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## public\_key

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# 1 public\_key User's Guide

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This application provides an API to public key infrastructure from RFC 3280 (X.509 certificates) and some public key formats defined by the PKCS-standard.

## 1.1 Introduction

### 1.1.1 Purpose

This application provides an API to public key infrastructure from RFC 3280 (X.509 certificates) and public key formats defined by the PKCS-standard.

### 1.1.2 Prerequisites

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

### 1.1.3 Performance tips

The public\_key decode and encode functions will try to use the nifs which are in the asn1 compilers runtime modules if they can be found. So for the best performance you want to have the asn1 application in the path of your system.

## 1.2 Public key records

This chapter briefly describes Erlang records derived from asn1 specifications used to handle public and private keys. The intent is to describe the data types and not to specify the meaning of each component for this we refer you to the relevant standards and RFCs.

Use the following include directive to get access to the records and constant macros used in the following sections.

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

### 1.2.1 RSA as defined by the PKCS-1 standard and RFC 3447.

```
#'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()
}.

```

## 1.2.2 DSA as defined by Digital Signature Standard (NIST FIPS PUB 186-2)

```

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

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

```

## 1.3 Certificate records

This chapter briefly describes erlang records derived from asn1 specifications used to handle X509 certificates. The intent is to describe the data types and not to specify the meaning of each component for this we refer you to RFC 5280.

Use the following include directive to get access to the records and constant macros (OIDs) described in the following sections.

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

The used asn1 specifications are available in the `asn1` subdirectory of the application `public_key`.

### 1.3.1 Common Data Types

Common non standard erlang data types used to describe the record fields in the below sections are defined in *public key reference manual* or follows here.

`oid()` - a tuple of integers as generated by the asn1 compiler.

`time() = uct_time() | general_time()`

`uct_time() = {utcTime, "YYMMDDHHMMSSZ"}`

`general_time() = {generalTime, "YYYYMMDDHHMMSSZ"}`

`general_name() = {rfc822Name, string()} | {dNSName, string()} | {x400Address, string()} | {directoryName, {rdnSequence, [#AttributeTypeAndValue'{}]}} | {eidPartyName, special_string()} | {eidPartyName, special_string(),`

## 1.3 Certificate records

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```
special_string() | {uniformResourceIdentifier, string()} | {ipAddress,
string()} | {registeredId, oid()} | {otherName, term()}

special_string() = {teletexString, string()} | {printableString, string()} |
{universalString, string()} | {utf8String, string()} | {bmpString, string()}

dist_reason() = unused | keyCompromise | cACompromise | affiliationChanged
| superseded | cessationOfOperation | certificateHold | privilegeWithdrawn |
aACompromise
```

### 1.3.2 PKIX Certificates

```
#'Certificate'{
  tbsCertificate,      % #'TBSCertificate'{}
  signatureAlgorithm,  % #'AlgorithmIdentifier'{}
  signature             % {0, binary()} - asnl compact bitstring
}.

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

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

```
#'OTPCertificate'{
  tbsCertificate,      % #'OTPTBSCertificate'{}
  signatureAlgorithm,  % #'SignatureAlgorithm'
  signature             % {0, binary()} - asnl compact bitstring
}.

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

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

```
}.
```

`id_signature_algorithm()` = `?oid_name_as_erlang_atom` for available oid names see table below.  
Ex: `?id-dsa-with-sha1`

OID name
<code>id-dsa-with-sha1</code>
<code>md2WithRSAEncryption</code>
<code>md5WithRSAEncryption</code>
<code>sha1WithRSAEncryption</code>
<code>ecdsa-with-SHA1</code>

**Table 3.1: Signature algorithm oids**

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

`id_attributes()`

OID name	Value type
<code>id-at-name</code>	<code>special_string()</code>
<code>id-at-surname</code>	<code>special_string()</code>
<code>id-at-givenName</code>	<code>special_string()</code>
<code>id-at-initials</code>	<code>special_string()</code>
<code>id-at-generationQualifier</code>	<code>special_string()</code>
<code>id-at-commonName</code>	<code>special_string()</code>
<code>id-at-localityName</code>	<code>special_string()</code>
<code>id-at-stateOrProvinceName</code>	<code>special_string()</code>
<code>id-at-organizationName</code>	<code>special_string()</code>
<code>id-at-title</code>	<code>special_string()</code>
<code>id-at-dnQualifier</code>	<code>{printableString, string()}</code>
<code>id-at-countryName</code>	<code>{printableString, string()}</code>

### 1.3 Certificate records

id-at-serialNumber	{printableString, string() }
id-at-pseudonym	special_string()

**Table 3.2: Attribute oids**

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

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

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

id\_public\_key\_algorithm()

OID name
rsaEncryption
id-dsa
dhpublicnumber
ecdsa-with-SHA1
id-keyExchangeAlgorithm

**Table 3.3: Public key algorithm oids**

```
#'Extension'{
  extnID,      % id_extensions() | oid()
  critical,    % boolean()
  extnValue    % asn1_der_encoded()
}.
```

id\_extensions() *Standard Certificate Extensions, Private Internet Extensions, CRL Extensions and CRL Entry Extensions.*

#### 1.3.3 Standard certificate extensions

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 3.4: Standard Certificate Extensions

```

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

```

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

Table 3.5: Key purpose oids

### 1.3 Certificate records

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```
#'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 % [asn1_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, % general_name() | [#AttributeTypeAndValue{}]
}
```

```

reasons,          % [dist_reason()]
cRLIssuer          % general_name()
}).

```

### 1.3.4 Private Internet Extensions

OID name	Value type
id-pe-authorityInfoAccess	[#AccessDescription'{}]
id-pe-subjectInfoAccess	[#AccessDescription'{}]

**Table 3.6: Private Internet Extensions**

```

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

```

### 1.3.5 CRL and CRL Extensions Profile

```

#CertificateList'{
    tbsCertList,      % #'TBSCertList{}
    signatureAlgorithm, % #'AlgorithmIdentifier{}
    signature          % {0, binary()} - asn1 compact 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

OID name	Value type
id-ce-authorityKeyIdentifier	#AuthorityKeyIdentifier{ }
id-ce-issuerAltName	{rdnSequence, [#AttributeTypeAndValue'{}]}

## 1.4 Using the public\_key API

id-ce-cRLNumber	integer()
id-ce-deltaCRLIndicator	integer()
id-ce-issuingDistributionPoint	#'IssuingDistributionPoint'{} }
id-ce-freshestCRL	[#'Distributionpoint'{} ]

**Table 3.7: CRL Extensions**

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

### CRL Entry Extensions

OID name	Value type
id-ce-cRLReason	crl_reason()
id-ce-holdInstructionCode	oid()
id-ce-invalidityDate	general_time()
id-ce-certificateIssuer	general_name()

**Table 3.8: CRL Entry Extensions**

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

## 1.4 Using the public\_key API

### 1.4.1 General information

This chapter is dedicated to showing some examples of how to use the public\_key API. Keys and certificates used in the following sections are generated only for the purpose of testing the public key application.

Note that some shell printouts, in the following examples, have been abbreviated for increased readability.

### 1.4.2 PEM files

Public key data (keys, certificates etc) may be stored in PEM format. PEM files come from the Private Enhanced Mail Internet standard and has a structure that looks like this:

```
<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 currently ignored except for Proc-Type and DEK-Info that are used when the DER data is encrypted.

## DSA private key

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"...>>}
```

This PEM file only has 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 = 510968529856012146351317363807366575075645839654}
```

## RSA private key encrypted with a password.

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

This PEM file only has 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", <<"kÛeø%puL">>}}]
```

In this 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,
```

## 1.4 Using the public\_key API

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```
prime1 = 11034766614656598484098...7326883017,  
prime2 = 10080459293561036618240...77738643771,  
exponent1 = 77928819327425934607...22152984217,  
exponent2 = 36287623121853605733...20588523793,  
coefficient = 924840412626098444...41820968343,  
otherPrimeInfos = asnl_NOVALUE}
```

### X509 Certificates

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

This 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 may of course 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 =
    {0,
     <<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 that parts ASN.1 type. Although application specific certificate extension requires application specific ASN.1 decode/encode-functions. Example, the first value of the `rdnSequence` above 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"}

```

## 1.4 Using the public\_key API

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... but certificates can also be decoded using the `pkix_decode_cert/2` that 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 =
        {0,
         <<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 you can do that by calling the functions `public_key:pem_entry_encode/2` and `pem_encode/1` and then saving the result to a file. For example assume 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 will be 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> PemBin = public_key:pem_entry_encode('SubjectPublicKeyInfo', RSAPubKey).
{'SubjectPublicKeyInfo', <<48,92,...>>, not_encrypted}

```

## 1.4 Using the public\_key API

---

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

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

### 1.4.3 RSA public key cryptography

Suppose you have `PrivateKey = #RSAPrivateKey{}` and the plaintext `Msg = binary()` and the corresponding public key `PublicKey = #RSAPublicKey{}` then you can do the following. Note that you normally will only do one of the encrypt or decrypt operations and the peer will do the other.

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),
```

### 1.4.4 Digital signatures

Suppose you have `PrivateKey = #RSAPrivateKey{}` or `#DSAPrivateKey{}` and the plaintext `Msg = binary()` and the corresponding public key `PublicKey = #RSAPublicKey{}` or `{integer(), #DssParams{}}` then you can do the following. Note that you normally will only do one of the sign or verify operations and the peer will do the other.

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

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

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

### 1.4.5 SSH files

SSH typically uses PEM files for private keys but has its own file format for storing public keys. The `erlang 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

```
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 = 1255626590179665817295475654204371833735706001853,
                 g = 10454211196...480338645}},
 [comment, "dhopsen@VMUubuntu-DSH"]}]
```

## Known hosts - openssh format

```
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 attributes 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|BW05qDxk/cFH0wa05JLdHn+j6xQ=|rXQvIxh5cDD3C43k5DPDamawVNA="]]}]
```

## Authorized keys - openssh format

```
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 attributes corresponds to one entry in the authorized key file.

```
2> public_key:ssh_decode(SshBin, auth_keys).
[{'#RSAPublicKey':{'modulus = 794430685...691663,
                    publicExponent = 35},
 [comment, "dhopsen@VMUubuntu-DSH"],
 [options,["command=\\"dump /home\\" ,no-pty",
           "no-port-forwarding"]]}],
 {{1564269258491...607694280725,
   #'Dss-Parms'{p = 17291273936185...763696123221,
                 q = 1255626590179665817295475654204371833735706001853,
                 g = 10454211195705...60511039590076780999046480338645}},
 [comment, "dhopsen@VMUubuntu-DSH"]}]
```

## 1.4 Using the public\_key API

---

### 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

---

Provides functions to handle public key infrastructure from RFC 3280 (X.509 certificates) and some parts of the PKCS-standard.

## public\_key

---

Erlang module

This module provides functions to handle public key infrastructure from RFC 5280 - X.509 certificates and some parts of the PKCS-standard.

### COMMON DATA TYPES

#### Note:

All records used in this manual are generated from ASN.1 specifications and are documented in the User's Guide. See *Public key records* and *X.509 Certificate 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").
```

#### Data Types

```
boolean() = true | false
```

```
string = [bytes()]
```

```
pki_asn1_type() = 'Certificate' | 'RSAPrivateKey' | 'RSAPublicKey'  
                'DSAPrivateKey' | 'DSAPublicKey' | 'DHParameter' | 'SubjectPublicKeyInfo' | 'PrivateKeyInfo'
```

```
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)} |  
               'PBES2-params' }
```

```
rsa_public_key() = #'RSAPublicKey' { }
```

```
rsa_private_key() = #'RSAPrivateKey' { }
```

```
dsa_public_key() = {integer(), #'Dss-Parms' { }}
```

```
dsa_private_key() = #'DSAPrivateKey' { }
```

```
public_crypt_options() = [{rsa_pad, rsa_padding()}].
```

```
rsa_padding() = 'rsa_pkcs1_padding' | 'rsa_pkcs1_oaep_padding'
              | 'rsa_no_padding'
```

```
rsa_digest_type() = 'md5' | 'sha' | 'sha224' | 'sha256' | 'sha384' | 'sha512'
```

```
dss_digest_type() = 'sha'
```

```
ssh_file() = openssh_public_key | rfc4716_public_key |
             known_hosts | auth_keys
```

## Exports

```
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.

```
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.

```
der_decode(Asn1type, Der) -> term()
```

Types:

```
Asn1Type = atom()
ASN.1 type present in the public_key applications asn1 specifications.
Der = der_encoded()
```

Decodes a public key ASN.1 der encoded entity.

```
der_encode(Asn1Type, Entity) -> der_encoded()
```

Types:

```
Asn1Type = atom()
Asn1 type present in the public_key applications ASN.1 specifications.
Entity = term()
```

The erlang representation of Asn1Type

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

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

Types:

```
PemBin = binary()
```

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

Decode PEM binary data and return 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. Note that if the pem entry is of type 'SubjectPublicKeyInfo' it will be 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()
```

The Erlang representation of Asn1Type. If Asn1Type is 'SubjectPublicKeyInfo' then Entity must be either an rsa\_public\_key() or a dsa\_public\_key() and this function will create the appropriate 'SubjectPublicKeyInfo' entry.

```
CipherInfo = cipher_info()
```

```
Password = string()
```

Creates a pem entry that can be feed to pem\_encode/1.

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

Types:

```
PlainText = binary()
```

```
Key = rsa_private_key()
```

Public key encryption using the private key.

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

Types:

```
PlainText = binary()
```



```
Key = rsa_public_key()
```

Public key encryption using the public key.

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

```
Cert = der_encoded()
```

Decodes an ASN.1 der encoded pkix certificate. The otp option will use 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 .

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 will directly call der\_encode/2.

```
pkix_is_issuer(Cert, IssuerCert) -> boolean()
```

Types:

```
Cert = der_encode() | #'OTPCertificate'{}
IssuerCert = der_encode() | #'OTPCertificate'{}
Checks if IssuerCert issued Cert
```

```
pkix_is_fixed_dh_cert(Cert) -> boolean()
```

Types:

```
Cert = der_encode() | #'OTPCertificate'{}
Checks if a Certificate is a fixed Diffie-Hellman Cert.
```

```
pkix_is_self_signed(Cert) -> boolean()
```

Types:

```
Cert = der_encode() | #'OTPCertificate'{}
Checks if a Certificate is self signed.
```

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

Types:

```
Cert = der_encode() | #'OTPCertificate'{}
IssuedBy = self | other
IssuerID = {integer(), {rdnSequence, [#'AttributeTypeAndValue'{}]}}
```

```
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 = {rdnSequence, [#'AttributeTypeAndValue'{}]}
Normalized = {rdnSequence, [#'AttributeTypeAndValue'{}]}
```

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

**pkix\_sign('#OTPTBSCertificate'{}, Key) -> der\_encode()**

Types:

```
Key = rsa_public_key() | dsa_public_key()
```

Signs a 'OTPTBSCertificate'. Returns the corresponding der encoded certificate.

**pkix\_verify(Cert, Key) -> boolean()**

Types:

```
Cert = der_encode()
Key = rsa_public_key() | dsa_public_key()
```

Verify 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" i.e. the digest.
DigestType = rsa_digest_type() | dss_digest_type()
Key = rsa_private_key() | dsa_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 may be either a rfc4716 public key or a openssh public key.

Decodes a ssh file-binary. In the case of know\_hosts or auth\_keys the binary may 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 man sshd

```
{comment, string()}
```

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

```
{bits, integer()} - In ssh version 1 files
```

known\_host attributes - see man 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 depends 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" i.e. the digest.  
DigestType = rsa_digest_type() | dss_digest_type()  
Signature = binary()  
Key = rsa_public_key() | dsa_public_key()
```

Verifies a digital signature