

Crypto Application

version 1.5

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 Reference Manual	5
2.1	crypto	7
2.2	crypto	9

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].

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

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```


Crypto Reference Manual

Short Summaries

- Application **crypto** [page 7] – The Crypto Application
- Erlang Module **crypto** [page 9] – Crypto Functions

crypto

No functions are exported.

crypto

The following functions are exported:

- `start()` -> `ok`
[page 9] Start the crypto server.
- `stop()` -> `ok`
[page 9] Stop the crypto server.
- `info()` -> `[atom()]`
[page 9] Provide a list of available crypto functions.
- `md5(Data)` -> `Digest`
[page 9] Compute an MD5message digest from Data
- `md5_init()` -> `Context`
[page 10] Creates an MD5 context
- `md5_update(Context, Data)` -> `NewContext`
[page 10] Update an MD5 Contextwith Data, and return a NewContext
- `md5_final(Context)` -> `Digest`
[page 10] Finish the update of an MD5 Contextand return the computed MD5message digest
- `sha(Data)` -> `Digest`
[page 10] Compute an SHAmessagedigest from Data
- `sha_init()` -> `Context`
[page 10] Create an SHA context
- `sha_update(Context, Data)` -> `NewContext`
[page 10] Update an SHA context
- `sha_final(Context)` -> `Digest`
[page 10] Finish the update of an SHA context

- `md5_mac(Key, Data) -> Mac`
[page 11] Compute an MD5 MACmessage authentication code
- `md5_mac_96(Key, Data) -> Mac`
[page 11] Compute an MD5 MACmessage authentication code
- `sha_mac(Key, Data) -> Mac`
[page 11] Compute an MD5 MACmessage authentication code
- `sha_mac_96(Key, Data) -> Mac`
[page 11] Compute an MD5 MACmessage authentication code
- `des_cbc_encrypt(Key, IVec, Text) -> Cipher`
[page 11] Encrypt Textaccording to DES in CBC mode
- `des_cbc_decrypt(Key, IVec, Cipher) -> Text`
[page 11] Decrypt Cipheraccording to DES in CBC mode
- `des3_cbc_encrypt(Key1, Key2, Key3, IVec, Text) -> Cipher`
[page 12] Encrypt Textaccording to DES3 in CBC mode
- `des3_cbc_decrypt(Key1, Key2, Key3, IVec, Cipher) -> Text`
[page 12] Decrypt Cipheraccording to DES in CBC mode
- `aes_cfb_128_encrypt(Key, IVec, Text) -> Cipher`
[page 12] Encrypt Textaccording to AES in Cipher Feedback mode or Cipher Block Chaining mode
- `aes_cbc_128_encrypt(Key, IVec, Text) -> Cipher`
[page 12] Encrypt Textaccording to AES in Cipher Feedback mode or Cipher Block Chaining mode
- `aes_cfb_128_decrypt(Key, IVec, Cipher) -> Text`
[page 12] Decrypt Cipheraccording to AES in Cipher Feedback mode or Cipher Block Chaining mode
- `aes_cbc_128_decrypt(Key, IVec, Cipher) -> Text`
[page 12] Decrypt Cipheraccording to AES in Cipher Feedback mode or Cipher Block Chaining mode
- `erlint(Mpint) ->`
[page 12] Convert between binary multi-precision integer and erlang big integer
- `mpint(N) -> Mpint`
[page 12] Convert between binary multi-precision integer and erlang big integer
- `rand_bytes(N) -> binary()`
[page 13] Generate a binary of random bytes
- `rand_uniform(Lo, Hi) -> N`
[page 13] Generate a random number
- `mod_exp(N, P, M) -> Result`
[page 13] Perform $N^P \text{ mod } M$
- `rsa_verify(Digest, Signature, Key) -> Verified`
[page 13] Verify the digest and signature using rsa with given public key.
- `dss_verify(Digest, Signature, Key) -> Verified`
[page 13] Verify the digest and signature using rsa with given public key.
- `rc4_encrypt(Key, Data) -> Result`
[page 14] Encrypt data using RC4
- `exor(Data1, Data2) -> Result`
[page 14] XOR data

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 180-2)
- hmac: Keyed-Hashing for Message Authentication (RFC 2104)
- des: Data Encryption Standard (FIPS 46-3)
- aes: Advanced Encryption Standard (AES) (FIPS 197)
- ecb, cbc, cfb, ofb: Recommendation for Block Cipher Modes of Operation (NIST SP 800-38A).
- rsa: Recommendation for Block Cipher Modes of Operation (NIST 800-38A)
- dss: Digital Signature Standard (FIPS 186-2)

The above publications can be found at NIST publications³, at IETF⁴.

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:

³URL: <http://csrc.nist.gov/publications>

⁴URL: <http://www.ietf.org>

- 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 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).

```
aes_cfb_128_encrypt(Key, IVec, Text) -> Cipher
```

```
aes_cbc_128_encrypt(Key, IVec, Text) -> Cipher
```

Types:

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

Encrypts Text according to AES in Cipher Feedback mode (CFB) or Cipher Block Chaining mode (CBC). Text must be a multiple of 128 bits (16 bytes). Key is the AES key, and IVec is an arbitrary initializing vector. The lengths of Key and IVec must be 128 bits (16 bytes).

```
aes_cfb_128_decrypt(Key, IVec, Cipher) -> Text
```

```
aes_cbc_128_decrypt(Key, IVec, Cipher) -> Text
```

Types:

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

Decrypts Cipher according to Cipher Feedback Mode (CFB) or Cipher Block Chaining mode (CBC). Key is the AES 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 128 bits (16 bytes). The lengths of Key and IVec must be 128 bits (16 bytes).

```
erlint(Mpint) ->
```

```
mpint(N) -> Mpint
```

Types:

- Mpint = binary()
- N = integer()

Convert a binary multi-precision integer Mpint to and from an erlang big integer. A multi-precision integer is a binary with the following form: <<ByteLen:32/integer, Bytes:ByteLen/binary>> where both ByteLen and Bytes are big-endian. Mpints are used in some of the functions in crypto and are not translated in the API for performance reasons.

rand_bytes(N) -> binary()

Types:

- N = integer()

Generates N bytes randomly uniform 0..255, and returns the result in a binary. Uses the crypto library pseudo-random number generator.

rand_uniform(Lo, Hi) -> N

Types:

- Lo, Hi, N = Mpint | integer()
- Mpint = binary()

Generate a random number N, $Lo \leq N < Hi$. Uses the crypto library pseudo-random number generator. The arguments (and result) can be either erlang integers or binary multi-precision integers.

mod_exp(N, P, M) -> Result

Types:

- N, P, M, Result = Mpint
- Mpint = binary()

This function performs the exponentiation $N^P \bmod M$, using the crypto library.

rsa_verify(Digest, Signature, Key) -> Verified

Types:

- Verified = boolean()
- Digest, Signature = MPint
- Key = [E, N]
- E, N = MPint
- MPint = binary()

Verifies the digest and signature using the public key Key, using the crypto library function for RSA signature verification.

dss_verify(Digest, Signature, Key) -> Verified

Types:

- Verified = boolean()
- Digest, Signature = MPint
- Key = [P, Q, G, Y]

- P, Q, G, Y = MPint
- MPint = binary()

Verifies the digest and signature using the public key `Key`, using the `crypto` library function for DSS signature verification.

`rc4_encrypt(Key, Data) -> Result`

Types:

- Key, Data = iolist() | binary()
- Result = binary()

Encrypts the data with RC4 symmetric stream encryption. Since it is symmetric, the same function is used for decryption.

`exor(Data1, Data2) -> Result`

Types:

- Data1, Data2 = iolist() | binary()
- Result = binary()

Performs bit-wise XOR (exclusive or) on the data supplied.

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 (NIST SP 800-38A). 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 old FIPS 81 standard (replaced by NIST SP 800-38A), 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*.

aes_cbc_128_decrypt/3 <i>crypto</i> , 12	sha_update/2, 10
aes_cbc_128_encrypt/3 <i>crypto</i> , 12	start/0, 9
aes_cfb_128_decrypt/3 <i>crypto</i> , 12	stop/0, 9
aes_cfb_128_encrypt/3 <i>crypto</i> , 12	des3_cbc_decrypt/5 <i>crypto</i> , 12
<i>crypto</i>	des3_cbc_encrypt/5 <i>crypto</i> , 12
aes_cbc_128_decrypt/3, 12	des_cbc_decrypt/3 <i>crypto</i> , 11
aes_cbc_128_encrypt/3, 12	des_cbc_encrypt/3 <i>crypto</i> , 11
aes_cfb_128_decrypt/3, 12	dss_verify/3 <i>crypto</i> , 13
aes_cfb_128_encrypt/3, 12	erlint/1 <i>crypto</i> , 12
des3_cbc_decrypt/5, 12	exor/2 <i>crypto</i> , 14
des3_cbc_encrypt/5, 12	info/0 <i>crypto</i> , 9
des_cbc_decrypt/3, 11	md5/1 <i>crypto</i> , 9
des_cbc_encrypt/3, 11	md5_final/1 <i>crypto</i> , 10
dss_verify/3, 13	md5_init/0 <i>crypto</i> , 10
erlint/1, 12	md5_mac/2 <i>crypto</i> , 11
exor/2, 14	md5_mac_96/2 <i>crypto</i> , 11
info/0, 9	md5_update/2 <i>crypto</i> , 10
md5/1, 9	
md5_final/1, 10	
md5_init/0, 10	
md5_mac/2, 11	
md5_mac_96/2, 11	
md5_update/2, 10	
mod_exp/3, 13	
mpint/1, 12	
rand_bytes/1, 13	
rand_uniform/2, 13	
rc4_encrypt/2, 14	
rsa_verify/3, 13	
sha/1, 10	
sha_final/1, 10	
sha_init/0, 10	
sha_mac/2, 11	
sha_mac_96/2, 11	

mod_exp/3
 crypto , 13

mpint/1
 crypto , 12

rand_bytes/1
 crypto , 13

rand_uniform/2
 crypto , 13

rc4_encrypt/2
 crypto , 14

rsa_verify/3
 crypto , 13

sha/1
 crypto , 10

sha_final/1
 crypto , 10

sha_init/0
 crypto , 10

sha_mac/2
 crypto , 11

sha_mac_96/2
 crypto , 11

sha_update/2
 crypto , 10

start/0
 crypto , 9

stop/0
 crypto , 9