2_PSEUDO_RANDOM_FUNCTION_TYPE;**
 4547 **CK_PKCS5_PBKD2_PSEUDO_RANDOM_FUNCTION_TYPE_PTR**

4548 **CK_PKCS5_PBKD2_PSEUDO_RANDOM_FUNCTION_TYPE** is used to indicate the Pseudo-Random
 4549 Function (PRF) used to generate key bits using PKCS #5 PBKDF2. It is defined as follows:

4550 `typedef CK_ULONG CK_PKCS5_PBKD2_PSEUDO_RANDOM_FUNCTION_TYPE;`

4551

4552 The following PRFs are defined in PKCS #5 v2.1. The following table lists the defined functions.

4553 Table 152, PKCS #5 PBKDF2 Key Generation: Pseudo-random functions

| PRF Identifier | Value | Parameter Type |
|---------------------------------|--------------|---|
| CKP_PKCS5_PBKD2_HMAC_SHA1 | 0x00000001UL | No Parameter. <i>pPrfData</i> must be NULL and <i>ulPrfDataLen</i> must be zero. |
| CKP_PKCS5_PBKD2_HMAC_GOSTR3411 | 0x00000002UL | This PRF uses GOST R34.11-94 hash to produce secret key value. <i>pPrfData</i> should point to DER-encoded OID, indicating GOSTR34.11-94 parameters. <i>ulPrfDataLen</i> holds encoded OID length in bytes. If <i>pPrfData</i> is set to NULL_PTR, then <i>id-GostR3411-94-CryptoProParamSet</i> parameters will be used (RFC 4357, 11.2), and <i>ulPrfDataLen</i> must be 0. |
| CKP_PKCS5_PBKD2_HMAC_SHA224 | 0x00000003UL | No Parameter. <i>pPrfData</i> must be NULL and <i>ulPrfDataLen</i> must be zero. |
| CKP_PKCS5_PBKD2_HMAC_SHA256 | 0x00000004UL | No Parameter. <i>pPrfData</i> must be NULL and <i>ulPrfDataLen</i> must be zero. |
| CKP_PKCS5_PBKD2_HMAC_SHA384 | 0x00000005UL | No Parameter. <i>pPrfData</i> must be NULL and <i>ulPrfDataLen</i> must be zero. |
| CKP_PKCS5_PBKD2_HMAC_SHA512 | 0x00000006UL | No Parameter. <i>pPrfData</i> must be NULL and <i>ulPrfDataLen</i> must be zero. |
| CKP_PKCS5_PBKD2_HMAC_SHA512_224 | 0x00000007UL | No Parameter. <i>pPrfData</i> must be NULL and <i>ulPrfDataLen</i> must be zero. |

| | | |
|---------------------------------|--------------|--|
| CKP_PKCS5_PBKD2_HMAC_SHA512_256 | 0x00000008UL | No Parameter. <i>pPrfData</i> must be NULL and <i>ulPrfDataLen</i> must be zero. |
|---------------------------------|--------------|--|

CK_PKCS5_PBKD2_PSEUDO_RANDOM_FUNCTION_TYPE_PTR is a pointer to a **CK_PKCS5_PBKD2_PSEUDO_RANDOM_FUNCTION_TYPE**.

◆ **CK_PKCS5_PBKDF2_SALT_SOURCE_TYPE;** **CK_PKCS5_PBKDF2_SALT_SOURCE_TYPE_PTR**

CK_PKCS5_PBKDF2_SALT_SOURCE_TYPE is used to indicate the source of the salt value when deriving a key using PKCS #5 PBKDF2. It is defined as follows:

```
typedef CK_ULONG CK_PKCS5_PBKDF2_SALT_SOURCE_TYPE;
```

The following salt value sources are defined in PKCS #5 v2.1. The following table lists the defined sources along with the corresponding data type for the *pSaltSourceData* field in the **CK_PKCS5_PBKD2_PARAMS2** structure defined below.

Table 153, PKCS #5 PBKDF2 Key Generation: Salt sources

| Source Identifier | Value | Data Type |
|--------------------|------------|--|
| CKZ_SALT_SPECIFIED | 0x00000001 | Array of CK_BYTE containing the value of the salt value. |

CK_PKCS5_PBKDF2_SALT_SOURCE_TYPE_PTR is a pointer to a **CK_PKCS5_PBKDF2_SALT_SOURCE_TYPE**.

◆ **CK_PKCS5_PBKD2_PARAMS2; CK_PKCS5_PBKD2_PARAMS2_PTR**

CK_PKCS5_PBKD2_PARAMS2 is a structure that provides the parameters to the **CKM_PKCS5_PBKD2** mechanism. The structure is defined as follows:

```
typedef struct CK_PKCS5_PBKD2_PARAMS2 {
    CK_PKCS5_PBKDF2_SALT_SOURCE_TYPE    saltSource;
    CK_VOID_PTR                          pSaltSourceData;
    CK_ULONG                             ulSaltSourceDataLen;
    CK_ULONG                             iterations;
    CK_PKCS5_PBKD2_PSEUDO_RANDOM_FUNCTION_TYPE prf;
    CK_VOID_PTR                          pPrfData;
    CK_ULONG                             ulPrfDataLen;
    CK_UTF8CHAR_PTR                     pPassword;
    CK_ULONG                             ulPasswordLen;
} CK_PKCS5_PBKD2_PARAMS2;
```

The fields of the structure have the following meanings:

saltSource *source of the salt value*

pSaltSourceData *data used as the input for the salt source*

ulSaltSourceDataLen *length of the salt source input*

| | | |
|------|----------------------|--|
| 4588 | <i>iterations</i> | <i>number of iterations to perform when generating each block of</i> |
| 4589 | | <i>random data</i> |
| 4590 | <i>prf</i> | <i>pseudo-random function used to generate the key</i> |
| 4591 | <i>pPrfData</i> | <i>data used as the input for PRF in addition to the salt value</i> |
| 4592 | <i>ulPrfDataLen</i> | <i>length of the input data for the PRF</i> |
| 4593 | <i>pPassword</i> | <i>points to the password to be used in the PBE key generation</i> |
| 4594 | <i>ulPasswordLen</i> | <i>length in bytes of the password information</i> |

4595 **CK_PKCS5_PBKD2_PARAMS2_PTR** is a pointer to a **CK_PKCS5_PBKD2_PARAMS2**.

4596 2.37.4 PKCS #5 PBKD2 key generation

4597 PKCS #5 PBKDF2 key generation, denoted **CKM_PKCS5_PBKD2**, is a mechanism used for generating
4598 a secret key from a password and a salt value. This functionality is defined in PKCS#5 as PBKDF2.

4599 It has a parameter, a **CK_PKCS5_PBKD2_PARAMS2** structure. The parameter specifies the salt value
4600 source, pseudo-random function, and iteration count used to generate the new key.

4601 Since this mechanism can be used to generate any type of secret key, new key templates must contain
4602 the **CKA_KEY_TYPE** and **CKA_VALUE_LEN** attributes. If the key type has a fixed length the
4603 **CKA_VALUE_LEN** attribute may be omitted.

4604 2.38 PKCS #12 password-based encryption/authentication 4605 mechanisms

4606 The mechanisms in this section are for generating keys and IVs for performing password-based
4607 encryption or authentication. The method used to generate keys and IVs is based on a method that was
4608 specified in PKCS #12.

4609 We specify here a general method for producing various types of pseudo-random bits from a password,
4610 p ; a string of salt bits, s ; and an iteration count, c . The “type” of pseudo-random bits to be produced is
4611 identified by an identification byte, ID , the meaning of which will be discussed later.

4612 Let H be a hash function built around a compression function $f: \mathbf{Z}_2^u \times \mathbf{Z}_2^v \rightarrow \mathbf{Z}_2^u$ (that is, H has a chaining
4613 variable and output of length u bits, and the message input to the compression function of H is v bits).
4614 For MD2 and MD5, $u=128$ and $v=512$; for SHA-1, $u=160$ and $v=512$.

4615 We assume here that u and v are both multiples of 8, as are the lengths in bits of the password and salt
4616 strings and the number n of pseudo-random bits required. In addition, u and v are of course nonzero.

- 4617 1. Construct a string, D (the “diversifier”), by concatenating $v/8$ copies of ID .
- 4618 2. Concatenate copies of the salt together to create a string S of length $v \lceil s/v \rceil$ bits (the final copy of the
4619 salt may be truncated to create S). Note that if the salt is the empty string, then so is S .
- 4620 3. Concatenate copies of the password together to create a string P of length $v \lceil p/v \rceil$ bits (the final copy
4621 of the password may be truncated to create P). Note that if the password is the empty string, then so
4622 is P .
- 4623 4. Set $I = S || P$ to be the concatenation of S and P .
- 4624 5. Set $j = \lceil n/u \rceil$.
- 4625 6. For $i=1, 2, \dots, j$, do the following:
 - 4626 a. Set $A_i = H^c(D || I)$, the c^{th} hash of $D || I$. That is, compute the hash of $D || I$; compute the hash of
4627 that hash; etc.; continue in this fashion until a total of c hashes have been computed, each on
4628 the result of the previous hash.

- b. Concatenate copies of A_i to create a string B of length v bits (the final copy of A_i may be truncated to create B).
- c. Treating I as a concatenation I_0, I_1, \dots, I_{k-1} of v -bit blocks, where $k = \lceil s/v \rceil + \lceil p/v \rceil$, modify I by setting $I_j = (I_j + B + 1) \bmod 2^v$ for each j . To perform this addition, treat each v -bit block as a binary number represented most-significant bit first.

7. Concatenate A_1, A_2, \dots, A_j together to form a pseudo-random bit string, A .

8. Use the first n bits of A as the output of this entire process.

When the password-based encryption mechanisms presented in this section are used to generate a key and IV (if needed) from a password, salt, and an iteration count, the above algorithm is used. To generate a key, the identifier byte ID is set to the value 1; to generate an IV, the identifier byte ID is set to the value 2.

When the password based authentication mechanism presented in this section is used to generate a key from a password, salt, and an iteration count, the above algorithm is used. The identifier byte ID is set to the value 3.

2.38.1 SHA-1-PBE for 3-key triple-DES-CBC

SHA-1-PBE for 3-key triple-DES-CBC, denoted **CKM_PBE_SHA1_DES3_EDE_CBC**, is a mechanism used for generating a 3-key triple-DES secret key and IV from a password and a salt value by using the SHA-1 digest algorithm and an iteration count. The method used to generate the key and IV is described above. Each byte of the key produced will have its low-order bit adjusted, if necessary, so that a valid 3-key triple-DES key with proper parity bits is obtained.

It has a parameter, a **CK_PBE_PARAMS** structure. The parameter specifies the input information for the key generation process and the location of the application-supplied buffer which will receive the 8-byte IV generated by the mechanism.

The key and IV produced by this mechanism will typically be used for performing password-based encryption.

2.38.2 SHA-1-PBE for 2-key triple-DES-CBC

SHA-1-PBE for 2-key triple-DES-CBC, denoted **CKM_PBE_SHA1_DES2_EDE_CBC**, is a mechanism used for generating a 2-key triple-DES secret key and IV from a password and a salt value by using the SHA-1 digest algorithm and an iteration count. The method used to generate the key and IV is described above. Each byte of the key produced will have its low-order bit adjusted, if necessary, so that a valid 2-key triple-DES key with proper parity bits is obtained.

It has a parameter, a **CK_PBE_PARAMS** structure. The parameter specifies the input information for the key generation process and the location of the application-supplied buffer which will receive the 8-byte IV generated by the mechanism.

The key and IV produced by this mechanism will typically be used for performing password-based encryption.

2.38.3 SHA-1-PBA for SHA-1-HMAC

SHA-1-PBA for SHA-1-HMAC, denoted **CKM_PBA_SHA1_WITH_SHA1_HMAC**, is a mechanism used for generating a 160-bit generic secret key from a password and a salt value by using the SHA-1 digest algorithm and an iteration count. The method used to generate the key is described above.

It has a parameter, a **CK_PBE_PARAMS** structure. The parameter specifies the input information for the key generation process. The parameter also has a field to hold the location of an application-supplied buffer which will receive an IV; for this mechanism, the contents of this field are ignored, since authentication with SHA-1-HMAC does not require an IV.

The key generated by this mechanism will typically be used for computing a SHA-1 HMAC to perform password-based authentication (not *password-based encryption*). At the time of this writing, this is primarily done to ensure the integrity of a PKCS #12 PDU.

2.39 SSL

Table 154, SSL Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-------------------------------|---------------------------------|-------------------------|--------------------|------------|---------------------------------|-------------------------|------------|
| | Encryp t & Decryp t | Sign & Verif y | SR & VR 1 | Diges t | Gen . Key/ Key Pair | Wrap & Unwra p | Deriv e |
| CKM_SSL3_PRE_MASTER_KEY_GEN | | | | | ✓ | | |
| CKM_TLS_PRE_MASTER_KEY_GEN | | | | | ✓ | | |
| CKM_SSL3_MASTER_KEY_DERIVE | | | | | | | ✓ |
| CKM_SSL3_MASTER_KEY_DERIVE_DH | | | | | | | ✓ |
| CKM_SSL3_KEY_AND_MAC_DERIVE | | | | | | | ✓ |
| CKM_SSL3_MD5_MAC | | ✓ | | | | | |
| CKM_SSL3_SHA1_MAC | | ✓ | | | | | |

2.39.1 Definitions

Mechanisms:

CKM_SSL3_PRE_MASTER_KEY_GEN
 CKM_TLS_PRE_MASTER_KEY_GEN
 CKM_SSL3_MASTER_KEY_DERIVE
 CKM_SSL3_KEY_AND_MAC_DERIVE
 CKM_SSL3_MASTER_KEY_DERIVE_DH
 CKM_SSL3_MD5_MAC
 CKM_SSL3_SHA1_MAC

2.39.2 SSL mechanism parameters

◆ CK_SSL3_RANDOM_DATA

CK_SSL3_RANDOM_DATA is a structure which provides information about the random data of a client and a server in an SSL context. This structure is used by both the **CKM_SSL3_MASTER_KEY_DERIVE** and the **CKM_SSL3_KEY_AND_MAC_DERIVE** mechanisms. It is defined as follows:

```
typedef struct CK_SSL3_RANDOM_DATA {
    CK_BYTE_PTR    pClientRandom;
    CK_ULONG       ulClientRandomLen;
    CK_BYTE_PTR    pServerRandom;
    CK_ULONG       ulServerRandomLen;
} CK_SSL3_RANDOM_DATA;
```

The fields of the structure have the following meanings:

pClientRandom *pointer to the client's random data*

ulClientRandomLen *length in bytes of the client's random data*

4702 *pServerRandom* *pointer to the server's random data*

4703 *ulServerRandomLen* *length in bytes of the server's random data*

4704 ♦ **CK_SSL3_MASTER_KEY_DERIVE_PARAMS;**
4705 **CK_SSL3_MASTER_KEY_DERIVE_PARAMS_PTR**

4706 **CK_SSL3_MASTER_KEY_DERIVE_PARAMS** is a structure that provides the parameters to the
4707 **CKM_SSL3_MASTER_KEY_DERIVE** mechanism. It is defined as follows:

```
4708        typedef struct CK_SSL3_MASTER_KEY_DERIVE_PARAMS {  
4709            CK_SSL3_RANDOM_DATA        RandomInfo;  
4710            CK_VERSION_PTR              pVersion;  
4711        } CK_SSL3_MASTER_KEY_DERIVE_PARAMS;
```

4712

4713 The fields of the structure have the following meanings:

4714 *RandomInfo* *client's and server's random data information.*

4715 *pVersion* *pointer to a **CK_VERSION** structure which receives the SSL*
4716 *protocol version information*

4717 **CK_SSL3_MASTER_KEY_DERIVE_PARAMS_PTR** is a pointer to a
4718 **CK_SSL3_MASTER_KEY_DERIVE_PARAMS**.

4719 ♦ **CK_SSL3_KEY_MAT_OUT; CK_SSL3_KEY_MAT_OUT_PTR**

4720 **CK_SSL3_KEY_MAT_OUT** is a structure that contains the resulting key handles and initialization vectors
4721 after performing a **C_DeriveKey** function with the **CKM_SSL3_KEY_AND_MAC_DERIVE** mechanism. It
4722 is defined as follows:

```
4723        typedef struct CK_SSL3_KEY_MAT_OUT {  
4724            CK_OBJECT_HANDLE    hClientMacSecret;  
4725            CK_OBJECT_HANDLE    hServerMacSecret;  
4726            CK_OBJECT_HANDLE    hClientKey;  
4727            CK_OBJECT_HANDLE    hServerKey;  
4728            CK_BYTE_PTR         pIVClient;  
4729            CK_BYTE_PTR         pIVServer;  
4730        } CK_SSL3_KEY_MAT_OUT;
```

4731

4732 The fields of the structure have the following meanings:

4733 *hClientMacSecret* *key handle for the resulting Client MAC Secret key*

4734 *hServerMacSecret* *key handle for the resulting Server MAC Secret key*

4735 *hClientKey* *key handle for the resulting Client Secret key*

4736 *hServerKey* *key handle for the resulting Server Secret key*

4737 *pIVClient* *pointer to a location which receives the initialization vector (IV)*
4738 *created for the client (if any)*

4739 *pIVServer* *pointer to a location which receives the initialization vector (IV)*
4740 *created for the server (if any)*

4741 **CK_SSL3_KEY_MAT_OUT_PTR** is a pointer to a **CK_SSL3_KEY_MAT_OUT**.

4742 ♦ **CK_SSL3_KEY_MAT_PARAMS; CK_SSL3_KEY_MAT_PARAMS_PTR**

4743 **CK_SSL3_KEY_MAT_PARAMS** is a structure that provides the parameters to the
4744 **CKM_SSL3_KEY_AND_MAC_DERIVE** mechanism. It is defined as follows:

```
4745     typedef struct CK_SSL3_KEY_MAT_PARAMS {  
4746         CK_ULONG          ulMacSizeInBits;  
4747         CK_ULONG          ulKeySizeInBits;  
4748         CK_ULONG          ulIVSizeInBits;  
4749         CK_BBOOL          bIsExport;  
4750         CK_SSL3_RANDOM_DATA RandomInfo;  
4751         CK_SSL3_KEY_MAT_OUT_PTR pReturnedKeyMaterial;  
4752     } CK_SSL3_KEY_MAT_PARAMS;
```

4753

4754 The fields of the structure have the following meanings:

| | | |
|------|-----------------------------|---|
| 4755 | <i>ulMacSizeInBits</i> | <i>the length (in bits) of the MACing keys agreed upon during the</i> |
| 4756 | | <i>protocol handshake phase</i> |
| 4757 | <i>ulKeySizeInBits</i> | <i>the length (in bits) of the secret keys agreed upon during the</i> |
| 4758 | | <i>protocol handshake phase</i> |
| 4759 | <i>ulIVSizeInBits</i> | <i>the length (in bits) of the IV agreed upon during the protocol</i> |
| 4760 | | <i>handshake phase. If no IV is required, the length should be set to 0</i> |
| 4761 | <i>bIsExport</i> | <i>a Boolean value which indicates whether the keys have to be</i> |
| 4762 | | <i>derived for an export version of the protocol</i> |
| 4763 | <i>RandomInfo</i> | <i>client's and server's random data information.</i> |
| 4764 | <i>pReturnedKeyMaterial</i> | <i>points to a CK_SSL3_KEY_MAT_OUT structures which receives</i> |
| 4765 | | <i>the handles for the keys generated and the IVs</i> |

4766 **CK_SSL3_KEY_MAT_PARAMS_PTR** is a pointer to a **CK_SSL3_KEY_MAT_PARAMS**.

4767 2.39.3 Pre-master key generation

4768 Pre-master key generation in SSL 3.0, denoted **CKM_SSL3_PRE_MASTER_KEY_GEN**, is a mechanism
4769 which generates a 48-byte generic secret key. It is used to produce the "pre_master" key used in SSL
4770 version 3.0 for RSA-like cipher suites.

4771 It has one parameter, a **CK_VERSION** structure, which provides the client's SSL version number.

4772 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
4773 key (as well as the **CKA_VALUE_LEN** attribute, if it is not supplied in the template). Other attributes may
4774 be specified in the template, or else are assigned default values.

4775 The template sent along with this mechanism during a **C_GenerateKey** call may indicate that the object
4776 class is **CKO_SECRET_KEY**, the key type is **CKK_GENERIC_SECRET**, and the **CKA_VALUE_LEN**
4777 attribute has value 48. However, since these facts are all implicit in the mechanism, there is no need to
4778 specify any of them.

4779 For this mechanism, the **ulMinKeySize** and **ulMaxKeySize** fields of the **CK_MECHANISM_INFO** structure
4780 both indicate 48 bytes.

4781 **CKM_TLS_PRE_MASTER_KEY_GEN** has identical functionality as
4782 **CKM_SSL3_PRE_MASTER_KEY_GEN**. It exists only for historical reasons, please use
4783 **CKM_SSL3_PRE_MASTER_KEY_GEN** instead.

4784 2.39.4 Master key derivation

4785 Master key derivation in SSL 3.0, denoted **CKM_SSL3_MASTER_KEY_DERIVE**, is a mechanism used
4786 to derive one 48-byte generic secret key from another 48-byte generic secret key. It is used to produce
4787 the "master_secret" key used in the SSL protocol from the "pre_master" key. This mechanism returns the
4788 value of the client version, which is built into the "pre_master" key as well as a handle to the derived
4789 "master_secret" key.

4790 It has a parameter, a **CK_SSL3_MASTER_KEY_DERIVE_PARAMS** structure, which allows for the
4791 passing of random data to the token as well as the returning of the protocol version number which is part
4792 of the pre-master key. This structure is defined in Section 2.39.

4793 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
4794 key (as well as the **CKA_VALUE_LEN** attribute, if it is not supplied in the template). Other attributes may
4795 be specified in the template; otherwise they are assigned default values.

4796 The template sent along with this mechanism during a **C_DeriveKey** call may indicate that the object
4797 class is **CKO_SECRET_KEY**, the key type is **CKK_GENERIC_SECRET**, and the **CKA_VALUE_LEN**
4798 attribute has value 48. However, since these facts are all implicit in the mechanism, there is no need to
4799 specify any of them.

4800 This mechanism has the following rules about key sensitivity and extractability:

- 4801 • The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both
4802 be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some
4803 default value.
- 4804 • If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_FALSE**, then the derived key
4805 will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_TRUE**, then the
4806 derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its
4807 **CKA_SENSITIVE** attribute.
- 4808 • Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_FALSE**, then the
4809 derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to
4810 **CK_TRUE**, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite*
4811 value from its **CKA_EXTRACTABLE** attribute.

4812 For this mechanism, the **ulMinKeySize** and **ulMaxKeySize** fields of the **CK_MECHANISM_INFO** structure
4813 both indicate 48 bytes.

4814 Note that the **CK_VERSION** structure pointed to by the **CK_SSL3_MASTER_KEY_DERIVE_PARAMS**
4815 structure's *pVersion* field will be modified by the **C_DeriveKey** call. In particular, when the call returns,
4816 this structure will hold the SSL version associated with the supplied pre_master key.

4817 Note that this mechanism is only useable for cipher suites that use a 48-byte "pre_master" secret with an
4818 embedded version number. This includes the RSA cipher suites, but excludes the Diffie-Hellman cipher
4819 suites.

4820 2.39.5 Master key derivation for Diffie-Hellman

4821 Master key derivation for Diffie-Hellman in SSL 3.0, denoted **CKM_SSL3_MASTER_KEY_DERIVE_DH**,
4822 is a mechanism used to derive one 48-byte generic secret key from another arbitrary length generic
4823 secret key. It is used to produce the "master_secret" key used in the SSL protocol from the "pre_master"
4824 key.

4825 It has a parameter, a **CK_SSL3_MASTER_KEY_DERIVE_PARAMS** structure, which allows for the
4826 passing of random data to the token. This structure is defined in Section 2.39. The *pVersion* field of the
4827 structure must be set to **NULL_PTR** since the version number is not embedded in the "pre_master" key
4828 as it is for RSA-like cipher suites.

4829 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
4830 key (as well as the **CKA_VALUE_LEN** attribute, if it is not supplied in the template). Other attributes may
4831 be specified in the template, or else are assigned default values.

4832 The template sent along with this mechanism during a **C_DeriveKey** call may indicate that the object
4833 class is **CKO_SECRET_KEY**, the key type is **CKK_GENERIC_SECRET**, and the **CKA_VALUE_LEN**
4834 attribute has value 48. However, since these facts are all implicit in the mechanism, there is no need to
4835 specify any of them.

4836 This mechanism has the following rules about key sensitivity and extractability:

- 4837 • The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both
4838 be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some
4839 default value.
- 4840 • If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_FALSE**, then the derived key
4841 will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_TRUE**, then the
4842 derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its
4843 **CKA_SENSITIVE** attribute.
- 4844 • Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_FALSE**, then the
4845 derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to
4846 **CK_TRUE**, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite*
4847 value from its **CKA_EXTRACTABLE** attribute.

4848 For this mechanism, the **ulMinKeySize** and **ulMaxKeySize** fields of the **CK_MECHANISM_INFO** structure
4849 both indicate 48 bytes.

4850 Note that this mechanism is only useable for cipher suites that do not use a fixed length 48-byte
4851 "pre_master" secret with an embedded version number. This includes the Diffie-Hellman cipher suites, but
4852 excludes the RSA cipher suites.

4853 2.39.6 Key and MAC derivation

4854 Key, MAC and IV derivation in SSL 3.0, denoted **CKM_SSL3_KEY_AND_MAC_DERIVE**, is a
4855 mechanism used to derive the appropriate cryptographic keying material used by a "CipherSuite" from the
4856 "master_secret" key and random data. This mechanism returns the key handles for the keys generated in
4857 the process, as well as the IVs created.

4858 It has a parameter, a **CK_SSL3_KEY_MAT_PARAMS** structure, which allows for the passing of random
4859 data as well as the characteristic of the cryptographic material for the given CipherSuite and a pointer to a
4860 structure which receives the handles and IVs which were generated. This structure is defined in Section
4861 2.39.

4862 This mechanism contributes to the creation of four distinct keys on the token and returns two IVs (if IVs
4863 are requested by the caller) back to the caller. The keys are all given an object class of
4864 **CKO_SECRET_KEY**.

4865 The two MACing keys ("client_write_MAC_secret" and "server_write_MAC_secret") are always given a
4866 type of **CKK_GENERIC_SECRET**. They are flagged as valid for signing, verification, and derivation
4867 operations.

4868 The other two keys ("client_write_key" and "server_write_key") are typed according to information found
4869 in the template sent along with this mechanism during a **C_DeriveKey** function call. By default, they are
4870 flagged as valid for encryption, decryption, and derivation operations.

4871 IVs will be generated and returned if the **ulIVSizeInBits** field of the **CK_SSL3_KEY_MAT_PARAMS** field
4872 has a nonzero value. If they are generated, their length in bits will agree with the value in the
4873 **ulIVSizeInBits** field.

4874 All four keys inherit the values of the **CKA_SENSITIVE**, **CKA_ALWAYS_SENSITIVE**,
4875 **CKA_EXTRACTABLE**, and **CKA_NEVER_EXTRACTABLE** attributes from the base key. The template
4876 provided to **C_DeriveKey** may not specify values for any of these attributes which differ from those held
4877 by the base key.

Note that the **CK_SSL3_KEY_MAT_OUT** structure pointed to by the **CK_SSL3_KEY_MAT_PARAMS** structure's *pReturnedKeyMaterial* field will be modified by the **C_DeriveKey** call. In particular, the four key handle fields in the **CK_SSL3_KEY_MAT_OUT** structure will be modified to hold handles to the newly-created keys; in addition, the buffers pointed to by the **CK_SSL3_KEY_MAT_OUT** structure's *pIVClient* and *pIVServer* fields will have IVs returned in them (if IVs are requested by the caller). Therefore, these two fields must point to buffers with sufficient space to hold any IVs that will be returned.

This mechanism departs from the other key derivation mechanisms in Cryptoki in its returned information. For most key-derivation mechanisms, **C_DeriveKey** returns a single key handle as a result of a successful completion. However, since the **CKM_SSL3_KEY_AND_MAC_DERIVE** mechanism returns all of its key handles in the **CK_SSL3_KEY_MAT_OUT** structure pointed to by the **CK_SSL3_KEY_MAT_PARAMS** structure specified as the mechanism parameter, the parameter *phKey* passed to **C_DeriveKey** is unnecessary, and should be a **NULL_PTR**.

If a call to **C_DeriveKey** with this mechanism fails, then *none* of the four keys will be created on the token.

2.39.7 MD5 MACing in SSL 3.0

MD5 MACing in SSL3.0, denoted **CKM_SSL3_MD5_MAC**, is a mechanism for single- and multiple-part signatures (data authentication) and verification using MD5, based on the SSL 3.0 protocol. This technique is very similar to the HMAC technique.

It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which specifies the length in bytes of the signatures produced by this mechanism.

Constraints on key types and the length of input and output data are summarized in the following table:

Table 155, MD5 MACing in SSL 3.0: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------------|-------------|------------------------------|
| C_Sign | generic secret | any | 4-8, depending on parameters |
| C_Verify | generic secret | any | 4-8, depending on parameters |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of generic secret key sizes, in bits.

2.39.8 SHA-1 MACing in SSL 3.0

SHA-1 MACing in SSL3.0, denoted **CKM_SSL3_SHA1_MAC**, is a mechanism for single- and multiple-part signatures (data authentication) and verification using SHA-1, based on the SSL 3.0 protocol. This technique is very similar to the HMAC technique.

It has a parameter, a **CK_MAC_GENERAL_PARAMS**, which specifies the length in bytes of the signatures produced by this mechanism.

Constraints on key types and the length of input and output data are summarized in the following table:

Table 156, SHA-1 MACing in SSL 3.0: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------------|-------------|------------------------------|
| C_Sign | generic secret | any | 4-8, depending on parameters |
| C_Verify | generic secret | any | 4-8, depending on parameters |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of generic secret key sizes, in bits.

2.40 TLS 1.2 Mechanisms

Details for TLS 1.2 and its key derivation and MAC mechanisms can be found in [TLS12]. TLS 1.2 mechanisms differ from TLS 1.0 and 1.1 mechanisms in that the base hash used in the underlying TLS PRF (pseudo-random function) can be negotiated. Therefore each mechanism parameter for the TLS 1.2 mechanisms contains a new value in the parameters structure to specify the hash function.

This section also specifies CKM_TLS12_MAC which should be used in place of CKM_TLS_PRF to calculate the verify_data in the TLS "finished" message.

This section also specifies CKM_TLS_KDF that can be used in place of CKM_TLS_PRF to implement key material exporters.

Table 157, TLS 1.2 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|--------------------------------|-------------------|---------------|----------------------|--------|-------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/Key Pair | Wrap & Unwrap | Derive |
| CKM_TLS12_MASTER_KEY_DERIVE | | | | | | | ✓ |
| CKM_TLS12_MASTER_KEY_DERIVE_DH | | | | | | | ✓ |
| CKM_TLS12_KEY_AND_MAC_DERIVE | | | | | | | ✓ |
| CKM_TLS12_KEY_SAFE_DERIVE | | | | | | | ✓ |
| CKM_TLS_KDF | | | | | | | ✓ |
| CKM_TLS12_MAC | | ✓ | | | | | |
| CKM_TLS12_KDF | | | | | | | ✓ |

2.40.1 Definitions

Mechanisms:

CKM_TLS12_MASTER_KEY_DERIVE
CKM_TLS12_MASTER_KEY_DERIVE_DH
CKM_TLS12_KEY_AND_MAC_DERIVE
CKM_TLS12_KEY_SAFE_DERIVE
CKM_TLS_KDF
CKM_TLS12_MAC
CKM_TLS12_KDF

2.40.2 TLS 1.2 mechanism parameters

◆ CK_TLS12_MASTER_KEY_DERIVE_PARAMS; CK_TLS12_MASTER_KEY_DERIVE_PARAMS_PTR

CK_TLS12_MASTER_KEY_DERIVE_PARAMS is a structure that provides the parameters to the CKM_TLS12_MASTER_KEY_DERIVE mechanism. It is defined as follows:

```
typedef struct CK_TLS12_MASTER_KEY_DERIVE_PARAMS {  
    CK_SSL3_RANDOM_DATA RandomInfo;  
    CK_VERSION_PTR pVersion;  
    CK_MECHANISM_TYPE prfHashMechanism;
```

4941 } CK_TLS12_MASTER_KEY_DERIVE_PARAMS;

4942

4943 The fields of the structure have the following meanings:

4944 *RandomInfo* *client's and server's random data information.*

4945 *pVersion* *pointer to a **CK_VERSION** structure which receives the SSL*
4946 *protocol version information*

4947 *prfHashMechanism* *base hash used in the underlying TLS1.2 PRF operation used to*
4948 *derive the master key.*

4949

4950 **CK_TLS12_MASTER_KEY_DERIVE_PARAMS_PTR** is a pointer to a

4951 **CK_TLS12_MASTER_KEY_DERIVE_PARAMS**.

4952 ♦ **CK_TLS12_KEY_MAT_PARAMS; CK_TLS12_KEY_MAT_PARAMS_PTR**

4953 **CK_TLS12_KEY_MAT_PARAMS** is a structure that provides the parameters to the

4954 **CKM_TLS12_KEY_AND_MAC_DERIVE** mechanism. It is defined as follows:

```
4955       typedef struct CK_TLS12_KEY_MAT_PARAMS {  
4956           CK_ULONG ulMacSizeInBits;  
4957           CK_ULONG ulKeySizeInBits;  
4958           CK_ULONG ulIVSizeInBits;  
4959           CK_BBOOL bIsExport;  
4960           CK_SSL3_RANDOM_DATA RandomInfo;  
4961           CK_SSL3_KEY_MAT_OUT_PTR pReturnedKeyMaterial;  
4962           CK_MECHANISM_TYPE prfHashMechanism;  
4963       } CK_TLS12_KEY_MAT_PARAMS;
```

4964

4965 The fields of the structure have the following meanings:

4966 *ulMacSizeInBits* *the length (in bits) of the MACing keys agreed upon during the*
4967 *protocol handshake phase. If no MAC key is required, the length*
4968 *should be set to 0.*

4969 *ulKeySizeInBits* *the length (in bits) of the secret keys agreed upon during the*
4970 *protocol handshake phase*

4971 *ulIVSizeInBits* *the length (in bits) of the IV agreed upon during the protocol*
4972 *handshake phase. If no IV is required, the length should be set to 0*

4973 *bIsExport* *must be set to CK_FALSE because export cipher suites must not be*
4974 *used in TLS 1.1 and later.*

4975 *RandomInfo* *client's and server's random data information.*

4976 *pReturnedKeyMaterial* *points to a CK_SSL3_KEY_MAT_OUT structures which receives*
4977 *the handles for the keys generated and the IVs*

4978 *prfHashMechanism* *base hash used in the underlying TLS1.2 PRF operation used to*
4979 *derive the master key.*

4980 **CK_TLS12_KEY_MAT_PARAMS_PTR** is a pointer to a **CK_TLS12_KEY_MAT_PARAMS**.

4981 ♦ **CK_TLS_KDF_PARAMS; CK_TLS_KDF_PARAMS_PTR**

4982 **CK_TLS_KDF_PARAMS** is a structure that provides the parameters to the **CKM_TLS_KDF** mechanism.
4983 It is defined as follows:

```
4984     typedef struct CK_TLS_KDF_PARAMS {  
4985         CK_MECHANISM_TYPE prfMechanism;  
4986         CK_BYTE_PTR pLabel;  
4987         CK_ULONG ulLabelLength;  
4988         CK_SSL3_RANDOM_DATA RandomInfo;  
4989         CK_BYTE_PTR pContextData;  
4990         CK_ULONG ulContextDataLength;  
4991     } CK_TLS_KDF_PARAMS;
```

4992

4993 The fields of the structure have the following meanings:

| | | |
|------|----------------------------|---|
| 4994 | <i>prfMechanism</i> | <i>the hash mechanism used in the TLS1.2 PRF construct or</i> |
| 4995 | | <i>CKM_TLS_PRF to use with the TLS1.0 and 1.1 PRF construct.</i> |
| 4996 | <i>pLabel</i> | <i>a pointer to the label for this key derivation</i> |
| 4997 | <i>ulLabelLength</i> | <i>length of the label in bytes</i> |
| 4998 | <i>RandomInfo</i> | <i>the random data for the key derivation</i> |
| 4999 | <i>pContextData</i> | <i>a pointer to the context data for this key derivation. NULL_PTR if not</i> |
| 5000 | | <i>present</i> |
| 5001 | <i>ulContextDataLength</i> | <i>length of the context data in bytes. 0 if not present.</i> |

5002 **CK_TLS_KDF_PARAMS_PTR** is a pointer to a **CK_TLS_KDF_PARAMS**.

5003 ♦ **CK_TLS_MAC_PARAMS; CK_TLS_MAC_PARAMS_PTR**

5004 **CK_TLS_MAC_PARAMS** is a structure that provides the parameters to the **CKM_TLS_MAC**
5005 mechanism. It is defined as follows:

```
5006     typedef struct CK_TLS_MAC_PARAMS {  
5007         CK_MECHANISM_TYPE prfMechanism;  
5008         CK_ULONG ulMacLength;  
5009         CK_ULONG ulServerOrClient;  
5010     } CK_TLS_MAC_PARAMS;
```

5011

5012 The fields of the structure have the following meanings:

| | | |
|------|---------------------|---|
| 5013 | <i>prfMechanism</i> | <i>the hash mechanism used in the TLS12 PRF construct or</i> |
| 5014 | | <i>CKM_TLS_PRF to use with the TLS1.0 and 1.1 PRF construct.</i> |
| 5015 | <i>ulMacLength</i> | <i>the length of the MAC tag required or offered. Always 12 octets in</i> |
| 5016 | | <i>TLS 1.0 and 1.1. Generally 12 octets, but may be negotiated to a</i> |
| 5017 | | <i>longer value in TLS1.2.</i> |

5018 *ulServerOrClient* 1 to use the label "server finished", 2 to use the label "client
5019 finished". All other values are invalid.

5020 **CK_TLS_MAC_PARAMS_PTR** is a pointer to a **CK_TLS_MAC_PARAMS**.

5021

5022 ♦ **CK_TLS_PRF_PARAMS; CK_TLS_PRF_PARAMS_PTR**

5023 **CK_TLS_PRF_PARAMS** is a structure, which provides the parameters to the **CKM_TLS_PRF**
5024 mechanism. It is defined as follows:

```
5025     typedef struct CK_TLS_PRF_PARAMS {  
5026         CK_BYTE_PTR      pSeed;  
5027         CK_ULONG         ulSeedLen;  
5028         CK_BYTE_PTR      pLabel;  
5029         CK_ULONG         ulLabelLen;  
5030         CK_BYTE_PTR      pOutput;  
5031         CK_ULONG_PTR     pulOutputLen;  
5032     } CK_TLS_PRF_PARAMS;
```

5033

5034 The fields of the structure have the following meanings:

| | | |
|------|---------------------|--|
| 5035 | <i>pSeed</i> | pointer to the input seed |
| 5036 | <i>ulSeedLen</i> | length in bytes of the input seed |
| 5037 | <i>pLabel</i> | pointer to the identifying label |
| 5038 | <i>ulLabelLen</i> | length in bytes of the identifying label |
| 5039 | <i>pOutput</i> | pointer receiving the output of the operation |
| 5040 | <i>pulOutputLen</i> | pointer to the length in bytes that the output to be created shall |
| 5041 | | have, has to hold the desired length as input and will receive the |
| 5042 | | calculated length as output |

5043 **CK_TLS_PRF_PARAMS_PTR** is a pointer to a **CK_TLS_PRF_PARAMS**.

5044 **2.40.3 TLS MAC**

5045 The TLS MAC mechanism is used to generate integrity tags for the TLS "finished" message. It replaces
5046 the use of the **CKM_TLS_PRF** function for TLS1.0 and 1.1 and that mechanism is deprecated.

5047 **CKM_TLS_MAC** takes a parameter of **CK_TLS_MAC_PARAMS**. To use this mechanism with TLS1.0
5048 and TLS1.1, use **CKM_TLS_PRF** as the value for *prfMechanism* in place of a hash mechanism. Note:
5049 Although **CKM_TLS_PRF** is deprecated as a mechanism for **C_DeriveKey**, the manifest value is retained
5050 for use with this mechanism to indicate the use of the TLS1.0/1.1 pseudo-random function.

5051 In TLS1.0 and 1.1 the "finished" message *verify_data* (i.e. the output signature from the MAC mechanism)
5052 is always 12 bytes. In TLS1.2 the "finished" message *verify_data* is a minimum of 12 bytes, defaults to 12
5053 bytes, but may be negotiated to longer length.

Table 158, General-length TLS MAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|----------------|-------------|------------------|
| C_Sign | generic secret | any | >=12 bytes |
| C_Verify | generic secret | any | >=12 bytes |

2.40.4 Master key derivation

Master key derivation in TLS 1.0, denoted **CKM_TLS_MASTER_KEY_DERIVE**, is a mechanism used to derive one 48-byte generic secret key from another 48-byte generic secret key. It is used to produce the "master_secret" key used in the TLS protocol from the "pre_master" key. This mechanism returns the value of the client version, which is built into the "pre_master" key as well as a handle to the derived "master_secret" key.

It has a parameter, a **CK_SSL3_MASTER_KEY_DERIVE_PARAMS** structure, which allows for the passing of random data to the token as well as the returning of the protocol version number which is part of the pre-master key. This structure is defined in Section 2.39.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key (as well as the **CKA_VALUE_LEN** attribute, if it is not supplied in the template). Other attributes may be specified in the template, or else are assigned default values.

The mechanism also contributes the **CKA_ALLOWED_MECHANISMS** attribute consisting only of **CKM_TLS12_KEY_AND_MAC_DERIVE**, **CKM_TLS12_KEY_SAFE_DERIVE**, **CKM_TLS12_KDF** and **CKM_TLS12_MAC**.

The template sent along with this mechanism during a **C_DeriveKey** call may indicate that the object class is **CKO_SECRET_KEY**, the key type is **CKK_GENERIC_SECRET**, and the **CKA_VALUE_LEN** attribute has value 48. However, since these facts are all implicit in the mechanism, there is no need to specify any of them.

This mechanism has the following rules about key sensitivity and extractability:

- The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some default value.
- If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_FALSE**, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_TRUE**, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.
- Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_FALSE**, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_TRUE**, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

For this mechanism, the **ulMinKeySize** and **ulMaxKeySize** fields of the **CK_MECHANISM_INFO** structure both indicate 48 bytes.

Note that the **CK_VERSION** structure pointed to by the **CK_SSL3_MASTER_KEY_DERIVE_PARAMS** structure's **pVersion** field will be modified by the **C_DeriveKey** call. In particular, when the call returns, this structure will hold the SSL version associated with the supplied pre_master key.

Note that this mechanism is only useable for cipher suites that use a 48-byte "pre_master" secret with an embedded version number. This includes the RSA cipher suites, but excludes the Diffie-Hellman cipher suites.

2.40.5 Master key derivation for Diffie-Hellman

Master key derivation for Diffie-Hellman in TLS 1.0, denoted **CKM_TLS_MASTER_KEY_DERIVE_DH**, is a mechanism used to derive one 48-byte generic secret key from another arbitrary length generic secret key. It is used to produce the "master_secret" key used in the TLS protocol from the "pre_master" key.

It has a parameter, a **CK_SSL3_MASTER_KEY_DERIVE_PARAMS** structure, which allows for the passing of random data to the token. This structure is defined in Section 2.39. The *pVersion* field of the structure must be set to **NULL_PTR** since the version number is not embedded in the "pre_master" key as it is for RSA-like cipher suites.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key (as well as the **CKA_VALUE_LEN** attribute, if it is not supplied in the template). Other attributes may be specified in the template, or else are assigned default values.

The mechanism also contributes the **CKA_ALLOWED_MECHANISMS** attribute consisting only of **CKM_TLS12_KEY_AND_MAC_DERIVE**, **CKM_TLS12_KEY_SAFE_DERIVE**, **CKM_TLS12_KDF** and **CKM_TLS12_MAC**.

The template sent along with this mechanism during a **C_DeriveKey** call may indicate that the object class is **CKO_SECRET_KEY**, the key type is **CKK_GENERIC_SECRET**, and the **CKA_VALUE_LEN** attribute has value 48. However, since these facts are all implicit in the mechanism, there is no need to specify any of them.

This mechanism has the following rules about key sensitivity and extractability:

- The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some default value.
- If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_FALSE**, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_TRUE**, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.
- Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_FALSE**, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_TRUE**, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

For this mechanism, the **ulMinKeySize** and **ulMaxKeySize** fields of the **CK_MECHANISM_INFO** structure both indicate 48 bytes.

Note that this mechanism is only useable for cipher suites that do not use a fixed length 48-byte "pre_master" secret with an embedded version number. This includes the Diffie-Hellman cipher suites, but excludes the RSA cipher suites.

2.40.6 Key and MAC derivation

Key, MAC and IV derivation in TLS 1.0, denoted **CKM_TLS_KEY_AND_MAC_DERIVE**, is a mechanism used to derive the appropriate cryptographic keying material used by a "CipherSuite" from the "master_secret" key and random data. This mechanism returns the key handles for the keys generated in the process, as well as the IVs created.

It has a parameter, a **CK_SSL3_KEY_MAT_PARAMS** structure, which allows for the passing of random data as well as the characteristic of the cryptographic material for the given CipherSuite and a pointer to a structure which receives the handles and IVs which were generated. This structure is defined in Section 2.39.

This mechanism contributes to the creation of four distinct keys on the token and returns two IVs (if IVs are requested by the caller) back to the caller. The keys are all given an object class of **CKO_SECRET_KEY**.

The two MACing keys ("client_write_MAC_secret" and "server_write_MAC_secret") (if present) are always given a type of **CKK_GENERIC_SECRET**. They are flagged as valid for signing and verification.

The other two keys ("client_write_key" and "server_write_key") are typed according to information found in the template sent along with this mechanism during a **C_DeriveKey** function call. By default, they are flagged as valid for encryption, decryption, and derivation operations.

For **CKM_TLS12_KEY_AND_MAC_DERIVE**, IVs will be generated and returned if the *ullvSizeInBits* field of the **CK_SSL3_KEY_MAT_PARAMS** field has a nonzero value. If they are generated, their length in bits will agree with the value in the *ullvSizeInBits* field.

Note Well: **CKM_TLS12_KEY_AND_MAC_DERIVE** produces both private (key) and public (IV) data. It is possible to "leak" private data by the simple expedient of decreasing the length of private data requested. E.g. Setting *ulMacSizeInBits* and *ulKeySizeInBits* to 0 (or other lengths less than the key size) will result in the private key data being placed in the destination designated for the IV's. Repeated calls with the same master key and same *RandomInfo* but with differing lengths for the private key material will result in different data being leaked.<

All four keys inherit the values of the **CKA_SENSITIVE**, **CKA_ALWAYS_SENSITIVE**, **CKA_EXTRACTABLE**, and **CKA_NEVER_EXTRACTABLE** attributes from the base key. The template provided to **C_DeriveKey** may not specify values for any of these attributes which differ from those held by the base key.

Note that the **CK_SSL3_KEY_MAT_OUT** structure pointed to by the **CK_SSL3_KEY_MAT_PARAMS** structure's *pReturnedKeyMaterial* field will be modified by the **C_DeriveKey** call. In particular, the four key handle fields in the **CK_SSL3_KEY_MAT_OUT** structure will be modified to hold handles to the newly-created keys; in addition, the buffers pointed to by the **CK_SSL3_KEY_MAT_OUT** structure's *pIVClient* and *pIVServer* fields will have IVs returned in them (if IVs are requested by the caller). Therefore, these two fields must point to buffers with sufficient space to hold any IVs that will be returned.

This mechanism departs from the other key derivation mechanisms in Cryptoki in its returned information. For most key-derivation mechanisms, **C_DeriveKey** returns a single key handle as a result of a successful completion. However, since the **CKM_SSL3_KEY_AND_MAC_DERIVE** mechanism returns all of its key handles in the **CK_SSL3_KEY_MAT_OUT** structure pointed to by the **CK_SSL3_KEY_MAT_PARAMS** structure specified as the mechanism parameter, the parameter *phKey* passed to **C_DeriveKey** is unnecessary, and should be a **NULL_PTR**.

If a call to **C_DeriveKey** with this mechanism fails, then *none* of the four keys will be created on the token.

2.40.7 CKM_TLS12_KEY_SAFE_DERIVE

CKM_TLS12_KEY_SAFE_DERIVE is identical to **CKM_TLS12_KEY_AND_MAC_DERIVE** except that it shall never produce IV data, and the *ullvSizeInBits* field of **CK_TLS12_KEY_MAT_PARAMS** is ignored and treated as 0. All of the other conditions and behavior described for **CKM_TLS12_KEY_AND_MAC_DERIVE**, with the exception of the black box warning, apply to this mechanism.

CKM_TLS12_KEY_SAFE_DERIVE is provided as a separate mechanism to allow a client to control the export of IV material (and possible leaking of key material) through the use of the **CKA_ALLOWED_MECHANISMS** key attribute.

2.40.8 Generic Key Derivation using the TLS PRF

CKM_TLS_KDF is the mechanism defined in [RFC 5705]. It uses the TLS key material and TLS PRF function to produce additional key material for protocols that want to leverage the TLS key negotiation mechanism. **CKM_TLS_KDF** has a parameter of **CK_TLS_KDF_PARAMS**. If the protocol using this mechanism does not use context information, the *pContextData* field shall be set to **NULL_PTR** and the *ulContextDataLength* field shall be set to 0.

To use this mechanism with TLS1.0 and TLS1.1, use **CKM_TLS_PRF** as the value for *prfMechanism* in place of a hash mechanism. Note: Although **CKM_TLS_PRF** is deprecated as a mechanism for **C_DeriveKey**, the manifest value is retained for use with this mechanism to indicate the use of the TLS1.0/1.1 Pseudo-random function.

5195 This mechanism can be used to derive multiple keys (e.g. similar to
5196 **CKM_TLS12_KEY_AND_MAC_DERIVE**) by first deriving the key stream as a **CKK_GENERIC_SECRET**
5197 of the necessary length and doing subsequent derives against that derived key using the
5198 **CKM_EXTRACT_KEY_FROM_KEY** mechanism to split the key stream into the actual operational keys.

5199 The mechanism should not be used with the labels defined for use with TLS, but the token does not
5200 enforce this behavior.

5201 This mechanism has the following rules about key sensitivity and extractability:

5202 • If the original key has its **CKA_SENSITIVE** attribute set to CK_TRUE, so does the derived key. If not,
5203 then the derived key's **CKA_SENSITIVE** attribute is set either from the supplied template or from the
5204 original key.

5205 • Similarly, if the original key has its **CKA_EXTRACTABLE** attribute set to CK_FALSE, so does the
5206 derived key. If not, then the derived key's **CKA_EXTRACTABLE** attribute is set either from the
5207 supplied template or from the original key.

5208 • The derived key's **CKA_ALWAYS_SENSITIVE** attribute is set to CK_TRUE if and only if the original
5209 key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE.

5210 • Similarly, the derived key's **CKA_NEVER_EXTRACTABLE** attribute is set to CK_TRUE if and only if
5211 the original key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_TRUE.

5212 2.40.9 Generic Key Derivation using the TLS12 PRF

5213 **CKM_TLS12_KDF** is the mechanism defined in [RFC 5705]. It uses the TLS key material and TLS PRF
5214 function to produce additional key material for protocols that want to leverage the TLS key negotiation
5215 mechanism. **CKM_TLS12_KDF** has a parameter of **CK_TLS_KDF_PARAMS**. If the protocol using this
5216 mechanism does not use context information, the *pContextData* field shall be set to NULL_PTR and the
5217 *ulContextDataLength* field shall be set to 0.

5218 To use this mechanism with TLS1.0 and TLS1.1, use **CKM_TLS_PRF** as the value for *prfMechanism* in
5219 place of a hash mechanism. Note: Although **CKM_TLS_PRF** is deprecated as a mechanism for
5220 C_DeriveKey, the manifest value is retained for use with this mechanism to indicate the use of the
5221 TLS1.0/1.1 Pseudo-random function.

5222 This mechanism can be used to derive multiple keys (e.g. similar to
5223 **CKM_TLS12_KEY_AND_MAC_DERIVE**) by first deriving the key stream as a **CKK_GENERIC_SECRET**
5224 of the necessary length and doing subsequent derives against that derived key stream using the
5225 **CKM_EXTRACT_KEY_FROM_KEY** mechanism to split the key stream into the actual operational keys.

5226 The mechanism should not be used with the labels defined for use with TLS, but the token does not
5227 enforce this behavior.

5228 This mechanism has the following rules about key sensitivity and extractability:

5229 • If the original key has its **CKA_SENSITIVE** attribute set to CK_TRUE, so does the derived key. If not,
5230 then the derived key's **CKA_SENSITIVE** attribute is set either from the supplied template or from the
5231 original key.

5232 • Similarly, if the original key has its **CKA_EXTRACTABLE** attribute set to CK_FALSE, so does the
5233 derived key. If not, then the derived key's **CKA_EXTRACTABLE** attribute is set either from the
5234 supplied template or from the original key.

5235 • The derived key's **CKA_ALWAYS_SENSITIVE** attribute is set to CK_TRUE if and only if the original
5236 key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE.

5237 • Similarly, the derived key's **CKA_NEVER_EXTRACTABLE** attribute is set to CK_TRUE if and only if
5238 the original key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_TRUE.

2.41 WTLS

Details can be found in [WTLS].

When comparing the existing TLS mechanisms with these extensions to support WTLS one could argue that there would be no need to have distinct handling of the client and server side of the handshake. However, since in WTLS the server and client use different sequence numbers, there could be instances (e.g. when WTLS is used to protect asynchronous protocols) where sequence numbers on the client and server side differ, and hence this motivates the introduced split.

Table 159, WTLS Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|------------------------------------|---------------------------------|-------------------------|--------------------|------------|-------------------------------------|-------------------------|------------|
| | Encry pt & Decry pt | Sign & Verif y | SR & VR 1 | Diges t | Gen · Key / Key Pair | Wrap & Unwra p | Deriv e |
| CKM_WTLS_PRE_MASTER_KEY_GEN | | | | | ✓ | | |
| CKM_WTLS_MASTER_KEY_DERIVE | | | | | | | ✓ |
| CKM_WTLS_MASTER_KEY_DERIVE_DH_ECC | | | | | | | ✓ |
| CKM_WTLS_SERVER_KEY_AND_MAC_DERIVE | | | | | | | ✓ |
| CKM_WTLS_CLIENT_KEY_AND_MAC_DERIVE | | | | | | | ✓ |
| CKM_WTLS_PRF | | | | | | | ✓ |

2.41.1 Definitions

Mechanisms:

CKM_WTLS_PRE_MASTER_KEY_GEN
CKM_WTLS_MASTER_KEY_DERIVE
CKM_WTLS_MASTER_KEY_DERIVE_DH_ECC
CKM_WTLS_PRF
CKM_WTLS_SERVER_KEY_AND_MAC_DERIVE
CKM_WTLS_CLIENT_KEY_AND_MAC_DERIVE

2.41.2 WTLS mechanism parameters

◆ CK_WTLS_RANDOM_DATA; CK_WTLS_RANDOM_DATA_PTR

CK_WTLS_RANDOM_DATA is a structure, which provides information about the random data of a client and a server in a WTLS context. This structure is used by the **CKM_WTLS_MASTER_KEY_DERIVE** mechanism. It is defined as follows:

```
typedef struct CK_WTLS_RANDOM_DATA {  
    CK_BYTE_PTR pClientRandom;  
    CK_ULONG    ulClientRandomLen;  
    CK_BYTE_PTR pServerRandom;
```

```

5265         CK_ULONG      ulServerRandomLen;
5266     } CK_WTLS_RANDOM_DATA;
5267

```

5268 The fields of the structure have the following meanings:

| | | |
|------|--------------------------|--|
| 5269 | <i>pClientRandom</i> | <i>pointer to the client's random data</i> |
| 5270 | <i>pClientRandomLen</i> | <i>length in bytes of the client's random data</i> |
| 5271 | <i>pServerRaandom</i> | <i>pointer to the server's random data</i> |
| 5272 | <i>ulServerRandomLen</i> | <i>length in bytes of the server's random data</i> |

5273 **CK_WTLS_RANDOM_DATA_PTR** is a pointer to a **CK_WTLS_RANDOM_DATA**.

5274 ♦ **CK_WTLS_MASTER_KEY_DERIVE_PARAMS;** 5275 **CK_WTLS_MASTER_KEY_DERIVE_PARAMS_PTR**

5276 **CK_WTLS_MASTER_KEY_DERIVE_PARAMS** is a structure, which provides the parameters to the
5277 **CKM_WTLS_MASTER_KEY_DERIVE** mechanism. It is defined as follows:

```

5278     typedef struct CK_WTLS_MASTER_KEY_DERIVE_PARAMS {
5279         CK_MECHANISM_TYPE    DigestMechanism;
5280         CK_WTLS_RANDOM_DATA  RandomInfo;
5281         CK_BYTE_PTR          pVersion;
5282     } CK_WTLS_MASTER_KEY_DERIVE_PARAMS;

```

5283
5284 The fields of the structure have the following meanings:

| | | |
|------|------------------------|---|
| 5285 | <i>DigestMechanism</i> | <i>the mechanism type of the digest mechanism to be used (possible</i> |
| 5286 | | <i>types can be found in [WTLS])</i> |
| 5287 | <i>RandomInfo</i> | <i>Client's and server's random data information</i> |
| 5288 | <i>pVersion</i> | <i>pointer to a CK_BYTE which receives the WTLS protocol version</i> |
| 5289 | | <i>information</i> |

5290 **CK_WTLS_MASTER_KEY_DERIVE_PARAMS_PTR** is a pointer to a
5291 **CK_WTLS_MASTER_KEY_DERIVE_PARAMS**.

5292 ♦ **CK_WTLS_PRF_PARAMS; CK_WTLS_PRF_PARAMS_PTR**

5293 **CK_WTLS_PRF_PARAMS** is a structure, which provides the parameters to the **CKM_WTLS_PRF**
5294 mechanism. It is defined as follows:

```

5295     typedef struct CK_WTLS_PRF_PARAMS {
5296         CK_MECHANISM_TYPE    DigestMechanism;
5297         CK_BYTE_PTR          pSeed;
5298         CK_ULONG              ulSeedLen;
5299         CK_BYTE_PTR          pLabel;
5300         CK_ULONG              ulLabelLen;
5301         CK_BYTE_PTR          pOutput;
5302         CK_ULONG_PTR          pulOutputLen;
5303     } CK_WTLS_PRF_PARAMS;

```

5304

5305 The fields of the structure have the following meanings:

| | | |
|------|-------------------------|---|
| 5306 | <i>Digest Mechanism</i> | <i>the mechanism type of the digest mechanism to be used (possible</i> |
| 5307 | | <i>types can be found in [WTLS])</i> |
| 5308 | <i>pSeed</i> | <i>pointer to the input seed</i> |
| 5309 | <i>ulSeedLen</i> | <i>length in bytes of the input seed</i> |
| 5310 | <i>pLabel</i> | <i>pointer to the identifying label</i> |
| 5311 | <i>ulLabelLen</i> | <i>length in bytes of the identifying label</i> |
| 5312 | <i>pOutput</i> | <i>pointer receiving the output of the operation</i> |
| 5313 | <i>pulOutputLen</i> | <i>pointer to the length in bytes that the output to be created shall</i> |
| 5314 | | <i>have, has to hold the desired length as input and will receive the</i> |
| 5315 | | <i>calculated length as output</i> |

5316 **CK_WTLS_PRF_PARAMS_PTR** is a pointer to a **CK_WTLS_PRF_PARAMS**.

5317 ♦ **CK_WTLS_KEY_MAT_OUT; CK_WTLS_KEY_MAT_OUT_PTR**

5318 **CK_WTLS_KEY_MAT_OUT** is a structure that contains the resulting key handles and initialization
 5319 vectors after performing a C_DeriveKey function with the
 5320 **CKM_WTLS_SERVER_KEY_AND_MAC_DERIVE** or with the
 5321 **CKM_WTLS_CLIENT_KEY_AND_MAC_DERIVE** mechanism. It is defined as follows:

```
5322 typedef struct CK_WTLS_KEY_MAT_OUT {
5323     CK_OBJECT_HANDLE hMacSecret;
5324     CK_OBJECT_HANDLE hKey;
5325     CK_BYTE_PTR      pIV;
5326 } CK_WTLS_KEY_MAT_OUT;
```

5327

5328 The fields of the structure have the following meanings:

| | | |
|------|-------------------|--|
| 5329 | <i>hMacSecret</i> | <i>Key handle for the resulting MAC secret key</i> |
| 5330 | <i>hKey</i> | <i>Key handle for the resulting secret key</i> |
| 5331 | <i>pIV</i> | <i>Pointer to a location which receives the initialization vector (IV)</i> |
| 5332 | | <i>created (if any)</i> |

5333 **CK_WTLS_KEY_MAT_OUT_PTR** is a pointer to a **CK_WTLS_KEY_MAT_OUT**.

5334 ♦ **CK_WTLS_KEY_MAT_PARAMS; CK_WTLS_KEY_MAT_PARAMS_PTR**

5335 **CK_WTLS_KEY_MAT_PARAMS** is a structure that provides the parameters to the
 5336 **CKM_WTLS_SERVER_KEY_AND_MAC_DERIVE** and the
 5337 **CKM_WTLS_CLIENT_KEY_AND_MAC_DERIVE** mechanisms. It is defined as follows:

```
5338 typedef struct CK_WTLS_KEY_MAT_PARAMS {
5339     CK_MECHANISM_TYPE    DigestMechanism;
5340     CK_ULONG             ulMacSizeInBits;
5341     CK_ULONG             ulKeySizeInBits;
```

```

5342         CK_ULONG          ulIVSizeInBits;
5343         CK_ULONG          ulSequenceNumber;
5344         CK_BBOOL          bIsExport;
5345         CK_WTLS_RANDOM_DATA RandomInfo;
5346         CK_WTLS_KEY_MAT_OUT_PTR pReturnedKeyMaterial;
5347     } CK_WTLS_KEY_MAT_PARAMS;

```

5348

5349 The fields of the structure have the following meanings:

| | | |
|------|-----------------------------|--|
| 5350 | <i>Digest Mechanism</i> | <i>the mechanism type of the digest mechanism to be used (possible types can be found in [WTLS])</i> |
| 5351 | | |
| 5352 | <i>ulMaxSizeInBits</i> | <i>the length (in bits) of the MACing key agreed upon during the protocol handshake phase</i> |
| 5353 | | |
| 5354 | <i>ulKeySizeInBits</i> | <i>the length (in bits) of the secret key agreed upon during the handshake phase</i> |
| 5355 | | |
| 5356 | <i>ulIVSizeInBits</i> | <i>the length (in bits) of the IV agreed upon during the handshake phase. If no IV is required, the length should be set to 0.</i> |
| 5357 | | |
| 5358 | <i>ulSequenceNumber</i> | <i>the current sequence number used for records sent by the client and server respectively</i> |
| 5359 | | |
| 5360 | <i>bIsExport</i> | <i>a boolean value which indicates whether the keys have to be derives for an export version of the protocol. If this value is true (i.e., the keys are exportable) then ulKeySizeInBits is the length of the key in bits before expansion. The length of the key after expansion is determined by the information found in the template sent along with this mechanism during a C_DeriveKey function call (either the CKA_KEY_TYPE or the CKA_VALUE_LEN attribute).</i> |
| 5361 | | |
| 5362 | | |
| 5363 | | |
| 5364 | | |
| 5365 | | |
| 5366 | | |
| 5367 | <i>RandomInfo</i> | <i>client's and server's random data information</i> |
| 5368 | <i>pReturnedKeyMaterial</i> | <i>points to a CK_WTLS_KEY_MAT_OUT structure which receives the handles for the keys generated and the IV</i> |
| 5369 | | |

5370 **CK_WTLS_KEY_MAT_PARAMS_PTR** is a pointer to a **CK_WTLS_KEY_MAT_PARAMS**.

5371 2.41.3 Pre master secret key generation for RSA key exchange suite

5372 Pre master secret key generation for the RSA key exchange suite in WTLS denoted
5373 **CKM_WTLS_PRE_MASTER_KEY_GEN**, is a mechanism, which generates a variable length secret key.
5374 It is used to produce the pre master secret key for RSA key exchange suite used in WTLS. This
5375 mechanism returns a handle to the pre master secret key.

5376 It has one parameter, a **CK_BYTE**, which provides the client's WTLS version.

5377 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE** and **CKA_VALUE** attributes to the new
5378 key (as well as the **CKA_VALUE_LEN** attribute, if it is not supplied in the template). Other attributes may
5379 be specified in the template, or else are assigned default values.

5380 The template sent along with this mechanism during a **C_GenerateKey** call may indicate that the object
5381 class is **CKO_SECRET_KEY**, the key type is **CKK_GENERIC_SECRET**, and the **CKA_VALUE_LEN**
5382 attribute indicates the length of the pre master secret key.

5383 For this mechanism, the **ulMinKeySize** field of the **CK_MECHANISM_INFO** structure shall indicate 20
5384 bytes.

2.41.4 Master secret key derivation

Master secret derivation in WTLS, denoted **CKM_WTLS_MASTER_KEY_DERIVE**, is a mechanism used to derive a 20 byte generic secret key from variable length secret key. It is used to produce the master secret key used in WTLS from the pre master secret key. This mechanism returns the value of the client version, which is built into the pre master secret key as well as a handle to the derived master secret key.

It has a parameter, a **CK_WTLS_MASTER_KEY_DERIVE_PARAMS** structure, which allows for passing the mechanism type of the digest mechanism to be used as well as the passing of random data to the token as well as the returning of the protocol version number which is part of the pre master secret key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key (as well as the **CKA_VALUE_LEN** attribute, if it is not supplied in the template). Other attributes may be specified in the template, or else are assigned default values.

The template sent along with this mechanism during a **C_DeriveKey** call may indicate that the object class is **CKO_SECRET_KEY**, the key type is **CKK_GENERIC_SECRET**, and the **CKA_VALUE_LEN** attribute has value 20. However, since these facts are all implicit in the mechanism, there is no need to specify any of them.

This mechanism has the following rules about key sensitivity and extractability:

The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some default value.

If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_FALSE**, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_TRUE**, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.

Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_FALSE**, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_TRUE**, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

For this mechanism, the **ulMinKeySize** and **ulMaxKeySize** fields of the **CK_MECHANISM_INFO** structure both indicate 20 bytes.

Note that the **CK_BYTE** pointed to by the **CK_WTLS_MASTER_KEY_DERIVE_PARAMS** structure's **pVersion** field will be modified by the **C_DeriveKey** call. In particular, when the call returns, this byte will hold the WTLS version associated with the supplied pre master secret key.

Note that this mechanism is only useable for key exchange suites that use a 20-byte pre master secret key with an embedded version number. This includes the RSA key exchange suites, but excludes the Diffie-Hellman and Elliptic Curve Cryptography key exchange suites.

2.41.5 Master secret key derivation for Diffie-Hellman and Elliptic Curve Cryptography

Master secret derivation for Diffie-Hellman and Elliptic Curve Cryptography in WTLS, denoted **CKM_WTLS_MASTER_KEY_DERIVE_DH_ECC**, is a mechanism used to derive a 20 byte generic secret key from variable length secret key. It is used to produce the master secret key used in WTLS from the pre master secret key. This mechanism returns a handle to the derived master secret key.

It has a parameter, a **CK_WTLS_MASTER_KEY_DERIVE_PARAMS** structure, which allows for the passing of the mechanism type of the digest mechanism to be used as well as random data to the token. The **pVersion** field of the structure must be set to **NULL_PTR** since the version number is not embedded in the pre master secret key as it is for RSA-like key exchange suites.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key (as well as the **CKA_VALUE_LEN** attribute, if it is not supplied in the template). Other attributes may be specified in the template, or else are assigned default values.

The template sent along with this mechanism during a **C_DeriveKey** call may indicate that the object class is **CKO_SECRET_KEY**, the key type is **CKK_GENERIC_SECRET**, and the **CKA_VALUE_LEN**

attribute has value 20. However, since these facts are all implicit in the mechanism, there is no need to specify any of them.

This mechanism has the following rules about key sensitivity and extractability:

The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some default value.

If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_FALSE**, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_TRUE**, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.

Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_FALSE**, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_TRUE**, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

For this mechanism, the **ulMinKeySize** and **ulMaxKeySize** fields of the **CK_MECHANISM_INFO** structure both indicate 20 bytes.

Note that this mechanism is only useable for key exchange suites that do not use a fixed length 20-byte pre master secret key with an embedded version number. This includes the Diffie-Hellman and Elliptic Curve Cryptography key exchange suites, but excludes the RSA key exchange suites.

2.41.6 WTLS PRF (pseudorandom function)

PRF (pseudo random function) in WTLS, denoted **CKM_WTLS_PRF**, is a mechanism used to produce a securely generated pseudo-random output of arbitrary length. The keys it uses are generic secret keys.

It has a parameter, a **CK_WTLS_PRF_PARAMS** structure, which allows for passing the mechanism type of the digest mechanism to be used, the passing of the input seed and its length, the passing of an identifying label and its length and the passing of the length of the output to the token and for receiving the output.

This mechanism produces securely generated pseudo-random output of the length specified in the parameter.

This mechanism departs from the other key derivation mechanisms in Cryptoki in not using the template sent along with this mechanism during a **C_DeriveKey** function call, which means the template shall be a **NULL_PTR**. For most key-derivation mechanisms, **C_DeriveKey** returns a single key handle as a result of a successful completion. However, since the **CKM_WTLS_PRF** mechanism returns the requested number of output bytes in the **CK_WTLS_PRF_PARAMS** structure specified as the mechanism parameter, the parameter *phKey* passed to **C_DeriveKey** is unnecessary, and should be a **NULL_PTR**.

If a call to **C_DeriveKey** with this mechanism fails, then no output will be generated.

2.41.7 Server Key and MAC derivation

Server key, MAC and IV derivation in WTLS, denoted **CKM_WTLS_SERVER_KEY_AND_MAC_DERIVE**, is a mechanism used to derive the appropriate cryptographic keying material used by a cipher suite from the master secret key and random data. This mechanism returns the key handles for the keys generated in the process, as well as the IV created.

It has a parameter, a **CK_WTLS_KEY_MAT_PARAMS** structure, which allows for the passing of the mechanism type of the digest mechanism to be used, random data, the characteristic of the cryptographic material for the given cipher suite, and a pointer to a structure which receives the handles and IV which were generated.

This mechanism contributes to the creation of two distinct keys and returns one IV (if an IV is requested by the caller) back to the caller. The keys are all given an object class of **CKO_SECRET_KEY**.

The MACing key (server write MAC secret) is always given a type of **CKK_GENERIC_SECRET**. It is flagged as valid for signing, verification and derivation operations.

The other key (server write key) is typed according to information found in the template sent along with this mechanism during a **C_DeriveKey** function call. By default, it is flagged as valid for encryption, decryption, and derivation operations.

An IV (server write IV) will be generated and returned if the *ulIVSizeInBits* field of the **CK_WTLS_KEY_MAT_PARAMS** field has a nonzero value. If it is generated, its length in bits will agree with the value in the *ulIVSizeInBits* field

Both keys inherit the values of the **CKA_SENSITIVE**, **CKA_ALWAYS_SENSITIVE**, **CKA_EXTRACTABLE**, and **CKA_NEVER_EXTRACTABLE** attributes from the base key. The template provided to **C_DeriveKey** may not specify values for any of these attributes that differ from those held by the base key.

Note that the **CK_WTLS_KEY_MAT_OUT** structure pointed to by the **CK_WTLS_KEY_MAT_PARAMS** structure's *pReturnedKeyMaterial* field will be modified by the **C_DeriveKey** call. In particular, the two key handle fields in the **CK_WTLS_KEY_MAT_OUT** structure will be modified to hold handles to the newly-created keys; in addition, the buffer pointed to by the **CK_WTLS_KEY_MAT_OUT** structure's *pIV* field will have the IV returned in them (if an IV is requested by the caller). Therefore, this field must point to a buffer with sufficient space to hold any IV that will be returned.

This mechanism departs from the other key derivation mechanisms in Cryptoki in its returned information. For most key-derivation mechanisms, **C_DeriveKey** returns a single key handle as a result of a successful completion. However, since the **CKM_WTLS_SERVER_KEY_AND_MAC_DERIVE** mechanism returns all of its key handles in the **CK_WTLS_KEY_MAT_OUT** structure pointed to by the **CK_WTLS_KEY_MAT_PARAMS** structure specified as the mechanism parameter, the parameter *phKey* passed to **C_DeriveKey** is unnecessary, and should be a **NULL_PTR**.

If a call to **C_DeriveKey** with this mechanism fails, then *none* of the two keys will be created.

2.41.8 Client key and MAC derivation

Client key, MAC and IV derivation in WTLS, denoted **CKM_WTLS_CLIENT_KEY_AND_MAC_DERIVE**, is a mechanism used to derive the appropriate cryptographic keying material used by a cipher suite from the master secret key and random data. This mechanism returns the key handles for the keys generated in the process, as well as the IV created.

It has a parameter, a **CK_WTLS_KEY_MAT_PARAMS** structure, which allows for the passing of the mechanism type of the digest mechanism to be used, random data, the characteristic of the cryptographic material for the given cipher suite, and a pointer to a structure which receives the handles and IV which were generated.

This mechanism contributes to the creation of two distinct keys and returns one IV (if an IV is requested by the caller) back to the caller. The keys are all given an object class of **CKO_SECRET_KEY**.

The MACing key (client write MAC secret) is always given a type of **CKK_GENERIC_SECRET**. It is flagged as valid for signing, verification and derivation operations.

The other key (client write key) is typed according to information found in the template sent along with this mechanism during a **C_DeriveKey** function call. By default, it is flagged as valid for encryption, decryption, and derivation operations.

An IV (client write IV) will be generated and returned if the *ulIVSizeInBits* field of the **CK_WTLS_KEY_MAT_PARAMS** field has a nonzero value. If it is generated, its length in bits will agree with the value in the *ulIVSizeInBits* field

Both keys inherit the values of the **CKA_SENSITIVE**, **CKA_ALWAYS_SENSITIVE**, **CKA_EXTRACTABLE**, and **CKA_NEVER_EXTRACTABLE** attributes from the base key. The template provided to **C_DeriveKey** may not specify values for any of these attributes that differ from those held by the base key.

Note that the **CK_WTLS_KEY_MAT_OUT** structure pointed to by the **CK_WTLS_KEY_MAT_PARAMS** structure's *pReturnedKeyMaterial* field will be modified by the **C_DeriveKey** call. In particular, the two key handle fields in the **CK_WTLS_KEY_MAT_OUT** structure will be modified to hold handles to the newly-created keys; in addition, the buffer pointed to by the **CK_WTLS_KEY_MAT_OUT** structure's *pIV* field will

have the IV returned in them (if an IV is requested by the caller). Therefore, this field must point to a buffer with sufficient space to hold any IV that will be returned.

This mechanism departs from the other key derivation mechanisms in Cryptoki in its returned information. For most key-derivation mechanisms, **C_DeriveKey** returns a single key handle as a result of a successful completion. However, since the **CKM_WTLS_CLIENT_KEY_AND_MAC_DERIVE** mechanism returns all of its key handles in the **CK_WTLS_KEY_MAT_OUT** structure pointed to by the **CK_WTLS_KEY_MAT_PARAMS** structure specified as the mechanism parameter, the parameter *phKey* passed to **C_DeriveKey** is unnecessary, and should be a **NULL_PTR**.

If a call to **C_DeriveKey** with this mechanism fails, then *none* of the two keys will be created.

2.42 SP 800-108 Key Derivation

NIST SP800-108 defines three types of key derivation functions (KDF); a Counter Mode KDF, a Feedback Mode KDF and a Double Pipeline Mode KDF.

This section defines a unique mechanism for each type of KDF. These mechanisms can be used to derive one or more symmetric keys from a single base symmetric key.

The KDFs defined in SP800-108 are all built upon pseudo random functions (PRF). In general terms, the PRFs accepts two pieces of input; a base key and some input data. The base key is taken from the *hBaseKey* parameter to **C_Derive**. The input data is constructed from an iteration variable (internally defined by the KDF/PRF) and the data provided in the **CK_PRF_DATA_PARAM** array that is part of the mechanism parameter.

Table 160, SP800-108 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-----------------------------------|-------------------------|---------------------|---------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SP800_108_COUNTER_KDF | | | | | | | ✓ |
| CKM_SP800_108_FEEDBACK_KDF | | | | | | | ✓ |
| CKM_SP800_108_DOUBLE_PIPELINE_KDF | | | | | | | ✓ |

For these mechanisms, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the minimum and maximum supported base key size in bits. Note, these mechanisms support multiple PRF types and key types; as such the values reported by *ulMinKeySize* and *ulMaxKeySize* specify the minimum and maximum supported base key size when all PRF and keys types are considered. For example, a Cryptoki implementation may support **CKK_GENERIC_SECRET** keys that can be as small as 8-bits in length and therefore *ulMinKeySize* could report 8-bits. However, for an AES-CMAC PRF the base key must be of type **CKK_AES** and must be either 16-bytes, 24-bytes or 32-bytes in lengths and therefore the value reported by *ulMinKeySize* could be misleading. Depending on the PRF type selected, additional key size restrictions may apply.

2.42.1 Definitions

Mechanisms:

CKM_SP800_108_COUNTER_KDF
 CKM_SP800_108_FEEDBACK_KDF
 CKM_SP800_108_DOUBLE_PIPELINE_KDF

Data Field Types:

5568 CK_SP800_108_ITERATION_VARIABLE
5569 CK_SP800_108_COUNTER
5570 CK_SP800_108_DKM_LENGTH
5571 CK_SP800_108_BYTE_ARRAY
5572
5573 DKM Length Methods:
5574 CK_SP800_108_DKM_LENGTH_SUM_OF_KEYS
5575 CK_SP800_108_DKM_LENGTH_SUM_OF_SEGMENTS

5576 **2.42.2 Mechanism Parameters**

5577 **◆ CK_SP800_108_PRF_TYPE**

5578 The **CK_SP800_108_PRF_TYPE** field of the mechanism parameter is used to specify the type of PRF
5579 that is to be used. It is defined as follows:

5580 `typedef CK_MECHANISM_TYPE CK_SP800_108_PRF_TYPE;`

5581 The **CK_SP800_108_PRF_TYPE** field reuses the existing mechanisms definitions. The following table
5582 lists the supported PRF types:

5583 *Table 161, SP800-108 Pseudo Random Functions*

| Pseudo Random Function Identifiers |
|------------------------------------|
| CKM_SHA_1_HMAC |
| CKM_SHA224_HMAC |
| CKM_SHA256_HMAC |
| CKM_SHA384_HMAC |
| CKM_SHA512_HMAC |
| CKM_SHA3_224_HMAC |
| CKM_SHA3_256_HMAC |
| CKM_SHA3_384_HMAC |
| CKM_SHA3_512_HMAC |
| CKM_DES3_CMAC |
| CKM_AES_CMAC |

5584

5585 **◆ CK_PRF_DATA_TYPE**

5586 Each mechanism parameter contains an array of **CK_PRF_DATA_PARAM** structures. The
5587 **CK_PRF_DATA_PARAM** structure contains **CK_PRF_DATA_TYPE** field. The **CK_PRF_DATA_TYPE**
5588 field is used to identify the type of data identified by each **CK_PRF_DATA_PARAM** element in the array.
5589 Depending on the type of KDF used, some data field types are mandatory, some data field types are
5590 optional and some data field types are not allowed. These requirements are defined on a per-mechanism
5591 basis in the sections below. The **CK_PRF_DATA_TYPE** is defined as follows:
5592 `typedef CK_ULONG CK_PRF_DATA_TYPE;`
5593 The following table lists all of the supported data field types:

| Data Field Identifier | Description |
|---------------------------------|---|
| CK_SP800_108_ITERATION_VARIABLE | Identifies the iteration variable defined internally by the KDF. |
| CK_SP800_108_COUNTER | Identifies an optional counter value represented as a binary string. Exact formatting of the counter value is defined by the CK_SP800_108_COUNTER_FORMAT structure. The value of the counter is defined by the KDF's internal loop counter. |
| CK_SP800_108_DKM_LENGTH | Identifies the length in bits of the derived keying material (DKM) represented as a binary string. Exact formatting of the length value is defined by the CK_SP800_108_DKM_LENGTH_FORMAT structure. |
| CK_SP800_108_BYTE_ARRAY | Identifies a generic byte array of data. This data type can be used to provide "context", "label", "separator bytes" as well as any other type of encoding information required by the higher level protocol. |

5595

5596 **◆ CK_PRF_DATA_PARAM**

5597 **CK_PRF_DATA_PARAM** is used to define a segment of input for the PRF. Each mechanism parameter
5598 supports an array of **CK_PRF_DATA_PARAM** structures. The **CK_PRF_DATA_PARAM** is defined as
5599 follows:

```
5600     typedef struct CK_PRF_DATA_PARAM
5601     {
5602         CK_PRF_DATA_TYPE      type;
5603         CK_VOID_PTR           pValue;
5604         CK_ULONG              ulValueLen;
5605     } CK_PRF_DATA_PARAM;
5606
5607     typedef CK_PRF_DATA_PARAM CK_PTR CK_PRF_DATA_PARAM_PTR
```

5609 The fields of the **CK_PRF_DATA_PARAM** structure have the following meaning:

- 5610 *type* defines the type of data pointed to by *pValue*
- 5611 *pValue* pointer to the data defined by *type*
- 5612 *ulValueLen* size of the data pointed to by *pValue*

5613 If the *type* field of the **CK_PRF_DATA_PARAM** structure is set to
5614 CK_SP800_108_ITERATION_VARIABLE, then *pValue* must be set the appropriate value for the KDF's
5615 iteration variable type. For the Counter Mode KDF, *pValue* must be assigned a valid
5616 CK_SP800_108_COUNTER_FORMAT_PTR and *ulValueLen* must be set to
5617 sizeof(CK_SP800_108_COUNTER_FORMAT). For all other KDF types, *pValue* must be set to
5618 NULL_PTR and *ulValueLen* must be set to 0.

5619

5620 If the *type* field of the **CK_PRF_DATA_PARAM** structure is set to CK_SP800_108_COUNTER, then
5621 *pValue* must be assigned a valid CK_SP800_108_COUNTER_FORMAT_PTR and *ulValueLen* must be
5622 set to sizeof(CK_SP800_108_COUNTER_FORMAT).

5623

5624 If the *type* field of the **CK_PRF_DATA_PARAM** structure is set to CK_SP800_108_DKM_LENGTH then

5625 *pValue* must be assigned a valid CK_SP800_108_DKM_LENGTH_FORMAT_PTR and *ulValueLen* must

5626 be set to sizeof(CK_SP800_108_DKM_LENGTH_FORMAT).

5627

5628 If the *type* field of the **CK_PRF_DATA_PARAM** structure is set to CK_SP800_108_BYTE_ARRAY, then

5629 *pValue* must be assigned a valid CK_BYTE_PTR value and *ulValueLen* must be set to a non-zero length.

5630 **◆ CK_SP800_108_COUNTER_FORMAT**

5631 **CK_SP800_108_COUNTER_FORMAT** is used to define the encoding format for a counter value. The

5632 **CK_SP800_108_COUNTER_FORMAT** is defined as follows:

```
5633     typedef struct CK_SP800_108_COUNTER_FORMAT
5634     {
5635         CK_BBOOL      bLittleEndian;
5636         CK_ULONG      ulWidthInBits;
5637     } CK_SP800_108_COUNTER_FORMAT;
5638
5639     typedef CK_SP800_108_COUNTER_FORMAT CK_PTR
5640     CK_SP800_108_COUNTER_FORMAT_PTR
```

5641

5642 The fields of the CK_SP800_108_COUNTER_FORMAT structure have the following meaning:

5643 *bLittleEndian* defines if the counter should be represented in Big Endian or Little

5644 Endian format

5645 *ulWidthInBits* defines the number of bits used to represent the counter value

5646 **◆ CK_SP800_108_DKM_LENGTH_METHOD**

5647 **CK_SP800_108_DKM_LENGTH_METHOD** is used to define how the DKM length value is calculated.

5648 The **CK_SP800_108_DKM_LENGTH_METHOD** type is defined as follows:

```
5649     typedef CK_ULONG CK_SP800_108_DKM_LENGTH_METHOD;
```

5650 The following table lists all of the supported DKM Length Methods:

5651 Table 163, SP800-108 DKM Length Methods

| DKM Length Method Identifier | Description |
|---|---|
| CK_SP800_108_DKM_LENGTH_SUM_OF_KEYS | Specifies that the DKM length should be set to the sum of the length of all keys derived by this invocation of the KDF. |
| CK_SP800_108_DKM_LENGTH_SUM_OF_SEGMENTS | Specifies that the DKM length should be set to the sum of the length of all segments of output produced by the PRF by this invocation of the KDF. |

5652

5653 **◆ CK_SP800_108_DKM_LENGTH_FORMAT**

5654 **CK_SP800_108_DKM_LENGTH_FORMAT** is used to define the encoding format for the DKM length

5655 value. The **CK_SP800_108_DKM_LENGTH_FORMAT** is defined as follows:

```
5656     typedef struct CK_SP800_108_DKM_LENGTH_FORMAT
```



```

5657     {
5658         CK_SP800_108_DKM_LENGTH_METHOD    dkmLengthMethod;
5659         CK_BBOOL                           bLittleEndian;
5660         CK_ULONG                           ulWidthInBits;
5661     } CK_SP800_108_DKM_LENGTH_FORMAT;
5662
5663     typedef CK_SP800_108_DKM_LENGTH_FORMAT CK_PTR
5664     CK_SP800_108_DKM_LENGTH_FORMAT_PTR
5665 
```

The fields of the CK_SP800_108_DKM_LENGTH_FORMAT structure have the following meaning:

| | | |
|------|------------------------|--|
| 5666 | <i>dkmLengthMethod</i> | <i>defines the method used to calculate the DKM length value</i> |
| 5668 | <i>bLittleEndian</i> | <i>defines if the DKM length value should be represented in Big</i> |
| 5669 | | <i>Endian or Little Endian format</i> |
| 5670 | <i>ulWidthInBits</i> | <i>defines the number of bits used to represent the DKM length value</i> |

5671 ♦ CK_DERIVED_KEY

5672 **CK_DERIVED_KEY** is used to define an additional key to be derived as well as provide a
5673 CK_OBJECT_HANDLE_PTR to receive the handle for the derived keys. The **CK_DERIVED_KEY** is
5674 defined as follows:

```

5675     typedef struct CK_DERIVED_KEY
5676     {
5677         CK_ATTRIBUTE_PTR    pTemplate;
5678         CK_ULONG             ulAttributeCount;
5679         CK_OBJECT_HANDLE_PTR phKey;
5680     } CK_DERIVED_KEY;
5681
5682     typedef CK_DERIVED_KEY CK_PTR CK_DERIVED_KEY_PTR
5683 
```

5684 The fields of the CK_DERIVED_KEY structure have the following meaning:

| | | |
|------|-------------------------|---|
| 5685 | <i>pTemplate</i> | <i>pointer to a template that defines a key to derive</i> |
| 5686 | <i>ulAttributeCount</i> | <i>number of attributes in the template pointed to by pTemplate</i> |
| 5687 | <i>phKey</i> | <i>pointer to receive the handle for a derived key</i> |

5688 ♦ CK_SP800_108_KDF_PARAMS, CK_SP800_108_KDF_PARAMS_PTR

5689 **CK_SP800_108_KDF_PARAMS** is a structure that provides the parameters for the
5690 **CKM_SP800_108_COUNTER_KDF** and **CKM_SP800_108_DOUBLE_PIPELINE_KDF** mechanisms.

```

5691     typedef struct CK_SP800_108_KDF_PARAMS
5692     {
5693         CK_SP800_108_PRF_TYPE    prfType;
5694         CK_ULONG                 ulNumberOfDataParams;
5695         CK_PRF_DATA_PARAM_PTR    pDataParams;
5696         CK_ULONG                 ulAdditionalDerivedKeys;
5697 
```

```

5698         CK_DERIVED_KEY_PTR      pAdditionalDerivedKeys;
5699     } CK_SP800_108_KDF_PARAMS;

```

```

5700
5701     typedef CK_SP800_108_KDF_PARAMS CK_PTR
5702     CK_SP800_108_KDF_PARAMS_PTR;
5703

```

5704 The fields of the **CK_SP800_108_KDF_PARAMS** structure have the following meaning:

| | | |
|------|--------------------------------|--|
| 5705 | <i>prfType</i> | <i>type of PRF</i> |
| 5706 | <i>ulNumberOfDataParams</i> | <i>number of elements in the array pointed to by pDataParams</i> |
| 5707 | <i>pDataParams</i> | <i>an array of CK_PRF_DATA_PARAM structures. The array defines</i> |
| 5708 | | <i>input parameters that are used to construct the “data” input to the</i> |
| 5709 | | <i>PRF.</i> |
| 5710 | <i>ulAdditionalDerivedKeys</i> | <i>number of additional keys that will be derived and the number of</i> |
| 5711 | | <i>elements in the array pointed to by pAdditionalDerivedKeys. If</i> |
| 5712 | | <i>pAdditionalDerivedKeys is set to NULL_PTR, this parameter must</i> |
| 5713 | | <i>be set to 0.</i> |
| 5714 | <i>pAdditionalDerivedKeys</i> | <i>an array of CK_DERIVED_KEY structures. If</i> |
| 5715 | | <i>ulAdditionalDerivedKeys is set to 0, this parameter must be set to</i> |
| 5716 | | <i>NULL_PTR</i> |

5717 ♦ **CK_SP800_108_FEEDBACK_KDF_PARAMS,** 5718 **CK_SP800_108_FEEDBACK_KDF_PARAMS_PTR**

5719 The **CK_SP800_108_FEEDBACK_KDF_PARAMS** structure provides the parameters for the
5720 CKM_SP800_108_FEEDBACK_KDF mechanism. It is defined as follows:

```

5721     typedef struct CK_SP800_108_FEEDBACK_KDF_PARAMS
5722     {
5723         CK_SP800_108_PRF_TYPE      prfType;
5724         CK_ULONG                    ulNumberOfDataParams;
5725         CK_PRF_DATA_PARAM_PTR      pDataParams;
5726         CK_ULONG                    ulIVLen;
5727         CK_BYTE_PTR                 pIV;
5728         CK_ULONG                    ulAdditionalDerivedKeys;
5729         CK_DERIVED_KEY_PTR          pAdditionalDerivedKeys;
5730     } CK_SP800_108_FEEDBACK_KDF_PARAMS;
5731
5732     typedef CK_SP800_108_FEEDBACK_KDF_PARAMS CK_PTR
5733     CK_SP800_108_FEEDBACK_KDF_PARAMS_PTR;
5734

```

5735 The fields of the **CK_SP800_108_FEEDBACK_KDF_PARAMS** structure have the following meaning:

| | | |
|------|-----------------------------|--|
| 5736 | <i>prfType</i> | <i>type of PRF</i> |
| 5737 | <i>ulNumberOfDataParams</i> | <i>number of elements in the array pointed to by pDataParams</i> |
| 5738 | <i>pDataParams</i> | <i>an array of CK_PRF_DATA_PARAM structures. The array defines</i> |
| 5739 | | <i>input parameters that are used to construct the “data” input to the</i> |
| 5740 | | <i>PRF.</i> |

5741 *ulIVLen* the length in bytes of the IV. If *pIV* is set to *NULL_PTR*, this
5742 parameter must be set to 0.

5743 *pIV* an array of bytes to be used as the IV for the feedback mode KDF.
5744 This parameter is optional and can be set to *NULL_PTR*. If *ulIVLen*
5745 is set to 0, this parameter must be set to *NULL_PTR*.

5746 *ulAdditionalDerivedKeys* number of additional keys that will be derived and the number of
5747 elements in the array pointed to by *pAdditionalDerivedKeys*. If
5748 *pAdditionalDerivedKeys* is set to *NULL_PTR*, this parameter must
5749 be set to 0.

5750 *pAdditionalDerivedKeys* an array of *CK_DERIVED_KEY* structures. If
5751 *ulAdditionalDerivedKeys* is set to 0, this parameter must be set to
5752 *NULL_PTR*.

5753 2.42.3 Counter Mode KDF

5754 The SP800-108 Counter Mode KDF mechanism, denoted **CKM_SP800_108_COUNTER_KDF**,
5755 represents the KDF defined SP800-108 section 5.1. **CKM_SP800_108_COUNTER_KDF** is a
5756 mechanism for deriving one or more symmetric keys from a symmetric base key.
5757 It has a parameter, a **CK_SP800_108_KDF_PARAMS** structure.
5758 The following table lists the data field types that are supported for this KDF type and their meaning:
5759 Table 164, Counter Mode data field requirements

| Data Field Identifier | Description |
|---------------------------------|---|
| CK_SP800_108_ITERATION_VARIABLE | This data field type is mandatory. This data field type identifies the location of the iteration variable in the constructed PRF input data. The iteration variable for this KDF type is a counter. Exact formatting of the counter value is defined by the CK_SP800_108_COUNTER_FORMAT structure. |
| CK_SP800_108_COUNTER | This data field type is invalid for this KDF type. |
| CK_SP800_108_DKM_LENGTH | This data field type is optional. This data field type identifies the location of the DKM length in the constructed PRF input data. Exact formatting of the DKM length is defined by the CK_SP800_108_DKM_LENGTH_FORMAT structure. If specified, only one instance of this type may be specified. |
| CK_SP800_108_BYTE_ARRAY | This data field type is optional. This data field type identifies the location and value of a byte array of data in the constructed PRF input data. This standard does not restrict the number of instances of this data type. |

5760

5761 SP800-108 limits the amount of derived keying material that can be produced by a Counter Mode KDF by
5762 limiting the internal loop counter to $(2^r - 1)$, where “r” is the number of bits used to represent the counter.
5763 Therefore the maximum number of bits that can be produced is $(2^r - 1)h$, where “h” is the length in bits of
5764 the output of the selected PRF.

2.42.4 Feedback Mode KDF

The SP800-108 Feedback Mode KDF mechanism, denoted **CKM_SP800_108_FEEDBACK_KDF**, represents the KDF defined SP800-108 section 5.2. **CKM_SP800_108_FEEDBACK_KDF** is a mechanism for deriving one or more symmetric keys from a symmetric base key.

It has a parameter, a **CK_SP800_108_FEEDBACK_KDF_PARAMS** structure.

The following table lists the data field types that are supported for this KDF type and their meaning:

Table 165, Feedback Mode data field requirements

| Data Field Identifier | Description |
|---------------------------------|---|
| CK_SP800_108_ITERATION_VARIABLE | This data field type is mandatory. This data field type identifies the location of the iteration variable in the constructed PRF input data. The iteration variable is defined as $K(i-1)$ in section 5.2 of SP800-108. The size, format and value of this data input is defined by the internal KDF structure and PRF output. Exact formatting of the counter value is defined by the CK_SP800_108_COUNTER_FORMAT structure. |
| CK_SP800_108_COUNTER | This data field type is optional. This data field type identifies the location of the counter in the constructed PRF input data. Exact formatting of the counter value is defined by the CK_SP800_108_COUNTER_FORMAT structure. If specified, only one instance of this type may be specified. |
| CK_SP800_108_DKM_LENGTH | This data field type is optional. This data field type identifies the location of the DKM length in the constructed PRF input data. Exact formatting of the DKM length is defined by the CK_SP800_108_DKM_LENGTH_FORMAT structure. If specified, only one instance of this type may be specified. |
| CK_SP800_108_BYTE_ARRAY | This data field type is optional. This data field type identifies the location and value of a byte array of data in the constructed PRF input data. This standard does not restrict the number of instances of this data type. |

SP800-108 limits the amount of derived keying material that can be produced by a Feedback Mode KDF by limiting the internal loop counter to $(2^{32}-1)$. Therefore the maximum number of bits that can be produced is $(2^{32}-1)h$, where “h” is the length in bits of the output of the selected PRF.

2.42.5 Double Pipeline Mode KDF

The SP800-108 Double Pipeline Mode KDF mechanism, denoted **CKM_SP800_108_DOUBLE_PIPELINE_KDF**, represents the KDF defined SP800-108 section 5.3. **CKM_SP800_108_DOUBLE_PIPELINE_KDF** is a mechanism for deriving one or more symmetric keys from a symmetric base key.

It has a parameter, a **CK_SP800_108_KDF_PARAMS** structure.

The following table lists the data field types that are supported for this KDF type and their meaning:

| Data Field Identifier | Description |
|---------------------------------|--|
| CK_SP800_108_ITERATION_VARIABLE | <p>This data field type is mandatory.</p> <p>This data field type identifies the location of the iteration variable in the constructed PRF input data.</p> <p>The iteration variable is defined as A(i) in section 5.3 of SP800-108.</p> <p>The size, format and value of this data input is defined by the internal KDF structure and PRF output.</p> <p>Exact formatting of the counter value is defined by the CK_SP800_108_COUNTER_FORMAT structure.</p> |
| CK_SP800_108_COUNTER | <p>This data field type is optional.</p> <p>This data field type identifies the location of the counter in the constructed PRF input data.</p> <p>Exact formatting of the counter value is defined by the CK_SP800_108_COUNTER_FORMAT structure.</p> <p>If specified, only one instance of this type may be specified.</p> |
| CK_SP800_108_DKM_LENGTH | <p>This data field type is optional.</p> <p>This data field type identifies the location of the DKM length in the constructed PRF input data.</p> <p>Exact formatting of the DKM length is defined by the CK_SP800_108_DKM_LENGTH_FORMAT structure.</p> <p>If specified, only one instance of this type may be specified.</p> |
| CK_SP800_108_BYTE_ARRAY | <p>This data field type is optional.</p> <p>This data field type identifies the location and value of a byte array of data in the constructed PRF input data.</p> <p>This standard does not restrict the number of instances of this data type.</p> |

5784

5785 SP800-108 limits the amount of derived keying material that can be produced by a Double-Pipeline Mode
5786 KDF by limiting the internal loop counter to $(2^{32}-1)$. Therefore the maximum number of bits that can be
5787 produced is $(2^{32}-1)h$, where “h” is the length in bits of the output of the selected PRF.

5788 The Double Pipeline KDF requires an internal IV value. The IV is constructed using the same method
5789 used to construct the PRF input data; the data/values identified by the array of **CK_PRF_DATA_PARAM**
5790 structures are concatenated in to a byte array that is used as the IV. As shown in SP800-108 section 5.3,
5791 the CK_SP800_108_ITERATION_VARIABLE and CK_SP800_108_COUNTER data field types are not
5792 included in IV construction process. All other data field types are included in the construction process.

5793 2.42.6 Deriving Additional Keys

5794 The KDFs defined in this section can be used to derive more than one symmetric key from the base key.
5795 The **C_Derive** function accepts one CK_ATTRIBUTE_PTR to define a single derived key and one
5796 CK_OBJECT_HANDLE_PTR to receive the handle for the derived key.

5797 To derive additional keys, the mechanism parameter structure can be filled in with one or more
5798 CK_DERIVED_KEY structures. Each structure contains a CK_ATTRIBUTE_PTR to define a derived key
5799 and a CK_OBJECT_HANDLE_PTR to receive the handle for the additional derived keys. The key
5800 defined by the **C_Derive** function parameters is always derived before the keys defined by the
5801 CK_DERIVED_KEY array that is part of the mechanism parameter. The additional keys that are defined
5802 by the CK_DERIVED_KEY array are derived in the order they are defined in the array. That is to say that
5803 the derived keying material produced by the KDF is processed from left to right, and bytes are assigned

first to the key defined by the **C_Derive** function parameters, and then bytes are assigned to the keys that are defined by the CK_DERIVED_KEY array in the order they are defined in the array.

Each internal iteration of a KDF produces a unique segment of PRF output. Sometimes, a single iteration will produce enough keying material for the key being derived. Other times, additional internal iterations are performed to produce multiple segments which are concatenated together to produce enough keying material for the derived key(s).

When deriving multiple keys, no key can be created using part of a segment that was used for another key. All keys must be created from disjoint segments. For example, if the parameters are defined such that a 48-byte key (defined by the **C_Derive** function parameters) and a 16-byte key (defined by the content of CK_DERIVED_KEY) are to be derived using **CKM_SHA256_HMAC** as a PRF, three internal iterations of the KDF will be performed and three segments of PRF output will be produced. The first segment and half of the second segment will be used to create the 48-byte key and the third segment will be used to create the 16-byte key.



In the above example, if the CK_SP800_108_DKM_LENGTH data field type is specified with method CK_SP800_108_DKM_LENGTH_SUM_OF_KEYS, then the DKM length value will be 512 bits. If the CK_SP800_108_DKM_LENGTH data field type is specified with method CK_SP800_108_DKM_LENGTH_SUM_OF_SEGMENTS, then the DKM length value will be 768 bits.

When deriving multiple keys, if any of the keys cannot be derived for any reason, none of the keys shall be derived. If the failure was caused by the content of a specific key's template (ie the template defined by the content of *pTemplate*), the corresponding *phKey* value will be set to CK_INVALID_HANDLE to identify the offending template.

2.42.7 Key Derivation Attribute Rules

The **CKM_SP800_108_COUNTER_KDF**, **CKM_SP800_108_FEEDBACK_KDF** and **CKM_SP800_108_DOUBLE_PIPELINE_KDF** mechanisms have the following rules about key sensitivity and extractability:

- The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key(s) can both be specified to be either CK_TRUE or CK_FALSE. If omitted, these attributes each take on some default value.
- If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_FALSE, then the derived key will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE, then the derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its **CKA_SENSITIVE** attribute.
- Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_FALSE, then the derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_TRUE, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite* value from its **CKA_EXTRACTABLE** attribute.

2.42.8 Constructing PRF Input Data

SP800-108 defines the PRF input data for each KDF at a high level using terms like "label", "context", "separator", "counter"...etc. The value, formatting and order of the input data is not strictly defined by SP800-108, instead it is described as being defined by the "encoding scheme".

To support any encoding scheme, these mechanisms construct the PRF input data from the array of CK_PRF_DATA_PARAM structures in the mechanism parameter. All of the values defined by the CK_PRF_DATA_PARAM array are concatenated in the order they are defined and passed in to the PRF as the data parameter.

2.42.8.1 Sample Counter Mode KDF

SP800-108 section 5.1 outlines a sample Counter Mode KDF which defines the following PRF input:

$PRF(K_L, [i]_2 || Label || 0x00 || Context || [L]_2)$

Section 5.1 does not define the number of bits used to represent the counter (the “r” value) or the DKM length (the “L” value), so 16-bits is assumed for both cases. The following sample code shows how to define this PRF input data using an array of CK_PRF_DATA_PARAM structures.

```
#define DIM(a) (sizeof((a))/sizeof((a)[0]))

CK_OBJECT_HANDLE hBaseKey;
CK_OBJECT_HANDLE hDerivedKey;
CK_ATTRIBUTE derivedKeyTemplate = { ... };

CK_BYTE baLabel[] = {0xde, 0xad, 0xbe, 0xef};
CK_ULONG ulLabelLen = sizeof(baLabel);
CK_BYTE baContext[] = {0xfe, 0xed, 0xbe, 0xef};
CK_ULONG ulContextLen = sizeof(baContext);

CK_SP800_108_COUNTER_FORMAT counterFormat = {0, 16};
CK_SP800_108_DKM_LENGTH_FORMAT dkmFormat
    = {CK_SP800_108_DKM_LENGTH_SUM_OF_KEYS, 0, 16};

CK_PRF_DATA_PARAM dataParams[] =
{
    { CK_SP800_108_ITERATION_VARIABLE,
      &counterFormat, sizeof(counterFormat) },
    { CK_SP800_108_BYTE_ARRAY, baLabel, ulLabelLen },
    { CK_SP800_108_BYTE_ARRAY, {0x00}, 1 },
    { CK_SP800_108_BYTE_ARRAY, baContext, ulContextLen },
    { CK_SP800_108_DKM_LENGTH, dkmFormat, sizeof(dkmFormat) }
};

CK_SP800_108_KDF_PARAMS kdfParams =
{
    CKM_AES_CMAC,
    DIM(dataParams),
    &dataParams,
    0, /* no addition derived keys */
    NULL /* no addition derived keys */
};

CK_MECHANISM = mechanism
{
    CKM_SP800_108_COUNTER_KDF,
    &kdfParams,
    sizeof(kdfParams)
};

hBaseKey = GetBaseKeyHandle(.....);

rv = C_DeriveKey(
    hSession,
    &mechanism,
    hBaseKey,
    &derivedKeyTemplate,
    DIM(derivedKeyTemplate),
    &hDerivedKey);
```


2.42.8.2 Sample SCP03 Counter Mode KDF

The SCP03 standard defines a variation of a counter mode KDF which defines the following PRF input:

PRF (*K_L*, *Label* || 0x00 || [*L*]₂ || [*i*]₂ || *Context*)

SCP03 defines the number of bits used to represent the counter (the “r” value) and number of bits used to represent the DKM length (the “L” value) as 16-bits. The following sample code shows how to define this PRF input data using an array of CK_PRF_DATA_PARAM structures.

```
#define DIM(a) (sizeof((a))/sizeof((a)[0]))

CK_OBJECT_HANDLE hBaseKey;
CK_OBJECT_HANDLE hDerivedKey;
CK_ATTRIBUTE derivedKeyTemplate = { ... };

CK_BYTE baLabel[] = {0xde, 0xad, 0xbe, 0xef};
CK_ULONG ulLabelLen = sizeof(baLabel);
CK_BYTE baContext[] = {0xfe, 0xed, 0xbe, 0xef};
CK_ULONG ulContextLen = sizeof(baContext);

CK_SP800_108_COUNTER_FORMAT counterFormat = {0, 16};
CK_SP800_108_DKM_LENGTH_FORMAT dkmFormat
    = {CK_SP800_108_DKM_LENGTH_SUM_OF_KEYS, 0, 16};

CK_PRF_DATA_PARAM dataParams[] =
{
    { CK_SP800_108_BYTE_ARRAY, baLabel, ulLabelLen },
    { CK_SP800_108_BYTE_ARRAY, {0x00}, 1 },
    { CK_SP800_108_DKM_LENGTH, dkmFormat, sizeof(dkmFormat) },
    { CK_SP800_108_ITERATION_VARIABLE,
      &counterFormat, sizeof(counterFormat) },
    { CK_SP800_108_BYTE_ARRAY, baContext, ulContextLen }
};

CK_SP800_108_KDF_PARAMS kdfParams =
{
    CKM_AES_CMACH,
    DIM(dataParams),
    &dataParams,
    0, /* no addition derived keys */
    NULL /* no addition derived keys */
};

CK_MECHANISM = mechanism
{
    CKM_SP800_108_COUNTER_KDF,
    &kdfParams,
    sizeof(kdfParams)
};

hBaseKey = GetBaseKeyHandle(.....);

rv = C_DeriveKey(
    hSession,
    &mechanism,
    hBaseKey,
    &derivedKeyTemplate,
    DIM(derivedKeyTemplate),
    &hDerivedKey);
```

2.42.8.3 Sample Feedback Mode KDF

SP800-108 section 5.2 outlines a sample Feedback Mode KDF which defines the following PRF input:

$PRF(K_i, K(i-1) \parallel [i]_2 \parallel Label \parallel 0x00 \parallel Context \parallel [L]_2)$

Section 5.2 does not define the number of bits used to represent the counter (the “r” value) or the DKM length (the “L” value), so 16-bits is assumed for both cases. The counter is defined as being optional and is included in this example. The following sample code shows how to define this PRF input data using an array of CK_PRF_DATA_PARAM structures.

```
#define DIM(a) (sizeof((a))/sizeof((a)[0]))

CK_OBJECT_HANDLE hBaseKey;
CK_OBJECT_HANDLE hDerivedKey;
CK_ATTRIBUTE derivedKeyTemplate = { ... };

CK_BYTE baFeedbackIV[] = {0x01, 0x02, 0x03, 0x04};
CK_ULONG ulFeedbackIVLen = sizeof(baFeedbackIV);
CK_BYTE baLabel[] = {0xde, 0xad, 0xbe, 0xef};
CK_ULONG ulLabelLen = sizeof(baLabel);
CK_BYTE baContext[] = {0xfe, 0xed, 0xbe, 0xef};
CK_ULONG ulContextLen = sizeof(baContext);

CK_SP800_108_COUNTER_FORMAT counterFormat = {0, 16};
CK_SP800_108_DKM_LENGTH_FORMAT dkmFormat
    = {CK_SP800_108_DKM_LENGTH_SUM_OF_KEYS, 0, 16};

CK_PRF_DATA_PARAM dataParams[] =
{
    { CK_SP800_108_ITERATION_VARIABLE,
      &counterFormat, sizeof(counterFormat) },
    { CK_SP800_108_BYTE_ARRAY, baLabel, ulLabelLen },
    { CK_SP800_108_BYTE_ARRAY, {0x00}, 1 },
    { CK_SP800_108_BYTE_ARRAY, baContext, ulContextLen },
    { CK_SP800_108_DKM_LENGTH, dkmFormat, sizeof(dkmFormat) }
};

CK_SP800_108_FEEDBACK_KDF_PARAMS kdfParams =
{
    CKM_AES_CMAC,
    DIM(dataParams),
    &dataParams,
    ulFeedbackIVLen,
    baFeedbackIV,
    0, /* no addition derived keys */
    NULL /* no addition derived keys */
};

CK_MECHANISM = mechanism
{
    CKM_SP800_108_FEEDBACK_KDF,
    &kdfParams,
    sizeof(kdfParams)
};

hBaseKey = GetBaseKeyHandle(.....);

rv = C_DeriveKey(
```

```

6017     hSession,
6018     &mechanism,
6019     hBaseKey,
6020     &derivedKeyTemplate,
6021     DIM(derivedKeyTemplate),
6022     &hDerivedKey);

```

6023 2.42.8.4 Sample Double-Pipeline Mode KDF

6024 SP800-108 section 5.3 outlines a sample Double-Pipeline Mode KDF which defines the two following
6025 PRF inputs:

```

6026     PRF(KI, A(i-1))
6027     PRF(KI, K(i-1) || [i]2 || Label || 0x00 || Context || [L]2)

```

6028 Section 5.3 does not define the number of bits used to represent the counter (the “r” value) or the DKM
6029 length (the “L” value), so 16-bits is assumed for both cases. The counter is defined as being optional so it
6030 is left out in this example. The following sample code shows how to define this PRF input data using an
6031 array of CK_PRF_DATA_PARAM structures.

```

6032     #define DIM(a) (sizeof((a))/sizeof((a)[0]))
6033
6034     CK_OBJECT_HANDLE hBaseKey;
6035     CK_OBJECT_HANDLE hDerivedKey;
6036     CK_ATTRIBUTE derivedKeyTemplate = { ... };
6037
6038     CK_BYTE baLabel[] = {0xde, 0xad, 0xbe, 0xef};
6039     CK_ULONG ulLabelLen = sizeof(baLabel);
6040     CK_BYTE baContext[] = {0xfe, 0xed, 0xbe, 0xef};
6041     CK_ULONG ulContextLen = sizeof(baContext);
6042
6043     CK_SP800_108_DKM_LENGTH_FORMAT dkmFormat
6044     = {CK_SP800_108_DKM_LENGTH_SUM_OF_KEYS, 0, 16};
6045
6046     CK_PRF_DATA_PARAM dataParams[] =
6047     {
6048         { CK_SP800_108_BYTE_ARRAY, baLabel, ulLabelLen },
6049         { CK_SP800_108_BYTE_ARRAY, {0x00}, 1 },
6050         { CK_SP800_108_BYTE_ARRAY, baContext, ulContextLen },
6051         { CK_SP800_108_DKM_LENGTH, dkmFormat, sizeof(dkmFormat) }
6052     };
6053
6054     CK_SP800_108_KDF_PARAMS kdfParams =
6055     {
6056         CKM_AES_CMAC,
6057         DIM(dataParams),
6058         &dataParams,
6059         0, /* no addition derived keys */
6060         NULL /* no addition derived keys */
6061     };
6062
6063     CK_MECHANISM = mechanism
6064     {
6065         CKM_SP800_108_DOUBLE_PIPELINE_KDF,
6066         &kdfParams,
6067         sizeof(kdfParams)
6068     };
6069
6070     hBaseKey = GetBaseKeyHandle(.....);

```

```

6071
6072     rv = C_DeriveKey(
6073         hSession,
6074         &mechanism,
6075         hBaseKey,
6076         &derivedKeyTemplate,
6077         DIM(derivedKeyTemplate),
6078         &hDerivedKey);

```

2.43 Miscellaneous simple key derivation mechanisms

Table 167, Miscellaneous simple key derivation Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-------------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_CONCATENATE_BASE_AND_KEY | | | | | | | ✓ |
| CKM_CONCATENATE_BASE_AND_DATA | | | | | | | ✓ |
| CKM_CONCATENATE_DATA_AND_BASE | | | | | | | ✓ |
| CKM_XOR_BASE_AND_DATA | | | | | | | ✓ |
| CKM_EXTRACT_KEY_FROM_KEY | | | | | | | ✓ |

2.43.1 Definitions

Mechanisms:

```

6083     CKM_CONCATENATE_BASE_AND_DATA
6084     CKM_CONCATENATE_DATA_AND_BASE
6085     CKM_XOR_BASE_AND_DATA
6086     CKM_EXTRACT_KEY_FROM_KEY
6087     CKM_CONCATENATE_BASE_AND_KEY

```

2.43.2 Parameters for miscellaneous simple key derivation mechanisms

◆ CK_KEY_DERIVATION_STRING_DATA; CK_KEY_DERIVATION_STRING_DATA_PTR

CK_KEY_DERIVATION_STRING_DATA provides the parameters for the CKM_CONCATENATE_BASE_AND_DATA, CKM_CONCATENATE_DATA_AND_BASE, and CKM_XOR_BASE_AND_DATA mechanisms. It is defined as follows:

```

6094     typedef struct CK_KEY_DERIVATION_STRING_DATA {
6095         CK_BYTE_PTR pData;
6096         CK_ULONG ulLen;
6097     } CK_KEY_DERIVATION_STRING_DATA;

```

The fields of the structure have the following meanings:

pData *pointer to the byte string*

ulLen *length of the byte string*

6102 **CK_KEY_DERIVATION_STRING_DATA_PTR** is a pointer to a
6103 **CK_KEY_DERIVATION_STRING_DATA**.

6104 ♦ **CK_EXTRACT_PARAMS; CK_EXTRACT_PARAMS_PTR**

6105 **CK_EXTRACT_PARAMS** provides the parameter to the **CKM_EXTRACT_KEY_FROM_KEY**
6106 mechanism. It specifies which bit of the base key should be used as the first bit of the derived key. It is
6107 defined as follows:

```
6108     typedef CK_ULONG CK_EXTRACT_PARAMS;
```

6109

6110 **CK_EXTRACT_PARAMS_PTR** is a pointer to a **CK_EXTRACT_PARAMS**.

6111 **2.43.3 Concatenation of a base key and another key**

6112 This mechanism, denoted **CKM_CONCATENATE_BASE_AND_KEY**, derives a secret key from the
6113 concatenation of two existing secret keys. The two keys are specified by handles; the values of the keys
6114 specified are concatenated together in a buffer.

6115 This mechanism takes a parameter, a **CK_OBJECT_HANDLE**. This handle produces the key value
6116 information which is appended to the end of the base key's value information (the base key is the key
6117 whose handle is supplied as an argument to **C_DeriveKey**).

6118 For example, if the value of the base key is 0x01234567, and the value of the other key is 0x89ABCDEF,
6119 then the value of the derived key will be taken from a buffer containing the string 0x0123456789ABCDEF.

- 6120 • If no length or key type is provided in the template, then the key produced by this mechanism will be a
6121 generic secret key. Its length will be equal to the sum of the lengths of the values of the two original
6122 keys.
- 6123 • If no key type is provided in the template, but a length is, then the key produced by this mechanism
6124 will be a generic secret key of the specified length.
- 6125 • If no length is provided in the template, but a key type is, then that key type must have a well-defined
6126 length. If it does, then the key produced by this mechanism will be of the type specified in the
6127 template. If it doesn't, an error will be returned.
- 6128 • If both a key type and a length are provided in the template, the length must be compatible with that
6129 key type. The key produced by this mechanism will be of the specified type and length.

6130 If a DES, DES2, DES3, or CDMF key is derived with this mechanism, the parity bits of the key will be set
6131 properly.

6132 If the requested type of key requires more bytes than are available by concatenating the two original keys'
6133 values, an error is generated.

6134 This mechanism has the following rules about key sensitivity and extractability:

- 6135 • If either of the two original keys has its **CKA_SENSITIVE** attribute set to **CK_TRUE**, so does the
6136 derived key. If not, then the derived key's **CKA_SENSITIVE** attribute is set either from the supplied
6137 template or from a default value.
- 6138 • Similarly, if either of the two original keys has its **CKA_EXTRACTABLE** attribute set to **CK_FALSE**,
6139 so does the derived key. If not, then the derived key's **CKA_EXTRACTABLE** attribute is set either
6140 from the supplied template or from a default value.
- 6141 • The derived key's **CKA_ALWAYS_SENSITIVE** attribute is set to **CK_TRUE** if and only if both of the
6142 original keys have their **CKA_ALWAYS_SENSITIVE** attributes set to **CK_TRUE**.
- 6143 • Similarly, the derived key's **CKA_NEVER_EXTRACTABLE** attribute is set to **CK_TRUE** if and only if
6144 both of the original keys have their **CKA_NEVER_EXTRACTABLE** attributes set to **CK_TRUE**.

2.43.4 Concatenation of a base key and data

This mechanism, denoted **CKM_CONCATENATE_BASE_AND_DATA**, derives a secret key by concatenating data onto the end of a specified secret key.

This mechanism takes a parameter, a **CK_KEY_DERIVATION_STRING_DATA** structure, which specifies the length and value of the data which will be appended to the base key to derive another key.

For example, if the value of the base key is 0x01234567, and the value of the data is 0x89ABCDEF, then the value of the derived key will be taken from a buffer containing the string 0x0123456789ABCDEF.

- If no length or key type is provided in the template, then the key produced by this mechanism will be a generic secret key. Its length will be equal to the sum of the lengths of the value of the original key and the data.
- If no key type is provided in the template, but a length is, then the key produced by this mechanism will be a generic secret key of the specified length.
- If no length is provided in the template, but a key type is, then that key type must have a well-defined length. If it does, then the key produced by this mechanism will be of the type specified in the template. If it doesn't, an error will be returned.
- If both a key type and a length are provided in the template, the length must be compatible with that key type. The key produced by this mechanism will be of the specified type and length.

If a DES, DES2, DES3, or CDMF key is derived with this mechanism, the parity bits of the key will be set properly.

If the requested type of key requires more bytes than are available by concatenating the original key's value and the data, an error is generated.

This mechanism has the following rules about key sensitivity and extractability:

- If the base key has its **CKA_SENSITIVE** attribute set to CK_TRUE, so does the derived key. If not, then the derived key's **CKA_SENSITIVE** attribute is set either from the supplied template or from a default value.
- Similarly, if the base key has its **CKA_EXTRACTABLE** attribute set to CK_FALSE, so does the derived key. If not, then the derived key's **CKA_EXTRACTABLE** attribute is set either from the supplied template or from a default value.
- The derived key's **CKA_ALWAYS_SENSITIVE** attribute is set to CK_TRUE if and only if the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE.
- Similarly, the derived key's **CKA_NEVER_EXTRACTABLE** attribute is set to CK_TRUE if and only if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_TRUE.

2.43.5 Concatenation of data and a base key

This mechanism, denoted **CKM_CONCATENATE_DATA_AND_BASE**, derives a secret key by prepending data to the start of a specified secret key.

This mechanism takes a parameter, a **CK_KEY_DERIVATION_STRING_DATA** structure, which specifies the length and value of the data which will be prepended to the base key to derive another key.

For example, if the value of the base key is 0x01234567, and the value of the data is 0x89ABCDEF, then the value of the derived key will be taken from a buffer containing the string 0x89ABCDEF01234567.

- If no length or key type is provided in the template, then the key produced by this mechanism will be a generic secret key. Its length will be equal to the sum of the lengths of the data and the value of the original key.
- If no key type is provided in the template, but a length is, then the key produced by this mechanism will be a generic secret key of the specified length.
- If no length is provided in the template, but a key type is, then that key type must have a well-defined length. If it does, then the key produced by this mechanism will be of the type specified in the template. If it doesn't, an error will be returned.

- 6192 • If both a key type and a length are provided in the template, the length must be compatible with that
6193 key type. The key produced by this mechanism will be of the specified type and length.
- 6194 If a DES, DES2, DES3, or CDMF key is derived with this mechanism, the parity bits of the key will be set
6195 properly.
- 6196 If the requested type of key requires more bytes than are available by concatenating the data and the
6197 original key's value, an error is generated.
- 6198 This mechanism has the following rules about key sensitivity and extractability:
- 6199 • If the base key has its **CKA_SENSITIVE** attribute set to CK_TRUE, so does the derived key. If not,
6200 then the derived key's **CKA_SENSITIVE** attribute is set either from the supplied template or from a
6201 default value.
- 6202 • Similarly, if the base key has its **CKA_EXTRACTABLE** attribute set to CK_FALSE, so does the
6203 derived key. If not, then the derived key's **CKA_EXTRACTABLE** attribute is set either from the
6204 supplied template or from a default value.
- 6205 • The derived key's **CKA_ALWAYS_SENSITIVE** attribute is set to CK_TRUE if and only if the base
6206 key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE.
- 6207 • Similarly, the derived key's **CKA_NEVER_EXTRACTABLE** attribute is set to CK_TRUE if and only if
6208 the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_TRUE.

6209 2.43.6 XORing of a key and data

- 6210 XORing key derivation, denoted **CKM_XOR_BASE_AND_DATA**, is a mechanism which provides the
6211 capability of deriving a secret key by performing a bit XORing of a key pointed to by a base key handle
6212 and some data.
- 6213 This mechanism takes a parameter, a **CK_KEY_DERIVATION_STRING_DATA** structure, which
6214 specifies the data with which to XOR the original key's value.
- 6215 For example, if the value of the base key is 0x01234567, and the value of the data is 0x89ABCDEF, then
6216 the value of the derived key will be taken from a buffer containing the string 0x88888888.
- 6217 • If no length or key type is provided in the template, then the key produced by this mechanism will be a
6218 generic secret key. Its length will be equal to the minimum of the lengths of the data and the value of
6219 the original key.
 - 6220 • If no key type is provided in the template, but a length is, then the key produced by this mechanism
6221 will be a generic secret key of the specified length.
 - 6222 • If no length is provided in the template, but a key type is, then that key type must have a well-defined
6223 length. If it does, then the key produced by this mechanism will be of the type specified in the
6224 template. If it doesn't, an error will be returned.
 - 6225 • If both a key type and a length are provided in the template, the length must be compatible with that
6226 key type. The key produced by this mechanism will be of the specified type and length.
- 6227 If a DES, DES2, DES3, or CDMF key is derived with this mechanism, the parity bits of the key will be set
6228 properly.
- 6229 If the requested type of key requires more bytes than are available by taking the shorter of the data and
6230 the original key's value, an error is generated.
- 6231 This mechanism has the following rules about key sensitivity and extractability:
- 6232 • If the base key has its **CKA_SENSITIVE** attribute set to CK_TRUE, so does the derived key. If not,
6233 then the derived key's **CKA_SENSITIVE** attribute is set either from the supplied template or from a
6234 default value.
 - 6235 • Similarly, if the base key has its **CKA_EXTRACTABLE** attribute set to CK_FALSE, so does the
6236 derived key. If not, then the derived key's **CKA_EXTRACTABLE** attribute is set either from the
6237 supplied template or from a default value.
 - 6238 • The derived key's **CKA_ALWAYS_SENSITIVE** attribute is set to CK_TRUE if and only if the base
6239 key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE.

- 6240 • Similarly, the derived key's **CKA_NEVER_EXTRACTABLE** attribute is set to CK_TRUE if and only if
6241 the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_TRUE.

6242 2.43.7 Extraction of one key from another key

6243 Extraction of one key from another key, denoted **CKM_EXTRACT_KEY_FROM_KEY**, is a mechanism
6244 which provides the capability of creating one secret key from the bits of another secret key.

6245 This mechanism has a parameter, a CK_EXTRACT_PARAMS, which specifies which bit of the original
6246 key should be used as the first bit of the newly-derived key.

6247 We give an example of how this mechanism works. Suppose a token has a secret key with the 4-byte
6248 value 0x329F84A9. We will derive a 2-byte secret key from this key, starting at bit position 21 (i.e., the
6249 value of the parameter to the CKM_EXTRACT_KEY_FROM_KEY mechanism is 21).

- 6250 1. We write the key's value in binary: 0011 0010 1001 1111 1000 0100 1010 1001. We regard this
6251 binary string as holding the 32 bits of the key, labeled as b0, b1, ..., b31.
- 6252 2. We then extract 16 consecutive bits (i.e., 2 bytes) from this binary string, starting at bit b21. We
6253 obtain the binary string 1001 0101 0010 0110.
- 6254 3. The value of the new key is thus 0x9526.

6255 Note that when constructing the value of the derived key, it is permissible to wrap around the end of the
6256 binary string representing the original key's value.

6257 If the original key used in this process is sensitive, then the derived key must also be sensitive for the
6258 derivation to succeed.

- 6259 • If no length or key type is provided in the template, then an error will be returned.
- 6260 • If no key type is provided in the template, but a length is, then the key produced by this mechanism
6261 will be a generic secret key of the specified length.
- 6262 • If no length is provided in the template, but a key type is, then that key type must have a well-defined
6263 length. If it does, then the key produced by this mechanism will be of the type specified in the
6264 template. If it doesn't, an error will be returned.
- 6265 • If both a key type and a length are provided in the template, the length must be compatible with that
6266 key type. The key produced by this mechanism will be of the specified type and length.

6267 If a DES, DES2, DES3, or CDMF key is derived with this mechanism, the parity bits of the key will be set
6268 properly.

6269 If the requested type of key requires more bytes than the original key has, an error is generated.

6270 This mechanism has the following rules about key sensitivity and extractability:

- 6271 • If the base key has its **CKA_SENSITIVE** attribute set to CK_TRUE, so does the derived key. If not,
6272 then the derived key's **CKA_SENSITIVE** attribute is set either from the supplied template or from a
6273 default value.
- 6274 • Similarly, if the base key has its **CKA_EXTRACTABLE** attribute set to CK_FALSE, so does the
6275 derived key. If not, then the derived key's **CKA_EXTRACTABLE** attribute is set either from the
6276 supplied template or from a default value.
- 6277 • The derived key's **CKA_ALWAYS_SENSITIVE** attribute is set to CK_TRUE if and only if the base
6278 key has its **CKA_ALWAYS_SENSITIVE** attribute set to CK_TRUE.
- 6279 • Similarly, the derived key's **CKA_NEVER_EXTRACTABLE** attribute is set to CK_TRUE if and only if
6280 the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to CK_TRUE.

6281 2.44 CMS

6282 *Table 168, CMS Mechanisms vs. Functions*

| Mechanism | Functions | | | | | | |
|-------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_CMS_SIG | | ✓ | ✓ | | | | |

2.44.1 Definitions

Mechanisms:

CKM_CMS_SIG

2.44.2 CMS Signature Mechanism Objects

These objects provide information relating to the CKM_CMS_SIG mechanism. CKM_CMS_SIG mechanism object attributes represent information about supported CMS signature attributes in the token. They are only present on tokens supporting the **CKM_CMS_SIG** mechanism, but must be present on those tokens.

Table 169, CMS Signature Mechanism Object Attributes

| Attribute | Data type | Meaning |
|------------------------------|------------|---|
| CKA_REQUIRED_CMS_ATTRIBUTES | Byte array | Attributes the token always will include in the set of CMS signed attributes |
| CKA_DEFAULT_CMS_ATTRIBUTES | Byte array | Attributes the token will include in the set of CMS signed attributes in the absence of any attributes specified by the application |
| CKA_SUPPORTED_CMS_ATTRIBUTES | Byte array | Attributes the token may include in the set of CMS signed attributes upon request by the application |

The contents of each byte array will be a DER-encoded list of CMS **Attributes** with optional accompanying values. Any attributes in the list shall be identified with its object identifier, and any values shall be DER-encoded. The list of attributes is defined in ASN.1 as:

```

Attributes ::= SET SIZE (1..MAX) OF Attribute
Attribute ::= SEQUENCE {
    attrType      OBJECT IDENTIFIER,
    attrValues SET OF ANY DEFINED BY OBJECT IDENTIFIER
                OPTIONAL
}

```

The client may not set any of the attributes.

2.44.3 CMS mechanism parameters

• CK_CMS_SIG_PARAMS, CK_CMS_SIG_PARAMS_PTR

CK_CMS_SIG_PARAMS is a structure that provides the parameters to the **CKM_CMS_SIG** mechanism. It is defined as follows:

```

typedef struct CK_CMS_SIG_PARAMS {
    CK_OBJECT_HANDLE      certificateHandle;
    CK_MECHANISM_PTR      pSigningMechanism;
    CK_MECHANISM_PTR      pDigestMechanism;
}

```

```

6310     CK_UTF8CHAR_PTR      pContentType;
6311     CK_BYTE_PTR           pRequestedAttributes;
6312     CK_ULONG              ulRequestedAttributesLen;
6313     CK_BYTE_PTR           pRequiredAttributes;
6314     CK_ULONG              ulRequiredAttributesLen;
6315 } CK_CMS_SIG_PARAMS;

```

6316

6317 The fields of the structure have the following meanings:

6318 *certificateHandle* *Object handle for a certificate associated with the signing key. The*
6319 *token may use information from this certificate to identify the signer*
6320 *in the **SignerInfo** result value. CertificateHandle may be NULL_PTR*
6321 *if the certificate is not available as a PKCS #11 object or if the*
6322 *calling application leaves the choice of certificate completely to the*
6323 *token.*

6324 *pSigningMechanism* *Mechanism to use when signing a constructed CMS*
6325 *SignedAttributes value. E.g. **CKM_SHA1_RSA_PKCS**.*

6326 *pDigestMechanism* *Mechanism to use when digesting the data. Value shall be*
6327 *NULL_PTR when the digest mechanism to use follows from the*
6328 *pSigningMechanism parameter.*

6329 *pContentType* *NULL-terminated string indicating complete MIME Content-type of*
6330 *message to be signed; or the value NULL_PTR if the message is a*
6331 *MIME object (which the token can parse to determine its MIME*
6332 *Content-type if required). Use the value "application/octet-stream" if*
6333 *the MIME type for the message is unknown or undefined. Note that*
6334 *the pContentType string shall conform to the syntax specified in*
6335 *RFC 2045, i.e. any parameters needed for correct presentation of*
6336 *the content by the token (such as, for example, a non-default*
6337 *"charset") must be present. The token must follow rules and*
6338 *procedures defined in RFC 2045 when presenting the content.*

6339 *pRequestedAttributes* *Pointer to DER-encoded list of CMS **Attributes** the caller requests to*
6340 *be included in the signed attributes. Token may freely ignore this list*
6341 *or modify any supplied values.*

6342 *ulRequestedAttributesLen* *Length in bytes of the value pointed to by pRequestedAttributes*

6343 *pRequiredAttributes* *Pointer to DER-encoded list of CMS **Attributes** (with accompanying*
6344 *values) required to be included in the resulting signed attributes.*
6345 *Token must not modify any supplied values. If the token does not*
6346 *support one or more of the attributes, or does not accept provided*
6347 *values, the signature operation will fail. The token will use its own*
6348 *default attributes when signing if both the pRequestedAttributes and*
6349 *pRequiredAttributes field are set to NULL_PTR.*

6350 *ulRequiredAttributesLen* *Length in bytes, of the value pointed to by pRequiredAttributes.*

6351 2.44.4 CMS signatures

6352 The CMS mechanism, denoted **CKM_CMS_SIG**, is a multi-purpose mechanism based on the structures
6353 defined in PKCS #7 and RFC 2630. It supports single- or multiple-part signatures with and without
6354 message recovery. The mechanism is intended for use with, e.g., PTDs (see MeT-PTD) or other capable
6355 tokens. The token will construct a CMS **SignedAttributes** value and compute a signature on this value.

The content of the **SignedAttributes** value is decided by the token, however the caller can suggest some attributes in the parameter *pRequestedAttributes*. The caller can also require some attributes to be present through the parameters *pRequiredAttributes*. The signature is computed in accordance with the parameter *pSigningMechanism*.

When this mechanism is used in successful calls to **C_Sign** or **C_SignFinal**, the *pSignature* return value will point to a DER-encoded value of type **SignerInfo**. **SignerInfo** is defined in ASN.1 as follows (for a complete definition of all fields and types, see RFC 2630):

```
SignerInfo ::= SEQUENCE {  
    version CMSVersion,  
    sid SignerIdentifier,  
    digestAlgorithm DigestAlgorithmIdentifier,  
    signedAttrs [0] IMPLICIT SignedAttributes OPTIONAL,  
    signatureAlgorithm SignatureAlgorithmIdentifier,  
    signature SignatureValue,  
    unsignedAttrs [1] IMPLICIT UnsignedAttributes  
    OPTIONAL }
```

The *certificateHandle* parameter, when set, helps the token populate the **sid** field of the **SignerInfo** value. If *certificateHandle* is **NULL_PTR** the choice of a suitable certificate reference in the **SignerInfo** result value is left to the token (the token could, e.g., interact with the user).

This mechanism shall not be used in calls to **C_Verify** or **C_VerifyFinal** (use the *pSigningMechanism* mechanism instead).

For the *pRequiredAttributes* field, the token may have to interact with the user to find out whether to accept a proposed value or not. The token should never accept any proposed attribute values without some kind of confirmation from its owner (but this could be through, e.g., configuration or policy settings and not direct interaction). If a user rejects proposed values, or the signature request as such, the value **CKR_FUNCTION_REJECTED** shall be returned.

When possible, applications should use the **CKM_CMS_SIG** mechanism when generating CMS-compatible signatures rather than lower-level mechanisms such as **CKM_SHA1_RSA_PKCS**. This is especially true when the signatures are to be made on content that the token is able to present to a user. Exceptions may include those cases where the token does not support a particular signing attribute. Note however that the token may refuse usage of a particular signature key unless the content to be signed is known (i.e. the **CKM_CMS_SIG** mechanism is used).

When a token does not have presentation capabilities, the PKCS #11-aware application may avoid sending the whole message to the token by electing to use a suitable signature mechanism (e.g. **CKM_RSA_PKCS**) as the *pSigningMechanism* value in the **CK_CMS_SIG_PARAMS** structure, and digesting the message itself before passing it to the token.

PKCS #11-aware applications making use of tokens with presentation capabilities, should attempt to provide messages to be signed by the token in a format possible for the token to present to the user. Tokens that receive multipart MIME-messages for which only certain parts are possible to present may fail the signature operation with a return value of **CKR_DATA_INVALID**, but may also choose to add a signing attribute indicating which parts of the message were possible to present.

2.45 Blowfish

Blowfish, a secret-key block cipher. It is a Feistel network, iterating a simple encryption function 16 times. The block size is 64 bits, and the key can be any length up to 448 bits. Although there is a complex initialization phase required before any encryption can take place, the actual encryption of data is very efficient on large microprocessors.

Table 170, *Blowfish Mechanisms vs. Functions*

| Mechanism | Functions | | | | | | |
|----------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_BLOWFISH_CBC | ✓ | | | | | ✓ | |
| CKM_BLOWFISH_CBC_PAD | ✓ | | | | | ✓ | |

2.45.1 Definitions

This section defines the key type “CKK_BLOWFISH” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

Mechanisms:

CKM_BLOWFISH_KEY_GEN

CKM_BLOWFISH_CBC

CKM_BLOWFISH_CBC_PAD

2.45.2 BLOWFISH secret key objects

Blowfish secret key objects (object class CKO_SECRET_KEY, key type CKK_BLOWFISH) hold Blowfish keys. The following table defines the Blowfish secret key object attributes, in addition to the common attributes defined for this object class:

Table 171, BLOWFISH Secret Key Object

| Attribute | Data type | Meaning |
|------------------------------|------------|--|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key value the key can be any length up to 448 bits. Bit length restricted to a byte array. |
| CKA_VALUE_LEN ^{2,3} | CK_ULONG | Length in bytes of key value |

- Refer to [PKCS11-Base] table 11 for footnotes

The following is a sample template for creating an Blowfish secret key object:

```

CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_BLOWFISH;
CK_UTF8CHAR label[] = "A blowfish secret key object";
CK_BYTE value[16] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_ENCRYPT, &true, sizeof(true)},
    {CKA_VALUE, value, sizeof(value)}
};

```

2.45.3 Blowfish key generation

The Blowfish key generation mechanism, denoted **CKM_BLOWFISH_KEY_GEN**, is a key generation mechanism Blowfish.

It does not have a parameter.

The mechanism generates Blowfish keys with a particular length, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of key sizes in bytes.

2.45.4 Blowfish-CBC

Blowfish-CBC, denoted **CKM_BLOWFISH_CBC**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping.

It has a parameter, a 8-byte initialization vector.

This mechanism can wrap and unwrap any secret key. For wrapping, the mechanism encrypts the value of the **CKA_VALUE** attribute of the key that is wrapped, padded on the trailing end with up to block size minus one null bytes so that the resulting length is a multiple of the block size. The output data is the same length as the padded input data. It does not wrap the key type, key length, or any other information about the key; the application must convey these separately.

For unwrapping, the mechanism decrypts the wrapped key, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one, and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

Constraints on key types and the length of data are summarized in the following table:

Table 172, BLOWFISH-CBC: Key and Data Length

| Function | Key type | Input Length | Output Length |
|-------------|----------|------------------------|---|
| C_Encrypt | BLOWFISH | Multiple of block size | Same as input length |
| C_Decrypt | BLOWFISH | Multiple of block size | Same as input length |
| C_WrapKey | BLOWFISH | Any | Input length rounded up to multiple of the block size |
| C_UnwrapKey | BLOWFISH | Multiple of block size | Determined by type of key being unwrapped or CKA_VALUE_LEN |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of BLOWFISH key sizes, in bytes.

2.45.5 Blowfish-CBC with PKCS padding

Blowfish-CBC-PAD, denoted **CKM_BLOWFISH_CBC_PAD**, is a mechanism for single- and multiple-part encryption and decryption, key wrapping and key unwrapping, cipher-block chaining mode and the block cipher padding method detailed in PKCS #7.

It has a parameter, a 8-byte initialization vector.

The PKCS padding in this mechanism allows the length of the plaintext value to be recovered from the ciphertext value. Therefore, when unwrapping keys with this mechanism, no value should be specified for the **CKA_VALUE_LEN** attribute.

The entries in the table below for data length constraints when wrapping and unwrapping keys do not apply to wrapping and unwrapping private keys.

Constraints on key types and the length of data are summarized in the following table:

Table 173, BLOWFISH-CBC with PKCS Padding: Key and Data Length

| Function | Key type | Input Length | Output Length |
|-------------|----------|------------------------|---|
| C_Encrypt | BLOWFISH | Any | Input length rounded up to multiple of the block size |
| C_Decrypt | BLOWFISH | Multiple of block size | Between 1 and block length block size bytes shorter than input length |
| C_WrapKey | BLOWFISH | Any | Input length rounded up to multiple of the block size |
| C_UnwrapKey | BLOWFISH | Multiple of block size | Between 1 and block length block size bytes shorter than input length |

2.46 Twofish

Ref. <https://www.schneier.com/twofish.html>

2.46.1 Definitions

This section defines the key type “CKK_TWOFISH” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

Mechanisms:

CKM_TWOFISH_KEY_GEN

CKM_TWOFISH_CBC

CKM_TWOFISH_CBC_PAD

2.46.2 Twofish secret key objects

Twofish secret key objects (object class **CKO_SECRET_KEY**, key type **CKK_TWOFISH**) hold Twofish keys. The following table defines the Twofish secret key object attributes, in addition to the common attributes defined for this object class:

Table 174, Twofish Secret Key Object

| Attribute | Data type | Meaning |
|------------------------------|------------|--------------------------------------|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key value 128-, 192-, or 256-bit key |
| CKA_VALUE_LEN ^{2,3} | CK_ULONG | Length in bytes of key value |

- Refer to [PKCS11-Base] table 11 for footnotes

The following is a sample template for creating an TWOFISH secret key object:

```
CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_TWOFISH;
CK_UTF8CHAR label[] = "A twofish secret key object";
CK_BYTE value[16] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
```



```

6496     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
6497     {CKA_TOKEN, &true, sizeof(true)},
6498     {CKA_LABEL, label, sizeof(label)-1},
6499     {CKA_ENCRYPT, &true, sizeof(true)},
6500     {CKA_VALUE, value, sizeof(value)}
6501 };

```

6502 2.46.3 Twofish key generation

6503 The Twofish key generation mechanism, denoted **CKM_TWOFISH_KEY_GEN**, is a key generation
6504 mechanism Twofish.

6505 It does not have a parameter.

6506 The mechanism generates Blowfish keys with a particular length, as specified in the **CKA_VALUE_LEN**
6507 attribute of the template for the key.

6508 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
6509 key. Other attributes supported by the key type (specifically, the flags indicating which functions the key
6510 supports) may be specified in the template for the key, or else are assigned default initial values.

6511 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
6512 specify the supported range of key sizes, in bytes.

6513 2.46.4 Twofish -CBC

6514 Twofish-CBC, denoted **CKM_TWOFISH_CBC**, is a mechanism for single- and multiple-part encryption
6515 and decryption; key wrapping; and key unwrapping.

6516 It has a parameter, a 16-byte initialization vector.

6517 2.46.5 Twofish-CBC with PKCS padding

6518 Twofish-CBC-PAD, denoted **CKM_TWOFISH_CBC_PAD**, is a mechanism for single- and multiple-part
6519 encryption and decryption, key wrapping and key unwrapping, cipher-block chaining mode and the block
6520 cipher padding method detailed in PKCS #7.

6521 It has a parameter, a 16-byte initialization vector.

6522 The PKCS padding in this mechanism allows the length of the plaintext value to be recovered from the
6523 ciphertext value. Therefore, when unwrapping keys with this mechanism, no value should be specified for
6524 the **CKA_VALUE_LEN** attribute.

6525 2.47 CAMELLIA

6526 Camellia is a block cipher with 128-bit block size and 128-, 192-, and 256-bit keys, similar to AES.
6527 Camellia is described e.g. in IETF RFC 3713.

6528 *Table 175, Camellia Mechanisms vs. Functions*

| Mechanism | Functions | | | | | | |
|----------------------|---------------------------------|-------------------------|--------------------|------------|---------------------------------|-------------------------|------------|
| | Encryp t & Decryp t | Sign & Verif y | SR & VR 1 | Diges t | Gen · Key/ Key Pair | Wrap & Unwra p | Deriv e |
| CKM_CAMELLIA_KEY_GEN | | | | | ✓ | | |
| CKM_CAMELLIA_ECB | ✓ | | | | | ✓ | |
| CKM_CAMELLIA_CBC | ✓ | | | | | ✓ | |

| Mechanism | Functions | | | | | | |
|-------------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ₁ | Digest | Gen- Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_CAMELLIA_CBC_PAD | ✓ | | | | | ✓ | |
| CKM_CAMELLIA_MAC_GENERAL | | ✓ | | | | | |
| CKM_CAMELLIA_MAC | | ✓ | | | | | |
| CKM_CAMELLIA_ECB_ENCRYPT_DATA | | | | | | | ✓ |
| CKM_CAMELLIA_CBC_ENCRYPT_DATA | | | | | | | ✓ |

2.47.1 Definitions

This section defines the key type “CKK_CAMELLIA” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

Mechanisms:

CKM_CAMELLIA_KEY_GEN
CKM_CAMELLIA_ECB
CKM_CAMELLIA_CBC
CKM_CAMELLIA_MAC
CKM_CAMELLIA_MAC_GENERAL
CKM_CAMELLIA_CBC_PAD

2.47.2 Camellia secret key objects

Camellia secret key objects (object class **CKO_SECRET_KEY**, key type **CKK_CAMELLIA**) hold Camellia keys. The following table defines the Camellia secret key object attributes, in addition to the common attributes defined for this object class:

Table 176, Camellia Secret Key Object Attributes

| Attribute | Data type | Meaning |
|--------------------------------|------------|---------------------------------|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key value (16, 24, or 32 bytes) |
| CKA_VALUE_LEN ^{2,3,6} | CK_ULONG | Length in bytes of key value |

- Refer to [PKCS11-Base] table 11 for footnotes.

The following is a sample template for creating a Camellia secret key object:

```
CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_CAMELLIA;
CK_UTF8CHAR label[] = "A Camellia secret key object";
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
```

```

6554     {CKA_TOKEN, &true, sizeof(true)},
6555     {CKA_LABEL, label, sizeof(label)-1},
6556     {CKA_ENCRYPT, &true, sizeof(true)},
6557     {CKA_VALUE, value, sizeof(value)}
6558 };

```

2.47.3 Camellia key generation

The Camellia key generation mechanism, denoted **CKM_CAMELLIA_KEY_GEN**, is a key generation mechanism for Camellia.

It does not have a parameter.

The mechanism generates Camellia keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the Camellia key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of Camellia key sizes, in bytes.

2.47.4 Camellia-ECB

Camellia-ECB, denoted **CKM_CAMELLIA_ECB**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on Camellia and electronic codebook mode.

It does not have a parameter.

This mechanism can wrap and unwrap any secret key. Of course, a particular token may not be able to wrap/unwrap every secret key that it supports. For wrapping, the mechanism encrypts the value of the **CKA_VALUE** attribute of the key that is wrapped, padded on the trailing end with up to block size minus one null bytes so that the resulting length is a multiple of the block size. The output data is the same length as the padded input data. It does not wrap the key type, key length, or any other information about the key; the application must convey these separately.

For unwrapping, the mechanism decrypts the wrapped key, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one, and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

Constraints on key types and the length of data are summarized in the following table:

Table 177, Camellia-ECB: Key and Data Length

| Function | Key type | Input length | Output length | Comments |
|-------------|--------------|------------------------|---|---------------|
| C_Encrypt | CKK_CAMELLIA | multiple of block size | same as input length | no final part |
| C_Decrypt | CKK_CAMELLIA | multiple of block size | same as input length | no final part |
| C_WrapKey | CKK_CAMELLIA | any | input length rounded up to multiple of block size | |
| C_UnwrapKey | CKK_CAMELLIA | multiple of block size | determined by type of key being unwrapped or CKA_VALUE_LEN | |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of Camellia key sizes, in bytes.

2.47.5 Camellia-CBC

Camellia-CBC, denoted **CKM_CAMELLIA_CBC**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on Camellia and cipher-block chaining mode.

It has a parameter, a 16-byte initialization vector.

This mechanism can wrap and unwrap any secret key. Of course, a particular token may not be able to wrap/unwrap every secret key that it supports. For wrapping, the mechanism encrypts the value of the **CKA_VALUE** attribute of the key that is wrapped, padded on the trailing end with up to block size minus one null bytes so that the resulting length is a multiple of the block size. The output data is the same length as the padded input data. It does not wrap the key type, key length, or any other information about the key; the application must convey these separately.

For unwrapping, the mechanism decrypts the wrapped key, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one, and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

Constraints on key types and the length of data are summarized in the following table:

Table 178, Camellia-CBC: Key and Data Length

| Function | Key type | Input length | Output length | Comments |
|-------------|--------------|------------------------|--|---------------|
| C_Encrypt | CKK_CAMELLIA | multiple of block size | same as input length | no final part |
| C_Decrypt | CKK_CAMELLIA | multiple of block size | same as input length | no final part |
| C_WrapKey | CKK_CAMELLIA | any | input length rounded up to multiple of the block size | |
| C_UnwrapKey | CKK_CAMELLIA | multiple of block size | determined by type of key being unwrapped or CKA_VALUE_LEN | |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of Camellia key sizes, in bytes.

2.47.6 Camellia-CBC with PKCS padding

Camellia-CBC with PKCS padding, denoted **CKM_CAMELLIA_CBC_PAD**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on Camellia; cipher-block chaining mode; and the block cipher padding method detailed in PKCS #7.

It has a parameter, a 16-byte initialization vector.

The PKCS padding in this mechanism allows the length of the plaintext value to be recovered from the ciphertext value. Therefore, when unwrapping keys with this mechanism, no value should be specified for the **CKA_VALUE_LEN** attribute.

In addition to being able to wrap and unwrap secret keys, this mechanism can wrap and unwrap RSA, Diffie-Hellman, X9.42 Diffie-Hellman, EC (also related to ECDSA) and DSA private keys (see Section TBA for details). The entries in the table below for data length constraints when wrapping and unwrapping keys do not apply to wrapping and unwrapping private keys.

Constraints on key types and the length of data are summarized in the following table:

6619 Table 179, Camellia-CBC with PKCS Padding: Key and Data Length

| Function | Key type | Input length | Output length |
|-------------|--------------|------------------------|--|
| C_Encrypt | CKK_CAMELLIA | any | input length rounded up to multiple of the block size |
| C_Decrypt | CKK_CAMELLIA | multiple of block size | between 1 and block size bytes shorter than input length |
| C_WrapKey | CKK_CAMELLIA | any | input length rounded up to multiple of the block size |
| C_UnwrapKey | CKK_CAMELLIA | multiple of block size | between 1 and block length bytes shorter than input length |

6620 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
6621 specify the supported range of Camellia key sizes, in bytes.

6622

6623 2.47.7 CAMELLIA with Counter mechanism parameters

6624 ♦ **CK_CAMELLIA_CTR_PARAMS; CK_CAMELLIA_CTR_PARAMS_PTR**

6625 **CK_CAMELLIA_CTR_PARAMS** is a structure that provides the parameters to the
6626 **CKM_CAMELLIA_CTR** mechanism. It is defined as follows:

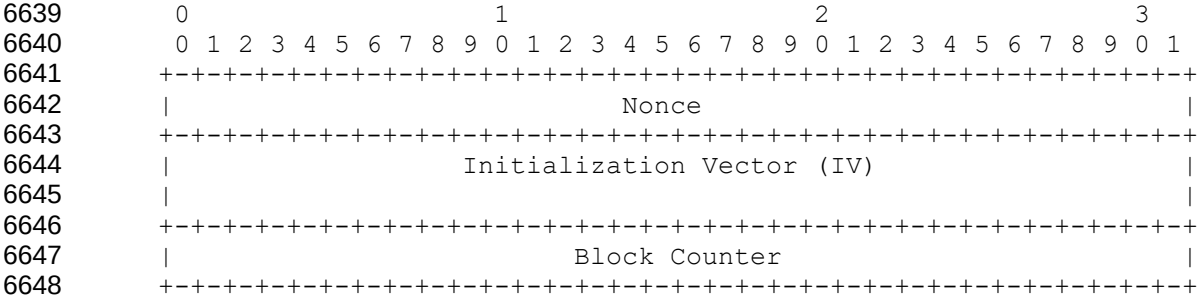
```
6627     typedef struct CK_CAMELLIA_CTR_PARAMS {  
6628         CK_ULONG ulCounterBits;  
6629         CK_BYTE cb[16];  
6630     } CK_CAMELLIA_CTR_PARAMS;
```

6631

6632 *ulCounterBits* specifies the number of bits in the counter block (*cb*) that shall be incremented. This
6633 number shall be such that $0 < ulCounterBits \leq 128$. For any values outside this range the mechanism
6634 shall return **CKR_MECHANISM_PARAM_INVALID**.

6635 It's up to the caller to initialize all of the bits in the counter block including the counter bits. The counter
6636 bits are the least significant bits of the counter block (*cb*). They are a big-endian value usually starting
6637 with 1. The rest of 'cb' is for the nonce, and maybe an optional IV.

6638 E.g. as defined in [RFC 3686]:



6649

6650 This construction permits each packet to consist of up to $2^{32}-1$ blocks = 4,294,967,295 blocks =
6651 68,719,476,720 octets.

6652 **CK_CAMELLIA_CTR_PARAMS_PTR** is a pointer to a **CK_CAMELLIA_CTR_PARAMS**.

6653

2.47.8 General-length Camellia-MAC

General-length Camellia -MAC, denoted **CKM_CAMELLIA_MAC_GENERAL**, is a mechanism for single- and multiple-part signatures and verification, based on Camellia and data authentication as defined in [CAMELLIA]

It has a parameter, a **CK_MAC_GENERAL_PARAMS** structure, which specifies the output length desired from the mechanism.

The output bytes from this mechanism are taken from the start of the final Camellia cipher block produced in the MACing process.

Constraints on key types and the length of data are summarized in the following table:

Table 180, General-length Camellia-MAC: Key and Data Length

| Function | Key type | Data length | Signature length |
|----------|--------------|-------------|--|
| C_Sign | CKK_CAMELLIA | any | 1-block size, as specified in parameters |
| C_Verify | CKK_CAMELLIA | any | 1-block size, as specified in parameters |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of Camellia key sizes, in bytes.

2.47.9 Camellia-MAC

Camellia-MAC, denoted by **CKM_CAMELLIA_MAC**, is a special case of the general-length Camellia-MAC mechanism. Camellia-MAC always produces and verifies MACs that are half the block size in length.

It does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

Table 181, Camellia-MAC: Key and Data Length

| Function | Key type | Data length | Signature length |
|----------|--------------|-------------|------------------------|
| C_Sign | CKK_CAMELLIA | any | ½ block size (8 bytes) |
| C_Verify | CKK_CAMELLIA | any | ½ block size (8 bytes) |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of Camellia key sizes, in bytes.

2.48 Key derivation by data encryption - Camellia

These mechanisms allow derivation of keys using the result of an encryption operation as the key value. They are for use with the C_DeriveKey function.

2.48.1 Definitions

Mechanisms:

CKM_CAMELLIA_ECB_ENCRYPT_DATA

CKM_CAMELLIA_CBC_ENCRYPT_DATA

```
typedef struct CK_CAMELLIA_CBC_ENCRYPT_DATA_PARAMS {
    CK_BYTE      iv[16];
    CK_BYTE_PTR  pData;
    CK_ULONG     length;
} CK_CAMELLIA_CBC_ENCRYPT_DATA_PARAMS;
```

```

6688
6689     typedef CK_CAMELLIA_CBC_ENCRYPT_DATA_PARAMS CK_PTR
6690             CK_CAMELLIA_CBC_ENCRYPT_DATA_PARAMS_PTR;

```

2.48.2 Mechanism Parameters

Uses CK_CAMELLIA_CBC_ENCRYPT_DATA_PARAMS, and CK_KEY_DERIVATION_STRING_DATA.

Table 182, Mechanism Parameters for Camellia-based key derivation

| | |
|-------------------------------|---|
| CKM_CAMELLIA_ECB_ENCRYPT_DATA | Uses CK_KEY_DERIVATION_STRING_DATA structure. Parameter is the data to be encrypted and must be a multiple of 16 long. |
| CKM_CAMELLIA_CBC_ENCRYPT_DATA | Uses CK_CAMELLIA_CBC_ENCRYPT_DATA_PARAMS. Parameter is an 16 byte IV value followed by the data. The data value part must be a multiple of 16 bytes long. |

2.49 ARIA

ARIA is a block cipher with 128-bit block size and 128-, 192-, and 256-bit keys, similar to AES. ARIA is described in NSRI “Specification of ARIA”.

Table 183, ARIA Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_ARIA_KEY_GEN | | | | | ✓ | | |
| CKM_ARIA_ECB | ✓ | | | | | ✓ | |
| CKM_ARIA_CBC | ✓ | | | | | ✓ | |
| CKM_ARIA_CBC_PAD | ✓ | | | | | ✓ | |
| CKM_ARIA_MAC_GENERAL | | ✓ | | | | | |
| CKM_ARIA_MAC | | ✓ | | | | | |
| CKM_ARIA_ECB_ENCRYPT_DATA | | | | | | | ✓ |
| CKM_ARIA_CBC_ENCRYPT_DATA | | | | | | | ✓ |

2.49.1 Definitions

This section defines the key type “CKK_ARIA” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

Mechanisms:

```

        CKM_ARIA_KEY_GEN
        CKM_ARIA_ECB
        CKM_ARIA_CBC
        CKM_ARIA_MAC
        CKM_ARIA_MAC_GENERAL

```


2.49.2 Aria secret key objects

ARIA secret key objects (object class **CKO_SECRET_KEY**, key type **CKK_ARIA**) hold ARIA keys. The following table defines the ARIA secret key object attributes, in addition to the common attributes defined for this object class:

Table 184, ARIA Secret Key Object Attributes

| Attribute | Data type | Meaning |
|--------------------------------|------------|---------------------------------|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key value (16, 24, or 32 bytes) |
| CKA_VALUE_LEN ^{2,3,6} | CK_ULONG | Length in bytes of key value |

- Refer to [PKCS11-Base] table 11 for footnotes.

The following is a sample template for creating an ARIA secret key object:

```

CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_ARIA;
CK_UTF8CHAR label[] = "An ARIA secret key object";
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_ENCRYPT, &true, sizeof(true)},
    {CKA_VALUE, value, sizeof(value)}
};

```

2.49.3 ARIA key generation

The ARIA key generation mechanism, denoted **CKM_ARIA_KEY_GEN**, is a key generation mechanism for Aria.

It does not have a parameter.

The mechanism generates ARIA keys with a particular length in bytes, as specified in the **CKA_VALUE_LEN** attribute of the template for the key.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the ARIA key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of ARIA key sizes, in bytes.

2.49.4 ARIA-ECB

ARIA-ECB, denoted **CKM_ARIA_ECB**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on Aria and electronic codebook mode.

It does not have a parameter.

This mechanism can wrap and unwrap any secret key. Of course, a particular token may not be able to wrap/unwrap every secret key that it supports. For wrapping, the mechanism encrypts the value of the **CKA_VALUE** attribute of the key that is wrapped, padded on the trailing end with up to block size minus

one null bytes so that the resulting length is a multiple of the block size. The output data is the same length as the padded input data. It does not wrap the key type, key length, or any other information about the key; the application must convey these separately.

For unwrapping, the mechanism decrypts the wrapped key, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one, and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

Constraints on key types and the length of data are summarized in the following table:

Table 185, ARIA-ECB: Key and Data Length

| Function | Key type | Input length | Output length | Comments |
|-------------|----------|------------------------|--|---------------|
| C_Encrypt | CKK_ARIA | multiple of block size | same as input length | no final part |
| C_Decrypt | CKK_ARIA | multiple of block size | same as input length | no final part |
| C_WrapKey | CKK_ARIA | any | input length rounded up to multiple of block size | |
| C_UnwrapKey | CKK_ARIA | multiple of block size | determined by type of key being unwrapped or CKA_VALUE_LEN | |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of ARIA key sizes, in bytes.

2.49.5 ARIA-CBC

ARIA-CBC, denoted **CKM_ARIA_CBC**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on ARIA and cipher-block chaining mode.

It has a parameter, a 16-byte initialization vector.

This mechanism can wrap and unwrap any secret key. Of course, a particular token may not be able to wrap/unwrap every secret key that it supports. For wrapping, the mechanism encrypts the value of the **CKA_VALUE** attribute of the key that is wrapped, padded on the trailing end with up to block size minus one null bytes so that the resulting length is a multiple of the block size. The output data is the same length as the padded input data. It does not wrap the key type, key length, or any other information about the key; the application must convey these separately.

For unwrapping, the mechanism decrypts the wrapped key, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one, and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. The mechanism contributes the result as the **CKA_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

Constraints on key types and the length of data are summarized in the following table:

6773 Table 186, ARIA-CBC: Key and Data Length

| Function | Key type | Input length | Output length | Comments |
|-------------|----------|------------------------|--|---------------|
| C_Encrypt | CKK_ARIA | multiple of block size | same as input length | no final part |
| C_Decrypt | CKK_ARIA | multiple of block size | same as input length | no final part |
| C_WrapKey | CKK_ARIA | any | input length rounded up to multiple of the block size | |
| C_UnwrapKey | CKK_ARIA | multiple of block size | determined by type of key being unwrapped or CKA_VALUE_LEN | |

6774 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
6775 specify the supported range of Aria key sizes, in bytes.

6776 2.49.6 ARIA-CBC with PKCS padding

6777 ARIA-CBC with PKCS padding, denoted **CKM_ARIA_CBC_PAD**, is a mechanism for single- and
6778 multiple-part encryption and decryption; key wrapping; and key unwrapping, based on ARIA; cipher-block
6779 chaining mode; and the block cipher padding method detailed in PKCS #7.

6780 It has a parameter, a 16-byte initialization vector.

6781 The PKCS padding in this mechanism allows the length of the plaintext value to be recovered from the
6782 ciphertext value. Therefore, when unwrapping keys with this mechanism, no value should be specified
6783 for the **CKA_VALUE_LEN** attribute.

6784 In addition to being able to wrap and unwrap secret keys, this mechanism can wrap and unwrap RSA,
6785 Diffie-Hellman, X9.42 Diffie-Hellman, EC (also related to ECDSA) and DSA private keys (see Section
6786 TBA for details). The entries in the table below for data length constraints when wrapping and
6787 unwrapping keys do not apply to wrapping and unwrapping private keys.

6788 Constraints on key types and the length of data are summarized in the following table:

6789 Table 187, ARIA-CBC with PKCS Padding: Key and Data Length

| Function | Key type | Input length | Output length |
|-------------|----------|------------------------|--|
| C_Encrypt | CKK_ARIA | any | input length rounded up to multiple of the block size |
| C_Decrypt | CKK_ARIA | multiple of block size | between 1 and block size bytes shorter than input length |
| C_WrapKey | CKK_ARIA | any | input length rounded up to multiple of the block size |
| C_UnwrapKey | CKK_ARIA | multiple of block size | between 1 and block length bytes shorter than input length |

6790 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
6791 specify the supported range of ARIA key sizes, in bytes.

6792 2.49.7 General-length ARIA-MAC

6793 General-length ARIA -MAC, denoted **CKM_ARIA_MAC_GENERAL**, is a mechanism for single- and
6794 multiple-part signatures and verification, based on ARIA and data authentication as defined in [FIPS 113].

6795 It has a parameter, a **CK_MAC_GENERAL_PARAMS** structure, which specifies the output length
6796 desired from the mechanism.

6797 The output bytes from this mechanism are taken from the start of the final ARIA cipher block produced in
6798 the MACing process.

6799 Constraints on key types and the length of data are summarized in the following table:

6800 *Table 188, General-length ARIA-MAC: Key and Data Length*

| Function | Key type | Data length | Signature length |
|----------|----------|-------------|--|
| C_Sign | CKK_ARIA | any | 1-block size, as specified in parameters |
| C_Verify | CKK_ARIA | any | 1-block size, as specified in parameters |

6801 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
6802 specify the supported range of ARIA key sizes, in bytes.

6803 **2.49.8 ARIA-MAC**

6804 ARIA-MAC, denoted by **CKM_ARIA_MAC**, is a special case of the general-length ARIA-MAC
6805 mechanism. ARIA-MAC always produces and verifies MACs that are half the block size in length.

6806 It does not have a parameter.

6807 Constraints on key types and the length of data are summarized in the following table:

6808 *Table 189, ARIA-MAC: Key and Data Length*

| Function | Key type | Data length | Signature length |
|----------|----------|-------------|------------------------|
| C_Sign | CKK_ARIA | any | ½ block size (8 bytes) |
| C_Verify | CKK_ARIA | any | ½ block size (8 bytes) |

6809 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
6810 specify the supported range of ARIA key sizes, in bytes.

6811 **2.50 Key derivation by data encryption - ARIA**

6812 These mechanisms allow derivation of keys using the result of an encryption operation as the key value.
6813 They are for use with the C_DeriveKey function.

6814 **2.50.1 Definitions**

6815 Mechanisms:

6816 CKM_ARIA_ECB_ENCRYPT_DATA

6817 CKM_ARIA_CBC_ENCRYPT_DATA

6818

```
6819 typedef struct CK_ARIA_CBC_ENCRYPT_DATA_PARAMS {  
6820     CK_BYTE      iv[16];  
6821     CK_BYTE_PTR  pData;  
6822     CK_ULONG     length;  
6823 } CK_ARIA_CBC_ENCRYPT_DATA_PARAMS;
```

6824

```
6825 typedef CK_ARIA_CBC_ENCRYPT_DATA_PARAMS CK_PTR  
6826         CK_ARIA_CBC_ENCRYPT_DATA_PARAMS_PTR;
```

6827 **2.50.2 Mechanism Parameters**

6828 Uses CK_ARIA_CBC_ENCRYPT_DATA_PARAMS, and CK_KEY_DERIVATION_STRING_DATA.

6829 *Table 190, Mechanism Parameters for Aria-based key derivation*

| | |
|---------------------------|---|
| CKM_ARIA_ECB_ENCRYPT_DATA | Uses CK_KEY_DERIVATION_STRING_DATA structure. Parameter is the data to be encrypted and must be a multiple of 16 long. |
| CKM_ARIA_CBC_ENCRYPT_DATA | Uses CK_ARIA_CBC_ENCRYPT_DATA_PARAMS. Parameter is an 16 byte IV value followed by the data. The data value part must be a multiple of 16 bytes long. |

6830

6831 2.51 SEED

6832 SEED is a symmetric block cipher developed by the South Korean Information Security Agency (KISA). It
6833 has a 128-bit key size and a 128-bit block size.

6834 Its specification has been published as Internet [RFC 4269].

6835 RFCs have been published defining the use of SEED in

6836 TLS <ftp://ftp.rfc-editor.org/in-notes/rfc4162.txt>

6837 IPsec <ftp://ftp.rfc-editor.org/in-notes/rfc4196.txt>

6838 CMS <ftp://ftp.rfc-editor.org/in-notes/rfc4010.txt>

6839

6840 TLS cipher suites that use SEED include:

```

6841     CipherSuite TLS_RSA_WITH_SEED_CBC_SHA      = { 0x00,
6842         0x96};
6843     CipherSuite TLS_DH_DSS_WITH_SEED_CBC_SHA    = { 0x00,
6844         0x97};
6845     CipherSuite TLS_DH_RSA_WITH_SEED_CBC_SHA    = { 0x00,
6846         0x98};
6847     CipherSuite TLS_DHE_DSS_WITH_SEED_CBC_SHA   = { 0x00,
6848         0x99};
6849     CipherSuite TLS_DHE_RSA_WITH_SEED_CBC_SHA   = { 0x00,
6850         0x9A};
6851     CipherSuite TLS_DH_anon_WITH_SEED_CBC_SHA    = { 0x00,
6852         0x9B};

```

6853

6854 As with any block cipher, it can be used in the ECB, CBC, OFB and CFB modes of operation, as well as
6855 in a MAC algorithm such as HMAC.

6856 OIDs have been published for all these uses. A list may be seen at

6857 <http://www.alvestrand.no/objectid/1.2.410.200004.1.html>

6858

6859 *Table 191, SEED Mechanisms vs. Functions*

| Mechanism | Functions | | | | | | |
|---------------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SEED_KEY_GEN | | | | | ✓ | | |
| CKM_SEED_ECB | | | ✓ | | | | |
| CKM_SEED_CBC | | | ✓ | | | | |
| CKM_SEED_CBC_PAD | ✓ | | | | | ✓ | |
| CKM_SEED_MAC_GENERAL | | | ✓ | | | | |
| CKM_SEED_MAC | | | | ✓ | | | |
| CKM_SEED_ECB_ENCRYPT_DATA | | | | | | | ✓ |
| CKM_SEED_CBC_ENCRYPT_DATA | | | | | | | ✓ |

2.51.1 Definitions

This section defines the key type "CKK_SEED" for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

Mechanisms:

CKM_SEED_KEY_GEN

CKM_SEED_ECB

CKM_SEED_CBC

CKM_SEED_MAC

CKM_SEED_MAC_GENERAL

CKM_SEED_CBC_PAD

For all of these mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** are always 16.

2.51.2 SEED secret key objects

SEED secret key objects (object class **CKO_SECRET_KEY**, key type **CKK_SEED**) hold SEED keys. The following table defines the secret key object attributes, in addition to the common attributes defined for this object class:

Table 192, SEED Secret Key Object Attributes

| Attribute | Data type | Meaning |
|------------------------------|------------|----------------------------------|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key value (always 16 bytes long) |

¹ - Refer to [PKCS11-Base] table 11 for footnotes.

The following is a sample template for creating a SEED secret key object:

```
CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_SEED;
CK_UTF8CHAR label[] = "A SEED secret key object";
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
```

```

6886     {CKA_CLASS, &class, sizeof(class)},
6887     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
6888     {CKA_TOKEN, &true, sizeof(true)},
6889     {CKA_LABEL, label, sizeof(label)-1},
6890     {CKA_ENCRYPT, &true, sizeof(true)},
6891     {CKA_VALUE, value, sizeof(value)}
6892 };

```

6893 2.51.3 SEED key generation

6894 The SEED key generation mechanism, denoted **CKM_SEED_KEY_GEN**, is a key generation mechanism
6895 for SEED.

6896 It does not have a parameter.

6897 The mechanism generates SEED keys.

6898 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
6899 key. Other attributes supported by the SEED key type (specifically, the flags indicating which functions
6900 the key supports) may be specified in the template for the key, or else are assigned default initial values.

6901 2.51.4 SEED-ECB

6902 SEED-ECB, denoted **CKM_SEED_ECB**, is a mechanism for single- and multiple-part encryption and
6903 decryption; key wrapping; and key unwrapping, based on SEED and electronic codebook mode.

6904 It does not have a parameter.

6905 2.51.5 SEED-CBC

6906 SEED-CBC, denoted **CKM_SEED_CBC**, is a mechanism for single- and multiple-part encryption and
6907 decryption; key wrapping; and key unwrapping, based on SEED and cipher-block chaining mode.

6908 It has a parameter, a 16-byte initialization vector.

6909 2.51.6 SEED-CBC with PKCS padding

6910 SEED-CBC with PKCS padding, denoted **CKM_SEED_CBC_PAD**, is a mechanism for single- and
6911 multiple-part encryption and decryption; key wrapping; and key unwrapping, based on SEED; cipher-
6912 block chaining mode; and the block cipher padding method detailed in PKCS #7.

6913 It has a parameter, a 16-byte initialization vector.

6914 2.51.7 General-length SEED-MAC

6915 General-length SEED-MAC, denoted **CKM_SEED_MAC_GENERAL**, is a mechanism for single- and
6916 multiple-part signatures and verification, based on SEED and data authentication as defined in 0.

6917 It has a parameter, a **CK_MAC_GENERAL_PARAMS** structure, which specifies the output length
6918 desired from the mechanism.

6919 The output bytes from this mechanism are taken from the start of the final cipher block produced in the
6920 MACing process.

6921 2.51.8 SEED-MAC

6922 SEED-MAC, denoted by **CKM_SEED_MAC**, is a special case of the general-length SEED-MAC
6923 mechanism. SEED-MAC always produces and verifies MACs that are half the block size in length.

6924 It does not have a parameter.

2.52 Key derivation by data encryption - SEED

These mechanisms allow derivation of keys using the result of an encryption operation as the key value. They are for use with the C_DeriveKey function.

2.52.1 Definitions

Mechanisms:

CKM_SEED_ECB_ENCRYPT_DATA

CKM_SEED_CBC_ENCRYPT_DATA

```
typedef struct CK_SEED_CBC_ENCRYPT_DATA_PARAMS {  
    CK_BYTE      iv[16];  
    CK_BYTE_PTR  pData;  
    CK_ULONG     length;  
} CK_SEED_CBC_ENCRYPT_DATA_PARAMS;
```

```
typedef CK_SEED_CBC_ENCRYPT_DATA_PARAMS CK_PTR  
CK_SEED_CBC_ENCRYPT_DATA_PARAMS_PTR;
```

2.52.2 Mechanism Parameters

Table 193, Mechanism Parameters for SEED-based key derivation

| | |
|---------------------------|---|
| CKM_SEED_ECB_ENCRYPT_DATA | Uses CK_KEY_DERIVATION_STRING_DATA structure. Parameter is the data to be encrypted and must be a multiple of 16 long. |
| CKM_SEED_CBC_ENCRYPT_DATA | Uses CK_SEED_CBC_ENCRYPT_DATA_PARAMS. Parameter is an 16 byte IV value followed by the data. The data value part must be a multiple of 16 bytes long. |

2.53 OTP

2.53.1 Usage overview

OTP tokens represented as PKCS #11 mechanisms may be used in a variety of ways. The usage cases can be categorized according to the type of sought functionality.

2.53.2 Case 1: Generation of OTP values

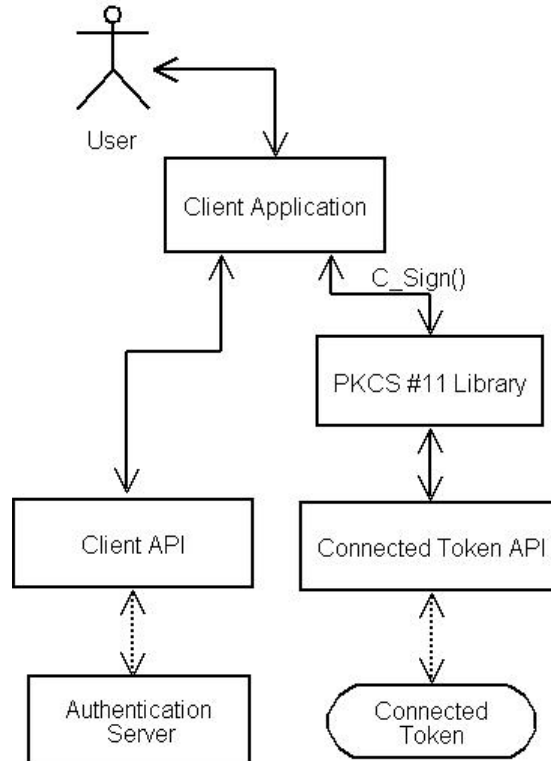


Figure 1: Retrieving OTP values through C_Sign

Figure 1 shows an integration of PKCS #11 into an application that needs to authenticate users holding OTP tokens. In this particular example, a connected hardware token is used, but a software token is equally possible. The application invokes **C_Sign** to retrieve the OTP value from the token. In the example, the application then passes the retrieved OTP value to a client API that sends it via the network to an authentication server. The client API may implement a standard authentication protocol such as RADIUS [RFC 2865] or EAP [RFC 3748], or a proprietary protocol such as that used by RSA Security's ACE/Agent® software.

2.53.3 Case 2: Verification of provided OTP values

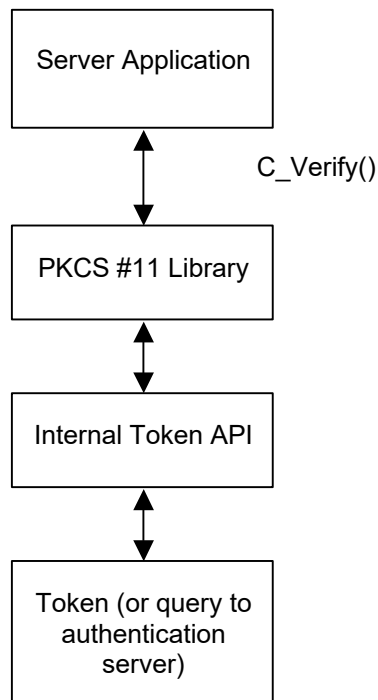
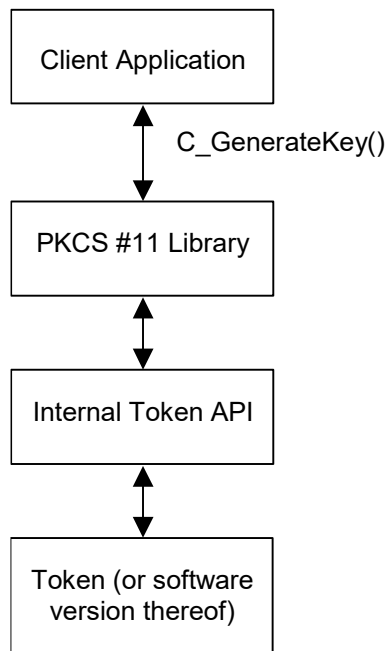


Figure 2: Server-side verification of OTP values

Figure 2 illustrates the server-side equivalent of the scenario depicted in Figure 1. In this case, a server application invokes **C_Verify** with the received OTP value as the signature value to be verified.

2.53.4 Case 3: Generation of OTP keys



6965 *Figure 3: Generation of an OTP key*

6966 Figure 3 shows an integration of PKCS #11 into an application that generates OTP keys. The application
6967 invokes **C_GenerateKey** to generate an OTP key of a particular type on the token. The key may
6968 subsequently be used as a basis to generate OTP values.

6969 2.53.5 OTP objects

6970 2.53.5.1 Key objects

6971 OTP key objects (object class **CKO_OTP_KEY**) hold secret keys used by OTP tokens. The following
6972 table defines the attributes common to all OTP keys, in addition to the attributes defined for secret keys,
6973 all of which are inherited by this class:

| Attribute | Data type | Meaning |
|--|-----------|---|
| CKA_OTP_FORMAT | CK_ULONG | Format of OTP values produced with this key: CK_OTP_FORMAT_DECIMAL = Decimal (default) (UTF8-encoded) CK_OTP_FORMAT_HEXADecimal = Hexadecimal (UTF8-encoded) CK_OTP_FORMAT_ALPHANUMERIC = Alphanumeric (UTF8-encoded) CK_OTP_FORMAT_BINARY = Only binary values. |
| CKA_OTP_LENGTH ⁹ | CK_ULONG | Default length of OTP values (in the CKA_OTP_FORMAT) produced with this key. |
| CKA_OTP_USER_FRIENDLY_MODE ⁹ | CK_BBOOL | Set to CK_TRUE when the token is capable of returning OTPs suitable for human consumption. See the description of CKF_USER_FRIENDLY_OTP below. |
| CKA_OTP_CHALLENGE_REQUIREMENT ⁹ | CK_ULONG | Parameter requirements when generating or verifying OTP values with this key: CK_OTP_PARAM_MANDATORY = A challenge must be supplied. CK_OTP_PARAM_OPTIONAL = A challenge may be supplied but need not be. CK_OTP_PARAM_IGNORED = A challenge, if supplied, will be ignored. |
| CKA_OTP_TIME_REQUIREMENT ⁹ | CK_ULONG | Parameter requirements when generating or verifying OTP values with this key: CK_OTP_PARAM_MANDATORY = A time value must be supplied. CK_OTP_PARAM_OPTIONAL = A time value may be supplied but need not be. CK_OTP_PARAM_IGNORED = A time value, if supplied, will be ignored. |

| | | |
|--|-----------------|---|
| CKA_OTP_COUNTER_REQUIREMENT ⁹ | CK_ULONG | Parameter requirements when generating or verifying OTP values with this key: CK_OTP_PARAM_MANDATORY = A counter value must be supplied. CK_OTP_PARAM_OPTIONAL = A counter value may be supplied but need not be. CK_OTP_PARAM_IGNORED = A counter value, if supplied, will be ignored. |
| CKA_OTP_PIN_REQUIREMENT ⁹ | CK_ULONG | Parameter requirements when generating or verifying OTP values with this key: CK_OTP_PARAM_MANDATORY = A PIN value must be supplied. CK_OTP_PARAM_OPTIONAL = A PIN value may be supplied but need not be (if not supplied, then library will be responsible for collecting it) CK_OTP_PARAM_IGNORED = A PIN value, if supplied, will be ignored. |
| CKA_OTP_COUNTER | Byte array | Value of the associated internal counter. Default value is empty (i.e. <i>ulValueLen</i> = 0). |
| CKA_OTP_TIME | RFC 2279 string | Value of the associated internal UTC time in the form YYYYMMDDhhmmss. Default value is empty (i.e. <i>ulValueLen</i> = 0). |
| CKA_OTP_USER_IDENTIFIER | RFC 2279 string | Text string that identifies a user associated with the OTP key (may be used to enhance the user experience). Default value is empty (i.e. <i>ulValueLen</i> = 0). |
| CKA_OTP_SERVICE_IDENTIFIER | RFC 2279 string | Text string that identifies a service that may validate OTPs generated by this key. Default value is empty (i.e. <i>ulValueLen</i> = 0). |
| CKA_OTP_SERVICE_LOGO | Byte array | Logotype image that identifies a service that may validate OTPs generated by this key. Default value is empty (i.e. <i>ulValueLen</i> = 0). |
| CKA_OTP_SERVICE_LOGO_TYPE | RFC 2279 string | MIME type of the CKA_OTP_SERVICE_LOGO attribute value. Default value is empty (i.e. <i>ulValueLen</i> = 0). |
| CKA_VALUE ^{1, 4, 6, 7} | Byte array | Value of the key. |
| CKA_VALUE_LEN ^{2, 3} | CK_ULONG | Length in bytes of key value. |

Note: A Cryptoki library may support PIN-code caching in order to reduce user interactions. An OTP-PKCS #11 application should therefore always consult the state of the CKA_OTP_PIN_REQUIREMENT attribute before each call to **C_SignInit**, as the value of this attribute may change dynamically.

For OTP tokens with multiple keys, the keys may be enumerated using **C_FindObjects**. The **CKA_OTP_SERVICE_IDENTIFIER** and/or the **CKA_OTP_SERVICE_LOGO** attribute may be used to distinguish between keys. The actual choice of key for a particular operation is however application-specific and beyond the scope of this document.

For all OTP keys, the CKA_ALLOWED_MECHANISMS attribute should be set as required.

2.53.6 OTP-related notifications

This document extends the set of defined notifications as follows:

CKN_OTP_CHANGED *Cryptoki is informing the application that the OTP for a key on a connected token just changed. This notification is particularly useful when applications wish to display the current OTP value for time-based mechanisms.*

2.53.7 OTP mechanisms

The following table shows, for the OTP mechanisms defined in this document, their support by different cryptographic operations. For any particular token, of course, a particular operation may well support only a subset of the mechanisms listed. There is also no guarantee that a token that supports one mechanism for some operation supports any other mechanism for any other operation (or even supports that same mechanism for any other operation).

Table 195: OTP mechanisms vs. applicable functions

| Mechanism | Functions | | | | | | |
|---------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SECURID_KEY_GEN | | | | | ✓ | | |
| CKM_SECURID | | ✓ | | | | | |
| CKM_HOTP_KEY_GEN | | | | | ✓ | | |
| CKM_HOTP | | ✓ | | | | | |
| CKM_ACTI_KEY_GEN | | | | | ✓ | | |
| CKM_ACTI | | ✓ | | | | | |

The remainder of this section will present in detail the OTP mechanisms and the parameters that are supplied to them.

2.53.7.1 OTP mechanism parameters

◆ CK_OTP_PARAM_TYPE

CK_OTP_PARAM_TYPE is a value that identifies an OTP parameter type. It is defined as follows:

```
typedef CK_ULONG CK_OTP_PARAM_TYPE;
```

The following **CK_OTP_PARAM_TYPE** types are defined:

7004 Table 196, OTP parameter types

| Parameter | Data type | Meaning |
|----------------------|-----------------|---|
| CK_OTP_PIN | RFC 2279 string | A UTF8 string containing a PIN for use when computing or verifying PIN-based OTP values. |
| CK_OTP_CHALLENGE | Byte array | Challenge to use when computing or verifying challenge-based OTP values. |
| CK_OTP_TIME | RFC 2279 string | UTC time value in the form YYYYMMDDhhmmss to use when computing or verifying time-based OTP values. |
| CK_OTP_COUNTER | Byte array | Counter value to use when computing or verifying counter-based OTP values. |
| CK_OTP_FLAGS | CK_FLAGS | Bit flags indicating the characteristics of the sought OTP as defined below. |
| CK_OTP_OUTPUT_LENGTH | CK_ULONG | Desired output length (overrides any default value). A Cryptoki library will return CKR_MECHANISM_PARAM_INVALID if a provided length value is not supported. |
| CK_OTP_OUTPUT_FORMAT | CK_ULONG | Returned OTP format (allowed values are the same as for CKA_OTP_FORMAT). This parameter is only intended for C_Sign output, see paragraphs below. When not present, the returned OTP format will be the same as the value of the CKA_OTP_FORMAT attribute for the key in question. |
| CK_OTP_VALUE | Byte array | An actual OTP value. This parameter type is intended for C_Sign output, see paragraphs below. |

7005

7006 The following table defines the possible values for the CK_OTP_FLAGS type:

7007 Table 197: OTP Mechanism Flags

| Bit flag | Mask | Meaning |
|--------------|------------|--|
| CKF_NEXT_OTP | 0x00000001 | True (i.e. set) if the OTP computation shall be for the next OTP, rather than the current one (current being interpreted in the context of the algorithm, e.g. for the current counter value or current time window). A Cryptoki library shall return CKR_MECHANISM_PARAM_INVALID if the CKF_NEXT_OTP flag is set and the OTP mechanism in question does not support the concept of "next" OTP or the library is not capable of generating the next OTP ⁹ . |

⁹ Applications that may need to retrieve the next OTP should be prepared to handle this situation. For example, an application could store the OTP value returned by C_Sign so that, if a next OTP is required, it can compare it to the OTP value returned by subsequent calls to C_Sign should it turn out that the library does not support the CKF_NEXT_OTP flag.

| Bit flag | Mask | Meaning |
|-----------------------|------------|---|
| CKF_EXCLUDE_TIME | 0x00000002 | True (i.e. set) if the OTP computation must not include a time value. Will have an effect only on mechanisms that do include a time value in the OTP computation and then only if the mechanism (and token) allows exclusion of this value. A Cryptoki library shall return CKR_MECHANISM_PARAM_INVALID if exclusion of the value is not allowed. |
| CKF_EXCLUDE_COUNTER | 0x00000004 | True (i.e. set) if the OTP computation must not include a counter value. Will have an effect only on mechanisms that do include a counter value in the OTP computation and then only if the mechanism (and token) allows exclusion of this value. A Cryptoki library shall return CKR_MECHANISM_PARAM_INVALID if exclusion of the value is not allowed. |
| CKF_EXCLUDE_CHALLENGE | 0x00000008 | True (i.e. set) if the OTP computation must not include a challenge. Will have an effect only on mechanisms that do include a challenge in the OTP computation and then only if the mechanism (and token) allows exclusion of this value. A Cryptoki library shall return CKR_MECHANISM_PARAM_INVALID if exclusion of the value is not allowed. |
| CKF_EXCLUDE_PIN | 0x00000010 | True (i.e. set) if the OTP computation must not include a PIN value. Will have an effect only on mechanisms that do include a PIN in the OTP computation and then only if the mechanism (and token) allows exclusion of this value. A Cryptoki library shall return CKR_MECHANISM_PARAM_INVALID if exclusion of the value is not allowed. |
| CKF_USER_FRIENDLY_OTP | 0x00000020 | True (i.e. set) if the OTP returned shall be in a form suitable for human consumption. If this flag is set, and the call is successful, then the returned CK_OTP_VALUE shall be a UTF8-encoded printable string. A Cryptoki library shall return CKR_MECHANISM_PARAM_INVALID if this flag is set when CKA_OTP_USER_FRIENDLY_MODE for the key in question is CK_FALSE. |

Note: Even if CKA_OTP_FORMAT is not set to CK_OTP_FORMAT_BINARY, then there may still be value in setting the CKF_USER_FRIENDLY_OTP flag (assuming CKA_OTP_USER_FRIENDLY_MODE is CK_TRUE, of course) if the intent is for a human to read the generated OTP value, since it may become shorter or otherwise better suited for a user. Applications that do not intend to provide a returned OTP value to a user should not set the CKF_USER_FRIENDLY_OTP flag.

◆ CK_OTP_PARAM; CK_OTP_PARAM_PTR

CK_OTP_PARAM is a structure that includes the type, value, and length of an OTP parameter. It is defined as follows:

```

7016     typedef struct CK_OTP_PARAM {
7017         CK_OTP_PARAM_TYPE type;
7018         CK_VOID_PTR pValue;
7019         CK_ULONG ulValueLen;
7020     } CK_OTP_PARAM;

```

7021 The fields of the structure have the following meanings:

| | | |
|------|-------------------|--|
| 7022 | <i>type</i> | <i>the parameter type</i> |
| 7023 | <i>pValue</i> | <i>pointer to the value of the parameter</i> |
| 7024 | <i>ulValueLen</i> | <i>length in bytes of the value</i> |

7025 If a parameter has no value, then *ulValueLen* = 0, and the value of *pValue* is irrelevant. Note that *pValue*
7026 is a “void” pointer, facilitating the passing of arbitrary values. Both the application and the Cryptoki library
7027 must ensure that the pointer can be safely cast to the expected type (*i.e.*, without word-alignment errors).

7028 **CK_OTP_PARAM_PTR** is a pointer to a **CK_OTP_PARAM**.

7029

7030 ♦ **CK_OTP_PARAMS; CK_OTP_PARAMS_PTR**

7031 **CK_OTP_PARAMS** is a structure that is used to provide parameters for OTP mechanisms in a generic
7032 fashion. It is defined as follows:

```

7033     typedef struct CK_OTP_PARAMS {
7034         CK_OTP_PARAM_PTR pParams;
7035         CK_ULONG ulCount;
7036     } CK_OTP_PARAMS;

```

7037 The fields of the structure have the following meanings:

| | | |
|------|----------------|--|
| 7038 | <i>pParams</i> | <i>pointer to an array of OTP parameters</i> |
| 7039 | <i>ulCount</i> | <i>the number of parameters in the array</i> |

7040 **CK_OTP_PARAMS_PTR** is a pointer to a **CK_OTP_PARAMS**.

7041

7042 When calling **C_SignInit** or **C_VerifyInit** with a mechanism that takes a **CK_OTP_PARAMS** structure as a
7043 parameter, the **CK_OTP_PARAMS** structure shall be populated in accordance with the
7044 **CKA_OTP_X_REQUIREMENT** key attributes for the identified key, where *X* is PIN, CHALLENGE, TIME,
7045 or COUNTER.

7046 For example, if **CKA_OTP_TIME_REQUIREMENT** = **CK_OTP_PARAM_MANDATORY**, then the
7047 **CK_OTP_TIME** parameter shall be present. If **CKA_OTP_TIME_REQUIREMENT** =
7048 **CK_OTP_PARAM_OPTIONAL**, then a **CK_OTP_TIME** parameter may be present. If it is not present,
7049 then the library may collect it (during the **C_Sign** call). If **CKA_OTP_TIME_REQUIREMENT** =
7050 **CK_OTP_PARAM_IGNORED**, then a provided **CK_OTP_TIME** parameter will always be ignored.
7051 Additionally, a provided **CK_OTP_TIME** parameter will always be ignored if **CKF_EXCLUDE_TIME** is set
7052 in a **CK_OTP_FLAGS** parameter. Similarly, if this flag is set, a library will not attempt to collect the value
7053 itself, and it will also instruct the token not to make use of any internal value, subject to token policies. It is
7054 an error (**CKR_MECHANISM_PARAM_INVALID**) to set the **CKF_EXCLUDE_TIME** flag when the
7055 **CKA_OTP_TIME_REQUIREMENT** attribute is **CK_OTP_PARAM_MANDATORY**.

7056 The above discussion holds for all **CKA_OTP_X_REQUIREMENT** attributes (*i.e.*,
7057 **CKA_OTP_PIN_REQUIREMENT**, **CKA_OTP_CHALLENGE_REQUIREMENT**,
7058 **CKA_OTP_COUNTER_REQUIREMENT**, **CKA_OTP_TIME_REQUIREMENT**). A library may set a
7059 particular **CKA_OTP_X_REQUIREMENT** attribute to **CK_OTP_PARAM_OPTIONAL** even if it is required

by the mechanism as long as the token (or the library itself) has the capability of providing the value to the computation. One example of this is a token with an on-board clock.

In addition, applications may use the CK_OTP_FLAGS, the CK_OTP_OUTPUT_FORMAT and the CKA_OTP_LENGTH parameters to set additional parameters.

◆ CK_OTP_SIGNATURE_INFO, CK_OTP_SIGNATURE_INFO_PTR

CK_OTP_SIGNATURE_INFO is a structure that is returned by all OTP mechanisms in successful calls to **C_Sign** (**C_SignFinal**). The structure informs applications of actual parameter values used in particular OTP computations in addition to the OTP value itself. It is used by all mechanisms for which the key belongs to the class CKO_OTP_KEY and is defined as follows:

```
typedef struct CK_OTP_SIGNATURE_INFO {  
    CK_OTP_PARAM_PTR pParams;  
    CK_ULONG ulCount;  
} CK_OTP_SIGNATURE_INFO;
```

The fields of the structure have the following meanings:

pParams *pointer to an array of OTP parameter values*

ulCount *the number of parameters in the array*

After successful calls to **C_Sign** or **C_SignFinal** with an OTP mechanism, the *pSignature* parameter will be set to point to a **CK_OTP_SIGNATURE_INFO** structure. One of the parameters in this structure will be the OTP value itself, identified with the **CK_OTP_VALUE** tag. Other parameters may be present for informational purposes, e.g. the actual time used in the OTP calculation. In order to simplify OTP validations, authentication protocols may permit authenticating parties to send some or all of these parameters in addition to OTP values themselves. Applications should therefore check for their presence in returned **CK_OTP_SIGNATURE_INFO** values whenever such circumstances apply.

Since **C_Sign** and **C_SignFinal** follows the convention described in [PKCS11-Base] Section 5.2 on producing output, a call to **C_Sign** (or **C_SignFinal**) with *pSignature* set to NULL_PTR will return (in the *pulSignatureLen* parameter) the required number of bytes to hold the **CK_OTP_SIGNATURE_INFO** structure as well as all the data in all its **CK_OTP_PARAM** components. If an application allocates a memory block based on this information, it shall therefore not subsequently de-allocate components of such a received value but rather de-allocate the complete **CK_OTP_PARAMS** structure itself. A Cryptoki library that is called with a non-NULL *pSignature* pointer will assume that it points to a *contiguous* memory block of the size indicated by the *pulSignatureLen* parameter.

When verifying an OTP value using an OTP mechanism, *pSignature* shall be set to the OTP value itself, e.g. the value of the **CK_OTP_VALUE** component of a **CK_OTP_PARAM** structure returned by a call to **C_Sign**. The **CK_OTP_PARAM** value supplied in the **C_VerifyInit** call sets the values to use in the verification operation.

CK_OTP_SIGNATURE_INFO_PTR points to a **CK_OTP_SIGNATURE_INFO**.

2.53.8 RSA SecurID

2.53.8.1 RSA SecurID secret key objects

RSA SecurID secret key objects (object class **CKO_OTP_KEY**, key type **CKK_SECURID**) hold RSA SecurID secret keys. The following table defines the RSA SecurID secret key object attributes, in addition to the common attributes defined for this object class:

Table 198, RSA SecurID secret key object attributes

| Attribute | Data type | Meaning |
|------------------------------------|-----------|--|
| CKA_OTP_TIME_INTERVAL ¹ | CK_ULONG | Interval between OTP values produced with this key, in seconds. Default is 60. |

Refer to [PKCS11-Base] table 11 for footnotes.

The following is a sample template for creating an RSA SecurID secret key object:

```

CK_OBJECT_CLASS class = CKO_OTP_KEY;
CK_KEY_TYPE keyType = CKK_SECURID;
CK_DATE endDate = {...};
CK_UTF8CHAR label[] = "RSA SecurID secret key object";
CK_BYTE keyId[] = {...};
CK_ULONG outputFormat = CK_OTP_FORMAT_DECIMAL;
CK_ULONG outputLength = 6;
CK_ULONG needPIN = CK_OTP_PARAM_MANDATORY;
CK_ULONG timeInterval = 60;
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_END_DATE, &endDate, sizeof(endDate)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_SENSITIVE, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_SIGN, &true, sizeof(true)},
    {CKA_VERIFY, &true, sizeof(true)},
    {CKA_ID, keyId, sizeof(keyId)},
    {CKA_OTP_FORMAT, &outputFormat, sizeof(outputFormat)},
    {CKA_OTP_LENGTH, &outputLength, sizeof(outputLength)},
    {CKA_OTP_PIN_REQUIREMENT, &needPIN, sizeof(needPIN)},
    {CKA_OTP_TIME_INTERVAL, &timeInterval,
        sizeof(timeInterval)},
    {CKA_VALUE, value, sizeof(value)}
};

```

2.53.8.2 RSA SecurID key generation

The RSA SecurID key generation mechanism, denoted **CKM_SECURID_KEY_GEN**, is a key generation mechanism for the RSA SecurID algorithm.

It does not have a parameter.

The mechanism generates RSA SecurID keys with a particular set of attributes as specified in the template for the key.

The mechanism contributes at least the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_VALUE_LEN**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the RSA SecurID key type may be specified in the template for the key, or else are assigned default initial values

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of SecurID key sizes, in bytes.

2.53.8.3 SecurID OTP generation and validation

CKM_SECURID is the mechanism for the retrieval and verification of RSA SecurID OTP values.

The mechanism takes a pointer to a **CK_OTP_PARAMS** structure as a parameter.

When signing or verifying using the **CKM_SECURID** mechanism, *pData* shall be set to **NULL_PTR** and *ulDataLen* shall be set to 0.

2.53.8.4 Return values

Support for the **CKM_SECURID** mechanism extends the set of return values for **C_Verify** with the following values:

- **CKR_NEW_PIN_MODE**: The supplied OTP was not accepted and the library requests a new OTP computed using a new PIN. The new PIN is set through means out of scope for this document.
- **CKR_NEXT_OTP**: The supplied OTP was correct but indicated a larger than normal drift in the token's internal state (e.g. clock, counter). To ensure this was not due to a temporary problem, the application should provide the next one-time password to the library for verification.

2.53.9 OATH HOTP

2.53.9.1 OATH HOTP secret key objects

HOTP secret key objects (object class **CKO_OTP_KEY**, key type **CKK_HOTP**) hold generic secret keys and associated counter values.

The **CKA_OTP_COUNTER** value may be set at key generation; however, some tokens may set it to a fixed initial value. Depending on the token's security policy, this value may not be modified and/or may not be revealed if the object has its **CKA_SENSITIVE** attribute set to **CK_TRUE** or its **CKA_EXTRACTABLE** attribute set to **CK_FALSE**.

For HOTP keys, the **CKA_OTP_COUNTER** value shall be an 8 bytes unsigned integer in big endian (i.e. network byte order) form. The same holds true for a **CK_OTP_COUNTER** value in a **CK_OTP_PARAM** structure.

The following is a sample template for creating a HOTP secret key object:

```
CK_OBJECT_CLASS class = CKO_OTP_KEY;
CK_KEY_TYPE keyType = CKK_HOTP;
CK_UTF8CHAR label[] = "HOTP secret key object";
CK_BYTE keyId[] = {...};
CK_ULONG outputFormat = CK_OTP_FORMAT_DECIMAL;
CK_ULONG outputLength = 6;
CK_DATE endDate = {...};
CK_BYTE counterValue[8] = {0};
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_END_DATE, &endDate, sizeof(endDate)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_SENSITIVE, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_SIGN, &true, sizeof(true)},
    {CKA_VERIFY, &true, sizeof(true)},
    {CKA_ID, keyId, sizeof(keyId)},
```

```

7189         {CKA_OTP_FORMAT, &outputFormat, sizeof(outputFormat)},
7190         {CKA_OTP_LENGTH, &outputLength, sizeof(outputLength)},
7191         {CKA_OTP_COUNTER, counterValue, sizeof(counterValue)},
7192         {CKA_VALUE, value, sizeof(value)}
7193     };

```

7194 2.53.9.2 HOTP key generation

7195 The HOTP key generation mechanism, denoted **CKM_HOTP_KEY_GEN**, is a key generation mechanism
7196 for the HOTP algorithm.

7197 It does not have a parameter.

7198 The mechanism generates HOTP keys with a particular set of attributes as specified in the template for
7199 the key.

7200 The mechanism contributes at least the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_OTP_COUNTER**,
7201 **CKA_VALUE** and **CKA_VALUE_LEN** attributes to the new key. Other attributes supported by the HOTP
7202 key type may be specified in the template for the key, or else are assigned default initial values.

7203 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
7204 specify the supported range of HOTP key sizes, in bytes.

7205 2.53.9.3 HOTP OTP generation and validation

7206 **CKM_HOTP** is the mechanism for the retrieval and verification of HOTP OTP values based on the current
7207 internal counter, or a provided counter.

7208 The mechanism takes a pointer to a **CK_OTP_PARAMS** structure as a parameter.

7209 As for the **CKM_SECURID** mechanism, when signing or verifying using the **CKM_HOTP** mechanism,
7210 *pData* shall be set to **NULL_PTR** and *ulDataLen* shall be set to 0.

7211 For verify operations, the counter value **CK_OTP_COUNTER** must be provided as a **CK_OTP_PARAM**
7212 parameter to **C_VerifyInit**. When verifying an OTP value using the **CKM_HOTP** mechanism, *pSignature*
7213 shall be set to the OTP value itself, e.g. the value of the **CK_OTP_VALUE** component of a
7214 **CK_OTP_PARAM** structure in the case of an earlier call to **C_Sign**.

7215 2.53.10 ActivIdentity ACTI

7216 2.53.10.1 ACTI secret key objects

7217 ACTI secret key objects (object class **CKO_OTP_KEY**, key type **CKK_ACTI**) hold ActivIdentity ACTI
7218 secret keys.

7219 For ACTI keys, the **CKA_OTP_COUNTER** value shall be an 8 bytes unsigned integer in big endian (i.e.
7220 network byte order) form. The same holds true for the **CK_OTP_COUNTER** value in the
7221 **CK_OTP_PARAM** structure.

7222 The **CKA_OTP_COUNTER** value may be set at key generation; however, some tokens may set it to a
7223 fixed initial value. Depending on the token's security policy, this value may not be modified and/or may
7224 not be revealed if the object has its **CKA_SENSITIVE** attribute set to **CK_TRUE** or its
7225 **CKA_EXTRACTABLE** attribute set to **CK_FALSE**.

7226 The **CKA_OTP_TIME** value may be set at key generation; however, some tokens may set it to a fixed
7227 initial value. Depending on the token's security policy, this value may not be modified and/or may not be
7228 revealed if the object has its **CKA_SENSITIVE** attribute set to **CK_TRUE** or its **CKA_EXTRACTABLE**
7229 attribute set to **CK_FALSE**.

7230 The following is a sample template for creating an ACTI secret key object:

```

7231     CK_OBJECT_CLASS class = CKO_OTP_KEY;
7232     CK_KEY_TYPE keyType = CKK_ACTI;
7233     CK_UTF8CHAR label[] = "ACTI secret key object";

```



```

7234     CK_BYTE keyId[] = {...};
7235     CK_ULONG outputFormat = CK_OTP_FORMAT_DECIMAL;
7236     CK_ULONG outputLength = 6;
7237     CK_DATE endDate = {...};
7238     CK_BYTE counterValue[8] = {0};
7239     CK_BYTE value[] = {...};
7240     CK_BBOOL true = CK_TRUE;
7241     CK_ATTRIBUTE template[] = {
7242         {CKA_CLASS, &class, sizeof(class)},
7243         {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
7244         {CKA_END_DATE, &endDate, sizeof(endDate)},
7245         {CKA_TOKEN, &true, sizeof(true)},
7246         {CKA_SENSITIVE, &true, sizeof(true)},
7247         {CKA_LABEL, label, sizeof(label)-1},
7248         {CKA_SIGN, &true, sizeof(true)},
7249         {CKA_VERIFY, &true, sizeof(true)},
7250         {CKA_ID, keyId, sizeof(keyId)},
7251         {CKA_OTP_FORMAT, &outputFormat,
7252          sizeof(outputFormat)},
7253         {CKA_OTP_LENGTH, &outputLength,
7254          sizeof(outputLength)},
7255         {CKA_OTP_COUNTER, counterValue,
7256          sizeof(counterValue)},
7257         {CKA_VALUE, value, sizeof(value)}
7258     };

```

7259 2.53.10.2 ACTI key generation

7260 The ACTI key generation mechanism, denoted **CKM_ACTI_KEY_GEN**, is a key generation mechanism
7261 for the ACTI algorithm.

7262 It does not have a parameter.

7263 The mechanism generates ACTI keys with a particular set of attributes as specified in the template for the
7264 key.

7265 The mechanism contributes at least the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_VALUE** and
7266 **CKA_VALUE_LEN** attributes to the new key. Other attributes supported by the ACTI key type may be
7267 specified in the template for the key, or else are assigned default initial values.

7268 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
7269 specify the supported range of ACTI key sizes, in bytes.

7270 2.53.10.3 ACTI OTP generation and validation

7271 **CKM_ACTI** is the mechanism for the retrieval and verification of ACTI OTP values.

7272 The mechanism takes a pointer to a **CK_OTP_PARAMS** structure as a parameter.

7273 When signing or verifying using the **CKM_ACTI** mechanism, *pData* shall be set to **NULL_PTR** and
7274 *ulDataLen* shall be set to 0.

7275 When verifying an OTP value using the **CKM_ACTI** mechanism, *pSignature* shall be set to the OTP value
7276 itself, e.g. the value of the **CK_OTP_VALUE** component of a **CK_OTP_PARAM** structure in the case of
7277 an earlier call to **C_Sign**.

2.54 CT-KIP

2.54.1 Principles of Operation

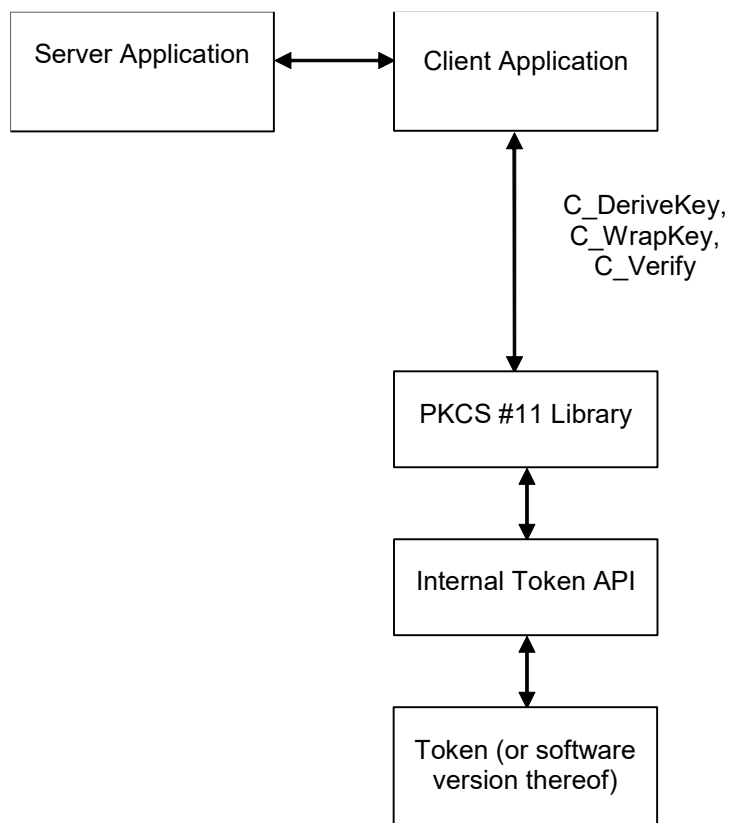


Figure 4: PKCS #11 and CT-KIP integration

Figure 4 shows an integration of PKCS #11 into an application that generates cryptographic keys through the use of CT-KIP. The application invokes **C_DeriveKey** to derive a key of a particular type on the token. The key may subsequently be used as a basis to e.g., generate one-time password values. The application communicates with a CT-KIP server that participates in the key derivation and stores a copy of the key in its database. The key is transferred to the server in wrapped form, after a call to **C_WrapKey**. The server authenticates itself to the client and the client verifies the authentication by calls to **C_Verify**.

2.54.2 Mechanisms

The following table shows, for the mechanisms defined in this document, their support by different cryptographic operations. For any particular token, of course, a particular operation may well support only a subset of the mechanisms listed. There is also no guarantee that a token that supports one mechanism for some operation supports any other mechanism for any other operation (or even supports that same mechanism for any other operation).

Table 199: CT-KIP Mechanisms vs. applicable functions

| Mechanism | Functions | | | | | | |
|----------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_KIP_DERIVE | | | | | | | ✓ |
| CKM_KIP_WRAP | | | | | | ✓ | |
| CKM_KIP_MAC | | ✓ | | | | | |

The remainder of this section will present in detail the mechanisms and the parameters that are supplied to them.

2.54.3 Definitions

Mechanisms:

CKM_KIP_DERIVE

CKM_KIP_WRAP

CKM_KIP_MAC

2.54.4 CT-KIP Mechanism parameters

◆ CK_KIP_PARAMS; CK_KIP_PARAMS_PTR

CK_KIP_PARAMS is a structure that provides the parameters to all the CT-KIP related mechanisms: The **CKM_KIP_DERIVE** key derivation mechanism, the **CKM_KIP_WRAP** key wrap and key unwrap mechanism, and the **CKM_KIP_MAC** signature mechanism. The structure is defined as follows:

```
typedef struct CK_KIP_PARAMS {
    CK_MECHANISM_PTR    pMechanism;
    CK_OBJECT_HANDLE    hKey;
    CK_BYTE_PTR         pSeed;
    CK_ULONG            ulSeedLen;
} CK_KIP_PARAMS;
```

The fields of the structure have the following meanings:

pMechanism pointer to the underlying cryptographic mechanism (e.g. AES, SHA-256), see further 0, Appendix D

hKey handle to a key that will contribute to the entropy of the derived key (CKM_KIP_DERIVE) or will be used in the MAC operation (CKM_KIP_MAC)

pSeed pointer to an input seed

ulSeedLen length in bytes of the input seed

CK_KIP_PARAMS_PTR is a pointer to a **CK_KIP_PARAMS** structure.

2.54.5 CT-KIP key derivation

The CT-KIP key derivation mechanism, denoted **CKM_KIP_DERIVE**, is a key derivation mechanism that is capable of generating secret keys of potentially any type, subject to token limitations.

It takes a parameter of type **CK_KIP_PARAMS** which allows for the passing of the desired underlying cryptographic mechanism as well as some other data. In particular, when the *hKey* parameter is a handle to an existing key, that key will be used in the key derivation in addition to the *hBaseKey* of **C_DeriveKey**. The *pSeed* parameter may be used to seed the key derivation operation.

The mechanism derives a secret key with a particular set of attributes as specified in the attributes of the template for the key.

The mechanism contributes the **CKA_CLASS** and **CKA_VALUE** attributes to the new key. Other attributes supported by the key type may be specified in the template for the key, or else will be assigned default initial values. Since the mechanism is generic, the **CKA_KEY_TYPE** attribute should be set in the template, if the key is to be used with a particular mechanism.

2.54.6 CT-KIP key wrap and key unwrap

The CT-KIP key wrap and unwrap mechanism, denoted **CKM_KIP_WRAP**, is a key wrap mechanism that is capable of wrapping and unwrapping generic secret keys.

It takes a parameter of type **CK_KIP_PARAMS**, which allows for the passing of the desired underlying cryptographic mechanism as well as some other data. It does not make use of the *hKey* parameter of **CK_KIP_PARAMS**.

2.54.7 CT-KIP signature generation

The CT-KIP signature (MAC) mechanism, denoted **CKM_KIP_MAC**, is a mechanism used to produce a message authentication code of arbitrary length. The keys it uses are secret keys.

It takes a parameter of type **CK_KIP_PARAMS**, which allows for the passing of the desired underlying cryptographic mechanism as well as some other data. The mechanism does not make use of the *pSeed* and the *ulSeedLen* parameters of **CT_KIP_PARAMS**.

This mechanism produces a MAC of the length specified by *puSignatureLen* parameter in calls to **C_Sign**.

If a call to **C_Sign** with this mechanism fails, then no output will be generated.

2.55 GOST 28147-89

GOST 28147-89 is a block cipher with 64-bit block size and 256-bit keys.

Table 200, GOST 28147-89 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|------------------------|-------------------|---------------|---------|--------|--------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_GOST28147_KEY_GEN | | | | | ✓ | | |
| CKM_GOST28147_ECB | ✓ | | | | | ✓ | |
| CKM_GOST28147 | ✓ | | | | | ✓ | |
| CKM_GOST28147_MAC | | ✓ | | | | | |
| CKM_GOST28147_KEY_WRAP | | | | | | ✓ | |

2.55.1 Definitions

This section defines the key type “CKK_GOST28147” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects and domain parameter objects.

Mechanisms:

CKM_GOST28147_KEY_GEN
CKM_GOST28147_ECB
CKM_GOST28147
CKM_GOST28147_MAC
CKM_GOST28147_KEY_WRAP

2.55.2 GOST 28147-89 secret key objects

GOST 28147-89 secret key objects (object class **CKO_SECRET_KEY**, key type **CKK_GOST28147**) hold GOST 28147-89 keys. The following table defines the GOST 28147-89 secret key object attributes, in addition to the common attributes defined for this object class:

Table 201, GOST 28147-89 Secret Key Object Attributes

| Attribute | Data type | Meaning |
|---------------------------------------|------------|---|
| CKA_VALUE ^{1,4,6,7} | Byte array | 32 bytes in little endian order |
| CKA_GOST28147_PARAMS ^{1,3,5} | Byte array | DER-encoding of the object identifier indicating the data object type of GOST 28147-89. When key is used the domain parameter object of key type CKK_GOST28147 must be specified with the same attribute CKA_OBJECT_ID |

Refer to [PKCS11-Base] Table 11 for footnotes

The following is a sample template for creating a GOST 28147-89 secret key object:

```
CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_GOST28147;
CK_UTF8CHAR label[] = "A GOST 28147-89 secret key object";
CK_BYTE value[32] = {...};
CK_BYTE params_oid[] = {0x06, 0x07, 0x2a, 0x85, 0x03, 0x02,
                        0x02, 0x1f, 0x00};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_ENCRYPT, &true, sizeof(true)},
    {CKA_GOST28147_PARAMS, params_oid, sizeof(params_oid)},
    {CKA_VALUE, value, sizeof(value)}
};
```

2.55.3 GOST 28147-89 domain parameter objects

GOST 28147-89 domain parameter objects (object class **CKO_DOMAIN_PARAMETERS**, key type **CKK_GOST28147**) hold GOST 28147-89 domain parameters.

The following table defines the GOST 28147-89 domain parameter object attributes, in addition to the common attributes defined for this object class:

Table 202, GOST 28147-89 Domain Parameter Object Attributes

| Attribute | Data Type | Meaning |
|----------------------------|------------|--|
| CKA_VALUE ¹ | Byte array | DER-encoding of the domain parameters as it was introduced in [4] section 8.1 (type <i>Gost28147-89-ParamSetParameters</i>) |
| CKA_OBJECT_ID ¹ | Byte array | DER-encoding of the object identifier indicating the domain parameters |

Refer to [PKCS11-Base] Table 11 for footnotes

For any particular token, there is no guarantee that a token supports domain parameters loading up and/or fetching out. Furthermore, applications, that make direct use of domain parameters objects, should take in account that **CKA_VALUE** attribute may be inaccessible.

The following is a sample template for creating a GOST 28147-89 domain parameter object:

```
CK_OBJECT_CLASS class = CKO_DOMAIN_PARAMETERS;
CK_KEY_TYPE keyType = CKK_GOST28147;
CK_UTF8CHAR label[] = "A GOST 28147-89 cryptographic
    parameters object";
CK_BYTE oid[] = {0x06, 0x07, 0x2a, 0x85, 0x03, 0x02, 0x02,
    0x1f, 0x00};
CK_BYTE value[] = {
    0x30, 0x62, 0x04, 0x40, 0x4c, 0xde, 0x38, 0x9c, 0x29, 0x89, 0xef, 0xb6,
    0xff, 0xeb, 0x56, 0xc5, 0x5e, 0xc2, 0x9b, 0x02, 0x98, 0x75, 0x61, 0x3b,
    0x11, 0x3f, 0x89, 0x60, 0x03, 0x97, 0x0c, 0x79, 0x8a, 0xa1, 0xd5, 0x5d,
    0xe2, 0x10, 0xad, 0x43, 0x37, 0x5d, 0xb3, 0x8e, 0xb4, 0x2c, 0x77, 0xe7,
    0xcd, 0x46, 0xca, 0xfa, 0xd6, 0x6a, 0x20, 0x1f, 0x70, 0xf4, 0x1e, 0xa4,
    0xab, 0x03, 0xf2, 0x21, 0x65, 0xb8, 0x44, 0xd8, 0x02, 0x01, 0x00, 0x02,
    0x01, 0x40, 0x30, 0x0b, 0x06, 0x07, 0x2a, 0x85, 0x03, 0x02, 0x02, 0x0e,
    0x00, 0x05, 0x00
};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_OBJECT_ID, oid, sizeof(oid)},
    {CKA_VALUE, value, sizeof(value)}
};
```

2.55.4 GOST 28147-89 key generation

The GOST 28147-89 key generation mechanism, denoted **CKM_GOST28147_KEY_GEN**, is a key generation mechanism for GOST 28147-89.

It does not have a parameter.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the GOST 28147-89 key type may be specified for objects of object class **CKO_SECRET_KEY**.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** are not used.

2.55.5 GOST 28147-89-ECB

GOST 28147-89-ECB, denoted **CKM_GOST28147_ECB**, is a mechanism for single and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on GOST 28147-89 and electronic codebook mode.

It does not have a parameter.

This mechanism can wrap and unwrap any secret key. Of course, a particular token may not be able to wrap/unwrap every secret key that it supports.

For wrapping (**C_WrapKey**), the mechanism encrypts the value of the **CKA_VALUE** attribute of the key that is wrapped, padded on the trailing end with up to block size so that the resulting length is a multiple of the block size.

For unwrapping (**C_UnwrapKey**), the mechanism decrypts the wrapped key, and truncates the result according to the **CKA_KEY_TYPE** attribute of the template and, if it has one, and the key type supports it, the **CKA_VALUE_LEN** attribute of the template. The mechanism contributes the result as the **CKA_VALUE** attribute of the new key.

Constraints on key types and the length of data are summarized in the following table:

Table 203, GOST 28147-89-ECB: Key and Data Length

| Function | Key type | Input length | Output length |
|-------------|---------------|------------------------|---|
| C_Encrypt | CKK_GOST28147 | Multiple of block size | Same as input length |
| C_Decrypt | CKK_GOST28147 | Multiple of block size | Same as input length |
| C_WrapKey | CKK_GOST28147 | Any | Input length rounded up to multiple of block size |
| C_UnwrapKey | CKK_GOST28147 | Multiple of block size | Determined by type of key being unwrapped |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure are not used.

2.55.6 GOST 28147-89 encryption mode except ECB

GOST 28147-89 encryption mode except ECB, denoted **CKM_GOST28147**, is a mechanism for single and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on [GOST 28147-89] and CFB, counter mode, and additional CBC mode defined in [RFC 4357] section 2. Encryption's parameters are specified in object identifier of attribute **CKA_GOST28147_PARAMS**.

It has a parameter, which is an 8-byte initialization vector. This parameter may be omitted then a zero initialization vector is used.

This mechanism can wrap and unwrap any secret key. Of course, a particular token may not be able to wrap/unwrap every secret key that it supports.

For wrapping (**C_WrapKey**), the mechanism encrypts the value of the **CKA_VALUE** attribute of the key that is wrapped.

For unwrapping (**C_UnwrapKey**), the mechanism decrypts the wrapped key, and contributes the result as the **CKA_VALUE** attribute of the new key.

Constraints on key types and the length of data are summarized in the following table:

Table 204, GOST 28147-89 encryption modes except ECB: Key and Data Length

| Function | Key type | Input length | Output length |
|-------------|---------------|--------------|---|
| C_Encrypt | CKK_GOST28147 | Any | For counter mode and CFB is the same as input length. For CBC is the same as input length padded on the trailing end with up to block size so that the resulting length is a multiple of the block size |
| C_Decrypt | CKK_GOST28147 | Any | |
| C_WrapKey | CKK_GOST28147 | Any | |
| C_UnwrapKey | CKK_GOST28147 | Any | |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure are not used.

2.55.7 GOST 28147-89-MAC

GOST 28147-89-MAC, denoted **CKM_GOST28147_MAC**, is a mechanism for data integrity and authentication based on GOST 28147-89 and key meshing algorithms [RFC 4357] section 2.3.

MACing parameters are specified in object identifier of attribute **CKA_GOST28147_PARAMS**.

The output bytes from this mechanism are taken from the start of the final GOST 28147-89 cipher block produced in the MACing process.

It has a parameter, which is an 8-byte MAC initialization vector. This parameter may be omitted then a zero initialization vector is used.

Constraints on key types and the length of data are summarized in the following table:

Table 205, GOST28147-89-MAC: Key and Data Length

| Function | Key type | Data length | Signature length |
|----------|---------------|-------------|------------------|
| C_Sign | CKK_GOST28147 | Any | 4 bytes |
| C_Verify | CKK_GOST28147 | Any | 4 bytes |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure are not used.

2.55.8 GOST 28147-89 keys wrapping/unwrapping with GOST 28147-89

GOST 28147-89 keys as a KEK (key encryption keys) for encryption GOST 28147-89 keys, denoted by **CKM_GOST28147_KEY_WRAP**, is a mechanism for key wrapping; and key unwrapping, based on GOST 28147-89. Its purpose is to encrypt and decrypt keys have been generated by key generation mechanism for GOST 28147-89.

For wrapping (**C_WrapKey**), the mechanism first computes MAC from the value of the **CKA_VALUE** attribute of the key that is wrapped and then encrypts in ECB mode the value of the **CKA_VALUE** attribute of the key that is wrapped. The result is 32 bytes of the key that is wrapped and 4 bytes of MAC.

For unwrapping (**C_UnwrapKey**), the mechanism first decrypts in ECB mode the 32 bytes of the key that was wrapped and then computes MAC from the unwrapped key. Then compared together 4 bytes MAC

has computed and 4 bytes MAC of the input. If these two MACs do not match the wrapped key is disallowed. The mechanism contributes the result as the **CKA_VALUE** attribute of the unwrapped key. It has a parameter, which is an 8-byte MAC initialization vector. This parameter may be omitted then a zero initialization vector is used.

Constraints on key types and the length of data are summarized in the following table:

Table 206, GOST 28147-89 keys as KEK: Key and Data Length

| Function | Key type | Input length | Output length |
|-------------|---------------|--------------|---------------|
| C_WrapKey | CKK_GOST28147 | 32 bytes | 36 bytes |
| C_UnwrapKey | CKK_GOST28147 | 32 bytes | 36 bytes |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure are not used.

2.56 GOST R 34.11-94

GOST R 34.11-94 is a mechanism for message digesting, following the hash algorithm with 256-bit message digest defined in [GOST R 34.11-94].

Table 207, GOST R 34.11-94 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|--------------------|-------------------|---------------|---------|--------|--------------------|---------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_GOSTR3411 | | | | ✓ | | | |
| CKM_GOSTR3411_HMAC | | ✓ | | | | | |

2.56.1 Definitions

This section defines the key type “CKK_GOSTR3411” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of domain parameter objects.

Mechanisms:

CKM_GOSTR3411

CKM_GOSTR3411_HMAC

2.56.2 GOST R 34.11-94 domain parameter objects

GOST R 34.11-94 domain parameter objects (object class **CKO_DOMAIN_PARAMETERS**, key type **CKK_GOSTR3411**) hold GOST R 34.11-94 domain parameters.

The following table defines the GOST R 34.11-94 domain parameter object attributes, in addition to the common attributes defined for this object class:

Table 208, GOST R 34.11-94 Domain Parameter Object Attributes

| Attribute | Data Type | Meaning |
|----------------------------|------------|--|
| CKA_VALUE ¹ | Byte array | DER-encoding of the domain parameters as it was introduced in [4] section 8.2 (type <i>GostR3411-94-ParamSetParameters</i>) |
| CKA_OBJECT_ID ¹ | Byte array | DER-encoding of the object identifier indicating the domain parameters |

Refer to [PKCS11-Base] Table 11 for footnotes

For any particular token, there is no guarantee that a token supports domain parameters loading up and/or fetching out. Furthermore, applications, that make direct use of domain parameters objects, should take in account that **CKA_VALUE** attribute may be inaccessible.

The following is a sample template for creating a GOST R 34.11-94 domain parameter object:

```

CK_OBJECT_CLASS class = CKO_DOMAIN_PARAMETERS;
CK_KEY_TYPE keyType = CKK_GOSTR3411;
CK_UTF8CHAR label[] = "A GOST R34.11-94 cryptographic
    parameters object";
CK_BYTE oid[] = {0x06, 0x07, 0x2a, 0x85, 0x03, 0x02, 0x02,
    0x1e, 0x00};
CK_BYTE value[] = {
    0x30, 0x64, 0x04, 0x40, 0x4e, 0x57, 0x64, 0xd1, 0xab, 0x8d, 0xcb, 0xbf,
    0x94, 0x1a, 0x7a, 0x4d, 0x2c, 0xd1, 0x10, 0x10, 0xd6, 0xa0, 0x57, 0x35,
    0x8d, 0x38, 0xf2, 0xf7, 0x0f, 0x49, 0xd1, 0x5a, 0xea, 0x2f, 0x8d, 0x94,
    0x62, 0xee, 0x43, 0x09, 0xb3, 0xf4, 0xa6, 0xa2, 0x18, 0xc6, 0x98, 0xe3,
    0xc1, 0x7c, 0xe5, 0x7e, 0x70, 0x6b, 0x09, 0x66, 0xf7, 0x02, 0x3c, 0x8b,
    0x55, 0x95, 0xbf, 0x28, 0x39, 0xb3, 0x2e, 0xcc, 0x04, 0x20, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00};
};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_OBJECT_ID, oid, sizeof(oid)},
    {CKA_VALUE, value, sizeof(value)}
};

```

2.56.3 GOST R 34.11-94 digest

GOST R 34.11-94 digest, denoted **CKM_GOSTR3411**, is a mechanism for message digesting based on GOST R 34.11-94 hash algorithm [GOST R 34.11-94].

As a parameter this mechanism utilizes a DER-encoding of the object identifier. A mechanism parameter may be missed then parameters of the object identifier *id-GostR3411-94-CryptoProParamSet* [RFC 4357] (section 11.2) must be used.

Constraints on the length of input and output data are summarized in the following table. For single-part digesting, the data and the digest may begin at the same location in memory.

7561 Table 209, GOST R 34.11-94: Data Length

| Function | Input length | Digest length |
|----------|--------------|---------------|
| C_Digest | Any | 32 bytes |

7562

7563 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
7564 are not used.

7565 2.56.4 GOST R 34.11-94 HMAC

7566 GOST R 34.11-94 HMAC mechanism, denoted **CKM_GOSTR3411_HMAC**, is a mechanism for
7567 signatures and verification. It uses the HMAC construction, based on the GOST R 34.11-94 hash
7568 function [GOST R 34.11-94] and core HMAC algorithm [RFC 2104]. The keys it uses are of generic key
7569 type **CKK_GENERIC_SECRET** or **CKK_GOST28147**.

7570 To be conformed to GOST R 34.11-94 hash algorithm [GOST R 34.11-94] the block length of core HMAC
7571 algorithm is 32 bytes long (see [RFC 2104] section 2, and [RFC 4357] section 3).

7572 As a parameter this mechanism utilizes a DER-encoding of the object identifier. A mechanism parameter
7573 may be missed then parameters of the object identifier *id-GostR3411-94-CryptoProParamSet* [RFC 4357]
7574 (section 11.2) must be used.

7575 Signatures (MACs) produced by this mechanism are of 32 bytes long.

7576 Constraints on the length of input and output data are summarized in the following table:

7577 Table 210, GOST R 34.11-94 HMAC: Key And Data Length

| Function | Key type | Data length | Signature length |
|----------|--|-------------|------------------|
| C_Sign | CKK_GENERIC_SECRET or CKK_GOST28147 | Any | 32 byte |
| C_Verify | CKK_GENERIC_SECRET or CKK_GOST28147 | Any | 32 bytes |

7578 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
7579 are not used.

7580 2.57 GOST R 34.10-2001

7581 GOST R 34.10-2001 is a mechanism for single- and multiple-part signatures and verification, following
7582 the digital signature algorithm defined in [GOST R 34.10-2001].

7583

7584 Table 211, GOST R34.10-2001 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|------------------------------|-------------------------|---------------------|---------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_GOSTR3410_KEY_PAIR_GEN | | | | | ✓ | | |
| CKM_GOSTR3410 | | ✓ ¹ | | | | | |
| CKM_GOSTR3410_WITH_GOSTR3411 | | ✓ | | | | | |
| CKM_GOSTR3410_KEY_WRAP | | | | | | ✓ | |
| CKM_GOSTR3410_DERIVE | | | | | | | ✓ |

7585 ¹ Single-part operations only

7586

7587 **2.57.1 Definitions**

7588 This section defines the key type “CKK_GOSTR3410” for type CK_KEY_TYPE as used in the
7589 CKA_KEY_TYPE attribute of key objects and domain parameter objects.

7590 Mechanisms:

- 7591 CKM_GOSTR3410_KEY_PAIR_GEN
- 7592 CKM_GOSTR3410
- 7593 CKM_GOSTR3410_WITH_GOSTR3411
- 7594 CKM_GOSTR3410
- 7595 CKM_GOSTR3410_KEY_WRAP
- 7596 CKM_GOSTR3410_DERIVE

7597 **2.57.2 GOST R 34.10-2001 public key objects**

7598 GOST R 34.10-2001 public key objects (object class **CKO_PUBLIC_KEY**, key type **CKK_GOSTR3410**)
7599 hold GOST R 34.10-2001 public keys.

7600 The following table defines the GOST R 34.10-2001 public key object attributes, in addition to the
7601 common attributes defined for this object class:

7602 *Table 212, GOST R 34.10-2001 Public Key Object Attributes*

| Attribute | Data Type | Meaning |
|---------------------------------------|------------|---|
| CKA_VALUE ^{1,4} | Byte array | 64 bytes for public key; 32 bytes for each coordinates X and Y of elliptic curve point P(X, Y) in little endian order |
| CKA_GOSTR3410_PARAMS ^{1,3} | Byte array | DER-encoding of the object identifier indicating the data object type of GOST R 34.10-2001. When key is used the domain parameter object of key type CKK_GOSTR3410 must be specified with the same attribute CKA_OBJECT_ID |
| CKA_GOSTR3411_PARAMS ^{1,3,8} | Byte array | DER-encoding of the object identifier indicating the data object type of GOST R 34.11-94. When key is used the domain parameter object of key type CKK_GOSTR3411 must be specified with the same attribute CKA_OBJECT_ID |
| CKA_GOST28147_PARAMS ⁸ | Byte array | DER-encoding of the object identifier indicating the data object type of GOST 28147-89. When key is used the domain parameter object of key type CKK_GOST28147 must be specified with the same attribute CKA_OBJECT_ID. The attribute value may be omitted |

7603 Refer to [PKCS11-Base] Table 11 for footnotes

7604 The following is a sample template for creating an GOST R 34.10-2001 public key object:

```

7605 CK_OBJECT_CLASS class = CKO_PUBLIC_KEY;
7606 CK_KEY_TYPE keyType = CKK_GOSTR3410;
7607 CK_UTF8CHAR label[] = "A GOST R34.10-2001 public key object";
7608 CK_BYTE gostR3410params_oid[] =
7609     {0x06, 0x07, 0x2a, 0x85, 0x03, 0x02, 0x02, 0x23, 0x00};
7610 CK_BYTE gostR3411params_oid[] =
7611     {0x06, 0x07, 0x2a, 0x85, 0x03, 0x02, 0x02, 0x1e, 0x00};
7612 CK_BYTE gost28147params_oid[] =
7613     {0x06, 0x07, 0x2a, 0x85, 0x03, 0x02, 0x02, 0x1f, 0x00};
7614 CK_BYTE value[64] = {...};
7615 CK_BBOOL true = CK_TRUE;
7616 CK_ATTRIBUTE template[] = {
7617     {CKA_CLASS, &class, sizeof(class)},
7618     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
7619     {CKA_TOKEN, &true, sizeof(true)},
7620     {CKA_LABEL, label, sizeof(label)-1},
7621     {CKA_GOSTR3410_PARAMS, gostR3410params_oid,
7622         sizeof(gostR3410params_oid)},
7623     {CKA_GOSTR3411_PARAMS, gostR3411params_oid,
7624         sizeof(gostR3411params_oid)},
7625     {CKA_GOST28147_PARAMS, gost28147params_oid,
7626         sizeof(gost28147params_oid)},
7627     {CKA_VALUE, value, sizeof(value)}
7628 };

```

2.57.3 GOST R 34.10-2001 private key objects

GOST R 34.10-2001 private key objects (object class **CKO_PRIVATE_KEY**, key type **CKK_GOSTR3410**) hold GOST R 34.10-2001 private keys.

The following table defines the GOST R 34.10-2001 private key object attributes, in addition to the common attributes defined for this object class:

Table 213, GOST R 34.10-2001 Private Key Object Attributes

| Attribute | Data Type | Meaning |
|---|------------|---|
| CKA_VALUE ^{1,4,6,7} | Byte array | 32 bytes for private key in little endian order |
| CKA_GOSTR3410_PARAMS ^{1,4,6} | Byte array | DER-encoding of the object identifier indicating the data object type of GOST R 34.10-2001. When key is used the domain parameter object of key type CKK_GOSTR3410 must be specified with the same attribute CKA_OBJECT_ID |
| CKA_GOSTR3411_PARAMS ^{1,4,6,8} | Byte array | DER-encoding of the object identifier indicating the data object type of GOST R 34.11-94. When key is used the domain parameter object of key type CKK_GOSTR3411 must be specified |

| Attribute | Data Type | Meaning |
|---------------------------------------|------------|---|
| | | with the same attribute CKA_OBJECT_ID |
| CKA_GOST28147_PARAMS ^{4,6,8} | Byte array | DER-encoding of the object identifier indicating the data object type of GOST 28147-89. When key is used the domain parameter object of key type CKK_GOST28147 must be specified with the same attribute CKA_OBJECT_ID. The attribute value may be omitted |

7635 Refer to [PKCS11-Base] Table 11 for footnotes

7636 Note that when generating an GOST R 34.10-2001 private key, the GOST R 34.10-2001 domain
7637 parameters are *not* specified in the key's template. This is because GOST R 34.10-2001 private keys are
7638 only generated as part of an GOST R 34.10-2001 key *pair*, and the GOST R 34.10-2001 domain
7639 parameters for the pair are specified in the template for the GOST R 34.10-2001 public key.

7640 The following is a sample template for creating an GOST R 34.10-2001 private key object:

```

7641 CK_OBJECT_CLASS class = CKO_PRIVATE_KEY;
7642 CK_KEY_TYPE keyType = CKK_GOSTR3410;
7643 CK_UTF8CHAR label[] = "A GOST R34.10-2001 private key
7644     object";
7645 CK_BYTE subject[] = {...};
7646 CK_BYTE id[] = {123};
7647 CK_BYTE gostR3410params_oid[] =
7648     {0x06, 0x07, 0x2a, 0x85, 0x03, 0x02, 0x02, 0x23, 0x00};
7649 CK_BYTE gostR3411params_oid[] =
7650     {0x06, 0x07, 0x2a, 0x85, 0x03, 0x02, 0x02, 0x1e, 0x00};
7651 CK_BYTE gost28147params_oid[] =
7652     {0x06, 0x07, 0x2a, 0x85, 0x03, 0x02, 0x02, 0x1f, 0x00};
7653 CK_BYTE value[32] = {...};
7654 CK_BBOOL true = CK_TRUE;
7655 CK_ATTRIBUTE template[] = {
7656     {CKA_CLASS, &class, sizeof(class)},
7657     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
7658     {CKA_TOKEN, &true, sizeof(true)},
7659     {CKA_LABEL, label, sizeof(label)-1},
7660     {CKA_SUBJECT, subject, sizeof(subject)},
7661     {CKA_ID, id, sizeof(id)},
7662     {CKA_SENSITIVE, &true, sizeof(true)},
7663     {CKA_SIGN, &true, sizeof(true)},
7664     {CKA_GOSTR3410_PARAMS, gostR3410params_oid,
7665         sizeof(gostR3410params_oid)},
7666     {CKA_GOSTR3411_PARAMS, gostR3411params_oid,
7667         sizeof(gostR3411params_oid)},
7668     {CKA_GOST28147_PARAMS, gost28147params_oid,
7669         sizeof(gost28147params_oid)},
7670     {CKA_VALUE, value, sizeof(value)}

```


};

2.57.4 GOST R 34.10-2001 domain parameter objects

GOST R 34.10-2001 domain parameter objects (object class **CKO_DOMAIN_PARAMETERS**, key type **CKK_GOSTR3410**) hold GOST R 34.10-2001 domain parameters.

The following table defines the GOST R 34.10-2001 domain parameter object attributes, in addition to the common attributes defined for this object class:

Table 214, GOST R 34.10-2001 Domain Parameter Object Attributes

| Attribute | Data Type | Meaning |
|----------------------------|------------|--|
| CKA_VALUE ¹ | Byte array | DER-encoding of the domain parameters as it was introduced in [4] section 8.4 (type <i>GostR3410-2001-ParamSetParameters</i>) |
| CKA_OBJECT_ID ¹ | Byte array | DER-encoding of the object identifier indicating the domain parameters |

Refer to [PKCS11-Base] Table 11 for footnotes

For any particular token, there is no guarantee that a token supports domain parameters loading up and/or fetching out. Furthermore, applications, that make direct use of domain parameters objects, should take in account that **CKA_VALUE** attribute may be inaccessible.

The following is a sample template for creating a GOST R 34.10-2001 domain parameter object:

```
CK_OBJECT_CLASS class = CKO_DOMAIN_PARAMETERS;
CK_KEY_TYPE keyType = CKK_GOSTR3410;
CK_UTF8CHAR label[] = "A GOST R34.10-2001 cryptographic
    parameters object";
CK_BYTE oid[] =
    {0x06, 0x07, 0x2a, 0x85, 0x03, 0x02, 0x02, 0x23, 0x00};
CK_BYTE value[] = {
    0x30, 0x81, 0x90, 0x02, 0x01, 0x07, 0x02, 0x20, 0x5f, 0xbf, 0xf4, 0x98,
    0xaa, 0x93, 0x8c, 0xe7, 0x39, 0xb8, 0xe0, 0x22, 0xfb, 0xaf, 0xef, 0x40,
    0x56, 0x3f, 0x6e, 0x6a, 0x34, 0x72, 0xfc, 0x2a, 0x51, 0x4c, 0x0c, 0xe9,
    0xda, 0xe2, 0x3b, 0x7e, 0x02, 0x21, 0x00, 0x80, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x04, 0x31, 0x02, 0x21, 0x00, 0x80, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x01, 0x50, 0xfe,
    0x8a, 0x18, 0x92, 0x97, 0x61, 0x54, 0xc5, 0x9c, 0xfc, 0x19, 0x3a, 0xcc,
    0xf5, 0xb3, 0x02, 0x01, 0x02, 0x02, 0x20, 0x08, 0xe2, 0xa8, 0xa0, 0xe6,
    0x51, 0x47, 0xd4, 0xbd, 0x63, 0x16, 0x03, 0x0e, 0x16, 0xd1, 0x9c, 0x85,
    0xc9, 0x7f, 0x0a, 0x9c, 0xa2, 0x67, 0x12, 0x2b, 0x96, 0xab, 0xbc, 0xea,
    0x7e, 0x8f, 0xc8
};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
};
```

```

7711         {CKA_OBJECT_ID, oid, sizeof(oid)},
7712         {CKA_VALUE, value, sizeof(value)}
7713     };
7714

```

7715 2.57.5 GOST R 34.10-2001 mechanism parameters

7716 ♦ CK_GOSTR3410_KEY_WRAP_PARAMS

7717 **CK_GOSTR3410_KEY_WRAP_PARAMS** is a structure that provides the parameters to the
7718 **CKM_GOSTR3410_KEY_WRAP** mechanism. It is defined as follows:

```

7719     typedef struct CK_GOSTR3410_KEY_WRAP_PARAMS {
7720         CK_BYTE_PTR      pWrapOID;
7721         CK_ULONG          ulWrapOIDLen;
7722         CK_BYTE_PTR      pUKM;
7723         CK_ULONG          ulUKMLen;
7724         CK_OBJECT_HANDLE hKey;
7725     } CK_GOSTR3410_KEY_WRAP_PARAMS;

```

7726

7727 The fields of the structure have the following meanings:

| | |
|---------------------|---|
| <i>pWrapOID</i> | pointer to a data with DER-encoding of the object identifier indicating the data object type of GOST 28147-89. If pointer takes NULL_PTR value in C_WrapKey operation then parameters are specified in object identifier of attribute CKA_GOSTR3411_PARAMS must be used. For C_UnwrapKey operation the pointer is not used and must take NULL_PTR value anytime |
| <i>ulWrapOIDLen</i> | length of data with DER-encoding of the object identifier indicating the data object type of GOST 28147-89 |
| <i>pUKM</i> | pointer to a data with UKM. If pointer takes NULL_PTR value in C_WrapKey operation then random value of UKM will be used. If pointer takes non-NULL_PTR value in C_UnwrapKey operation then the pointer value will be compared with UKM value of wrapped key. If these two values do not match the wrapped key will be rejected |
| <i>ulUKMLen</i> | length of UKM data. If <i>pUKM</i> -pointer is different from NULL_PTR then equal to 8 |
| <i>hKey</i> | key handle. Key handle of a sender for C_WrapKey operation. Key handle of a receiver for C_UnwrapKey operation. When key handle takes CK_INVALID_HANDLE value then an ephemeral (one time) key pair of a sender will be used |

7728 **CK_GOSTR3410_KEY_WRAP_PARAMS_PTR** is a pointer to a
7729 **CK_GOSTR3410_KEY_WRAP_PARAMS**.

7730 ♦ CK_GOSTR3410_DERIVE_PARAMS

7731 **CK_GOSTR3410_DERIVE_PARAMS** is a structure that provides the parameters to the
7732 **CKM_GOSTR3410_DERIVE** mechanism. It is defined as follows:

```

7733     typedef struct CK_GOSTR3410_DERIVE_PARAMS {

```

```

7734     CK_EC_KDF_TYPE kdf;
7735     CK_BYTE_PTR    pPublicData;
7736     CK_ULONG       ulPublicDataLen;
7737     CK_BYTE_PTR    pUKM;
7738     CK_ULONG       ulUKMLen;
7739 } CK_GOSTR3410_DERIVE_PARAMS;

```

7740

7741 The fields of the structure have the following meanings:

| | |
|---------------------------------|--|
| <i>kdf</i> | additional key diversification algorithm identifier. Possible values are CKD_NULL and CKD_CPVERSIFY_KDF. In case of CKD_NULL, result of the key derivation function described in [RFC 4357], section 5.2 is used directly; In case of CKD_CPVERSIFY_KDF, the resulting key value is additionally processed with algorithm from [RFC 4357], section 6.5. |
| <i>pPublicData</i> ¹ | pointer to data with public key of a receiver |
| <i>ulPublicDataLen</i> | length of data with public key of a receiver (must be 64) |
| <i>pUKM</i> | pointer to a UKM data |
| <i>ulUKMLen</i> | length of UKM data in bytes (must be 8) |

7742

7743 ¹ Public key of a receiver is an octet string of 64 bytes long. The public key octets correspond to the concatenation of X and Y coordinates of a point. Any one of
7744 them is 32 bytes long and represented in little endian order.

7745 CK_GOSTR3410_DERIVE_PARAMS_PTR is a pointer to a CK_GOSTR3410_DERIVE_PARAMS.

7746 2.57.6 GOST R 34.10-2001 key pair generation

7747 The GOST R 34.10-2001 key pair generation mechanism, denoted
7748 **CKM_GOSTR3410_KEY_PAIR_GEN**, is a key pair generation mechanism for GOST R 34.10-2001.

7749 This mechanism does not have a parameter.

7750 The mechanism generates GOST R 34.10-2001 public/private key pairs with particular
7751 GOST R 34.10-2001 domain parameters, as specified in the **CKA_GOSTR3410_PARAMS**,
7752 **CKA_GOSTR3411_PARAMS**, and **CKA_GOST28147_PARAMS** attributes of the template for the public
7753 key. Note that **CKA_GOST28147_PARAMS** attribute may not be present in the template.

7754 The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new
7755 public key and the **CKA_CLASS**, **CKA_KEY_TYPE**, **CKA_VALUE**, and **CKA_GOSTR3410_PARAMS**,
7756 **CKA_GOSTR3411_PARAMS**, **CKA_GOST28147_PARAMS** attributes to the new private key.

7757 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
7758 are not used.

7759 2.57.7 GOST R 34.10-2001 without hashing

7760 The GOST R 34.10-2001 without hashing mechanism, denoted **CKM_GOSTR3410**, is a mechanism for
7761 single-part signatures and verification for GOST R 34.10-2001. (This mechanism corresponds only to the
7762 part of GOST R 34.10-2001 that processes the 32-bytes hash value; it does not compute the hash value.)

7763 This mechanism does not have a parameter.

For the purposes of these mechanisms, a GOST R 34.10-2001 signature is an octet string of 64 bytes long. The signature octets correspond to the concatenation of the GOST R 34.10-2001 values *s* and *r'*, both represented as a 32 bytes octet string in big endian order with the most significant byte first [RFC 4490] section 3.2, and [RFC 4491] section 2.2.2.

The input for the mechanism is an octet string of 32 bytes long with digest has computed by means of GOST R 34.11-94 hash algorithm in the context of signed or should be signed message.

Table 215, GOST R 34.10-2001 without hashing: Key and Data Length

| Function | Key type | Input length | Output length |
|-----------------------|---------------|--------------|---------------|
| C_Sign ¹ | CKK_GOSTR3410 | 32 bytes | 64 bytes |
| C_Verify ¹ | CKK_GOSTR3410 | 32 bytes | 64 bytes |

¹ Single-part operations only.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure are not used.

2.57.8 GOST R 34.10-2001 with GOST R 34.11-94

The GOST R 34.10-2001 with GOST R 34.11-94, denoted **CKM_GOSTR3410_WITH_GOSTR3411**, is a mechanism for signatures and verification for GOST R 34.10-2001. This mechanism computes the entire GOST R 34.10-2001 specification, including the hashing with GOST R 34.11-94 hash algorithm.

As a parameter this mechanism utilizes a DER-encoding of the object identifier indicating GOST R 34.11-94 data object type. A mechanism parameter may be missed then parameters are specified in object identifier of attribute **CKA_GOSTR3411_PARAMS** must be used.

For the purposes of these mechanisms, a GOST R 34.10-2001 signature is an octet string of 64 bytes long. The signature octets correspond to the concatenation of the GOST R 34.10-2001 values *s* and *r'*, both represented as a 32 bytes octet string in big endian order with the most significant byte first [RFC 4490] section 3.2, and [RFC 4491] section 2.2.2.

The input for the mechanism is signed or should be signed message of any length. Single- and multiple-part signature operations are available.

Table 216, GOST R 34.10-2001 with GOST R 34.11-94: Key and Data Length

| Function | Key type | Input length | Output length |
|----------|---------------|--------------|---------------|
| C_Sign | CKK_GOSTR3410 | Any | 64 bytes |
| C_Verify | CKK_GOSTR3410 | Any | 64 bytes |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure are not used.

2.57.9 GOST 28147-89 keys wrapping/unwrapping with GOST R 34.10-2001

GOST R 34.10-2001 keys as a KEK (key encryption keys) for encryption GOST 28147 keys, denoted by **CKM_GOSTR3410_KEY_WRAP**, is a mechanism for key wrapping; and key unwrapping, based on GOST R 34.10-2001. Its purpose is to encrypt and decrypt keys have been generated by key generation mechanism for GOST 28147-89. An encryption algorithm from [RFC 4490] (section 5.2) must be used. Encrypted key is a DER-encoded structure of ASN.1 *GostR3410-KeyTransport* type [RFC 4490] section 4.2.

It has a parameter, a **CK_GOSTR3410_KEY_WRAP_PARAMS** structure defined in section 2.57.5.

For unwrapping (**C_UnwrapKey**), the mechanism decrypts the wrapped key, and contributes the result as the **CKA_VALUE** attribute of the new key.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure are not used.

2.57.10 Common key derivation with assistance of GOST R 34.10-2001 keys

Common key derivation, denoted **CKM_GOSTR3410_DERIVE**, is a mechanism for key derivation with assistance of GOST R 34.10-2001 private and public keys. The key of the mechanism must be of object class **CKO_DOMAIN_PARAMETERS** and key type **CKK_GOSTR3410**. An algorithm for key derivation from [RFC 4357] (section 5.2) must be used.

The mechanism contributes the result as the **CKA_VALUE** attribute of the new private key. All other attributes must be specified in a template for creating private key object.

2.58 ChaCha20

ChaCha20 is a secret-key stream cipher described in [CHACHA].

Table 217, ChaCha20 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|----------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_CHACHA20_KEY_GEN | | | | | ✓ | | |
| CKM_CHACHA20 | ✓ | | | | | ✓ | |

2.58.1 Definitions

This section defines the key type “CKK_CHACHA20” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

Mechanisms:

CKM_CHACHA20_KEY_GEN

CKM_CHACHA20

2.58.2 ChaCha20 secret key objects

ChaCha20 secret key objects (object class CKO_SECRET_KEY, key type CKK_CHACHA20) hold ChaCha20 keys. The following table defines the ChaCha20 secret key object attributes, in addition to the common attributes defined for this object class:

Table 218, ChaCha20 Secret Key Object

| Attribute | Data type | Meaning |
|------------------------------|------------|---|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key length is fixed at 256 bits. Bit length restricted to a byte array. |
| CKA_VALUE_LEN ^{2,3} | CK_ULONG | Length in bytes of key value |

The following is a sample template for creating a ChaCha20 secret key object:

```
CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_CHACHA20;
CK_UTF8CHAR label[] = "A ChaCha20 secret key object";
CK_BYTE value[32] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
```

```

7832     {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
7833     {CKA_TOKEN, &true, sizeof(true)},
7834     {CKA_LABEL, label, sizeof(label)-1},
7835     {CKA_ENCRYPT, &true, sizeof(true)},
7836     {CKA_VALUE, value, sizeof(value)}
7837 };

```

7838 CKA_CHECK_VALUE: The value of this attribute is derived from the key object by taking the first
7839 three bytes of the SHA-1 hash of the ChaCha20 secret key object's CKA_VALUE attribute.

7840 2.58.3 ChaCha20 mechanism parameters

7841 ♦ CK_CHACHA20_PARAMS; CK_CHACHA20_PARAMS_PTR

7842 CK_CHACHA20_PARAMS provides the parameters to the CKM_CHACHA20 mechanism. It is defined
7843 as follows:

```

7844     typedef struct CK_CHACHA20_PARAMS {
7845         CK_BYTE_PTR    pBlockCounter;
7846         CK_ULONG       blockCounterBits;
7847         CK_BYTE_PTR    pNonce;
7848         CK_ULONG       ulNonceBits;
7849     } CK_CHACHA20_PARAMS;

```

7850 The fields of the structure have the following meanings:

| | | |
|------|---------------------------|--|
| 7851 | <i>pBlockCounter</i> | <i>pointer to block counter</i> |
| 7852 | <i>ulBlockCounterBits</i> | <i>length of block counter in bits (can be either 32 or 64)</i> |
| 7853 | <i>pNonce</i> | <i>nonce (This should be never re-used with the same key.)</i> |
| 7854 | <i>ulNonceBits</i> | <i>length of nonce in bits (is 64 for original, 96 for IETF and 192 for xchacha20 variant)</i> |
| 7855 | | |

7856 The block counter is used to address 512 bit blocks in the stream. In certain settings (e.g. disk encryption)
7857 it is necessary to address these blocks in random order, thus this counter is exposed here.

7858 CK_CHACHA20_PARAMS_PTR is a pointer to CK_CHACHA20_PARAMS.

7859 2.58.4 ChaCha20 key generation

7860 The ChaCha20 key generation mechanism, denoted CKM_CHACHA20_KEY_GEN, is a key generation
7861 mechanism for ChaCha20.

7862 It does not have a parameter.

7863 The mechanism generates ChaCha20 keys of 256 bits.

7864 The mechanism contributes the CKA_CLASS, CKA_KEY_TYPE, and CKA_VALUE attributes to the new
7865 key. Other attributes supported by the key type (specifically, the flags indicating which functions the key
7866 supports) may be specified in the template for the key, or else are assigned default initial values.

7867 For this mechanism, the ulMinKeySize and ulMaxKeySize fields of the CK_MECHANISM_INFO structure
7868 specify the supported range of key sizes in bytes. As a practical matter, the key size for ChaCha20 is
7869 fixed at 256 bits.

7870

2.58.5 ChaCha20 mechanism

ChaCha20, denoted **CKM_CHACHA20**, is a mechanism for single and multiple-part encryption and decryption based on the ChaCha20 stream cipher. It comes in 3 variants, which only differ in the size and handling of their nonces, affecting the safety of using random nonces and the maximum size that can be encrypted safely.

Chacha20 has a parameter, **CK_CHACHA20_PARAMS**, which indicates the nonce and initial block counter value.

Constraints on key types and the length of input and output data are summarized in the following table:

Table 219, ChaCha20: Key and Data Length

| Function | Key type | Input length | Output length | Comments |
|-----------|----------|---|----------------------|---------------|
| C_Encrypt | ChaCha20 | Any / only up to 256 GB in case of IETF variant | Same as input length | No final part |
| C_Decrypt | ChaCha20 | Any / only up to 256 GB in case of IETF variant | Same as input length | No final part |

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of ChaCha20 key sizes, in bits.

Table 220, ChaCha20: Nonce and block counter lengths

| Variant | Nonce | Block counter | Maximum message | Nonce generation |
|-----------|---------|---------------|---------------------|---|
| original | 64 bit | 64 bit | Virtually unlimited | 1 st msg: nonce ₀ =random n th msg: nonce _{n-1} ++ |
| IETF | 96 bit | 32 bit | Max ~256 GB | 1 st msg: nonce ₀ =random n th msg: nonce _{n-1} ++ |
| XChaCha20 | 192 bit | 64 bit | Virtually unlimited | Each nonce can be randomly generated. |

Nonces must not ever be reused with the same key. However due to the birthday paradox the first two variants cannot guarantee that randomly generated nonces are never repeating. Thus the recommended way to handle this is to generate the first nonce randomly, then increase this for follow-up messages. Only the last (XChaCha20) has large enough nonces so that it is virtually impossible to trigger with randomly generated nonces the birthday paradox.

2.59 Salsa20

Salsa20 is a secret-key stream cipher described in [SALSA].

Table 221, Salsa20 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_SALSA20_KEY_GEN | | | | | ✓ | | |
| CKM_SALSA20 | ✓ | | | | | ✓ | |

2.59.1 Definitions

This section defines the key type “CKK_SALSA20” and “CKK_SALSA20” for type CK_KEY_TYPE as used in the CKA_KEY_TYPE attribute of key objects.

Mechanisms:

CKM_SALSA20_KEY_GEN

CKM_SALSA20

2.59.2 Salsa20 secret key objects

Salsa20 secret key objects (object class CKO_SECRET_KEY, key type CKK_SALSA20) hold Salsa20 keys. The following table defines the Salsa20 secret key object attributes, in addition to the common attributes defined for this object class:

Table 222, ChaCha20 Secret Key Object

| Attribute | Data type | Meaning |
|------------------------------|------------|---|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key length is fixed at 256 bits. Bit length restricted to a byte array. |
| CKA_VALUE_LEN ^{2,3} | CK_ULONG | Length in bytes of key value |

The following is a sample template for creating a Salsa20 secret key object:

```
CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_SALSA20;
CK_UTF8CHAR label[] = "A Salsa20 secret key object";
CK_BYTE value[32] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_ENCRYPT, &true, sizeof(true)},
    {CKA_VALUE, value, sizeof(value)}
};
```

CKA_CHECK_VALUE: The value of this attribute is derived from the key object by taking the first three bytes of the SHA-1 hash of the ChaCha20 secret key object's CKA_VALUE attribute.

2.59.3 Salsa20 mechanism parameters

◆ CK_SALSA20_PARAMS; CK_SALSA20_PARAMS_PTR

CK_SALSA20_PARAMS provides the parameters to the **CKM_SALSA20** mechanism. It is defined as follows:

```
typedef struct CK_SALSA20_PARAMS {  
    CK_BYTE_PTR    pBlockCounter;  
    CK_BYTE_PTR    pNonce;  
    CK_ULONG       ulNonceBits;  
} CK_SALSA20_PARAMS;
```

The fields of the structure have the following meanings:

pBlockCounter *pointer to block counter (64 bits)*

pNonce *nonce*

ulNonceBits *size of the nonce in bits (64 for classic and 192 for XSalsa20)*

The block counter is used to address 512 bit blocks in the stream. In certain settings (e.g. disk encryption) it is necessary to address these blocks in random order, thus this counter is exposed here.

CK_SALSA20_PARAMS_PTR is a pointer to **CK_SALSA20_PARAMS**.

2.59.4 Salsa20 key generation

The Salsa20 key generation mechanism, denoted **CKM_SALSA20_KEY_GEN**, is a key generation mechanism for Salsa20.

It does not have a parameter.

The mechanism generates Salsa20 keys of 256 bits.

The mechanism contributes the **CKA_CLASS**, **CKA_KEY_TYPE**, and **CKA_VALUE** attributes to the new key. Other attributes supported by the key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure specify the supported range of key sizes in bytes. As a practical matter, the key size for Salsa20 is fixed at 256 bits.

2.59.5 Salsa20 mechanism

Salsa20, denoted **CKM_SALSA20**, is a mechanism for single and multiple-part encryption and decryption based on the Salsa20 stream cipher. Salsa20 comes in two variants which only differ in the size and handling of their nonces, affecting the safety of using random nonces.

Salsa20 has a parameter, **CK_SALSA20_PARAMS**, which indicates the nonce and initial block counter value.

Constraints on key types and the length of input and output data are summarized in the following table:

Table 223, Salsa20: Key and Data Length

| Function | Key type | Input length | Output length | Comments |
|-----------|----------|--------------|----------------------|---------------|
| C_Encrypt | Salsa20 | Any | Same as input length | No final part |
| C_Decrypt | Salsa20 | Any | Same as input length | No final part |

7955 For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK_MECHANISM_INFO** structure
 7956 specify the supported range of ChaCha20 key sizes, in bits.

7957 *Table 224, Salsa20: Nonce sizes*

| Variant | Nonce | Maximum message | Nonce generation |
|----------|---------|---------------------|---|
| original | 64 bit | Virtually unlimited | 1 st msg: nonce ₀ =random n th msg: nonce _{n-1} ++ |
| XSalsa20 | 192 bit | Virtually unlimited | Each nonce can be randomly generated. |

7958 Nonces must not ever be reused with the same key. However due to the birthday paradox the original
 7959 variant cannot guarantee that randomly generated nonces are never repeating. Thus the recommended
 7960 way to handle this is to generate the first nonce randomly, then increase this for follow-up messages.
 7961 Only the XSalsa20 has large enough nonces so that it is virtually impossible to trigger with randomly
 7962 generated nonces the birthday paradox.

7963 2.60 Poly1305

7964 Poly1305 is a message authentication code designed by D.J Bernsterin **[POLY1305]**. Poly1305 takes a
 7965 256 bit key and a message and produces a 128 bit tag that is used to verify the message.

7966 *Table 225, Poly1305 Mechanisms vs. Functions*

| Mechanism | Functions | | | | | | |
|----------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_POLY1305_KEY_GEN | | | | | ✓ | | |
| CKM_POLY1305 | | ✓ | | | | | |

7967 2.60.1 Definitions

7968 This section defines the key type “CKK_POLY1305” for type CK_KEY_TYPE as used in the
 7969 CKA_KEY_TYPE attribute of key objects.

7970 Mechanisms:

7971 CKM_POLY1305_KEY_GEN

7972 CKM_POLY1305

2.60.2 Poly1305 secret key objects

Poly1305 secret key objects (object class CKO_SECRET_KEY, key type CKK_POLY1305) hold Poly1305 keys. The following table defines the Poly1305 secret key object attributes, in addition to the common attributes defined for this object class:

Table 226, Poly1305 Secret Key Object

| Attribute | Data type | Meaning |
|------------------------------|------------|---|
| CKA_VALUE ^{1,4,6,7} | Byte array | Key length is fixed at 256 bits. Bit length restricted to a byte array. |
| CKA_VALUE_LEN ^{2,3} | CK_ULONG | Length in bytes of key value |

The following is a sample template for creating a Poly1305 secret key object:

```
CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_POLY1305;
CK_UTF8CHAR label[] = "A Poly1305 secret key object";
CK_BYTE value[32] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_SIGN, &true, sizeof(true)},
    {CKA_VALUE, value, sizeof(value)}
};
```

2.60.3 Poly1305 mechanism

Poly1305, denoted **CKM_POLY1305**, is a mechanism for producing an output tag based on a 256 bit key and arbitrary length input.

It has no parameters.

Signatures (MACs) produced by this mechanism will be fixed at 128 bits in size.

Table 227, Poly1305: Key and Data Length

| Function | Key type | Data length | Signature Length |
|----------|----------|-------------|------------------|
| C_Sign | Poly1305 | Any | 128 bits |
| C_Verify | Poly1305 | Any | 128 bits |

2.61 Chacha20/Poly1305 and Salsa20/Poly1305 Authenticated Encryption / Decryption

The stream ciphers Salsa20 and ChaCha20 are normally used in conjunction with the Poly1305 authenticator, in such a construction they also provide Authenticated Encryption with Associated Data (AEAD). This section defines the combined mechanisms and their usage in an AEAD setting.

Table 228, Poly1305 Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|-----------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_CHACHA20_POLY1305 | ✓ | | | | | | |
| CKM_SALSA20_POLY1305 | ✓ | | | | | | |

2.61.1 Definitions

Mechanisms:

CKM_CHACHA20_POLY1305

CKM_SALSA20_POLY1305

2.61.2 Usage

Generic ChaCha20, Salsa20, Poly1305 modes are described in [CHACHA], [SALSA] and [POLY1305]. To set up for ChaCha20/Poly1305 or Salsa20/Poly1305 use the following process. ChaCha20/Poly1305 and Salsa20/Poly1305 both use CK_SALSA20_CHACHA20_POLY1305_PARAMS for Encrypt, Decrypt and CK_SALSA20_CHACHA20_POLY1305_MSG_PARAMS for MessageEncrypt, and MessageDecrypt.

Encrypt:

- Set the Nonce length *ulNonceLen* in the parameter block. (this affects which variant of Chacha20 will be used: 64 bits → original, 96 bits → IETF, 192 bits → XChaCha20)
- Set the Nonce data *pNonce* in the parameter block.
- Set the AAD data *pAAD* and size *ulAADLen* in the parameter block. *pAAD* may be NULL if *ulAADLen* is 0.
- Call C_EncryptInit() for **CKM_CHACHA20_POLY1305** or **CKM_SALSA20_POLY1305** mechanism with parameters and key *K*.
- Call C_Encrypt(), or C_EncryptUpdate()*¹⁰ C_EncryptFinal(), for the plaintext obtaining ciphertext and authentication tag output.

Decrypt:

- Set the Nonce length *ulNonceLen* in the parameter block. (this affects which variant of Chacha20 will be used: 64 bits → original, 96 bits → IETF, 192 bits → XChaCha20)
- Set the Nonce data *pNonce* in the parameter block.
- Set the AAD data *pAAD* and size *ulAADLen* in the parameter block. *pAAD* may be NULL if *ulAADLen* is 0.
- Call C_DecryptInit() for **CKM_CHACHA20_POLY1305** or **CKM_SALSA20_POLY1305** mechanism with parameters and key *K*.
- Call C_Decrypt(), or C_DecryptUpdate()*¹ C_DecryptFinal(), for the ciphertext, including the appended tag, obtaining plaintext output. Note: since **CKM_CHACHA20_POLY1305** and **CKM_SALSA20_POLY1305** are AEAD ciphers, no data should be returned until C_Decrypt() or C_DecryptFinal().

¹⁰ "*" indicates 0 or more calls may be made as required

8036 MessageEncrypt::

- 8037 • Set the Nonce length *ulNonceLen* in the parameter block. (this affects which variant of ChaCha20
- 8038 will be used: 64 bits → original, 96 bits → IETF, 192 bits → XChaCha20)
- 8039 • Set the Nonce data *pNonce* in the parameter block.
- 8040 • Set *pTag* to hold the tag data returned from `C_EncryptMessage()` or the final
- 8041 `C_EncryptMessageNext()`.
- 8042 • Call `C_MessageEncryptInit()` for **CKM_CHACHA20_POLY1305** or **CKM_SALSA20_POLY1305**
- 8043 mechanism with key *K*.
- 8044 • Call `C_EncryptMessage()`, or `C_EncryptMessageBegin` followed by `C_EncryptMessageNext()`^{*11}.
- 8045 The mechanism parameter is passed to all three of these functions.
- 8046 • Call `C_MessageEncryptFinal()` to close the message decryption.

8047 MessageDecrypt:

- 8048 • Set the Nonce length *ulNonceLen* in the parameter block. (this affects which variant of ChaCha20
- 8049 will be used: 64 bits → original, 96 bits → IETF, 192 bits → XChaCha20)
- 8050 • Set the Nonce data *pNonce* in the parameter block.
- 8051 • Set the tag data *pTag* in the parameter block before `C_DecryptMessage` or the final
- 8052 `C_DecryptMessageNext()`
- 8053 • Call `C_MessageDecryptInit()` for **CKM_CHACHA20_POLY1305** or **CKM_SALSA20_POLY1305**
- 8054 mechanism with key *K*.
- 8055 • Call `C_DecryptMessage()`, or `C_DecryptMessageBegin` followed by `C_DecryptMessageNext()`^{*12}.
- 8056 The mechanism parameter is passed to all three of these functions.
- 8057 • Call `C_MessageDecryptFinal()` to close the message decryption

8058

8059 *ulNonceLen* is the length of the nonce in bits.

8060 In Encrypt and Decrypt the tag is appended to the cipher text. In MessageEncrypt the tag is returned in
8061 the *pTag* field of **CK_SALSA20_CHACHA20_POLY1305_MSG_PARAMS**. In MessageDecrypt the tag is
8062 provided by the *pTag* field of **CK_SALSA20_CHACHA20_POLY1305_MSG_PARAMS**. The application
8063 must provide 16 bytes of space for the tag.

8064 The key type for *K* must be compatible with **CKM_CHACHA20** or **CKM_SALSA20** respectively and the
8065 `C_EncryptInit/C_DecryptInit` calls shall behave, with respect to *K*, as if they were called directly with
8066 **CKM_CHACHA20** or **CKM_SALSA20**, *K* and NULL parameters.

8067 Unlike the atomic Salsa20/ChaCha20 mechanism the AEAD mechanism based on them does not expose
8068 the block counter, as the AEAD construction is based on a message metaphor in which random access is
8069 not needed.

8070 2.61.3 ChaCha20/Poly1305 and Salsa20/Poly1305 Mechanism parameters

8071 ♦ **CK_SALSA20_CHACHA20_POLY1305_PARAMS;**
8072 **CK_SALSA20_CHACHA20_POLY1305_PARAMS_PTR**

8073 **CK_SALSA20_CHACHA20_POLY1305_PARAMS** is a structure that provides the parameters to the
8074 **CKM_CHACHA20_POLY1305** and **CKM_SALSA20_POLY1305** mechanisms. It is defined as follows:

11. "*" indicates 0 or more calls may be made as required

12. "*" indicates 0 or more calls may be made as required

```

8075     typedef struct CK_SALSA20_CHACHA20_POLY1305_PARAMS {
8076         CK_BYTE_PTR    pNonce;
8077         CK_ULONG        ulNonceLen;
8078         CK_BYTE_PTR    pAAD;
8079         CK_ULONG        ulAADLen;
8080     } CK_SALSA20_CHACHA20_POLY1305_PARAMS;

```

8081 The fields of the structure have the following meanings:

| | | |
|------|-------------------|--|
| 8082 | <i>pNonce</i> | <i>nonce (This should be never re-used with the same key.)</i> |
| 8083 | <i>ulNonceLen</i> | <i>length of nonce in bits (is 64 for original, 96 for IETF (only for</i> |
| 8084 | | <i>chacha20) and 192 for xchacha20/xsalsa20 variant)</i> |
| 8085 | <i>pAAD</i> | <i>pointer to additional authentication data. This data is authenticated</i> |
| 8086 | | <i>but not encrypted.</i> |
| 8087 | <i>ulAADLen</i> | <i>length of pAAD in bytes.</i> |

8088 **CK_SALSA20_CHACHA20_POLY1305_PARAMS_PTR** is a pointer to a
8089 **CK_SALSA20_CHACHA20_POLY1305_PARAMS**.

8090 ♦ **CK_SALSA20_CHACHA20_POLY1305_MSG_PARAMS;** 8091 **CK_SALSA20_CHACHA20_POLY1305_MSG_PARAMS_PTR**

8092 CK_CHACHA20POLY1305_PARAMS is a structure that provides the parameters to the CKM_
8093 CHACHA20_POLY1305 mechanism. It is defined as follows:

```

8094     typedef struct CK_SALSA20_CHACHA20_POLY1305_MSG_PARAMS {
8095         CK_BYTE_PTR    pNonce;
8096         CK_ULONG        ulNonceLen;
8097         CK_BYTE_PTR    pTag;
8098     } CK_SALSA20_CHACHA20_POLY1305_MSG_PARAMS;

```

8099 The fields of the structure have the following meanings:

| | | |
|------|-------------------|---|
| 8100 | <i>pNonce</i> | <i>pointer to nonce</i> |
| 8101 | <i>ulNonceLen</i> | <i>length of nonce in bits. The length of the influences which variant of</i> |
| 8102 | | <i>the ChaCha20 will be used (64 original, 96 IETF (only for</i> |
| 8103 | | <i>ChaCha20), 192 XChaCha20/XSalsa20)</i> |
| 8104 | <i>pTag</i> | <i>location of the authentication tag which is returned on</i> |
| 8105 | | <i>MessageEncrypt, and provided on MessageDecrypt.</i> |

8106 **CK_SALSA20_CHACHA20_POLY1305_MSG_PARAMS_PTR** is a pointer to a
8107 **CK_SALSA20_CHACHA20_POLY1305_MSG_PARAMS**.

8108 2.62 HKDF Mechanisms

8109 Details for HKDF key derivation mechanisms can be found in [RFC 5869].

8110

8111 *Table 229, HKDF Mechanisms vs. Functions*

| Mechanism | Functions | | | | | | |
|------------------|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_HKDF_DERIVE | | | | | | | ✓ |
| CKM_HKDF_DATA | | | | | | | ✓ |
| CKM_HKDF_KEY_GEN | | | | | ✓ | | |

2.62.1 Definitions

Mechanisms:

CKM_HKDF_DERIVE
CKM_HKDF_DATA
CKM_HKDF_KEY_GEN

Key Types:

CKK_HKDF

2.62.2 HKDF mechanism parameters

◆ CK_HKDF_PARAMS; CK_HKDF_PARAMS_PTR

CK_HKDF_PARAMS is a structure that provides the parameters to the **CKM_HKDF_DERIVE** and **CKM_HKDF_DATA** mechanisms. It is defined as follows:

```
typedef struct CK_HKDF_PARAMS {
    CK_BBOOL bExtract;
    CK_BBOOL bExpand;
    CK_MECHANISM_TYPE prfHashMechanism;
    CK_ULONG ulSaltType;
    CK_BYTE_PTR pSalt;
    CK_ULONG ulSaltLen;
    CK_OBJECT_HANDLE hSaltKey;
    CK_BYTE_PTR pInfo;
    CK_ULONG ulInfoLen;
} CK_HKDF_PARAMS;
```

The fields of the structure have the following meanings:

bExtract execute the extract portion of HKDF.

bExpand execute the expand portion of HKDF.

prfHashMechanism base hash used for the HMAC in the underlying HKDF operation.

ulSaltType specifies how the salt for the extract portion of the KDF is supplied.

CKF_HKDF_SALT_NULL no salt is supplied.

CKF_HKDF_SALT_DATA salt is supplied as a data in *pSalt* with length *ulSaltLen*.

8144 *CKF_HKDF_SALT_KEY* salt is supplied as a key in *hSaltKey*.

8145 *pSalt* pointer to the salt.

8146 *ulSaltLen* length of the salt pointed to in *pSalt*.

8147 *hSaltKey* object handle to the salt key.

8148 *pInfo* info string for the expand stage.

8149 *ullInfoLen* length of the info string for the expand stage.

8150

8151 **CK_HKDF_PARAMS_PTR** is a pointer to a **CK_HKDF_PARAMS**.

8152 2.62.3 HKDF derive

8153 HKDF derivation implements the HKDF as specified in [RFC 5869]. The two booleans *bExtract* and
8154 *bExpand* control whether the extract section of the HKDF or the expand section of the HKDF is in use.

8155 It has a parameter, a **CK_HKDF_PARAMS** structure, which allows for the passing of the salt and or the
8156 expansion info. The structure contains the bools *bExtract* and *bExpand* which control whether the extract
8157 or expand portions of the HKDF is to be used. This structure is defined in Section 2.62.2.

8158 The input key must be of type **CKK_HKDF** or **CKK_GENERIC_SECRET** and the length must be the size
8159 of the underlying hash function specified in *prfHashMechanism*. The exception is a data object which has
8160 the same size as the underlying hash function, and which may be supplied as an input key. In this case
8161 *bExtract* should be true and non-null salt should be supplied.

8162 Either *bExtract* or *bExpand* must be set to true. If they are both set to true, input key is first extracted then
8163 expanded. The salt is used in the extraction stage. If *bExtract* is set to true and no salt is given, a 'zero'
8164 salt (salt whose length is the same as the underlying hash and values all set to zero) is used as specified
8165 by the RFC. If *bExpand* is set to true, **CKA_VALUE_LEN** should be set to the desired key length. If it is
8166 false **CKA_VALUE_LEN** may be set to the length of the hash, but that is not necessary as the mechanism
8167 will supply this value. The salt should be ignored if *bExtract* is false. The *pInfo* should be ignored if
8168 *bExpand* is set to false.

8169 The mechanism also contributes the **CKA_CLASS**, and **CKA_VALUE** attributes to the new key. Other
8170 attributes may be specified in the template, or else are assigned default values.

8171 The template sent along with this mechanism during a **C_DeriveKey** call may indicate that the object
8172 class is **CKO_SECRET_KEY**. However, since these facts are all implicit in the mechanism, there is no
8173 need to specify any of them.

8174 This mechanism has the following rules about key sensitivity and extractability:

- 8175 • The **CKA_SENSITIVE** and **CKA_EXTRACTABLE** attributes in the template for the new key can both
8176 be specified to be either **CK_TRUE** or **CK_FALSE**. If omitted, these attributes each take on some
8177 default value.
- 8178 • If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_FALSE**, then the derived key
8179 will as well. If the base key has its **CKA_ALWAYS_SENSITIVE** attribute set to **CK_TRUE**, then the
8180 derived key has its **CKA_ALWAYS_SENSITIVE** attribute set to the same value as its
8181 **CKA_SENSITIVE** attribute.
- 8182 • Similarly, if the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to **CK_FALSE**, then the
8183 derived key will, too. If the base key has its **CKA_NEVER_EXTRACTABLE** attribute set to
8184 **CK_TRUE**, then the derived key has its **CKA_NEVER_EXTRACTABLE** attribute set to the *opposite*
8185 value from its **CKA_EXTRACTABLE** attribute.

2.62.4 HKDF Data

HKDF Data derive mechanism, denoted **CKM_HKDF_DATA**, is identical to HKDF Derive except the output is a **CKO_DATA** object whose value is the result to the derive operation. Some tokens may restrict what data may be successfully derived based on the *plInfo* portion of the CK_HKDF_PARAMS. All tokens must minimally support *bExtract* set to true and *plInfo* values which contain the value "tls1.3 iv" as opaque label as per [TLS13] struct HkdfLabel. Future additional required combinations may be specified in the profile document and applications could then query the appropriate profile before depending on the mechanism.

2.62.5 HKDF Key gen

HKDF key gen, denoted CKM_HKDF_KEY_GEN generates a new random HKDF key. CKA_VALUE_LEN must be set in the template.

2.63 NULL Mechanism

CKM_NULL is a mechanism used to implement the trivial pass-through function.

Table 230, CKM_NULL Mechanisms vs. Functions

| Mechanism | Functions | | | | | | |
|---|-------------------------|---------------------|----------------------------|--------|-----------------------------|---------------------|--------|
| | Encrypt & Decrypt | Sign & Verify | SR & VR ¹ | Digest | Gen. Key/ Key Pair | Wrap & Unwrap | Derive |
| CKM_NULL | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ |
| ¹ SR = SignRecover, VR = VerifyRecover | | | | | | | |

2.63.1 Definitions

Mechanisms:

CKM_NULL

2.63.2 CKM_NULL mechanism parameters

CKM_NULL does not have a parameter.

When used for encrypting / decrypting data, the input data is copied unchanged to the output data.

When used for signing, the input data is copied to the signature. When used for signature verification, it compares the input data and the signature, and returns CKR_OK (indicating that both are identical) or CKR_SIGNATURE_INVALID.

When used for digesting data, the input data is copied to the message digest.

When used for wrapping a private or secret key object, the wrapped key will be identical to the key to be wrapped. When used for unwrapping, a new object with the same value as the wrapped key will be created.

When used for deriving a key, the derived key has the same value as the base key.

8217 3 PKCS #11 Implementation Conformance

8218 An implementation is a conforming implementation if it meets the conditions specified in one or more
8219 server profiles specified in **[PKCS11-Prof]**.

8220 If a PKCS #11 implementation claims support for a particular profile, then the implementation SHALL
8221 conform to all normative statements within the clauses specified for that profile and for any subclauses to
8222 each of those clauses .

Appendix A. Acknowledgments

The following individuals have participated in the creation of this specification and are gratefully acknowledged:

Participants:

Gil Abel, Athena Smartcard Solutions, Inc.
Warren Armstrong, QuintessenceLabs
Jeff Bartell, Semper Foris Solutions LLC
Peter Bartok, Venafi, Inc.
Anthony Berglas, Cryptsoft
Joseph Brand, Semper Fortis Solutions LLC
Kelley Burgin, National Security Agency
Robert Burns, Thales e-Security
Wan-Teh Chang, Google Inc.
Hai-May Chao, Oracle
Janice Cheng, Vormetric, Inc.
Sangrae Cho, Electronics and Telecommunications Research Institute (ETRI)
Doron Cohen, SafeNet, Inc.
Fadi Cotran, Futurex
Tony Cox, Cryptsoft
Christopher Duane, EMC
Chris Dunn, SafeNet, Inc.
Valerie Fenwick, Oracle
Terry Fletcher, SafeNet, Inc.
Susan Gleeson, Oracle
Sven Gossel, Charismathics
John Green, QuintessenceLabs
Robert Griffin, EMC
Paul Grojean, Individual
Peter Gutmann, Individual
Dennis E. Hamilton, Individual
Thomas Hardjono, M.I.T.
Tim Hudson, Cryptsoft
Gershon Janssen, Individual
Seunghun Jin, Electronics and Telecommunications Research Institute (ETRI)
Wang Jingman, Feitan Technologies
Andrey Jivsov, Symantec Corp.
Mark Joseph, P6R
Stefan Kaesar, Infineon Technologies
Greg Kazmierczak, Wave Systems Corp.
Mark Knight, Thales e-Security
Darren Krahn, Google Inc.

8264 Alex Krasnov, Infineon Technologies AG
8265 Dina Kurktchi-Nimeh, Oracle
8266 Mark Lambiase, SecureAuth Corporation
8267 Lawrence Lee, GoTrust Technology Inc.
8268 John Leiseboer, QuintessenceLabs
8269 Sean Leon, Infineon Technologies
8270 Geoffrey Li, Infineon Technologies
8271 Howie Liu, Infineon Technologies
8272 Hal Lockhart, Oracle
8273 Robert Lockhart, Thales e-Security
8274 Dale Moberg, Axway Software
8275 Darren Moffat, Oracle
8276 Valery Osheter, SafeNet, Inc.
8277 Sean Parkinson, EMC
8278 Rob Philpott, EMC
8279 Mark Powers, Oracle
8280 Ajai Puri, SafeNet, Inc.
8281 Robert Relyea, Red Hat
8282 Saikat Saha, Oracle
8283 Subhash Sankuratripati, NetApp
8284 Anthony Scarpino, Oracle
8285 Johann Schoetz, Infineon Technologies AG
8286 Rayees Shamsuddin, Wave Systems Corp.
8287 Radhika Siravara, Oracle
8288 Brian Smith, Mozilla Corporation
8289 David Smith, Venafi, Inc.
8290 Ryan Smith, Futurex
8291 Jerry Smith, US Department of Defense (DoD)
8292 Oscar So, Oracle
8293 Graham Steel, Cryptosense
8294 Michael Stevens, QuintessenceLabs
8295 Michael StJohns, Individual
8296 Jim Susoy, P6R
8297 Sander Temme, Thales e-Security
8298 Kiran Thota, VMware, Inc.
8299 Walter-John Turnes, Gemini Security Solutions, Inc.
8300 Stef Walter, Red Hat
8301 James Wang, Vormetric
8302 Jeff Webb, Dell
8303 Peng Yu, Feitian Technologies
8304 Magda Zdunkiewicz, Cryptsoft
8305 Chris Zimman, Individual

Appendix B. Manifest Constants

8306

8307

8308

The definitions for manifest constants specified in this document can be found in the following normative computer language definition files:

8309

- [include/pkcs11-v3.00/pkcs11.h](#)

8310

- [include/pkcs11-v3.00/pkcs11t.h](#)

8311

- [include/pkcs11-v3.00/pkcs11f.h](#)

8312

8313

Appendix C. Revision History

| Revision | Date | Editor | Changes Made |
|------------------------|------------|-------------------------------|---|
| csprd 02 wd01 | Oct 2 2019 | Dieter Bong | Created csprd02 based on csprd01 |
| csprd 02 wd02 .. 04 | | Dieter Bong, Daniel Minder | Intermediate versions |
| csprd 02 wd05 | Dec 3 2019 | Dieter Bong, Daniel Minder | Changes as per “PKCS11 mechanisms review- v9.docx” |

8314