

crypto

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December 1, 2017

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 (eay@cryptsoft.com).

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

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```

2 Reference Manual

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

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crypto

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

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, CTR and GCM**
- **RSA encryption RFC 1321**
- Digital signatures **Digital Signature Standard (DSS)** and **Elliptic Curve Digital Signature Algorithm (ECDSA)**
- **Secure Remote Password Protocol (SRP - RFC 2945)**
- gcm: Dworkin, M., "Recommendation for Block Cipher Modes of Operation: Galois/Counter Mode (GCM) and GMAC", National Institute of Standards and Technology SP 800- 38D, November 2007.

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_explicit_curve()
```

```
ec_explicit_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|
      brainpoolP160r1| brainpoolP160t1| brainpoolP192r1| brainpoolP192t1| brainpoolP224r1|
      brainpoolP224t1| brainpoolP256r1| brainpoolP256t1| brainpoolP320r1| brainpoolP320t1|
      brainpoolP384r1| brainpoolP384t1| brainpoolP512r1| brainpoolP512t1
```

Note that the *sect* curves are GF2m (characteristic two) curves and are only supported if the underlying OpenSSL has support for them. See also *crypto:supports/0*

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

```
block_cipher() =  aes_cbc128 | aes_cfb8 | aes_cfb128 | aes_ige256 | blowfish_cbc |
     blowfish_cfb64 | des_cbc | des_cfb | des3_cbc | des3_cbf
     | des_ede3 | rc2_cbc
```

```
aead_cipher() =  aes_gcm | chacha20_poly1305
```

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

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

```
aes_key() = iodata()
```

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_cfb8 | aes_cfb128| aes_cbc256 | aes_ige256 | aes_gcm | cha
```

```
public_key_algorithms() =   rsa |dss | ecdsa | dh | ecdh | ec_gf2m
```

Note that ec_gf2m is not strictly a public key algorithm, but a restriction on what curves are supported with ecdsa and ecdh.

Exports

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

Types:

Type = des_ecb | blowfish_ecb | aes_ecb
Key = block_key()
PlainText = iodata()

Encrypt `PlainText` according to `Type` block cipher.

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

block_decrypt(Type, Key, CipherText) -> PlainText

Types:

Type = des_ecb | blowfish_ecb | aes_ecb
Key = block_key()
PlainText = iodata()

Decrypt `CipherText` according to `Type` block cipher.

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

block_encrypt(Type, Key, Ivec, PlainText) -> CipherText
block_encrypt(AeadType, Key, Ivec, {AAD, PlainText}) -> {CipherText, CipherTag}

Types:

Type = block_cipher()
AeadType = aead_cipher()
Key = block_key()
PlainText = iodata()
AAD = IVec = CipherText = CipherTag = binary()

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

In AEAD (Authenticated Encryption with Associated Data) mode, encrypt `PlainText`according to `Type` block cipher and calculate `CipherTag` that also authenticates the `AAD` (Associated Authenticated Data).

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

block_decrypt(Type, Key, Ivec, CipherText) -> PlainText
block_decrypt(AeadType, Key, Ivec, {AAD, CipherText, CipherTag}) -> PlainText | error

Types:

Type = block_cipher()
AeadType = aead_cipher()
Key = block_key()
PlainText = iodata()
AAD = IVec = CipherText = CipherTag = binary()

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

In AEAD (Authenticated Encryption with Associated Data) mode, decrypt `CipherText`according to `Type` block cipher and check the authenticity the `PlainText` and `AAD` (Associated Authenticated Data) using the `CipherTag`. May return `error` if the decryption or validation fail's

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

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() | ecdh_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*

> Warning:
>
> Do not use a `Context` as argument in more than one call to hmac_update or hmac_final. The semantics of reusing old contexts in any way is undefined and could even crash the VM in earlier releases. The reason for this limitation is a lack of support in the underlying OpenSSL API.

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 mod 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 `CipherText`, 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) -> 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.

PublicKey = rsa_public()

Padding = rsa_pkcs1_padding | rsa_pkcs1_oaep_padding | rsa_no_padding

CipherText = 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.

This function is not recommended for cryptographic purposes. Please use *strong_rand_bytes/1* instead.

rand_seed(Seed) -> ok

Types:

Seed = binary()

Set the seed for PRNG to the given binary. This calls the RAND_seed function from openssl. Only use this if the system you are running on does not have enough "randomness" built in. Normally this is when *strong_rand_bytes/1* returns `low_entropy`

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_decrypt`.

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

ec_curves() -> EllipticCurveList

Types:

EllipticCurveList = [ec_named_curve()]

Can be used to determine which named elliptic curves are supported.

ec_curve(NamedCurve) -> EllipticCurve

Types:

NamedCurve = ec_named_curve()

EllipticCurve = ec_explicit_curve()

Return the defining parameters of a elliptic curve.

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*.