# crypto

crypto 2.2
December 6 2012

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# 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.

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

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# crypto

Application

The purpose of the Crypto application is to provide message digest and DES encryption for SMNPv3. 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 **OpenSSL** 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 OpenSSL** 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.

## SEE ALSO

application(3)

# crypto

Erlang module

This module provides a set of cryptographic functions.

References:

- md4: The MD4 Message Digest Algorithm (RFC 1320)
- 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, ctr: 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 publications**, at **IETF**.

*Types*

```
byte() = 0 ... 255
ioelem() = byte() | binary() | iolist()
iolist() = [ioelem()]
Mpint() = <<ByteLen:32/integer-big, Bytes:ByteLen/binary>>
```

## 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.


**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">>}]
```

**md4(Data) -> Digest**

Types:

   **Data = iolist() | binary()**

   **Digest = binary()**

Computes an MD4 message digest from Data, where the length of the digest is 128 bits (16 bytes).

**md4_init() -> Context**

Types:

   **Context = binary()**

Creates an MD4 context, to be used in subsequent calls to md4_update/2.

**md4_update(Context, Data) -> NewContext**

Types:

   **Data = iolist() | binary()**

   **Context = NewContext = binary()**

Updates an MD4 Context with Data, and returns a NewContext.

**md4_final(Context) -> Digest**

Types:

   **Context = Digest = binary()**

Finishes the update of an MD4 Context and returns the computed MD4 message digest.

**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.

**hash(Type, Data) -> Digest**

Types:

**Type = md4 | md5 | sha | sha224 | sha256 | sha384 | sha512**

**Data = iodata()**

**Digest = binary()**

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

**hash_init(Type) -> Context**

Types:

**Type = md4 | md5 | sha | sha224 | sha256 | sha384 | sha512**

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

### 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.

### md5_mac(Key, Data) -> Mac

Types:

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

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

### hmac_init(Type, Key) -> Context

Types:

    Type = sha | md5 | ripemd160
    Key = iolist() | binary()
    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 = iolist() | binary()

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.

**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.

**sha_mac(Key, Data) -> Mac**
**sha_mac(Key, Data, MacLength) -> Mac**

Types:

**Key = Data = iolist() | binary()**

**Mac = binary()**

**MacLenength = integer() =< 20**

Computes an `SHA MAC` message authentification code from `Key` and `Data`, where the default 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 authentification 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).

**des_cbc_ivec(Data) -> IVec**

Types:

   **Data = iolist() | binary()**

   **IVec = binary()**

Returns the `IVec` to be used in a next iteration of `des_cbc_[encrypt|decrypt]`. `Data` is the encrypted data from the previous iteration step.

**des_cfb_encrypt(Key, IVec, Text) -> Cipher**

Types:

   **Key = Text = iolist() | binary()**

   **IVec = Cipher = binary()**

Encrypts `Text` according to DES in 8-bit CFB mode. `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_cfb_decrypt(Key, IVec, Cipher) -> Text**

Types:

   **Key = Cipher = iolist() | binary()**

   **IVec = Text = binary()**

Decrypts `Cipher` according to DES in 8-bit CFB 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. The lengths of `Key` and `IVec` must be 64 bits (8 bytes).

**des_cfb_ivec(IVec, Data) -> NextIVec**

Types:

   **IVec = iolist() | binary()**

   **Data = iolist() | binary()**

   **NextIVec = binary()**

Returns the `IVec` to be used in a next iteration of `des_cfb_[encrypt|decrypt]`. `IVec` is the vector used in the previous iteration step. `Data` is the encrypted data from the previous iteration step.

**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).

**des3_cfb_encrypt(Key1, Key2, Key3, IVec, Text) -> Cipher**

Types:

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

Encrypts `Text` according to DES3 in 8-bit CFB mode. `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_cfb_decrypt(Key1, Key2, Key3, IVec, Cipher) -> Text**

Types:

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

Decrypts `Cipher` according to DES3 in 8-bit CFB 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. The lengths of `Key1`, `Key2`, `Key3`, and `IVec` must be 64 bits (8 bytes).

**des_ecb_encrypt(Key, Text) -> Cipher**

Types:

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

Encrypts `Text` according to DES in ECB mode. `Key` is the DES key. The lengths of `Key` and `Text` must be 64 bits (8 bytes).

**des_ecb_decrypt(Key, Cipher) -> Text**

Types:

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

Decrypts `Cipher` according to DES in ECB mode. `Key` is the DES key. The lengths of `Key` and `Cipher` must be 64 bits (8 bytes).

**blowfish_ecb_encrypt(Key, Text) -> Cipher**

Types:

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

Encrypts the first 64 bits of `Text` using Blowfish in ECB mode. `Key` is the Blowfish key. The length of `Text` must be at least 64 bits (8 bytes).

**blowfish_ecb_decrypt(Key, Text) -> Cipher**

Types:

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

Decrypts the first 64 bits of `Text` using Blowfish in ECB mode. `Key` is the Blowfish key. The length of `Text` must be at least 64 bits (8 bytes).

**blowfish_cbc_encrypt(Key, IVec, Text) -> Cipher**

Types:

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

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

**blowfish_cbc_decrypt(Key, IVec, Text) -> Cipher**

Types:

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

Decrypts `Text` using Blowfish in CBC mode. `Key` is the Blowfish key, and `IVec` is an arbitrary initializing vector. The length of `IVec` must be 64 bits (8 bytes). The length of `Text` must be a multiple 64 bits (8 bytes).

**blowfish_cfb64_encrypt(Key, IVec, Text) -> Cipher**

Types:

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

Encrypts `Text` using Blowfish in CFB mode with 64 bit feedback. `Key` is the Blowfish key, and `IVec` is an arbitrary initializing vector. The length of `IVec` must be 64 bits (8 bytes).

**blowfish_cfb64_decrypt(Key, IVec, Text) -> Cipher**

Types:

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

Decrypts `Text` using Blowfish in CFB mode with 64 bit feedback. `Key` is the Blowfish key, and `IVec` is an arbitrary initializing vector. The length of `IVec` must be 64 bits (8 bytes).

**blowfish_ofb64_encrypt(Key, IVec, Text) -> Cipher**

Types:

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

Encrypts `Text` using Blowfish in OFB mode with 64 bit feedback. `Key` is the Blowfish key, and `IVec` is an arbitrary initializing vector. The length of `IVec` must be 64 bits (8 bytes).

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

Types:

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

Encrypts `Text` according to AES in Cipher Feedback mode (CFB). `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**

Types:

    **Key = Cipher = iolist() | binary()**

    **IVec = Text = binary()**

Decrypts `Cipher` according to AES in Cipher Feedback Mode (CFB). `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. The lengths of `Key` and `IVec` must be 128 bits (16 bytes).

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

Types:

    **Key = Text = iolist() | binary()**

    **IVec = Cipher = binary()**

Encrypts `Text` according to AES in 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_cbc_128_decrypt(Key, IVec, Cipher) -> Text**

Types:

    **Key = Cipher = iolist() | binary()**

    **IVec = Text = binary()**

Decrypts `Cipher` according to AES in 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).

**aes_cbc_ivec(Data) -> IVec**

Types:

    **Data = iolist() | binary()**

    **IVec = binary()**

Returns the `IVec` to be used in a next iteration of `aes_cbc_*_[encrypt|decrypt]`. `Data` is the encrypted data from the previous iteration step.

**aes_ctr_encrypt(Key, IVec, Text) -> Cipher**

Types:

    **Key = Text = iolist() | binary()**

    **IVec = Cipher = binary()**

Encrypts `Text` according to AES in Counter mode (CTR). `Text` can be any number of bytes. `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).

**aes_ctr_decrypt(Key, IVec, Cipher) -> Text**

Types:

    **Key = Cipher = iolist() | binary()**

    **IVec = Text = binary()**

Decrypts `Cipher` according to AES in Counter mode (CTR). `Cipher` can be any number of bytes. `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).

**`aes_ctr_stream_init(Key, IVec) -> State`**

Types:

   **`State = { K, I, E, C }`**

   **`Key = K = iolist()`**

   **`IVec = I = E = binary()`**

   **`C = integer()`**

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 bts long. `IVec` is an arbitrary initializing vector of 128 bits (16 bytes). This state is for use with *aes_ctr_stream_encrypt* and *aes_ctr_stream_decrypt*.

**`aes_ctr_stream_encrypt(State, Text) -> { NewState, Cipher}`**

Types:

   **`Text = iolist() | binary()`**

   **`Cipher = binary()`**

Encrypts `Text` according to AES in Counter mode (CTR). This function can be used to encrypt a stream of text using a series of calls instead of requiring all text to be in memory. `Text` can be any number of bytes. State is initialized using *aes_ctr_stream_init*. `NewState` is the new streaming encryption state that must be passed to the next call to `aes_ctr_stream_encrypt`. `Cipher` is the encrypted cipher text.

**`aes_ctr_stream_decrypt(State, Cipher) -> { NewState, Text }`**

Types:

   **`Cipher = iolist() | binary()`**

   **`Text = binary()`**

Decrypts `Cipher` according to AES in Counter mode (CTR). This function can be used to decrypt a stream of ciphertext using a series of calls instead of requiring all ciphertext to be in memory. `Cipher` can be any number of bytes. State is initialized using *aes_ctr_stream_init*. `NewState` is the new streaming encryption state that must be passed to the next call to `aes_ctr_stream_encrypt`. `Text` is the decrypted data.

**`erlint(Mpint) -> N`**

**`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.

**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".

**rand_uniform(Lo, Hi) -> N**

Types:

   **Lo, Hi, N = Mpint | integer()**

   **Mpint = binary()**

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

**strong_rand_mpint(N, Top, Bottom) -> Mpint**

Types:

   **N = non_neg_integer()**

   **Top = -1 | 0 | 1**

   **Bottom = 0 | 1**

   **Mpint = binary()**

Generate an N bit random number using OpenSSL's cryptographically strong pseudo random number generator `BN_rand`.

The parameter `Top` places constraints on the most significant bits of the generated number. If `Top` is 1, then the two most significant bits will be set to 1, if `Top` is 0, the most significant bit will be 1, and if `Top` is -1 then no constraints are applied and thus the generated number may be less than N bits long.

If `Bottom` is 1, then the generated number is constrained to be odd.

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

**mod_exp(N, P, M) -> Result**

Types:

   **N, P, M, Result = Mpint**

   **Mpint = binary()**

This function performs the exponentiation `N ^ P mod M`, using the `crypto` library.

**rsa_sign(DataOrDigest, Key) -> Signature**

**rsa_sign(DigestType, DataOrDigest, Key) -> Signature**

Types:

   **DataOrDigest = Data | {digest,Digest}**

   **Data = Mpint**

   **Digest = binary()**

   **Key = [E, N, D] | [E, N, D, P1, P2, E1, E2, C]**

   **E, N, D = Mpint**

Where `E` is the public exponent, `N` is public modulus and `D` is the private exponent.

**P1, P2, E1, E2, C = Mpint**

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.

**DigestType = md5 | sha | sha224 | sha256 | sha384 | sha512**

The default `DigestType` is sha.

**Mpint = binary()**

**Signature = binary()**

Creates a RSA signature with the private key `Key` of a digest. The digest is either calculated as a `DigestType` digest of `Data` or a precalculated binary `Digest`.

**rsa_verify(DataOrDigest, Signature, Key) -> Verified**

**rsa_verify(DigestType, DataOrDigest, Signature, Key) -> Verified**

Types:

    **Verified = boolean()**

    **DataOrDigest = Data | {digest|Digest}**

    **Data, Signature = Mpint**

    **Digest = binary()**

    **Key = [E, N]**

    **E, N = Mpint**

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

    **DigestType = md5 | sha | sha224 | sha256 | sha384 | sha512**

    The default `DigestType` is sha.

    **Mpint = binary()**

Verifies that a digest matches the RSA signature using the signer's public key `Key`. The digest is either calculated as a `DigestType` digest of `Data` or a precalculated binary `Digest`.

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

**rsa_public_encrypt(PlainText, PublicKey, Padding) -> ChipherText**

Types:

    **PlainText = binary()**

    **PublicKey = [E, N]**

    **E, N = Mpint**

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

    **Padding = rsa_pkcs1_padding | rsa_pkcs1_oaep_padding | rsa_no_padding**

    **ChipherText = binary()**

Encrypts the `PlainText` (usually a session key) using the `PublicKey` and returns the cipher. The `Padding` decides what padding mode is used, `rsa_pkcs1_padding` is PKCS #1 v1.5 currently the most used mode and `rsa_pkcs1_oaep_padding` is EME-OAEP as defined in PKCS #1 v2.0 with SHA-1, MGF1 and an empty encoding parameter. This mode is recommended for all new applications. The size of the `Msg` must be less than `byte_size(N)-11` if `rsa_pkcs1_padding` is used, `byte_size(N)-41` if `rsa_pkcs1_oaep_padding` is used and `byte_size(N)` if `rsa_no_padding` is used. Where byte_size(N) is the size part of an `Mpint-1`.

**rsa_private_decrypt(ChipherText, PrivateKey, Padding) -> PlainText**

Types:

**ChipherText = binary()**

**PrivateKey = [E, N, D] | [E, N, D, P1, P2, E1, E2, C]**

**E, N, D = Mpint**

Where E is the public exponent, N is public modulus and D is the private exponent.

**P1, P2, E1, E2, C = Mpint**

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.

**Padding = rsa_pkcs1_padding | rsa_pkcs1_oaep_padding | rsa_no_padding**

**PlainText = binary()**

Decrypts the ChipherText (usually a session key encrypted with *rsa_public_encrypt/3*) using the PrivateKey and returns the message. The Padding is the padding mode that was used to encrypt the data, see *rsa_public_encrypt/3*.

**rsa_private_encrypt(PlainText, PrivateKey, Padding) -> ChipherText**

Types:

**PlainText = binary()**

**PrivateKey = [E, N, D] | [E, N, D, P1, P2, E1, E2, C]**

**E, N, D = Mpint**

Where E is the public exponent, N is public modulus and D is the private exponent.

**P1, P2, E1, E2, C = Mpint**

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.

**Padding = rsa_pkcs1_padding | rsa_no_padding**

**ChipherText = binary()**

Encrypts the PlainText using the PrivateKey and returns the cipher. The Padding decides what padding mode is used, rsa_pkcs1_padding is PKCS #1 v1.5 currently the most used mode. The size of the Msg 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 byte_size(N) is the size part of an Mpint-1.

**rsa_public_decrypt(ChipherText, PublicKey, Padding) -> PlainText**

Types:

**ChipherText = binary()**

**PublicKey = [E, N]**

**E, N = Mpint**

Where E is the public exponent and N is public modulus

**Padding = rsa_pkcs1_padding | rsa_no_padding**

**PlainText = binary()**

Decrypts the ChipherText (encrypted with *rsa_private_encrypt/3*) using the PrivateKey and returns the message. The Padding is the padding mode that was used to encrypt the data, see *rsa_private_encrypt/3*.

```
dss_sign(DataOrDigest, Key) -> Signature
dss_sign(DigestType, DataOrDigest, Key) -> Signature
```
Types:

   `DigestType = sha`

   `DataOrDigest = Mpint | {digest,Digest}`

   `Key = [P, Q, G, X]`

   `P, Q, G, X = Mpint`

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

   `Digest = binary() with length 20 bytes`

   `Signature = binary()`

Creates a DSS signature with the private key `Key` of a digest. The digest is either calculated as a SHA1 digest of `Data` or a precalculated binary `Digest`.

A deprecated feature is having `DigestType = 'none'` in which case `DataOrDigest` is a precalculated SHA1 digest.

```
dss_verify(DataOrDigest, Signature, Key) -> Verified
dss_verify(DigestType, DataOrDigest, Signature, Key) -> Verified
```
Types:

   `Verified = boolean()`

   `DigestType = sha`

   `DataOrDigest = Mpint | {digest,Digest}`

   `Data = Mpint | ShaDigest`

   `Signature = Mpint`

   `Key = [P, Q, G, Y]`

   `P, Q, G, Y = Mpint`

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

   `Digest = binary() with length 20 bytes`

Verifies that a digest matches the DSS signature using the public key `Key`. The digest is either calculated as a SHA1 digest of `Data` or is a precalculated binary `Digest`.

A deprecated feature is having `DigestType = 'none'` in which case `DataOrDigest` is a precalculated SHA1 digest binary.

```
rc2_cbc_encrypt(Key, IVec, Text) -> Cipher
```
Types:

   `Key = Text = iolist() | binary()`

   `Ivec = Cipher = binary()`

Encrypts `Text` according to RC2 in CBC mode.

```
rc2_cbc_decrypt(Key, IVec, Cipher) -> Text
```
Types:

   `Key = Text = iolist() | binary()`

   `Ivec = Cipher = binary()`

Decrypts `Cipher` according to RC2 in CBC mode.

**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.

**dh_generate_key(DHParams) -> {PublicKey,PrivateKey}**

**dh_generate_key(PrivateKey, DHParams) -> {PublicKey,PrivateKey}**

Types:

    **DHParameters = [P, G]**

    **P, G = Mpint**

    Where P is the shared prime number and G is the shared generator.

    **PublicKey, PrivateKey = Mpint()**

Generates a Diffie-Hellman PublicKey and PrivateKey (if not given).

**dh_compute_key(OthersPublicKey, MyPrivateKey, DHParams) -> SharedSecret**

Types:

    **DHParameters = [P, G]**

    **P, G = Mpint**

    Where P is the shared prime number and G is the shared generator.

    **OthersPublicKey, MyPrivateKey = Mpint()**

    **SharedSecret = binary()**

Computes the shared secret from the private key and the other party's public key.

**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 an initial initializing vector. That vector could be chosen at random, or be a 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. The following 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(Key, IVec, P),
        % Which is the same as
    P1 = "Now is t", P2 = "he time ", P3 = "for all ",
    C1 = crypto:des_cbc_encrypt(Key, IVec, P1),
    C2 = crypto:des_cbc_encrypt(Key, C1, P2),
    C3 = crypto:des_cbc_encrypt(Key, C2, P3),

    C = <<C1/binary, C2/binary, C3/binary>>,
    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 `P1 ++ P2 = 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 `C1 ++ C2`, where `C1` is obtained by encrypting `P1` with `Key` and the initializing vector `IVec`, and where `C2` is obtained by encrypting `P2` with `Key` and the initializing vector `last8(C1)`, where `last(Binary)` denotes the last 8 bytes of the binary `Binary`.

Similarly, for all decompositions `C1 ++ C2 = 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 `P1 ++ P2`, where `P1` is obtained by decrypting `C1` with `Key` and the initializing vector `IVec`, and where `P2` is obtained by decrypting `C2` with `Key` and the initializing vector `last8(C1)`, where `last8(Binary)` is as above.

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