

public_key

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1 public_key User's Guide

This application provides an API to public-key infrastructure from **RFC 5280** (X.509 certificates) and public-key formats defined by the **PKCS** standard.

1.1 Introduction

1.1.1 Purpose

The Public Key application deals with public-key related file formats, digital signatures, and **X-509 certificates**. It is a library application that provides encode/decode, sign/verify, encrypt/decrypt, and similar functionality. It does not read or write files, it expects or returns file contents or partial file contents as binaries.

1.1.2 Prerequisites

It is assumed that the reader is familiar with the Erlang programming language and has a basic understanding of the concepts of using public-keys and digital certificates.

1.1.3 Performance Tips

The Public Key decode- and encode-functions try to use the NIFs in the ASN.1 compilers runtime modules, if they can be found. Thus, to have the ASN1 application in the path of your system gives the best performance.

1.2 Public-Key Records

This chapter briefly describes Erlang records derived from ASN.1 specifications used to handle public key infrastructure. The scope is to describe the data types of each component, not the semantics. For information on the semantics, refer to the relevant standards and RFCs linked in the sections below.

Use the following include directive to get access to the records and constant macros described in the following sections:

```
-include_lib("public_key/include/public_key.hrl").
```

1.2.1 Data Types

Common non-standard Erlang data types used to describe the record fields in the following sections and which are not defined in the Public Key *Reference Manual* follows here:

```
time() =
   utc_time() | general_time()
utc_time() =
   {utcTime, "YYMMDDHHMMSSZ"}
general_time() =
   {generalTime, "YYYYMMDDHHMMSSZ"}
```

```
general_name() =
    {rfc822Name, string()}
    | {dNSName, string()}
    | {x400Address, string()}
    | {directoryName, {rdnSequence, [#AttributeTypeAndValue'{}]}}
    | {eidPartyName, special_string()}
    | {eidPartyName, special_string(), special_string()}
    | {uniformResourceIdentifier, string()}
    | {ipAddress, string()}
    | {registeredId, oid()}
    | {otherName, term()}
special_string() =
    {teletexString, string()}
    | {printableString, string()}
    | {universalString, string()}
    | {utf8String, binary()}
    | {bmpString, string()}
dist_reason() =
    unused
    | keyCompromise
    | cACompromise
    | affiliationChanged
    | superseded
    | cessationOfOperation
    | certificateHold
    | privilegeWithdrawn
    | aACompromise
OID_macro() =
    ?OID_name()
OID_name() =
    atom()
```

1.2.2 RSA

Erlang representation of **Rivest-Shamir-Adleman cryptosystem (RSA)** keys follows:

```
#'RSAPublicKey'{
   modulus,       % integer()
   publicExponent % integer()
```

```
   }.

#'RSAPrivateKey'{
          version,         % two-prime | multi
   modulus,         % integer()
   publicExponent,  % integer()
   privateExponent, % integer()
   prime1,          % integer()
   prime2,          % integer()
   exponent1,       % integer()
   exponent2,       % integer()
   coefficient,     % integer()
   otherPrimeInfos  % [#OtherPrimeInfo{}] | asn1_NOVALUE
  }.

#'OtherPrimeInfo'{
 prime,           % integer()
 exponent,        % integer()
 coefficient      % integer()
   }.
```

1.2.3 DSA

Erlang representation of **Digital Signature Algorithm (DSA)** keys

```
#'DSAPrivateKey',{
   version,      % integer()
   p,            % integer()
   q,            % integer()
   g,            % integer()
   y,            % integer()
   x             % integer()
   }.

#'Dss-Parms',{
         p,         % integer()
  q,         % integer()
  g          % integer()
  }.
```

1.2.4 ECDSA

Erlang representation of **Elliptic Curve Digital Signature Algorithm (ECDSA)** keys follows:

```
#'ECPrivateKey'{
          version,       % integer()
   privateKey,    % binary()
   parameters,    % der_encoded() - {'EcpkParameters', #'ECParameters'{}} |
                                   {'EcpkParameters', {namedCurve, oid()}} |
                                   {'EcpkParameters', 'NULL'} % Inherited by CA
   publicKey      % bitstring()
   }.

#'ECParameters'{
      version,    % integer()
      fieldID,    % #'FieldID'{}
      curve,      % #'Curve'{}
      base,       % binary()
      order,      % integer()
```

```
      cofactor    % integer()
      }.

#'Curve'{
 a,        % binary()
 b,        % binary()
 seed      % bitstring() - optional

 }.

#'FieldID'{
 fieldType,    % oid()
 parameters    % Depending on fieldType
 }.

#'ECPoint'{
      point %  binary() - the public key
      }.
```

1.2.5 PKIX Certificates

Erlang representation of PKIX certificates derived from ASN.1 specifications see also **X509 certificates (RFC 5280)**, also referred to as `plain` type, are as follows:

```
#'Certificate'{
  tbsCertificate,        % #'TBSCertificate'{}
  signatureAlgorithm,    % #'AlgorithmIdentifier'{}
  signature              % bitstring()
        }.

#'TBSCertificate'{
   version,              % v1 | v2 | v3
   serialNumber,         % integer()
   signature,            % #'AlgorithmIdentifier'{}
   issuer,               % {rdnSequence, [#AttributeTypeAndValue'{}]}
   validity,             % #'Validity'{}
   subject,              % {rdnSequence, [#AttributeTypeAndValue'{}]}
   subjectPublicKeyInfo, % #'SubjectPublicKeyInfo'{}
   issuerUniqueID,       % binary() | asn1_novalue
   subjectUniqueID,      % binary() | asn1_novalue
   extensions            % [#'Extension'{}]
  }.

#'AlgorithmIdentifier'{
   algorithm,  % oid()
   parameters  % der_encoded()
  }.
```

Erlang alternate representation of PKIX certificate, also referred to as `otp` type

```
#'OTPCertificate'{
  tbsCertificate,        % #'OTPTBSCertificate'{}
  signatureAlgorithm,    % #'SignatureAlgorithm'
  signature              % bitstring()
        }.

#'OTPTBSCertificate'{
   version,              % v1 | v2 | v3
   serialNumber,         % integer()
```

```
   signature,            % #'SignatureAlgorithm'
   issuer,               % {rdnSequence, [#AttributeTypeAndValue'{}]}
   validity,             % #'Validity'{}
   subject,              % {rdnSequence, [#AttributeTypeAndValue'{}]}
   subjectPublicKeyInfo, % #'OTPSubjectPublicKeyInfo'{}
   issuerUniqueID,       % binary() | asn1_novalue
   subjectUniqueID,      % binary() | asn1_novalue
   extensions            % [#'Extension'{}]
  }.

#'SignatureAlgorithm'{
   algorithm,  % id_signature_algorithm()
   parameters  % asn1_novalue | #'Dss-Parms'{}
  }.
```

`id_signature_algorithm() = OID_macro()`

The available OID names are as follows:

OID Name
id-dsa-with-sha1
id-dsaWithSHA1 (ISO or OID to above)
md2WithRSAEncryption
md5WithRSAEncryption
sha1WithRSAEncryption
sha-1WithRSAEncryption (ISO or OID to above)
sha224WithRSAEncryption
sha256WithRSAEncryption
sha512WithRSAEncryption
ecdsa-with-SHA1

Table 2.1: Signature Algorithm OIDs

The data type `'AttributeTypeAndValue'`, is represented as the following erlang record:

```
#'AttributeTypeAndValue'{
   type,   % id_attributes()
   value   % term()
  }.
```

The attribute OID name atoms and their corresponding value types are as follows:

OID Name	*Value Type*

id-at-name	special_string()
id-at-surname	special_string()
id-at-givenName	special_string()
id-at-initials	special_string()
id-at-generationQualifier	special_string()
id-at-commonName	special_string()
id-at-localityName	special_string()
id-at-stateOrProvinceName	special_string()
id-at-organizationName	special_string()
id-at-title	special_string()
id-at-dnQualifier	{printableString, string()}
id-at-countryName	{printableString, string()}
id-at-serialNumber	{printableString, string()}
id-at-pseudonym	special_string()

Table 2.2: Attribute OIDs

The data types `'Validity'`, `'SubjectPublicKeyInfo'`, and `'SubjectPublicKeyInfoAlgorithm'` are represented as the following Erlang records:

```
#'Validity'{
   notBefore, % time()
   notAfter   % time()
  }.

#'SubjectPublicKeyInfo'{
   algorithm,       % #AlgorithmIdentifier{}
   subjectPublicKey % binary()
  }.

#'SubjectPublicKeyInfoAlgorithm'{
   algorithm,  % id_public_key_algorithm()
   parameters  % public_key_params()
  }.
```

The public-key algorithm OID name atoms are as follows:

OID Name

rsaEncryption
id-dsa
dhpublicnumber
id-keyExchangeAlgorithm
id-ecPublicKey

Table 2.3: Public-Key Algorithm OIDs

```
#'Extension'{
   extnID,    % id_extensions() | oid()
   critical,  % boolean()
   extnValue  % der_encoded()
  }.
```

`id_extensions()` *Standard Certificate Extensions*, *Private Internet Extensions*, *CRL Extensions* and *CRL Entry Extensions*.

1.2.6 Standard Certificate Extensions

The standard certificate extensions OID name atoms and their corresponding value types are as follows:

OID Name	*Value Type*
id-ce-authorityKeyIdentifier	#'AuthorityKeyIdentifier'{}
id-ce-subjectKeyIdentifier	oid()
id-ce-keyUsage	[key_usage()]
id-ce-privateKeyUsagePeriod	#'PrivateKeyUsagePeriod'{}
id-ce-certificatePolicies	#'PolicyInformation'{}
id-ce-policyMappings	#'PolicyMappings_SEQOF'{}
id-ce-subjectAltName	general_name()
id-ce-issuerAltName	general_name()
id-ce-subjectDirectoryAttributes	[#'Attribute'{}]
id-ce-basicConstraints	#'BasicConstraints'{}
id-ce-nameConstraints	#'NameConstraints'{}
id-ce-policyConstraints	#'PolicyConstraints'{}
id-ce-extKeyUsage	[id_key_purpose()]

id-ce-cRLDistributionPoints	[#'DistributionPoint'{}]
id-ce-inhibitAnyPolicy	integer()
id-ce-freshestCRL	[#'DistributionPoint'{}]

Table 2.4: Standard Certificate Extensions

Here:

```
key_usage()
    =
    digitalSignature
    | nonRepudiation
    | keyEncipherment
    | dataEncipherment
    | keyAgreement
    | keyCertSign
    | cRLSign
    | encipherOnly
    | decipherOnly
```

And for `id_key_purpose()`:

OID Name
id-kp-serverAuth
id-kp-clientAuth
id-kp-codeSigning
id-kp-emailProtection
id-kp-timeStamping
id-kp-OCSPSigning

Table 2.5: Key Purpose OIDs

```
#'AuthorityKeyIdentifier'{
   keyIdentifier,     % oid()
   authorityCertIssuer,      % general_name()
   authorityCertSerialNumber % integer()
  }.

#'PrivateKeyUsagePeriod'{
   notBefore,   % general_time()
   notAfter     % general_time()
```

```
  }.

#'PolicyInformation'{
   policyIdentifier,  % oid()
   policyQualifiers   % [#PolicyQualifierInfo{}]
  }.

#'PolicyQualifierInfo'{
   policyQualifierId,   % oid()
   qualifier            % string() | #'UserNotice'{}
  }.

#'UserNotice'{
         noticeRef,   % #'NoticeReference'{}
  explicitText % string()
  }.

#'NoticeReference'{
         organization,    % string()
  noticeNumbers    % [integer()]
  }.

#'PolicyMappings_SEQOF'{
   issuerDomainPolicy,  % oid()
   subjectDomainPolicy  % oid()
  }.

#'Attribute'{
          type,  % oid()
   values % [der_encoded()]
   }).

#'BasicConstraints'{
   cA,      % boolean()
   pathLenConstraint % integer()
  }).

#'NameConstraints'{
   permittedSubtrees, % [#'GeneralSubtree'{}]
   excludedSubtrees   % [#'GeneralSubtree'{}]
  }).

#'GeneralSubtree'{
   base,    % general_name()
   minimum, % integer()
   maximum  % integer()
  }).

#'PolicyConstraints'{
   requireExplicitPolicy, % integer()
   inhibitPolicyMapping   % integer()
  }).

#'DistributionPoint'{
   distributionPoint, % {fullName, [general_name()]} | {nameRelativeToCRLIssuer,
   [#AttributeTypeAndValue{}]}
   reasons,           % [dist_reason()]
   cRLIssuer          % [general_name()]
  }).
```

1.2.7 Private Internet Extensions

The private internet extensions OID name atoms and their corresponding value types are as follows:

OID Name	*Value Type*
id-pe-authorityInfoAccess	[#'AccessDescription'{}]
id-pe-subjectInfoAccess	[#'AccessDescription'{}]

Table 2.6: Private Internet Extensions

```
#'AccessDescription'{
          accessMethod,    % oid()
   accessLocation   % general_name()
  }).
```

1.2.8 CRL and CRL Extensions Profile

Erlang representation of CRL and CRL extensions profile derived from ASN.1 specifications and RFC 5280 are as follows:

```
#'CertificateList'{
         tbsCertList,        % #'TBSCertList{}
         signatureAlgorithm, % #'AlgorithmIdentifier'{}
         signature           % bitstring()
   }).

#'TBSCertList'{
      version,             % v2 (if defined)
      signature,           % #AlgorithmIdentifier{}
      issuer,              % {rdnSequence, [#AttributeTypeAndValue'{}]}
      thisUpdate,          % time()
      nextUpdate,          % time()
      revokedCertificates, % [#'TBSCertList_revokedCertificates_SEQOF'{}]
      crlExtensions        % [#'Extension'{}]
      }).

#'TBSCertList_revokedCertificates_SEQOF'{
        userCertificate,      % integer()
   revocationDate,       % timer()
  crlEntryExtensions    % [#'Extension'{}]
  }).
```

CRL Extensions

The CRL extensions OID name atoms and their corresponding value types are as follows:

OID Name	*Value Type*
id-ce-authorityKeyIdentifier	#'AuthorityKeyIdentifier{}
id-ce-issuerAltName	{rdnSequence, [#AttributeTypeAndValue'{}]}
id-ce-cRLNumber	integer()
id-ce-deltaCRLIndicator	integer()

id-ce-issuingDistributionPoint	#'IssuingDistributionPoint'{}
id-ce-freshestCRL	[#'Distributionpoint'{}]

Table 2.7: CRL Extensions

Here, the data type `'IssuingDistributionPoint'` is represented as the following Erlang record:

```
#'IssuingDistributionPoint'{
          distributionPoint,         % {fullName, [general_name()]} | {nameRelativeToCRLIssuer,
   [#AttributeTypeAndValue'{}]}
   onlyContainsUserCerts,     % boolean()
   onlyContainsCACerts,       % boolean()
   onlySomeReasons,           % [dist_reason()]
   indirectCRL,               % boolean()
   onlyContainsAttributeCerts % boolean()
   }).
```

CRL Entry Extensions

The CRL entry extensions OID name atoms and their corresponding value types are as follows:

OID Name	*Value Type*
id-ce-cRLReason	crl_reason()
id-ce-holdInstructionCode	oid()
id-ce-invalidityDate	general_time()
id-ce-certificateIssuer	general_name()

Table 2.8: CRL Entry Extensions

Here:

```
crl_reason()
    =
    unspecified
    | keyCompromise
    | cACompromise
    | affiliationChanged
    | superseded
    | cessationOfOperation
    | certificateHold
    | removeFromCRL
    | privilegeWithdrawn
```

```
   | aACompromise
```

PKCS#10 Certification Request

Erlang representation of a PKCS#10 certification request derived from ASN.1 specifications and RFC 5280 are as follows:

```
#'CertificationRequest'{
          certificationRequestInfo #'CertificationRequestInfo'{},
   signatureAlgorithm    #'CertificationRequest_signatureAlgorithm'{}}.
   signature               bitstring()
   }

#'CertificationRequestInfo'{
   version       atom(),
   subject       {rdnSequence, [#AttributeTypeAndValue'{}]} ,
   subjectPKInfo #'CertificationRequestInfo_subjectPKInfo'{},
   attributes    [#'AttributePKCS-10' {}]
   }

#'CertificationRequestInfo_subjectPKInfo'{
          algorithm  #'CertificationRequestInfo_subjectPKInfo_algorithm'{}
   subjectPublicKey    bitstring()
   }

#'CertificationRequestInfo_subjectPKInfo_algorithm'{
     algorithm = oid(),
     parameters = der_encoded()
}

#'CertificationRequest_signatureAlgorithm'{
     algorithm = oid(),
     parameters = der_encoded()
     }

#'AttributePKCS-10'{
    type = oid(),
    values = [der_encoded()]
}
```

1.3 Getting Started

This section describes examples of how to use the Public Key API. Keys and certificates used in the following sections are generated only for testing the Public Key application.

Some shell printouts in the following examples are abbreviated for increased readability.

1.3.1 PEM Files

Public-key data (keys, certificates, and so on) can be stored in Privacy Enhanced Mail (PEM) format. The PEM files have the following structure:

```
   <text>
   -----BEGIN <SOMETHING>-----
   <Attribute> : <Value>
   <Base64 encoded DER data>
   -----END <SOMETHING>-----
   <text>
```

A file can contain several `BEGIN/END` blocks. Text lines between blocks are ignored. Attributes, if present, are ignored except for `Proc-Type` and `DEK-Info`, which are used when `DER` data is encrypted.

DSA Private Key

A DSA private key can look as follows:

> **Note:**
>
> File handling is not done by the Public Key application.

```
1> {ok, PemBin} = file:read_file("dsa.pem").
{ok,<<"-----BEGIN DSA PRIVATE KEY-----\nMIIBuw"...>>}
```

The following PEM file has only one entry, a private DSA key:

```
2> [DSAEntry] =  public_key:pem_decode(PemBin).
[{'DSAPrivateKey',<<48,130,1,187,2,1,0,2,129,129,0,183,
                    179,230,217,37,99,144,157,21,228,204,
      162,207,61,246,...>>,
      not_encrypted}]
```

```
3> Key = public_key:pem_entry_decode(DSAEntry).
#'DSAPrivateKey'{version = 0,
                 p = 12900045185019966618...6593,
                 q = 1216700114794736143432235288305776850295620488937,
                 g = 10442040227452349332...47213,
                 y = 87256807980030509074...403143,
                 x = 5109685298560121463513173638073665750756458396 54}
```

RSA Private Key with Password

An RSA private key encrypted with a password can look as follows:

```
1> {ok, PemBin} = file:read_file("rsa.pem").
{ok,<<"Bag Attribut"...>>}
```

The following PEM file has only one entry, a private RSA key:

```
2>[RSAEntry] = public_key:pem_decode(PemBin).
[{'RSAPrivateKey',<<224,108,117,203,152,40,15,77,128,126,
                    221,195,154,249,85,208,202,251,109,
                    119,120,57,29,89,19,9,...>>,
                  {"DES-EDE3-CBC",<<"kÙeø¼pµL">>}}]
```

In this following example, the password is `"abcd1234"`:

```
3> Key = public_key:pem_entry_decode(RSAEntry, "abcd1234").
    #'RSAPrivateKey'{version = 'two-prime',
                 modulus = 1112355156729921663373...2737107,
                 publicExponent = 65537,
                 privateExponent = 58064406231183...2239766033,
                 prime1 = 11034766614656598484098...7326883017,
```

```
                prime2 = 10080459293561036618240...77738643771,
                exponent1 = 77928819327425934607...22152984217,
                exponent2 = 36287623121853605733...20588523793,
                coefficient = 924840412626098444...41820968343,
                otherPrimeInfos = asn1_NOVALUE}
```

X509 Certificates

The following is an example of X509 certificates:

```
1> {ok, PemBin} = file:read_file("cacerts.pem").
{ok,<<"-----BEGIN CERTIFICATE-----\nMIIC7jCCAl"...>>}
```

The following file includes two certificates:

```
2> [CertEntry1, CertEntry2] = public_key:pem_decode(PemBin).
[{'Certificate',<<48,130,2,238,48,130,2,87,160,3,2,1,2,2,
                  9,0,230,145,97,214,191,2,120,150,48,13,
                  ...>>,
                not_encrypted},
 {'Certificate',<<48,130,3,200,48,130,3,49,160,3,2,1,2,2,1,
                  1,48,13,6,9,42,134,72,134,247,...>>>,
                not_encrypted}]
```

Certificates can be decoded as usual:

```
2> Cert = public_key:pem_entry_decode(CertEntry1).
#'Certificate'{
    tbsCertificate =
        #'TBSCertificate'{
            version = v3,serialNumber = 16614168075301976214,
            signature =
                #'AlgorithmIdentifier'{
                    algorithm = {1,2,840,113549,1,1,5},
                    parameters = <<5,0>>},
            issuer =
                {rdnSequence,
                    [[#'AttributeTypeAndValue'{
                          type = {2,5,4,3},
                          value = <<19,8,101,114,108,97,110,103,67,65>>}],
                     [#'AttributeTypeAndValue'{
                          type = {2,5,4,11},
                          value = <<19,10,69,114,108,97,110,103,32,79,84,80>>}],
                     [#'AttributeTypeAndValue'{
                          type = {2,5,4,10},
                          value = <<19,11,69,114,105,99,115,115,111,110,32,65,66>>}],
                     [#'AttributeTypeAndValue'{
                          type = {2,5,4,7},
                          value = <<19,9,83,116,111,99,107,104,111,108,109>>}],
                     [#'AttributeTypeAndValue'{
                          type = {2,5,4,6},
                          value = <<19,2,83,69>>}],
                     [#'AttributeTypeAndValue'{
                          type = {1,2,840,113549,1,9,1},
                          value = <<22,22,112,101,116,101,114,64,101,114,...>>}]]},
            validity =
                #'Validity'{
                    notBefore = {utcTime,"080109082929Z"},
                    notAfter = {utcTime,"080208082929Z"}},
            subject =
```

```
               {rdnSequence,
                   [[#'AttributeTypeAndValue'{
                         type = {2,5,4,3},
                         value = <<19,8,101,114,108,97,110,103,67,65>>}],
                    [#'AttributeTypeAndValue'{
                         type = {2,5,4,11},
                         value = <<19,10,69,114,108,97,110,103,32,79,84,80>>}],
                    [#'AttributeTypeAndValue'{
                         type = {2,5,4,10},
                         value = <<19,11,69,114,105,99,115,115,111,110,32,...>>}],
                    [#'AttributeTypeAndValue'{
                         type = {2,5,4,7},
                         value = <<19,9,83,116,111,99,107,104,111,108,...>>}],
                    [#'AttributeTypeAndValue'{
                         type = {2,5,4,6},
                         value = <<19,2,83,69>>}],
                    [#'AttributeTypeAndValue'{
                         type = {1,2,840,113549,1,9,1},
                         value = <<22,22,112,101,116,101,114,64,...>>}]]},
           subjectPublicKeyInfo =
               #'SubjectPublicKeyInfo'{
                   algorithm =
                       #'AlgorithmIdentifier'{
                           algorithm = {1,2,840,113549,1,1,1},
                           parameters = <<5,0>>},
                   subjectPublicKey =
                       {0,<<48,129,137,2,129,129,0,203,209,187,77,73,231,90,...>>}},
           issuerUniqueID = asn1_NOVALUE,
           subjectUniqueID = asn1_NOVALUE,
           extensions =
               [#'Extension'{
                    extnID = {2,5,29,19},
                    critical = true,
                    extnValue = [48,3,1,1,255]},
                #'Extension'{
                    extnID = {2,5,29,15},
                    critical = false,
                    extnValue = [3,2,1,6]},
                #'Extension'{
                    extnID = {2,5,29,14},
                    critical = false,
                    extnValue = [4,20,27,217,65,152,6,30,142|...]},
                #'Extension'{
                    extnID = {2,5,29,17},
                    critical = false,
                    extnValue = [48,24,129,22,112,101,116,101|...]}]},
   signatureAlgorithm =
       #'AlgorithmIdentifier'{
           algorithm = {1,2,840,113549,1,1,5},
           parameters = <<5,0>>},
   signature =
   <<163,186,7,163,216,152,63,47,154,234,139,73,154,96,120,
   165,2,52,196,195,109,167,192,...>>}
```

Parts of certificates can be decoded with `public_key:der_decode/2`, using the ASN.1 type of that part. However, an application-specific certificate extension requires application-specific ASN.1 decode/encode-functions. In the recent example, the first value of `rdnSequence` is of ASN.1 type `'X520CommonName'. ({2,5,4,3} = ?id-at-commonName)`:

```
public_key:der_decode('X520CommonName', <<19,8,101,114,108,97,110,103,67,65>>).
{printableString,"erlangCA"}
```

However, certificates can also be decoded using `pkix_decode_cert/2`, which can customize and recursively decode standard parts of a certificate:

```
3>{_, DerCert, _} = CertEntry1.
```

```
4> public_key:pkix_decode_cert(DerCert, otp).
#'OTPCertificate'{
    tbsCertificate =
        #'OTPTBSCertificate'{
            version = v3,serialNumber = 16614168075301976214,
            signature =
                #'SignatureAlgorithm'{
                    algorithm = {1,2,840,113549,1,1,5},
                    parameters = 'NULL'},
            issuer =
                {rdnSequence,
                    [[#'AttributeTypeAndValue'{
                          type = {2,5,4,3},
                          value = {printableString,"erlangCA"}}],
                     [#'AttributeTypeAndValue'{
                          type = {2,5,4,11},
                          value = {printableString,"Erlang OTP"}}],
                     [#'AttributeTypeAndValue'{
                          type = {2,5,4,10},
                          value = {printableString,"Ericsson AB"}}],
                     [#'AttributeTypeAndValue'{
                          type = {2,5,4,7},
                          value = {printableString,"Stockholm"}}],
                     [#'AttributeTypeAndValue'{type = {2,5,4,6},value = "SE"}],
                     [#'AttributeTypeAndValue'{
                          type = {1,2,840,113549,1,9,1},
                          value = "peter@erix.ericsson.se"}]]},
            validity =
                #'Validity'{
                    notBefore = {utcTime,"080109082929Z"},
                    notAfter = {utcTime,"080208082929Z"}},
            subject =
                {rdnSequence,
                    [[#'AttributeTypeAndValue'{
                          type = {2,5,4,3},
                          value = {printableString,"erlangCA"}}],
                     [#'AttributeTypeAndValue'{
                          type = {2,5,4,11},
                          value = {printableString,"Erlang OTP"}}],
                     [#'AttributeTypeAndValue'{
                          type = {2,5,4,10},
                          value = {printableString,"Ericsson AB"}}],
                     [#'AttributeTypeAndValue'{
                          type = {2,5,4,7},
                          value = {printableString,"Stockholm"}}],
                     [#'AttributeTypeAndValue'{type = {2,5,4,6},value = "SE"}],
                     [#'AttributeTypeAndValue'{
                          type = {1,2,840,113549,1,9,1},
                          value = "peter@erix.ericsson.se"}]]},
            subjectPublicKeyInfo =
                #'OTPSubjectPublicKeyInfo'{
                    algorithm =
                        #'PublicKeyAlgorithm'{
                            algorithm = {1,2,840,113549,1,1,1},
                            parameters = 'NULL'},
                    subjectPublicKey =
                        #'RSAPublicKey'{
```

```
                          modulus =
                              1431267547247997...37419,
                          publicExponent = 65537}},
          issuerUniqueID = asn1_NOVALUE,
          subjectUniqueID = asn1_NOVALUE,
          extensions =
              [#'Extension'{
                   extnID = {2,5,29,19},
                   critical = true,
                   extnValue =
                       #'BasicConstraints'{
                            cA = true,pathLenConstraint = asn1_NOVALUE}},
               #'Extension'{
                   extnID = {2,5,29,15},
                   critical = false,
                   extnValue = [keyCertSign,cRLSign]},
               #'Extension'{
                   extnID = {2,5,29,14},
                   critical = false,
                   extnValue = [27,217,65,152,6,30,142,132,245|...]},
               #'Extension'{
                   extnID = {2,5,29,17},
                   critical = false,
                   extnValue = [{rfc822Name,"peter@erix.ericsson.se"}]}]},
   signatureAlgorithm =
       #'SignatureAlgorithm'{
           algorithm = {1,2,840,113549,1,1,5},
           parameters = 'NULL'},
   signature =
        <<163,186,7,163,216,152,63,47,154,234,139,73,154,96,120,
          165,2,52,196,195,109,167,192,...>>}
```

This call is equivalent to `public_key:pem_entry_decode(CertEntry1)`:

```
5> public_key:pkix_decode_cert(DerCert, plain).
#'Certificate'{ ...}
```

Encoding Public-Key Data to PEM Format

If you have public-key data and want to create a PEM file this can be done by calling functions `public_key:pem_entry_encode/2` and `pem_encode/1` and saving the result to a file. For example, assume that you have `PubKey = 'RSAPublicKey'{}`. Then you can create a PEM-"RSA PUBLIC KEY" file (ASN.1 type `'RSAPublicKey'`) or a PEM-"PUBLIC KEY" file (`'SubjectPublicKeyInfo'` ASN.1 type).

The second element of the PEM-entry is the ASN.1 `DER` encoded key data:

```
1> PemEntry = public_key:pem_entry_encode('RSAPublicKey', RSAPubKey).
{'RSAPublicKey', <<48,72,...>>, not_encrypted}

2> PemBin = public_key:pem_encode([PemEntry]).
<<"-----BEGIN RSA PUBLIC KEY-----\nMEgC...>>

3> file:write_file("rsa_pub_key.pem", PemBin).
ok
```

or:

```
1> PemEntry = public_key:pem_entry_encode('SubjectPublicKeyInfo', RSAPubKey).
{'SubjectPublicKeyInfo', <<48,92...>>, not_encrypted}
```

```
2> PemBin = public_key:pem_encode([PemEntry]).
<<"-----BEGIN PUBLIC KEY-----\nMFw...>>

3> file:write_file("pub_key.pem", PemBin).
ok
```

1.3.2 RSA Public-Key Cryptography

Suppose you have the following private key and a corresponding public key:

- `PrivateKey = #'RSAPrivateKey{}'` and the plaintext `Msg = binary()`
- `PublicKey = #'RSAPublicKey'{}`

Then you can proceed as follows:

Encrypt with the private key:

```
RsaEncrypted = public_key:encrypt_private(Msg, PrivateKey),
Msg = public_key:decrypt_public(RsaEncrypted, PublicKey),
```

Encrypt with the public key:

```
RsaEncrypted = public_key:encrypt_public(Msg, PublicKey),
Msg = public_key:decrypt_private(RsaEncrypted, PrivateKey),
```

> **Note:**
>
> You normally do only one of the encrypt or decrypt operations, and the peer does the other. This normaly used in legacy applications as a primitive digital signature.

1.3.3 Digital Signatures

Suppose you have the following private key and a corresponding public key:

- `PrivateKey = #'RSAPrivateKey{}'` or `#'DSAPrivateKey'{}` and the plaintext `Msg = binary()`
- `PublicKey = #'RSAPublicKey'{}` or `{integer(), #'DssParams'{}}`

Then you can proceed as follows:

```
Signature = public_key:sign(Msg, sha, PrivateKey),
true = public_key:verify(Msg, sha, Signature, PublicKey),
```

> **Note:**
>
> You normally do only one of the sign or verify operations, and the peer does the other.

It can be appropriate to calculate the message digest before calling `sign` or `verify`, and then use `none` as second argument:

```
Digest = crypto:sha(Msg),
Signature = public_key:sign(Digest, none, PrivateKey),
true = public_key:verify(Digest, none, Signature, PublicKey),
```

1.3.4 SSH Files

SSH typically uses PEM files for private keys but has its own file format for storing public keys. The `public_key` application can be used to parse the content of SSH public-key files.

RFC 4716 SSH Public-Key Files

RFC 4716 SSH files looks confusingly like PEM files, but there are some differences:

```
1> {ok, SshBin} = file:read_file("ssh2_rsa_pub").
{ok, <<"---- BEGIN SSH2 PUBLIC KEY ----\nAAAA"...>>}
```

This is equivalent to calling `public_key:ssh_decode(SshBin, rfc4716_public_key)`:

```
2> public_key:ssh_decode(SshBin, public_key).
[{#'RSAPublicKey'{modulus = 794430685...91663,
                  publicExponent = 35}, []}]
```

OpenSSH Public-Key Format

OpenSSH public-key format looks as follows:

```
1> {ok, SshBin} = file:read_file("openssh_dsa_pub").
{ok,<<"ssh-dss AAAAB3Nza"...>>}
```

This is equivalent to calling `public_key:ssh_decode(SshBin, openssh_public_key)`:

```
2>  public_key:ssh_decode(SshBin, public_key).
[{{15642692...694280725,
   #'Dss-Parms'{p = 17291273936...696123221,
                q = 125562659017966581729547565420437183373570600185 3,
                g = 10454211196...480338645}},
  [{comment,"dhopson@VMUbuntu-DSH"}]}]
```

Known Hosts - OpenSSH Format

Known hosts - OpenSSH format looks as follows:

```
1> {ok, SshBin} = file:read_file("known_hosts").
{ok,<<"hostname.domain.com,192.168.0.1 ssh-rsa AAAAB...>>}
```

Returns a list of public keys and their related attributes. Each pair of key and attribute corresponds to one entry in the known hosts file:

```
2>  public_key:ssh_decode(SshBin, known_hosts).
[{#'RSAPublicKey'{modulus = 1498979460408...72721699,
                  publicExponent = 35},
  [{hostnames,["hostname.domain.com","192.168.0.1"]}]},
 {#'RSAPublicKey'{modulus = 14989794604088...2721699,
                  publicExponent = 35},
  [{comment,"foo@bar.com"},
```

```
   {hostnames,["|1|BWO5qDxk/cFH0wa05JLdHn+j6xQ=|rXQvIxh5cDD3C43k5DPDamawVNA="]}]}]
```

Authorized Keys - OpenSSH Format

Authorized keys - OpenSSH format looks as follows:

```
1> {ok, SshBin} = file:read_file("auth_keys").
{ok, <<"command=\"dump /home\",no-pty,no-port-forwarding ssh-rsa AAA...>>}
```

Returns a list of public keys and their related attributes. Each pair of key and attribute corresponds to one entry in the authorized key file:

```
2> public_key:ssh_decode(SshBin, auth_keys).
[{#'RSAPublicKey'{modulus = 794430685...691663,
                  publicExponent = 35},
  [{comment,"dhopson@VMUbuntu-DSH"},
   {options,["command=\"dump/home\"","no-pty",
             "no-port-forwarding"]}]},
 {{1564269258491...607694280725,
   #'Dss-Parms'{p = 17291273936185...763696123221,
                q = 125562659017966581729547565420437183373570600185 3,
                g = 10454211195705...605110395900767809990464803386 45}},
  [{comment,"dhopson@VMUbuntu-DSH"}]}]
```

Creating an SSH File from Public-Key Data

If you got a public key `PubKey` and a related list of attributes `Attributes` as returned by `ssh_decode/2`, you can create a new SSH file, for example:

```
N> SshBin = public_key:ssh_encode([{PubKey, Attributes}], openssh_public_key),
<<"ssh-rsa "...>>
N+1> file:write_file("id_rsa.pub", SshBin).
ok
```

2 Reference Manual

The `public_key` application provides functions to handle public-key infrastructure from RFC 3280 (X.509 certificates) and parts of the PKCS standard.

public_key

Erlang module

This module provides functions to handle public-key infrastructure. It can encode/decode different file formats (PEM, OpenSSH), sign and verify digital signatures, and validate certificate paths and certificate revocation lists.

public_key

- Public Key requires the Crypto and ASN1 applications, the latter as OTP R16 (hopefully the runtime dependency on ASN1 will be removed again in the future).
- Supports **RFC 5280** - Internet X.509 Public-Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile
- Supports **PKCS-1** - RSA Cryptography Standard
- Supports **DSS** - Digital Signature Standard (DSA - Digital Signature Algorithm)
- Supports **PKCS-3** - Diffie-Hellman Key Agreement Standard
- Supports **PKCS-5** - Password-Based Cryptography Standard
- Supports **PKCS-8** - Private-Key Information Syntax Standard
- Supports **PKCS-10** - Certification Request Syntax Standard

DATA TYPES

> **Note:**
>
> All records used in this Reference Manual are generated from ASN.1 specifications and are documented in the User's Guide. See *Public-key Records*.

Use the following include directive to get access to the records and constant macros described here and in the User's Guide:

```
-include_lib("public_key/include/public_key.hrl").
```

The following data types are used in the functions for `public_key`:

`oid()`

Object identifier, a tuple of integers as generated by the `ASN.1` compiler.

```
boolean() =
    true | false
string() =
    [bytes()]
der_encoded() =
    binary()
pki_asn1_type() =
    'Certificate'
```

```
    | 'RSAPrivateKey'
    | 'RSAPublicKey'
    | 'DSAPrivateKey'
    | 'DSAPublicKey'
    | 'DHParameter'
    | 'SubjectPublicKeyInfo'
    | 'PrivateKeyInfo'
    | 'CertificationRequest'
    | 'CertificateList'
    | 'ECPrivateKey'
    | 'EcpkParameters'
pem_entry () =
    {pki_asn1_type(), binary(), %% DER or encrypted DER
    not_encrypted | cipher_info()}
cipher_info() =
    {"RC2-CBC" | "DES-CBC" | "DES-EDE3-CBC", crypto:rand_bytes(8)
    | {#'PBEParameter{}, digest_type()} | #'PBES2-params'{}}
public_key() =
    rsa_public_key() | dsa_public_key() | ec_public_key()
private_key() =
    rsa_private_key() | dsa_private_key() | ec_private_key()
rsa_public_key() =
    #'RSAPublicKey'{}
rsa_private_key() =
    #'RSAPrivateKey'{}
dsa_public_key() =
    {integer(), #'Dss-Parms'{}}
dsa_private_key() =
    #'DSAPrivateKey'{}
ec_public_key()
    = {#'ECPoint'{}, #'EcpkParameters'{} | {namedCurve, oid()}}
ec_private_key() =
    #'ECPrivateKey'{}
public_crypt_options() =
    [{rsa_pad, rsa_padding()}]
rsa_padding() =
    'rsa_pkcs1_padding'
```

```
    | 'rsa_pkcs1_oaep_padding'
    | 'rsa_no_padding'
digest_type() =
```

Union of `rsa_digest_type()`, `dss_digest_type()`, and `ecdsa_digest_type()`.

```
rsa_digest_type() =
    'md5' | 'sha' | 'sha224' | 'sha256' | 'sha384' | 'sha512'
dss_digest_type() =
    'sha'
ecdsa_digest_type() =
    'sha'| 'sha224' | 'sha256' | 'sha384' | 'sha512'
crl_reason() =
    unspecified
    | keyCompromise
    | cACompromise
    | affiliationChanged
    | superseded
    | cessationOfOperation
    | certificateHold
    | privilegeWithdrawn
    | aACompromise
issuer_name() =
    {rdnSequence,[#'AttributeTypeAndValue'{}]}
ssh_file() =
    openssh_public_key
    | rfc4716_public_key
    | known_hosts
    | auth_keys
```

Exports

`compute_key(OthersKey, MyKey)->`
`compute_key(OthersKey, MyKey, Params)->`

Types:

`OthersKey = #'ECPoint'{} | binary(), MyKey = #'ECPrivateKey'{} | binary()`
`Params = #'DHParameter'{}`

Computes shared secret.

decrypt_private(CipherText, Key) -> binary()
decrypt_private(CipherText, Key, Options) -> binary()

Types:

CipherText = binary()
Key = rsa_private_key()
Options = public_crypt_options()

Public-key decryption using the private key. See also *crypto:private_decrypt/4*

decrypt_public(CipherText, Key) - > binary()
decrypt_public(CipherText, Key, Options) - > binary()

Types:

CipherText = binary()
Key = rsa_public_key()
Options = public_crypt_options()

Public-key decryption using the public key. See also *crypto:public_decrypt/4*

der_decode(Asn1type, Der) -> term()

Types:

Asn1Type = atom()

ASN.1 type present in the Public Key applications ASN.1 specifications.

Der = der_encoded()

Decodes a public-key ASN.1 DER encoded entity.

der_encode(Asn1Type, Entity) -> der_encoded()

Types:

Asn1Type = atom()

ASN.1 type present in the Public Key applications ASN.1 specifications.

Entity = term()

Erlang representation of `Asn1Type`

Encodes a public-key entity with ASN.1 DER encoding.

dh_gex_group(MinSize, SuggestedSize, MaxSize, Groups) -> {ok, {Size,Group}} | {error,Error}

Types:

MinSize = positive_integer()
SuggestedSize = positive_integer()
MaxSize = positive_integer()
Groups = undefined | [{Size,[{G,P}]}]
Size = positive_integer()
Group = {G,P}
G = positive_integer()
P = positive_integer()

Selects a group for Diffie-Hellman key exchange with the key size in the range `MinSize...MaxSize` and as close to `SuggestedSize` as possible. If `Groups == undefined` a default set will be used, otherwise the group is selected from `Groups`.

First a size, as close as possible to SuggestedSize, is selected. Then one group with that key size is randomly selected from the specified set of groups. If no size within the limits of `MinSize` and `MaxSize` is available, `{error,no_group_found}` is returned.

The default set of groups is listed in `lib/public_key/priv/moduli`. This file may be regenerated like this:

```
$> cd $ERL_TOP/lib/public_key/priv/
$> generate
        ---- wait until all background jobs has finished. It may take several days !
$> cat moduli-* > moduli
$> cd ..; make
```

`encrypt_private(PlainText, Key) -> binary()`

Types:

`PlainText = binary()`

`Key = rsa_private_key()`

Public-key encryption using the private key. See also *crypto:private_encrypt/4*.

`encrypt_public(PlainText, Key) -> binary()`

Types:

`PlainText = binary()`

`Key = rsa_public_key()`

Public-key encryption using the public key. See also *crypto:public_encrypt/4*.

`generate_key(Params) -> {Public::binary(), Private::binary()} | #'ECPrivateKey'{}`

Types:

`Params = #'DHParameter'{} | {namedCurve, oid()} | #'ECParameters'{}`

Generates a new keypair.

`pem_decode(PemBin) -> [pem_entry()]`

Types:

`PemBin = binary()`

Example {ok, PemBin} = file:read_file("cert.pem").

Decodes PEM binary data and returns entries as ASN.1 DER encoded entities.

`pem_encode(PemEntries) -> binary()`

Types:

`PemEntries = [pem_entry()]`

Creates a PEM binary.

pem_entry_decode(PemEntry) -> term()
pem_entry_decode(PemEntry, Password) -> term()

Types:

PemEntry = pem_entry()
Password = string()

Decodes a PEM entry. `pem_decode/1` returns a list of PEM entries. Notice that if the PEM entry is of type 'SubjectPublickeyInfo', it is further decoded to an `rsa_public_key()` or `dsa_public_key()`.

pem_entry_encode(Asn1Type, Entity) -> pem_entry()
pem_entry_encode(Asn1Type, Entity, {CipherInfo, Password}) -> pem_entry()

Types:

Asn1Type = pki_asn1_type()
Entity = term()

Erlang representation of `Asn1Type`. If `Asn1Type` is 'SubjectPublicKeyInfo', `Entity` must be either an `rsa_public_key()` or a `dsa_public_key()` and this function creates the appropriate 'SubjectPublicKeyInfo' entry.

CipherInfo = cipher_info()
Password = string()

Creates a PEM entry that can be feed to `pem_encode/1`.

pkix_decode_cert(Cert, otp|plain) -> #'Certificate'{} | #'OTPCertificate'{}

Types:

Cert = der_encoded()

Decodes an ASN.1 DER-encoded PKIX certificate. Option `otp` uses the customized ASN.1 specification OTP-PKIX.asn1 for decoding and also recursively decode most of the standard parts.

pkix_encode(Asn1Type, Entity, otp | plain) -> der_encoded()

Types:

Asn1Type = atom()

The ASN.1 type can be 'Certificate', 'OTPCertificate' or a subtype of either.

Entity = #'Certificate'{} | #'OTPCertificate'{} | a valid subtype

DER encodes a PKIX x509 certificate or part of such a certificate. This function must be used for encoding certificates or parts of certificates that are decoded/created in the `otp` format, whereas for the plain format this function directly calls `der_encode/2`.

pkix_is_issuer(Cert, IssuerCert) -> boolean()

Types:

Cert = der_encoded() | #'OTPCertificate'{} | #'CertificateList'{}
IssuerCert = der_encoded() | #'OTPCertificate'{}

Checks if `IssuerCert` issued `Cert`.

pkix_is_fixed_dh_cert(Cert) -> boolean()

Types:

Cert = der_encoded() | #'OTPCertificate'{}

Checks if a certificate is a fixed Diffie-Hellman certificate.

pkix_is_self_signed(Cert) -> boolean()

Types:

Cert = der_encoded() | #'OTPCertificate'{}

Checks if a certificate is self-signed.

pkix_issuer_id(Cert, IssuedBy) -> {ok, IssuerID} | {error, Reason}

Types:

Cert = der_encoded() | #'OTPCertificate'{}

IssuedBy = self | other

IssuerID = {integer(), issuer_name()}

The issuer id consists of the serial number and the issuers name.

Reason = term()

Returns the issuer id.

pkix_normalize_name(Issuer) -> Normalized

Types:

Issuer = issuer_name()

Normalized = issuer_name()

Normalizes an issuer name so that it can be easily compared to another issuer name.

pkix_path_validation(TrustedCert, CertChain, Options) -> {ok, {PublicKeyInfo, PolicyTree}} | {error, {bad_cert, Reason}}

Types:

TrustedCert = #'OTPCertificate'{} | der_encoded() | atom()

Normally a trusted certificate, but it can also be a path-validation error that can be discovered while constructing the input to this function and that is to be run through the `verify_fun`. Examples are `unknown_ca` and `selfsigned_peer`.

CertChain = [der_encoded()]

A list of DER-encoded certificates in trust order ending with the peer certificate.

Options = proplists:proplist()

PublicKeyInfo = {?'rsaEncryption' | ?'id-dsa', rsa_public_key() | integer(), 'NULL' | 'Dss-Parms'{}}

PolicyTree = term()

At the moment this is always an empty list as policies are not currently supported.

Reason = cert_expired | invalid_issuer | invalid_signature | name_not_permitted | missing_basic_constraint | invalid_key_usage | {revoked, crl_reason()} | atom()

Performs a basic path validation according to **RFC 5280.** However, CRL validation is done separately by *pkix_crls_validate/3* and is to be called from the supplied `verify_fun`.

Available options:

{verify_fun, fun()}

The fun must be defined as:

```
fun(OtpCert :: #'OTPCertificate'{},
    Event :: {bad_cert, Reason :: atom() | {revoked, atom()}} |
             {extension, #'Extension'{}},
    InitialUserState :: term()) ->
 {valid, UserState :: term()} |
 {valid_peer, UserState :: term()} |
 {fail, Reason :: term()} |
 {unknown, UserState :: term()}.
```

If the verify callback fun returns `{fail, Reason}`, the verification process is immediately stopped. If the verify callback fun returns `{valid, UserState}`, the verification process is continued. This can be used to accept specific path validation errors, such as `selfsigned_peer`, as well as verifying application-specific extensions. If called with an extension unknown to the user application, the return value `{unknown, UserState}` is to be used.

{max_path_length, integer()}

The `max_path_length` is the maximum number of non-self-issued intermediate certificates that can follow the peer certificate in a valid certification path. So, if `max_path_length` is 0, the PEER must be signed by the trusted ROOT-CA directly, if it is 1, the path can be PEER, CA, ROOT-CA, if it is 2, the path can be PEER, CA, CA, ROOT-CA, and so on.

Possible reasons for a bad certificate:

cert_expired

Certificate is no longer valid as its expiration date has passed.

invalid_issuer

Certificate issuer name does not match the name of the issuer certificate in the chain.

invalid_signature

Certificate was not signed by its issuer certificate in the chain.

name_not_permitted

Invalid Subject Alternative Name extension.

missing_basic_constraint

Certificate, required to have the basic constraints extension, does not have a basic constraints extension.

invalid_key_usage

Certificate key is used in an invalid way according to the key-usage extension.

{revoked, crl_reason()}

Certificate has been revoked.

atom()

Application-specific error reason that is to be checked by the `verify_fun`.

`pkix_crl_issuer(CRL) -> issuer_name()`

Types:

`CRL = der_encoded() | #'CertificateList'{}`

Returns the issuer of the `CRL`.

pkix_crls_validate(OTPCertificate, DPAndCRLs, Options) -> CRLStatus()

Types:

OTPCertificate = #'OTPCertificate'{}

DPAndCRLs = [{DP::#'DistributionPoint'{}, {DerCRL::der_encoded(), CRL::#'CertificateList'{}}}]

Options = proplists:proplist()

CRLStatus() = valid | {bad_cert, revocation_status_undetermined} | {bad_cert, {revoked, crl_reason()}}

Performs CRL validation. It is intended to be called from the verify fun of *pkix_path_validation/3* .

Available options:

{update_crl, fun()}

The fun has the following type specification:

```
fun(#'DistributionPoint'{}, #'CertificateList'{}) ->
       #'CertificateList'{}
```

The fun uses the information in the distribution point to access the latest possible version of the CRL. If this fun is not specified, Public Key uses the default implementation:

```
fun(_DP, CRL) -> CRL end
```

{issuer_fun, fun()}

The fun has the following type specification:

```
fun(#'DistributionPoint'{}, #'CertificateList'{},
    {rdnSequence,[#'AttributeTypeAndValue'{}]}, term()) ->
 {ok, #'OTPCertificate'{}, [der_encoded]}
```

The fun returns the root certificate and certificate chain that has signed the CRL.

```
fun(DP, CRL, Issuer, UserState) -> {ok, RootCert, CertChain}
```

pkix_crl_verify(CRL, Cert) -> boolean()

Types:

CRL = der_encoded() | #'CertificateList'{}

Cert = der_encoded() | #'OTPCertificate'{}

Verify that `Cert` is the `CRL` signer.

pkix_dist_point(Cert) -> DistPoint

Types:

Cert = der_encoded() | #'OTPCertificate'{}

DistPoint = #'DistributionPoint'{}

Creates a distribution point for CRLs issued by the same issuer as `Cert`. Can be used as input to *pkix_crls_validate/3*

pkix_dist_points(Cert) -> DistPoints

Types:

Cert = der_encoded() | #'OTPCertificate'{}

DistPoints = [#'DistributionPoint'{}]

Extracts distribution points from the certificates extensions.

pkix_sign(#'OTPTBSCertificate'{}, Key) -> der_encoded()

Types:

Key = rsa_private_key() | dsa_private_key()

Signs an 'OTPTBSCertificate'. Returns the corresponding DER-encoded certificate.

pkix_sign_types(AlgorithmId) -> {DigestType, SignatureType}

Types:

AlgorithmId = oid()

Signature OID from a certificate or a certificate revocation list.

DigestType = rsa_digest_type() | dss_digest_type()

SignatureType = rsa | dsa | ecdsa

Translates signature algorithm OID to Erlang digest and signature types.

pkix_verify(Cert, Key) -> boolean()

Types:

Cert = der_encoded()

Key = rsa_public_key() | dsa_public_key() | ec_public_key()

Verifies PKIX x.509 certificate signature.

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

Types:

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

The `Msg` is either the binary "plain text" data to be signed or it is the hashed value of "plain text", that is, the digest.

DigestType = rsa_digest_type() | dss_digest_type() | ecdsa_digest_type()

Key = rsa_private_key() | dsa_private_key() | ec_private_key()

Creates a digital signature.

ssh_decode(SshBin, Type) -> [{public_key(), Attributes::list()}]

Types:

SshBin = binary()

Example `{ok, SshBin} = file:read_file("known_hosts")`.

Type = public_key | ssh_file()

If `Type` is `public_key` the binary can be either an RFC4716 public key or an OpenSSH public key.

Decodes an SSH file-binary. In the case of `known_hosts` or `auth_keys`, the binary can include one or more lines of the file. Returns a list of public keys and their attributes, possible attribute values depends on the file type represented by the binary.

RFC4716 attributes - see RFC 4716.

{headers, [{string(), utf8_string()}]}

auth_key attributes - see manual page for sshd.

{comment, string()}
{options, [string()]}

{bits, integer()} - In SSH version 1 files.

known_host attributes - see manual page for sshd.

{hostnames, [string()]}
{comment, string()}

{bits, integer()} - In SSH version 1 files.

`ssh_encode([{Key, Attributes}], Type) -> binary()`

Types:

`Key = public_key()`
`Attributes = list()`
`Type = ssh_file()`

Encodes a list of SSH file entries (public keys and attributes) to a binary. Possible attributes depend on the file type, see *ssh_decode/2* .

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

Types:

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

The `Msg` is either the binary "plain text" data or it is the hashed value of "plain text", that is, the digest.

`DigestType = rsa_digest_type() | dss_digest_type() | ecdsa_digest_type()`
`Signature = binary()`
`Key = rsa_public_key() | dsa_public_key() | ec_public_key()`

Verifies a digital signature.