

Crypto Application

version 1.2

The Erlang/OTP SSL application includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit (<http://www.openssl.org/>). Copyright (c) 1998-2002 The OpenSSL Project. All rights reserved.

This product includes cryptographic software written by Eric Young (ey@cryptsoft.com). This product includes software written by Tim Hudson (tjh@cryptsoft.com). Copyright (C) 1995-1998 Eric Young (ey@cryptsoft.com). All rights reserved.

For further OpenSSL and SSLeay license information see the chapter **Licenses**.

<http://www.erlang.org>

Contents

1	Crypto User's Guide	1
1.1	Licenses	1
1.1.1	OpenSSL License	1
1.1.2	SSLey License	2
2	Crypto Release Notes	5
2.1	Crypto Release Notes	5
2.1.1	Crypto 1.2	5
2.1.2	Crypto 1.1.3	6
2.1.3	Crypto 1.1.2	6
2.1.4	Crypto 1.1.1	6
2.1.5	Crypto 1.1	6
2.1.6	Crypto 1.0	6
3	Crypto Reference Manual	7
3.1	crypto	9
3.2	crypto	11

Chapter 1

Crypto User's Guide

The *Crypto* application provides functions for computation of message digests, and functions for encryption and decryption.

This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit (<http://www.openssl.org/>).

This product includes cryptographic software written by Eric Young (ey@cryptsoft.com).

This product includes software written by Tim Hudson (tjh@cryptsoft.com).

For full OpenSSL and SSLeay license texts, see Licenses [page 1].

1.1 Licenses

This chapter contains in extenso versions of the OpenSSL and SSLeay licenses.

1.1.1 OpenSSL License

```
/* =====  
 * Copyright (c) 1998-2002 The OpenSSL Project. All rights reserved.  
 *  
 * Redistribution and use in source and binary forms, with or without  
 * modification, are permitted provided that the following conditions  
 * are met:  
 *  
 * 1. Redistributions of source code must retain the above copyright  
 * notice, this list of conditions and the following disclaimer.  
 *  
 * 2. Redistributions in binary form must reproduce the above copyright  
 * notice, this list of conditions and the following disclaimer in  
 * the documentation and/or other materials provided with the  
 * distribution.  
 *  
 * 3. All advertising materials mentioning features or use of this  
 * software must display the following acknowledgment:  
 * "This product includes software developed by the OpenSSL Project  
 * for use in the OpenSSL Toolkit. (http://www.openssl.org/)"  
 *
```

```
* 4. The names "OpenSSL Toolkit" and "OpenSSL Project" must not be used to
* endorse or promote products derived from this software without
* prior written permission. For written permission, please contact
* openssl-core@openssl.org.
*
* 5. Products derived from this software may not be called "OpenSSL"
* nor may "OpenSSL" appear in their names without prior written
* permission of the OpenSSL Project.
*
* 6. Redistributions of any form whatsoever must retain the following
* acknowledgment:
* "This product includes software developed by the OpenSSL Project
* for use in the OpenSSL Toolkit (http://www.openssl.org/)"
*
* THIS SOFTWARE IS PROVIDED BY THE OpenSSL PROJECT 'AS IS' AND ANY
* EXPRESSED OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR
* PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE OpenSSL PROJECT OR
* ITS CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL,
* SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT
* NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES;
* LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION)
* HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT,
* STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE)
* ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED
* OF THE POSSIBILITY OF SUCH DAMAGE.
* =====
*
* This product includes cryptographic software written by Eric Young
* (eay@cryptsoft.com). This product includes software written by Tim
* Hudson (tjh@cryptsoft.com).
*
*/
```

1.1.2 SSLeay License

```
/* Copyright (C) 1995-1998 Eric Young (eay@cryptsoft.com)
* All rights reserved.
*
* This package is an SSL implementation written
* by Eric Young (eay@cryptsoft.com).
* The implementation was written so as to conform with Netscapes SSL.
*
* This library is free for commercial and non-commercial use as long as
* the following conditions are aheared to. The following conditions
* apply to all code found in this distribution, be it the RC4, RSA,
* lhash, DES, etc., code; not just the SSL code. The SSL documentation
* included with this distribution is covered by the same copyright terms
* except that the holder is Tim Hudson (tjh@cryptsoft.com).
*
* Copyright remains Eric Young's, and as such any Copyright notices in
* the code are not to be removed.
```

```
* If this package is used in a product, Eric Young should be given attribution
* as the author of the parts of the library used.
* This can be in the form of a textual message at program startup or
* in documentation (online or textual) provided with the package.
*
* Redistribution and use in source and binary forms, with or without
* modification, are permitted provided that the following conditions
* are met:
* 1. Redistributions of source code must retain the copyright
*   notice, this list of conditions and the following disclaimer.
* 2. Redistributions in binary form must reproduce the above copyright
*   notice, this list of conditions and the following disclaimer in the
*   documentation and/or other materials provided with the distribution.
* 3. All advertising materials mentioning features or use of this software
*   must display the following acknowledgement:
*   "This product includes cryptographic software written by
*     Eric Young (eay@cryptsoft.com)"
*   The word 'cryptographic' can be left out if the routines from the library
*   being used are not cryptographic related :-).
* 4. If you include any Windows specific code (or a derivative thereof) from
*   the apps directory (application code) you must include an acknowledgement:
*   "This product includes software written by Tim Hudson (tjh@cryptsoft.com)"
*
* THIS SOFTWARE IS PROVIDED BY ERIC YOUNG "AS IS" AND
* ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
* ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE
* FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL
* DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS
* OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION)
* HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT
* LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY
* OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF
* SUCH DAMAGE.
*
* The licence and distribution terms for any publically available version or
* derivative of this code cannot be changed. i.e. this code cannot simply be
* copied and put under another distribution licence
* [including the GNU Public Licence.]
*/
```


Chapter 2

Crypto Release Notes

The Crypto Application provides functions for computation of message digests, and encryption and decryption functions.

This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit (<http://www.openssl.org/>).

This product includes cryptographic software written by Eric Young (ey@cryptsoft.com).

This product includes software written by Tim Hudson (tjh@cryptsoft.com).

For full OpenSSL and SSLeay license texts, see Licenses [page 1].

2.1 Crypto Release Notes

This document describes the changes made to the Crypto application.

2.1.1 Crypto 1.2

Improvements and New Features

- Previous versions of Crypto were delivered with statically linked binaries based on SSLeay. That is not longer the case. The current version of Crypto requires dynamically linked OpenSSL libraries that the user has to install. The library needed is `libcrypto.so` (Unix) or `libeay32.[lib|dll]` (Win32). For further details see the `crypto(6)` application manual page.
- This version of Crypto uses the new DES interface of OpenSSL 0.9.7, which is not backward compatible with earlier versions of OpenSSL.
- The functions `des_ede3_cbc_encrypt/5` and `des_ede3_cbc_decrypt/5` have been renamed to `des3_cbc_encrypt/5` and `des3_cbc_decrypt/5`, respectively. The old functions have been retained (they are deprecated and not listed in the `crypto(3)` manual page).

Reported Fixed Bugs and Malfunctions

- The start of `crypto` failed on Windows, due to erroneous addition of a DES3 algorithm.
Own Id: OTP-4684
Aux Id: seq7864

2.1.2 Crypto 1.1.3

Reported Fixed Bugs and Malfunctions

- To obtain backward compatibility with the old SSLeay package, and with earlier versions of OpenSSL, the macro `OPENSSL_DES_LIBDES_COMPATIBILITY` has been added to `crypto_drv.c`. This is of importance only for the open source version of Crypto.

2.1.3 Crypto 1.1.2

Reported Fixed Bugs and Malfunctions

- In the manual page `crypto(3)` the function names `md5_finish` and `sha_finish` have been changed to `md5_final` and `sha_final` to correctly document the implementation. Own Id: OTP-3409

2.1.4 Crypto 1.1.1

Code replacement in runtime is supported. Upgrade can be done from from version 1.1 and downgrade to version 1.1.

Improvements and New Features

- The driver part of the Crypto application has been updated to use the `erl_driver` header file. Version 1.1.1 requires emulator version 4.9.1 or later.

2.1.5 Crypto 1.1

Reported Fixed Bugs and Malfunctions

- On Windows the `crypto_drv` was incorrectly linked to static run-time libraries instead of dynamic ones. Own Id: OTP-3240

2.1.6 Crypto 1.0

New application.

Crypto Reference Manual

Short Summaries

- Application **crypto** [page 9] – The Crypto Application
- Erlang Module **crypto** [page 11] – Crypto Functions

crypto

No functions are exported.

crypto

The following functions are exported:

- `start()` -> `ok`
[page 11] Start the crypto server.
- `stop()` -> `ok`
[page 11] Stop the crypto server.
- `info()` -> `[atom()]`
[page 11] Provide a list of available crypto functions.
- `md5(Data)` -> `Digest`
[page 11] Compute an MD5 message digest from `Data`
- `md5_init()` -> `Context`
[page 11] Creates an MD5 context
- `md5_update(Context, Data)` -> `NewContext`
[page 12] Update an MD5 Context with `Data`, and return a `NewContext`
- `md5_final(Context)` -> `Digest`
[page 12] Finish the update of an MD5 Context and return the computed MD5 message digest
- `sha(Data)` -> `Digest`
[page 12] Compute an SHA message digest from `Data`
- `sha_init()` -> `Context`
[page 12] Create an SHA context
- `sha_update(Context, Data)` -> `NewContext`
[page 12] Update an SHA context
- `sha_final(Context)` -> `Digest`
[page 12] Finish the update of an SHA context

- `md5_mac(Key, Data) -> Mac`
[page 12] Compute an MD5 MAC message authentication code
- `md5_mac_96(Key, Data) -> Mac`
[page 13] Compute an MD5 MAC message authentication code
- `sha_mac(Key, Data) -> Mac`
[page 13] Compute an MD5 MAC message authentication code
- `sha_mac_96(Key, Data) -> Mac`
[page 13] Compute an MD5 MAC message authentication code
- `des_cbc_encrypt(Key, IVec, Text) -> Cipher`
[page 13] Encrypt Text according to DES in CBC mode
- `des_cbc_decrypt(Key, IVec, Cipher) -> Text`
[page 13] Decrypt Cipher according to DES in CBC mode
- `des3_cbc_encrypt(Key1, Key2, Key3, IVec, Text) -> Cipher`
[page 13] Encrypt Text according to DES3 in CBC mode
- `des3_cbc_decrypt(Key1, Key2, Key3, IVec, Cipher) -> Text`
[page 14] Decrypt Cipher according to DES in CBC mode

crypto

Application

The purpose of the Crypto application is to provide message digest and DES encryption for SNMPv3. It provides computation of message digests MD5 and SHA, and CBC-DES encryption and decryption.

Configuration

The following environment configuration parameters are defined for the Crypto application. Refer to application(3) for more information about configuration parameters.

`debug = true | false <optional>` Causes debug information to be written to standard error or standard output. Default is false.

OpenSSL libraries

The current implementation of the Erlang Crypto application is based on the *OpenSSL* package version 0.9.7 or higher. There are source and binary releases on the web.

Source releases of OpenSSL can be downloaded from the OpenSSL¹ project home page, or mirror sites listed there.

The same URL also contains links to some compiled binaries and libraries of OpenSSL (see the *Related/Binaries* menu) of which the Shining Light Productions Win32 and OpenSSL² pages are of interest for the Win32 user.

For some Unix flavours there are binary packages available on the net.

If you cannot find a suitable binary OpenSSL package, you have to fetch an OpenSSL source release and compile it.

You then have to compile and install the library `libcrypto.so` (Unix), or the library `libeay32.dll` (Win32).

For Unix The `crypto_drv` dynamic driver is delivered linked to OpenSSL libraries in `/usr/local/lib`, but the default dynamic linking will also accept libraries in `/lib` and `/usr/lib`.

If that is not applicable to the particular Unix operating system used, the example `Makefile` in the `Crypto priv/obj` directory, should be used as a basis for relinking the final version of the port program.

For Win32 it is only required that the library can be found from the `PATH` environment variable, or that they reside in the appropriate `SYSTEM32` directory; hence no particular relinking is need. Hence no example `Makefile` for Win32 is provided.

¹URL: <http://www.openssl.org>

²URL: <http://www.shininglightpro.com/search.php?searchname=Win32+OpenSSL>

SEE ALSO

application(3)

crypto

Erlang Module

This module provides a set of cryptographic functions.

References:

- md5: The MD5 Message Digest Algorithm (RFC 1321)
- sha: Secure Hash Standard (FIPS 180-1)
- hmac: Keyed-Hashing for Message Authentication (RFC 2104)
- des: Data Encryption Standard (FIPS 46-2)
- ecb, cbc, cfb, ofb: DES modes of operation (FIPS 81).

Types

```
byte() = 0 ... 255
ioelem() = byte() | binary() | iolist()
iolist() = [ioelem()]
```

Exports

`start()` -> `ok`

Starts the crypto server.

`stop()` -> `ok`

Stops the crypto server.

`info()` -> [`atom()`]

Provides the available crypto functions in terms of a list of atoms.

`md5(Data)` -> `Digest`

Types:

- `Data` = `iolist()` | `binary()`
- `Digest` = `binary()`

Computes an MD5 message digest from `Data`, where the length of the digest is 128 bits (16 bytes).

`md5_init()` -> `Context`

Types:

- Context = binary()

Creates an MD5 context, to be used in subsequent calls to md5_update/2.

md5_update(Context, Data) -> NewContext

Types:

- Data = iolist() | binary()
- Context = NewContext = binary()

Updates an MD5 Context with Data, and returns a NewContext.

md5_final(Context) -> Digest

Types:

- Context = Digest = binary()

Finishes the update of an MD5 Context and returns the computed MD5 message digest.

sha(Data) -> Digest

Types:

- Data = iolist() | binary()
- Digest = binary()

Computes an SHA message digest from Data, where the length of the digest is 160 bits (20 bytes).

sha_init() -> Context

Types:

- Context = binary()

Creates an SHA context, to be used in subsequent calls to sha_update/2.

sha_update(Context, Data) -> NewContext

Types:

- Data = iolist() | binary()
- Context = NewContext = binary()

Updates an SHA Context with Data, and returns a NewContext.

sha_final(Context) -> Digest

Types:

- Context = Digest = binary()

Finishes the update of an SHA Context and returns the computed SHA message digest.

md5_mac(Key, Data) -> Mac

Types:

- Key = Data = iolist() | binary()
- Mac = binary()

Computes an MD5 MAC message authentication code from `Key` and `Data`, where the length of the `Mac` is 128 bits (16 bytes).

`md5_mac_96(Key, Data) -> Mac`

Types:

- `Key = Data = iolist() | binary()`
- `Mac = binary()`

Computes an MD5 MAC message authentication code from `Key` and `Data`, where the length of the `Mac` is 96 bits (12 bytes).

`sha_mac(Key, Data) -> Mac`

Types:

- `Key = Data = iolist() | binary()`
- `Mac = binary()`

Computes an SHA MAC message authentication code from `Key` and `Data`, where the length of the `Mac` is 160 bits (20 bytes).

`sha_mac_96(Key, Data) -> Mac`

Types:

- `Key = Data = iolist() | binary()`
- `Mac = binary()`

Computes an SHA MAC message authentication code from `Key` and `Data`, where the length of the `Mac` is 96 bits (12 bytes).

`des_cbc_encrypt(Key, IVec, Text) -> Cipher`

Types:

- `Key = Text = iolist() | binary()`
- `IVec = Cipher = binary()`

Encrypts `Text` according to DES in CBC mode. `Text` must be a multiple of 64 bits (8 bytes). `Key` is the DES key, and `IVec` is an arbitrary initializing vector. The lengths of `Key` and `IVec` must be 64 bits (8 bytes).

`des_cbc_decrypt(Key, IVec, Cipher) -> Text`

Types:

- `Key = Cipher = iolist() | binary()`
- `IVec = Text = binary()`

Decrypts `Cipher` according to DES in CBC mode. `Key` is the DES key, and `IVec` is an arbitrary initializing vector. `Key` and `IVec` must have the same values as those used when encrypting. `Cipher` must be a multiple of 64 bits (8 bytes). The lengths of `Key` and `IVec` must be 64 bits (8 bytes).

`des3_cbc_encrypt(Key1, Key2, Key3, IVec, Text) -> Cipher`

Types:

- `Key1 = Key2 = Key3 Text = iolist() | binary()`

- `IVec = Cipher = binary()`

Encrypts `Text` according to DES3 in CBC mode. `Text` must be a multiple of 64 bits (8 bytes). `Key1`, `Key2`, `Key3`, are the DES keys, and `IVec` is an arbitrary initializing vector. The lengths of each of `Key1`, `Key2`, `Key3` and `IVec` must be 64 bits (8 bytes).

```
des3_cbc_decrypt(Key1, Key2, Key3, IVec, Cipher) -> Text
```

Types:

- `Key1 = Key2 = Key3 = Cipher = iolist() | binary()`
- `IVec = Text = binary()`

Decrypts `Cipher` according to DES3 in CBC mode. `Key1`, `Key2`, `Key3` are the DES key, and `IVec` is an arbitrary initializing vector. `Key1`, `Key2`, `Key3` and `IVec` must have the same values as those used when encrypting. `Cipher` must be a multiple of 64 bits (8 bytes). The lengths of `Key1`, `Key2`, `Key3`, and `IVec` must be 64 bits (8 bytes).

DES in CBC mode

The Data Encryption Standard (DES) defines an algorithm for encrypting and decrypting an 8 byte quantity using an 8 byte key (actually only 56 bits of the key is used).

When it comes to encrypting and decrypting blocks that are multiples of 8 bytes various modes are defined (FIPS 81). One of those modes is the Cipher Block Chaining (CBC) mode, where the encryption of an 8 byte segment depend not only of the contents of the segment itself, but also on the result of encrypting the previous segment: the encryption of the previous segment becomes the initializing vector of the encryption of the current segment.

Thus the encryption of every segment depends on the encryption key (which is secret) and the encryption of the previous segment, except the first segment which has to be provided with a first initializing vector. That vector could be chosen at random, or be counter of some kind. It does not have to be secret.

The following example is drawn from the FIPS 81 standard, where both the plain text and the resulting cipher text is settled. We use the Erlang bitsyntax to define binary literals. The following Erlang code fragment returns 'true'.

```
Key = <<16#01,16#23,16#45,16#67,16#89,16#ab,16#cd,16#ef>>,
IVec = <<16#12,16#34,16#56,16#78,16#90,16#ab,16#cd,16#ef>>,
P = "Now is the time for all ",
C = crypto:des_cbc_encrypt(K, I, P),
C == <<16#e5,16#c7,16#cd,16#de,16#87,16#2b,16#f2,16#7c,
    16#43,16#e9,16#34,16#00,16#8c,16#38,16#9c,16#0f,
    16#68,16#37,16#88,16#49,16#9a,16#7c,16#05,16#f6>>,
<<"Now is the time for all ">> ==
    crypto:des_cbc_decrypt(Key,IVec,C) .
```

The following is true for the DES CBC mode. For all decompositions $P_1 \mathbin{||} P_2 = P$ of a plain text message P (where the length of all quantities are multiples of 8 bytes), the encryption C of P is equal to $C_1 \mathbin{||} C_2$, where C_1 is obtained by encrypting P_1 with Key and the initializing vector $IVec$, and where C_2 is obtained by encrypting P_2 with Key and the initializing vector $l(C_1)$, where $l(B)$ denotes the last 8 bytes of the binary B .

Similarly, for all decompositions $C_1 \mathbin{||} C_2 = C$ of a cipher text message C (where the length of all quantities are multiples of 8 bytes), the decryption P of C is equal to $P_1 \mathbin{||} P_2$, where P_1 is obtained by decrypting C_1 with Key and the initializing vector $IVec$, and where P_2 is obtained by decrypting C_2 with Key and the initializing vector $l(C_1)$, where $l(\cdot)$ is as above.

For DES3 (which uses three 64 bit keys) the situation is the same.

Index of Modules and Functions

Modules are typed in *this way*.
Functions are typed in *this way*.

crypto

- des3_cbc_decrypt/5, 14
- des3_cbc_encrypt/5, 13
- des_cbc_decrypt/3, 13
- des_cbc_encrypt/3, 13
- info/0, 11
- md5/1, 11
- md5_final/1, 12
- md5_init/0, 11
- md5_mac/2, 12
- md5_mac_96/2, 13
- md5_update/2, 12
- sha/1, 12
- sha_final/1, 12
- sha_init/0, 12
- sha_mac/2, 13
- sha_mac_96/2, 13
- sha_update/2, 12
- start/0, 11
- stop/0, 11

des3_cbc_decrypt/5
crypto, 14

des3_cbc_encrypt/5
crypto, 13

des_cbc_decrypt/3
crypto, 13

des_cbc_encrypt/3
crypto, 13

info/0
crypto, 11

md5/1
crypto, 11

md5_final/1
crypto, 12

md5_init/0

crypto, 11

md5_mac/2
crypto, 12

md5_mac_96/2
crypto, 13

md5_update/2
crypto, 12

sha/1
crypto, 12

sha_final/1
crypto, 12

sha_init/0
crypto, 12

sha_mac/2
crypto, 13

sha_mac_96/2
crypto, 13

sha_update/2
crypto, 12

start/0
crypto, 11

stop/0
crypto, 11

