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crypto

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crypto 3.2  
November 2, 2018

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**November 2, 2018**

# 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](mailto:ey@cryptsoft.com)).

This product includes software written by Tim Hudson ([tjh@cryptsoft.com](mailto:tjh@cryptsoft.com)).

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# 2 Reference Manual

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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/>).

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## crypto

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Application

The purpose of the Crypto application is to provide an Erlang API to cryptographic functions, see *crypto(3)*. Note that the API is on a fairly low level and there are some corresponding API functions available in *public\_key(3)*, on a higher abstraction level, that uses the crypto application in its implementation.

### DEPENDENCIES

The current crypto implementation uses nifs to interface OpenSSLs crypto library and requires *OpenSSL* package version 0.9.8 or higher.

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

### SEE ALSO

application(3)

## crypto

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Erlang module

This module provides a set of cryptographic functions.

- Hash functions - **Secure Hash Standard**, **The MD5 Message Digest Algorithm (RFC 1321)** and **The MD4 Message Digest Algorithm (RFC 1320)**
- Hmac functions - **Keyed-Hashing for Message Authentication (RFC 2104)**
- Block ciphers - DES and AES in Block Cipher Modes - **ECB, CBC, CFB, OFB and CTR**
- **RSA encryption RFC 1321**
- Digital signatures **Digital Signature Standard (DSS)** and **Elliptic Curve Digital Signature Algorithm (ECDSA)**
- **Secure Remote Password Protocol (SRP - RFC 2945)**

## DATA TYPES

```
key_value() = integer() | binary()
```

Always `binary()` when used as return value

```
rsa_public() = [key_value()] = [E, N]
```

Where E is the public exponent and N is public modulus.

```
rsa_private() = [key_value()] = [E, N, D] | [E, N, D, P1, P2, E1, E2, C]
```

Where E is the public exponent, N is public modulus and D is the private exponent. The longer key format contains redundant information that will make the calculation faster. P1,P2 are first and second prime factors. E1,E2 are first and second exponents. C is the CRT coefficient. Terminology is taken from **RFC 3447**.

```
dss_public() = [key_value()] = [P, Q, G, Y]
```

Where P, Q and G are the dss parameters and Y is the public key.

```
dss_private() = [key_value()] = [P, Q, G, X]
```

Where P, Q and G are the dss parameters and X is the private key.

```
srp_public() = key_value()
```

Where is A or B from **SRP design**

```
srp_private() = key_value()
```

Where is a or b from **SRP design**



Where Verifier is  $v$ , Generator is  $g$  and Prime is  $N$ , DerivedKey is  $X$ , and Scrambler is  $u$  (optional will be generated if not provided) from **SRP design** Version = '3' | '6' | '6a'

```
dh_public() = key_value()
```

```
dh_private() = key_value()
```

```
dh_params() = [key_value()] = [P, G]
```

```
ecdh_public() = key_value()
```

```
ecdh_private() = key_value()
```

```
ecdh_params() = ec_named_curve() |  
  {ec_field(), Prime :: key_value(), Point :: key_value(), Order :: integer(), CoFactor :: none | integer() }
```

```
ec_field() = {prime_field, Prime :: integer()} |  
  {characteristic_two_field, M :: integer(), Basis :: ec_basis() }
```

```
ec_basis() = {tpbasis, K :: non_neg_integer()} |  
  {ppbasis, K1 :: non_neg_integer(), K2 :: non_neg_integer(), K3 :: non_neg_integer()} |  
  onbasis
```

```
ec_named_curve() ->  
  sect571r1| sect571k1| sect409r1| sect409k1| secp521r1| secp384r1| secp224r1| secp224k1|  
  secp192k1| secp160r2| secp128r2| secp128r1| sect233r1| sect233k1| sect193r2| sect193r1|  
  sect131r2| sect131r1| sect283r1| sect283k1| sect163r2| secp256k1| secp160k1| secp160r1|  
  secp112r2| secp112r1| sect113r2| sect113r1| sect239k1| sect163r1| sect163k1| secp256r1|  
  secp192r1
```

```
stream_cipher() = rc4 | aes_ctr
```

```
block_cipher() = aes_cbc128 | aes_cfb128 | blowfish_cbc |  
  blowfish_cfb64 | des_cbc | des_cfb | des3_cbc | des3_cbf  
  | des_ede3 | rc2_cbc
```

```
stream_key() = aes_key() | rc4_key()
```

```
block_key() = aes_key() | blowfish_key() | des_key() | des3_key()
```

```
aes_key() = ioddata()
```

Key length is 128, 192 or 256 bits

```
rc4_key() = iodata()
```

Variable key length from 8 bits up to 2048 bits (usually between 40 and 256)

```
blowfish_key() = iodata()
```

Variable key length from 32 bits up to 448 bits

```
des_key() = iodata()
```

Key length is 64 bits (in CBC mode only 8 bits are used)

```
des3_key() = [binary(), binary(), binary()]
```

Each key part is 64 bits (in CBC mode only 8 bits are used)

```
digest_type() = md5 | sha | sha224 | sha256 | sha384 | sha512
```

```
hash_algorithms() = md5 | ripemd160 | sha | sha224 | sha256 | sha384 | sha512
```

md4 is also supported for hash\_init/1 and hash/2. Note that both md4 and md5 are recommended only for compatibility with existing applications.

```
cipher_algorithms() = des_cbc | des_cfb | des3_cbc | des3_cbf | des_ede3 |  
    blowfish_cbc | blowfish_cfb64 | aes_cbc128 | aes_cfb128 | aes_cbc256 | rc2_cbc | aes_ctr | rc4
```

```
public_key_algorithms() = rsa | dss | ecdsa | dh | ecdh
```

## Exports

`block_encrypt(Type, Key, Ivec, PlainText) -> CipherText`

Types:

```
Type = block_cipher()  
Key = block_key()  
PlainText = iodata()  
Ivec = CipherText = binary()
```

Encrypt PlainText according to Type block cipher. Ivec is an arbitrary initializing vector.

`block_decrypt(Type, Key, Ivec, CipherText) -> PlainText`

Types:

```
Type = block_cipher()  
Key = block_key()  
PlainText = iodata()  
Ivec = CipherText = binary()
```

Decrypt `CipherText` according to `Type` block cipher. `IVec` is an arbitrary initializing vector.

`bytes_to_integer(Bin) -> Integer`

Types:

```
Bin = binary() - as returned by crypto functions
Integer = integer()
```

Convert binary representation, of an integer, to an Erlang integer.

`compute_key(Type, OthersPublicKey, MyKey, Params) -> SharedSecret`

Types:

```
Type = dh | ecdh | srp
OthersPublicKey = dh_public() | ecdh_public() | srp_public()
MyKey = dh_private() | ecdh_private() | {srp_public(),srp_private()}
Params = dh_params() | ecdh_params() | SrpUserParams | SrpHostParams
SrpUserParams = {user, [DerivedKey::binary(), Prime::binary(),
Generator::binary(), Version::atom() | [Scrambler:binary()]]}
SrpHostParams = {host, [Verifier::binary(), Prime::binary(),
Version::atom() | [Scrambler::binary()]]}
SharedSecret = binary()
```

Computes the shared secret from the private key and the other party's public key. See also *public\_key:compute\_key/2*

`exor(Data1, Data2) -> Result`

Types:

```
Data1, Data2 = iodata()
Result = binary()
```

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

`generate_key(Type, Params) -> {PublicKey, PrivKeyOut}`

`generate_key(Type, Params, PrivKeyIn) -> {PublicKey, PrivKeyOut}`

Types:

```
Type = dh | ecdh | srp
Params = dh_params() | ecdh_params() | SrpUserParams | SrpHostParams
SrpUserParams = {user, [Generator::binary(), Prime::binary(),
Version::atom()]}
SrpHostParams = {host, [Verifier::binary(), Generator::binary(),
Prime::binary(), Version::atom()]}
PublicKey = dh_public() | ecdh_public() | srp_public()
PrivKeyIn = undefined | dh_private() | srp_private()
PrivKeyOut = dh_private() | ecdh_private() | srp_private()
```

Generates public keys of type `Type`. See also *public\_key:generate\_key/1*

`hash(Type, Data) -> Digest`

Types:

```
Type = md4 | hash_algorithms()
```

```
Data = iodata()  
Digest = binary()
```

Computes a message digest of type `Type` from `Data`.

May throw exception `notsup` in case the chosen `Type` is not supported by the underlying OpenSSL implementation.

`hash_init(Type) -> Context`

Types:

```
Type = md4 | hash_algorithms()
```

Initializes the context for streaming hash operations. `Type` determines which digest to use. The returned context should be used as argument to *hash\_update*.

May throw exception `notsup` in case the chosen `Type` is not supported by the underlying OpenSSL implementation.

`hash_update(Context, Data) -> NewContext`

Types:

```
Data = iodata()
```

Updates the digest represented by `Context` using the given `Data`. `Context` must have been generated using *hash\_init* or a previous call to this function. `Data` can be any length. `NewContext` must be passed into the next call to *hash\_update* or *hash\_final*.

`hash_final(Context) -> Digest`

Types:

```
Digest = binary()
```

Finalizes the hash operation referenced by `Context` returned from a previous call to *hash\_update*. The size of `Digest` is determined by the type of hash function used to generate it.

`hmac(Type, Key, Data) -> Mac`

`hmac(Type, Key, Data, MacLength) -> Mac`

Types:

```
Type = hash_algorithms() - except ripemd160  
Key = iodata()  
Data = iodata()  
MacLength = integer()  
Mac = binary()
```

Computes a HMAC of type `Type` from `Data` using `Key` as the authentication key.

`MacLength` will limit the size of the resultant `Mac`.

`hmac_init(Type, Key) -> Context`

Types:

```
Type = hash_algorithms() - except ripemd160  
Key = iodata()  
Context = binary()
```

Initializes the context for streaming HMAC operations. `Type` determines which hash function to use in the HMAC operation. `Key` is the authentication key. The key can be any length.

```
hmac_update(Context, Data) -> NewContext
```

Types:

```
Context = NewContext = binary()
Data = iodata()
```

Updates the HMAC represented by `Context` using the given `Data`. `Context` must have been generated using an HMAC init function (such as `hmac_init`). `Data` can be any length. `NewContext` must be passed into the next call to `hmac_update` or to one of the functions `hmac_final` and `hmac_final_n`

```
hmac_final(Context) -> Mac
```

Types:

```
Context = Mac = binary()
```

Finalizes the HMAC operation referenced by `Context`. The size of the resultant MAC is determined by the type of hash function used to generate it.

```
hmac_final_n(Context, HashLen) -> Mac
```

Types:

```
Context = Mac = binary()
HashLen = non_neg_integer()
```

Finalizes the HMAC operation referenced by `Context`. `HashLen` must be greater than zero. `Mac` will be a binary with at most `HashLen` bytes. Note that if `HashLen` is greater than the actual number of bytes returned from the underlying hash, the returned hash will have fewer than `HashLen` bytes.

```
info_lib() -> [{Name, VerNum, VerStr}]
```

Types:

```
Name = binary()
VerNum = integer()
VerStr = binary()
```

Provides the name and version of the libraries used by `crypto`.

`Name` is the name of the library. `VerNum` is the numeric version according to the library's own versioning scheme. `VerStr` contains a text variant of the version.

```
> info_lib().
[{<<"OpenSSL">>,9469983,<<"OpenSSL 0.9.8a 11 Oct 2005">>}]
```

### Note:

From OTP R16 the *numeric version* represents the version of the OpenSSL *header files* (`openssl/opensslv.h`) used when `crypto` was compiled. The text variant represents the OpenSSL library used at runtime. In earlier OTP versions both numeric and text was taken from the library.

```
mod_pow(N, P, M) -> Result
```

Types:

```
N, P, M = binary() | integer()  
Result = binary() | error
```

Computes the function  $N^P \bmod M$ .

```
next_iv(Type, Data) -> NextIVec  
next_iv(Type, Data, IVec) -> NextIVec
```

Types:

```
Type = des_cbc | des3_cbc | aes_cbc | des_cfb  
Data = iodata()  
IVec = NextIVec = binary()
```

Returns the initialization vector to be used in the next iteration of encrypt/decrypt of type `Type`. `Data` is the encrypted data from the previous iteration step. The `IVec` argument is only needed for `des_cfb` as the vector used in the previous iteration step.

```
private_decrypt(Type, CipherText, PrivateKey, Padding) -> PlainText
```

Types:

```
Type = rsa  
CipherText = binary()  
PrivateKey = rsa_private()  
Padding = rsa_pkcs1_padding | rsa_pkcs1_oaep_padding | rsa_no_padding  
PlainText = binary()
```

Decrypts the `CipherText`, encrypted with `public_encrypt/4` (or equivalent function) using the `PrivateKey`, and returns the plaintext (message digest). This is a low level signature verification operation used for instance by older versions of the SSL protocol. See also `public_key:decrypt_private/[2,3]`

```
private_encrypt(Type, PlainText, PrivateKey, Padding) -> CipherText
```

Types:

```
Type = rsa  
PlainText = binary()  
The size of the PlainText must be less than byte_size(N)-11 if rsa_pkcs1_padding is used, and  
byte_size(N) if rsa_no_padding is used, where N is public modulus of the RSA key.  
PrivateKey = rsa_private()  
Padding = rsa_pkcs1_padding | rsa_no_padding  
CipherText = binary()
```

Encrypts the `PlainText` using the `PrivateKey` and returns the ciphertext. This is a low level signature operation used for instance by older versions of the SSL protocol. See also `public_key:encrypt_private/[2,3]`

```
public_decrypt(Type, CipherText, PublicKey, Padding) -> PlainText
```

Types:

```
Type = rsa  
CipherText = binary()  
PublicKey = rsa_public()  
Padding = rsa_pkcs1_padding | rsa_no_padding  
PlainText = binary()
```

Decrypts the `ChipherText`, encrypted with `private_encrypt/4`(or equivalent function) using the `PrivateKey`, and returns the plaintext (message digest). This is a low level signature verification operation used for instance by older versions of the SSL protocol. See also `public_key:decrypt_public/[2,3]`

`public_encrypt(Type, PlainText, PublicKey, Padding) -> ChipherText`

Types:

`Type = rsa`

`PlainText = binary()`

The size of the `PlainText` must be less than `byte_size(N)-11` if `rsa_pkcs1_padding` is used, and `byte_size(N)` if `rsa_no_padding` is used, where `N` is public modulus of the RSA key.

`PublicKey = rsa_public()`

`Padding = rsa_pkcs1_padding | rsa_pkcs1_oaep_padding | rsa_no_padding`

`ChipherText = binary()`

Encrypts the `PlainText` (message digest) using the `PublicKey` and returns the `CipherText`. This is a low level signature operation used for instance by older versions of the SSL protocol. See also `public_key:encrypt_public/[2,3]`

`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 = integer()`

Generate a random number `N`, `Lo <= N < Hi`. Uses the `crypto` library pseudo-random number generator. `Hi` must be larger than `Lo`.

`sign(Algorithm, DigestType, Msg, Key) -> binary()`

Types:

`Algorithm = rsa | dss | ecdsa`

`Msg = binary() | {digest,binary()}`

The `msg` is either the binary "cleartext" data to be signed or it is the hashed value of "cleartext" i.e. the digest (plaintext).

`DigestType = digest_type()`

`Key = rsa_private() | dss_private() | [ecdh_private(),ecdh_params()]`

Creates a digital signature.

Algorithm `dss` can only be used together with digest type `sha`.

See also `public_key:sign/3`

`start() -> ok`

Equivalent to `application:start(crypto)`.

`stop()` -> ok

Equivalent to `application:stop(crypto)`.

`strong_rand_bytes(N)` -> `binary()`

Types:

**`N = integer()`**

Generates `N` bytes randomly uniform 0..255, and returns the result in a binary. Uses a cryptographically secure prng seeded and periodically mixed with operating system provided entropy. By default this is the `RAND_bytes` method from OpenSSL.

May throw exception `low_entropy` in case the random generator failed due to lack of secure "randomness".

`stream_init(Type, Key)` -> `State`

Types:

**`Type = rc4`**

**`State = opaque()`**

**`Key = iodata()`**

Initializes the state for use in RC4 stream encryption *stream\_encrypt* and *stream\_decrypt*

`stream_init(Type, Key, IVec)` -> `State`

Types:

**`Type = aes_ctr`**

**`State = opaque()`**

**`Key = iodata()`**

**`IVec = binary()`**

Initializes the state for use in streaming AES encryption using Counter mode (CTR). `Key` is the AES key and must be either 128, 192, or 256 bits long. `IVec` is an arbitrary initializing vector of 128 bits (16 bytes). This state is for use with *stream\_encrypt* and *stream\_decrypt*.

`stream_encrypt(State, PlainText)` -> { `NewState`, `CipherText` }

Types:

**`Text = iodata()`**

**`CipherText = binary()`**

Encrypts `PlainText` according to the stream cipher `Type` specified in `stream_init/3`. `Text` can be any number of bytes. The initial `State` is created using *stream\_init*. `NewState` must be passed into the next call to *stream\_encrypt*.

`stream_decrypt(State, CipherText)` -> { `NewState`, `PlainText` }

Types:

**`CipherText = iodata()`**

**`PlainText = binary()`**

Decrypts `CipherText` according to the stream cipher `Type` specified in `stream_init/3`. `PlainText` can be any number of bytes. The initial `State` is created using *stream\_init*. `NewState` must be passed into the next call to *stream\_encrypt*.



`supports() -> AlgorithmList`

Types:

```
AlgorithmList = [{hashs, [hash_algorithms()]}, {ciphers,  
[cipher_algorithms()]}, {public_keys, [public_key_algorithms()]}
```

Can be used to determine which crypto algorithms that are supported by the underlying OpenSSL library

`verify(Algorithm, DigestType, Msg, Signature, Key) -> boolean()`

Types:

```
Algorithm = rsa | dss | ecdsa
```

```
Msg = binary() | {digest,binary()}
```

The msg is either the binary "cleartext" data or it is the hashed value of "cleartext" i.e. the digest (plaintext).

```
DigestType = digest_type()
```

```
Signature = binary()
```

```
Key = rsa_public() | dss_public() | [ecdh_public(),ecdh_params()]
```

Verifies a digital signature

Algorithm dss can only be used together with digest type sha.

See also *public\_key:verify/4*